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CONSTRUCTION SPECIFICATION

2003

CONSTRUCTION SPECIFICATION

Section 1
General Specification

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1 GENERAL

1.1 INTRODUCTION AND SCOPE

1.1.1 PREAMBLE

The General Specifications have been developed by the Ministry of Public Works and Transport, to provide for the following types of activities:

i) Rehabilitation of existing road network.

ii) Construction of new highways and bridges.

iii) Maintenance of existing roads and structures.

1.1.2 STANDARDS

The General Specifications describe the requirements and procedures for execution of the various work items to achieve the required workmanship and quality. The materials to be used shall conform to specifications and testing procedures as per the American Association of State Highway and Transportation Official (AASHTO), the American Society for Testing and Material (ASTM) or Australian Standards (AS) as indicated in their latest editions. Sampling of materials for laboratory tests and their subsequent approval shall be executed according to these references unless otherwise directed by the Engineer.

1.1.3 SCOPE

1.1.3.1 Contract Works

Where Works are to be executed by contract the General Specifications is a contract document which shall be read in conjunction with the following contract documents in the order of precedence as defined in Sub-Clause 5.2 of the Conditions of Particular Application.

(1) the Contract Agreement;

(2) the Letter of Acceptance;

(3) the Bid and the Appendix to Bid;

(4) Part II – The Conditions of Particular Application;

(5) Part I – The General Conditions;

(6) the Special Provisions

(7) the General Specifications;

(8) the Drawings; and

(9) the priced Bill of Quantities

In the event that situations exist which are not satisfactorily covered by the General Specifications or where particular conditions pertaining to a specific contract occur, the relevant clauses of the General Conditions will be modified by the terms of the Special Provisions which will be prepared for each individual contract.

1.1.3.2 Force Account Works

Where Works are to be implemented by the Ministry's own force account workforce (day-labour) the General Specifications are the document which shall form the basis of the agreement between the Ministry's designated supervision organisation (PIU) and the selected implementing agency (e.g. Provincial Works Department) for the execution of the Works.

1.1.3.3 Silence of Specifications

The apparent silence of the Specifications, Drawings or other Contract Documents as to any detail or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best general practice is to be used. All interpretations of the specifications will be made by the Engineer on this basis

1.2 ABBREVIATIONS AND DEFINITIONS

1.2.1 ABBREVIATIONS

Wherever in these specifications or in other contract documents the following abbreviations and terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

AASHTO	American Association of State Highway and Transportation Officials.
AS	Australian Standards
ASTM	American Society for Testing and Material
AWG	American Wire Gauge
AWPA	American Wood Preservers Association
BS	British Standard Code of Practice
ACI	American Concrete Institute
FHWA	U.S. Federal Highway Administration
PCA	Portland Cement Association
Wt.	Weight
Lb.	Pound
AWS	American Welding Society
Gallon	U.S. Gallon
in.	Inch
ft.	Foot
yd.	Yard
Ltr.	Litre
mm	Millimetre
cm.	Centimetre
m	Metre
Km	Kilometre
sq-m	Square Metre
ºC	Degree Centigrade
ºF	Degree Fahrenheit
sq-cm	Square Centimetre
cu-m	Cubic Metre
Ha	Hectare
Kg	Kilogram
tonne	Metric Ton (1000 Kg)

1.2.2 DEFINITIONS

Wherever in these specifications or in other contract documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

Acceptable	In compliance with any conditions that the Engineer may set for acceptance of the work item, material or process.
Accepted	Completion of the work item to the Engineer's satisfaction.
Addendum	A written amendment or revision to the Contract documents or plans issued to bidders prior to the final date and time for submission of Tenders in the "Instruction to Tenderer."
Aggregates	Crushed stone or processed gravel
Amenities	Recreational facilities and similar items provided to improve living conditions at site with characteristics conducive to pleasantness.
Apron	A concrete, rock or masonry slab forming a part, or for the protection of a structure.
Asphalt Concrete	High quality, thoroughly controlled hot mixture of bitumen and well-graded, high quality aggregate, thoroughly compacted into a uniform, dense mass
Asphalt Concrete Pavement	All courses of asphalt concrete mixtures placed above the layer of base course, subbase or improved subgrade. When placed directly on the subgrade, it is called full-depth asphalt pavement
Asphalt Surface Course	The uppermost layer of specified thickness of an asphalt concrete pavement; also called "Wearing course".
Asphalt Base Course	The lowermost layer of specified thickness of an asphalt concrete pavement which may include an asphalt concrete levelling course.
Asphalt Concrete Levelling Course	The layer of specified material of variable thickness placed generally on an existing road surface to compensate for depressions and undulations in order to correct grades and cross fails according to design.
Auxiliary lane	That portion of the roadway adjoining the travelled way for speed change or other purposes supplementary to through traffic movements.
Barrage	A low dam or weir across a river equipped with a series of gates to regulate the water surface level above the weir.
Basecourse	The layer of specified material and thickness placed immediately below the surface course
Batten	Beam, a structural member
Bid / Tender Price	The sum of the products of the quantities of work with the quoted unit prices in the Tender by the Contractor.
Bill of Quantities	A list showing work quantities and specifying unit price and/or lump sum for specific items of work.
Blinding layer	A layer of concrete or other material (Generally thin) covering the surface of excavated ground or fill, forming a stable surface on which further work may be constructed.
Boulder	A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 10 centimetres or more.
Boundary	Limit of right-of-way or other zones
Bridge	Any structure other than a culvert, which carries a utility, facility, or railroad highway, pedestrian, or other traffic over a water course, or over or under or around any obstruction and with 2 independent abutments (with or without

	intermediate piers) connected at the top with girders and a deck
Bund	A continuous embankment, dike or levee (generally associated with training or containing the flow of rivers).
Catchment	The watershed or area which contributes runoff to a drain or other channel.
Culvert	Any structure, other than a bridge which provides an opening under a roadway for drainage, irrigation, or other purposes comprising a monolithic cell (circular or rectangular) or multiple of cells, without abutments.
cumec	A rate of flow of one cubic metre per second
cusec	A rate of flow of one cubic foot per second
Daywork	Work to be paid for on the basis of actual labour, material, and plant used against agreed rates provided in the Bill of Quantities.
Detour (Diversion)	A temporary roadway which leaves the main route and rejoins it later, generally to provide for the uninterrupted flow of traffic around an obstruction or works in progress.
Earth	Sediments or other unconsolidated accumulations of solid particles, produced by the physical and chemical disintegration of rock, and which may or may not contain organic matter.
Flexible Pavement	A combination of pavement layers which allows reasonable deflection under traffic loading without cracking
Forms / Formwork	Shuttering comprising removable sections of timber or steel or other rigid material into which wet concrete is placed to provide its final shape including its supports and falsework
Frustrated Contract	Contract rendered impossible for performance by either or both parties from an external unforeseen cause
Gasoline	Motor spirit, petrol
Godown	Warehouse, store room or storage shed
Gravel	Naturally occurring mixture composed primarily of rock fragments between 2mm and 75mm in diameter, generally containing much sand.
Guide Bank	A protective and training embankment or levee for directing river flow
Highway	A general term denoting a major public way for purposes of vehicular travel, including the entire area within the right-of-way. (Recommended Usage: in urban areas-highway or street; in rural areas-highway or road).
Laboratory	A facility within which the testing of materials in accordance with specified test methods and procedures can be carried out
Laterite	Decomposed rock, generally reddish in colour with a high content of iron oxide and aluminium hydroxide
Leading Hand	Experienced workman or labourer in charge of a small group of workmen or labourers.
Monsoon	The rainy season associated with south-west monsoon generally between June and October
Plans	The approved plans (drawings), profiles, typical cross-sections, working drawings and supplementary drawings or exact reproduction thereof, which show the location, character, dimensions and details of the work.
Regulator	A canal structure, usually equipped with gates for control, or checking of flow in the canal or a take-off channel.
Return	Report
Revetment	Rock
Right-of-Way	A general term denoting land, property, or interest therein,

	usually in a strip, acquired for or devoted to the provision of corridors for transportation, and other services.
Roadside	A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside
Roadbed	The graded portion of a road or highway, usually considered as the area between the intersection of top and side slopes, upon which the subbase, basecourse, surface course, shoulders and median are constructed. Also commonly called the formation
Setting Out	Laying out or (staking out) and establishing on the site the lines, levels and grades to which the works are to be constructed.
Shoulders	The portion of the roadway contiguous with the travelled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.
Sidewalk	That portion of the roadway primarily constructed for the use of pedestrians.
Sleepers	Railroad ties, cross ties
Stake, staked	Mark, or be marked, by means of poles or pegs set by a surveyor.
Stone Pitching (Rip-Rap)	Broken stone, brickwork or other similar materials placed usually on the side slopes of embankments for protection of the earth surface, particularly adjacent to structures
Structures	Bridges, culverts, catch basins, drop Inlets. Retaining walls, manholes, headwalls, service pipes and other features which may be encountered in the work and are not otherwise classed herein.
Spoil Area	Disposal area for excess excavation.
Surfacing (Surface Course)	The uppermost layer of specified material placed on the travelled way or shoulder. Types of surfacing may consist of bituminous sprayed surface treatment (hot surface dressing), asphalt concrete surface course, or concrete pavement.
Subbase	The layer of specified material and thickness placed between the base course and subgrade.
Subgrade	The top surface of a roadbed upon which the pavement structures and shoulders including curbs are constructed.
Subgrade level	That level of the roadbed (or, embankment) on which other road materials have to be placed.
Subgrade treatment	Modification of roadbed material by various treatment such as compaction, stabilisation, etc
Substructure	All of that part of a structure below the bearings of simple and continuous spans, or rigid frames, including back walls, and wing walls.
Superstructure	All of that part of a structure above and including the bearings of simple and continuous spans, or rigid frames, including beams, diaphragms, deck and protection railings
Traffic Lane	That portion of a travelled way for the movement of a single line of vehicles.

1.3 WORKFORCE

1.3.1 GENERAL REQUIREMENTS

The Contractor shall provide suitably skilled labour in adequate numbers, who can adequately carry out the works to the quality and with the standard of workmanship in accordance with the requirements of each individual work item and with Sub-Clause 16.1 of the General Conditions.

The Contractor shall make all necessary arrangement for employing and maintaining the workforce required for the execution of the Works in accordance with Sub-Clause 34.1 of the General Conditions and Sub-Clauses 34.2 to 34.16 and 35.3 of the Conditions of Particular Application

Any person employed by the Contractor who is not capable of performing the required works in a proper and skilful manner or who behaves in an improper manner may be removed from the site in accordance with the requirements of Sub-Clause 16.2 of the General Conditions.

1.3.2 MEASUREMENT AND PAYMENT

Unless specifically instructed in accordance with Sub-Clause 52.4 of the General Conditions no separate measurement for payment will be made for the provision of the labour for the execution of the Works.

Full compensation for furnishing all labour shall be considered as included in the price paid for the contract item of work involving such labour and no additional compensation will be allowed therefor.

Where Daywork is instructed in accordance with the requirements of Sub-Clause 52.4 of the General Conditions, the provisions of Section 10 Daywork of these Specifications will apply for measurement and payment thereof.

1.4 MATERIALS

1.4.1 SUPPLY, SAMPLES AND QUALITY REQUIREMENTS

All materials, manufactured articles and machinery to be incorporated in the Works shall meet all quality requirements of the relevant provisions of the Contract. They must in all cases be approved by the Engineer prior to their inclusion into the Work.

In order to expedite the Work, the Contractor shall, before placing any purchase order for materials, manufactured articles and machinery to be incorporated in the Works, submit for the approval of the Engineer, a complete description of such items, the names of the firms from which it is proposed to obtain such items, together with a list of the items it is proposed for each firm to supply. No such materials, manufactured articles or machinery shall be ordered from any firm without the written approval of the Engineer.

When directed by the Engineer or otherwise specified in the Contract the Contractor shall submit samples for approval.

If it is found after trials that sources of supply for previously approved materials, manufactured articles or machinery do not produce items in accordance with the Specifications, the Contractor shall furnish such items from other sources approved by the Engineer.

1.4.2 LOCAL MATERIAL SOURCES

When material deposits are not designated on the Drawings or described in the Special Provisions, the Contractor shall locate and provide materials acceptable to the Engineer.

When sources of local materials are designated on the Drawings and/or described in the Special Provisions, the quality of materials in such deposits is considered to be acceptable in general, but the Contractor shall determine for itself the quality and the amount of equipment and work required to produce a material meeting the requirements of he Specifications. The designation of a source of material in no way relieves the Contractor of his responsibility to produce materials meeting the requirements of the Specifications.

It shall be understood that it is not feasible to ascertain from the samples the limits for an entire deposit, and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

When sources of local materials are not designated on the Drawings and / or described in the Special Provisions, the Contractor shall be totally responsible for locating and producing materials that conform to the requirements of the Specifications. The exploring, testing of samples and developing of such material sources and the costs thereof are the responsibility of the Contractor.

No material, regardless of its source, shall be incorporated in the Work until representative samples taken by the Contractor in the presence of the Engineer or tested by the Contractor in the presence of the Engineer have been approved and written authority is issued by the Engineer for the use thereof.

1.4.3 QUARRY MATERIALS

Quarry material is rock, sand, gravel, earth or other mineral material, other than local borrow or selected material, obtained on the project. Quarry material does not include materials such as cement, lime, marble powder etc. obtained from established commercial sources.

Quarry Materials shall be furnished by the Contractor from any source he may select, except that when mandatory local sources of certain materials are designated on the Drawings or in the Special Provisions, the Contractor shall furnish material from such designated mandatory sources.

The furnishing of quarry materials from any source is subject to the provisions of Sub-Clauses 37.1 Inspection of Operations and 37.2 Inspection and Testing of the General Conditions.

Unless approved in writing by the Engineer, material sources shall not be excavated allocations where the resulting scars will present an unsightly appearance from any highway. No payment will be made for material obtained in violation of this provision.

The Contractor shall, at his expense, make any arrangements necessary for hauling over local public and private roads from any source and shall comply in all respects with the relevant provisions of the General Conditions.

1.4.4 STORAGE OF MATERIALS

Articles or materials to be incorporated in the work shall be stored in such a manner as to ensure the preservation of their quality and fitness for the work and to facilitate their prompt inspection.

Stored materials, even though approved before storage, may again be inspected prior to their incorporation in the Works.

Materials and articles shall not be stored on the right-of-way except where and as permitted by the Engineer. Stockpiling of aggregate material within the right-of-way shall be confined to such authorised areas as may be approved by the Engineer. Where stockpiling is done outside the roadway on Government or private property, the site shall be abandoned immediately upon completion of the utilisation of he stockpile material and the natural surface shall be restored as nearly as possible to the original condition by the Contractor at its expense and to the satisfaction of the Engineer.

Any costs for the use of privately owned land for storage and/or for the placing of the Contractor's plant and equipment shall be borne by the Contractor. Private property shall not be used for storage purposes without written permission and release of the owner or lessee, and a copy of such written permission and release shall be furnished to the Engineer prior to any use of the land by the Contractor.

1.4.5 DEFECTIVE MATERIALS

All materials which the Engineer has determined do not conform to the requirements of the drawings and specifications will be rejected whether in place or not. In accordance with the provisions of Sub-Clause 39.1 of the General Conditions they shall be removed immediately from the site of the work, unless otherwise permitted by the Engineer. No

rejected material, the defects of which have been subsequently corrected, shall be used in the work, unless approval in writing has been given by the Engineer.

Upon failure of the Contractor to comply promptly with any order of the Engineer made under the provisions in this clause, the Engineer shall have authority to cause the removal of rejected material and to deduct the cost thereof from any monies due or to become due to the Contractor in accordance with the provisions of Sub-Clause 39.2 of the General Conditions.

1.4.6 TRADE NAMES AND ALTERNATIVES

For convenience in designation on the plans or in the specifications, certain articles or materials to be incorporated in the work may be designated under a trade name or the name of a manufacturer and his catalogue information. The use of an alternative article or material which is of equal quality and of the required characteristics for the purpose intended will be permitted, subject to the following requirements:

(i) The burden of proof as to quality and suitability of alternatives shall be upon the Contractor and he shall furnish all information necessary as required by the Engineer.

(ii) The Engineer shall be the sole judge as to the quality and suitability of alternative articles or materials and his decision shall be final.

Whenever the specifications permit the substitution of a similar or equivalent material or article, no tests or action relating to the approval of such substitute material will be made until the request for the substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. Such request shall be made in ample time to permit approval without delaying the work.

1.4.7 LOAD RESTRICTIONS

The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the Works in accordance with Sub-Clause 26.1 of the General Conditions.

The Contractor shall use every reasonable means to prevent any of the roads or bridges communicating with or on the routes to the Site from being damaged or injured by any traffic of the Contractor or any of its Subcontractors and in particular shall select routes, choose and use vehicles and restrict and distribute loads so that any such extraordinary traffic as will inevitably arise from the moving of plant and materials from and to the Site shall be limited as far as reasonably possible and so that no unnecessary damage or injury may be caused to such roads and bridges.

Should it be found necessary for the Contractor to move one or more loads of constructional plant, machinery of preconstructed units, or parts of units of Work, over part of a road or bridge, the moving whereof is likely to damage any road or bridge unless special protection or strengthening is carried out, then the Contractor shall, before moving the load on to such road or bridge, give notice to the Engineer of the weight and other particulars of the load to be moved and its proposals for protecting or strengthening the said road or bridge. Unless within fourteen days of the receipt of such notice the Engineer shall by counter-notice direct that such protection or strengthening is unnecessary, then the Contractor will carry out at its own expense such proposals or any modification thereof that the Engineer shall require.

The Contractor shall bear all responsibility and liability for damages or injury resulting from its failure to abide by these provisions, in accordance with Sub-Clause 22.1 of the General Conditions except when such transport or passage is done by special written permission of the Employer. The Contractor shall be responsible for all damage caused by his hauling within the limits of the Works.

1.4.8 MEASUREMENT AND PAYMENT

Unless specifically instructed in accordance with Sub-Clause 52.4 of the General Conditions no separate measurement for payment will be made for the provision of the materials for the execution of the Works.

Full compensation for furnishing all materials and for doing all the work involved in conforming to the provisions in this Section of these Specifications, for furnishing and producing materials from any source shall be considered as included in the price paid for the contract item of work involving such Material and no additional compensation will be allowed therefor.

Where Daywork is instructed in accordance with the requirements of Sub-Clause 52.4 of the General Conditions, the provisions of Section 10 Daywork of these Specifications will apply for measurement and payment thereof.

1.5 EQUIPMENT

1.5.1 GENERAL REQUIREMENTS

All equipment which is proposed to be used on the Work shall be of sufficient size and in such mechanical condition as to met the requirements of the Work and to produce a satisfactory quality of the Work in accordance with Sub-Clause 36.1 of the General Conditions.

Equipment used on any portion of the Works shall be such that no injury to the roadway, adjacent property, or other highways or works will result from its use.

The number and types of equipment required for different items of work shall be planned by the contractor keeping in view the workmanship required by a particular item and the quantity of the finished item required to be carried out in an eight hour shift. Any such planning shall be approved by the Engineer and changes may be proposed for the guidance of the Contractor. However this procedure shall not relieve the Contractor of his contractual obligations.

1.5.2 ALTERNATIVE EQUIPMENT

While certain of these specifications may provide that equipment of a particular size and type is to be used to perform portions of the work, it is to be understood that the development and use of new or improved equipment is to be encouraged.

The Contractor may request, in writing, permission from the Engineer to use equipment of a different size or type in place of the equipment specified.

The Engineer, before considering or granting such a request, may require the Contractor to furnish, at his expense, evidence satisfactory to the Engineer that the equipment proposed for use by the Contractor is capable of producing work equal to, or better than, that which can be produced by the equipment specified.

If such permission is granted by the Engineer, it shall be understood that such permission is granted for the purpose of testing the quality of work actually produced by such equipment and is subject to continuous alignment of results which, in the opinion of the Engineer, are equal to, or better than, that which can be obtained with the equipment specified. The Engineer shall have the right to withdraw such permission at any time that he determines that the alternative equipment is not producing work that is equal, in all respects, to that which can be produced by the equipment specified. Upon withdrawal of such permission by the Engineer, the Contractor will be required to use the equipment originally specified and shall, in accordance with the directions of the Engineer, remove and dispose of or otherwise remedy, at his expense, any defective or unsatisfactory work produced with the alternative equipment.

Neither the Employer nor the Contractor shall have any claim against the other for either the withholding or the granting of permission to use alternative equipment, or for the withdrawal of such permission.

Permission to use alternative equipment in place of equipment specified will only be granted where such equipment is new or improved and its use is deemed by the Engineer to be in furtherance of the purposes of this clause. The approval for use of particular equipment on any activity or project shall in no way be considered as an approval of the use of such equipment on any other activity or project.

Nothing in this clause shall relieve the Contractor of his responsibility for providing appropriate equipment or producing finished work of the quality specified in these specifications.

1.5.3 REMOVAL OF UNSUITABLE EQUIPMENT

The Contractor is required, upon signing of the contract and prior to payment of the balance of the Advance Payment as stipulated in Sub-Clause 60.7 of the Conditions of Particular Application to provide sufficient, suitable equipment to implement the programme for the execution of the Works.

In the event that the equipment specified by the Contractor in Schedule VI, Section 9, Schedules of Supplementary Information in its Bid is not provided on site, or is considered unsuitable for the proper execution of the Works, payment of the balance of the Advance Payment will be withheld and any equipment considered unsuitable shall be removed from the site in accordance with the provisions of Sub-Clause 39.1 of he General Conditions

1.5.4 LOAD RESTRICTIONS

The provisions of Clause 1.4.7 will apply for the transport of equipment on public roads beyond the limits of the Works.

Any type of equipment of such weight or so loaded as to cause damage to drainage structures of any kind, or to any other type of construction, either being constructed or previously constructed will not be permitted to operate in any location where damage would be caused.

1.5.5 MEASUREMENT AND PAYMENT

Unless specifically instructed in accordance with Sub-Clause 52.4 of the General Conditions no separate measurement for payment will be made for the provision of the equipment for the execution of the Works.

Full compensation for furnishing all tools, equipment, and incidentals shall be considered as included in the price paid for the contract item of work involving such tools, equipment and incidentals and no additional compensation will be allowed.

Where Daywork is instructed in accordance with the requirements of Sub-Clause 52.4 of the General Conditions, the provisions of Section 10 Daywork of these Specifications will apply for measurement and payment thereof.

1.6 ALTERNATIVE METHODS OF CONSTRUCTION

1.6.1 RESPONSIBILITIES

The Contractor shall submit to the Engineer, in accordance with the requirements of Clause 14.1 of the General Conditions, a general description of his proposed arrangements and methods for the execution of the Works, including inter-alia, temporary offices, buildings, access roads, detours, Constructional Plant and its intended production output, working shift arrangements, labour strength, skilled and unskilled labour and supervision arrangements, power arrangements, supply of materials, stone crushing, aggregate production and storage, cement handling, concrete mixing and handling, methods of excavation, dealing with water, testing methods and facilities.

During the execution of the Works, the Contractor shall also submit to the Engineer full and detailed particulars of any proposed amendments to the arrangements and methods submitted in accordance with the above requirements.

Whenever the plans or specifications provide that more than one specified method of construction or more than one specified type of constructional equipment may be used to perform portions of the Work and leave the selection of the method of construction or the type of equipment to be used to the discretion of the Contractor, it is understood that the Employer does not guarantee that every such method of construction or type of equipment can be used successfully throughout all or any of the Works.

It shall be the Contractor's responsibility to select and use the alternative or alternatives which will satisfactorily perform the work under the conditions encountered. In the event some of the alternatives are not feasible or it is necessary to use more than one of the alternatives on any project, full compensation for any additional cost involved shall be considered as included in the contract price paid for, the item of work involved and no additional compensation will be allowed thereof.

1.6.2 ALTERNATIVE METHODS

When the Contract specifies that the construction be performed by the use of certain methods, such methods shall be used unless others are authorised by the Engineer.

If the Contractor desires to use a method other than that specified in the Contract, it may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing Work that conforms to the requirements of the Specifications.

If after trial use of the alternative methods, the Engineer determines that the Work produced does not conform to the Contract requirements, the Contractor shall discontinue the use of the alternative method and shall complete the remaining construction with the specified methods. The Contractor shall remove the deficient Work and replace it with Work of he specified quality in accordance with the provisions of Clause 39.1 of the General Conditions, or take such other corrective action as the Engineer may direct.

No change will be made in the basis of payment for the construction items involved or in the Contract Time for Completion as a result of approving a change in the method of construction.

1.7 LAND REQUIREMENTS

1.7.1 DESCRIPTION

The land available to the Contractor free of charge shall be that to be occupied by the Permanent Works plus a working area of 5 metres on either side of that area occupied by the Permanent Works. It is the responsibility of the Employer to ensure that this land is made available and, in the event of objections being raised by the local population, the Contractor shall immediately report the circumstances to the Engineer.

All necessary negotiations, agreements and payments for additional land for whatever purpose, including that required for the Engineer's facilities, shall be the responsibility of the Contractor.

The Contractor shall indemnify the Employer and the Engineer against any claims or proceedings resulting from the occupancy and use of such areas of additional land in accordance with the requirements of Sub-clause 22.1 of the General Conditions.

1.7.2 MEASUREMENT AND PAYMENT

No measurement or payment shall be made in respect of the provision of land, and no payment shall be made to the Contractor for any additional land, as defined in Sub-clause 1.7.1 above, provided by the Contractor.

1.8 SERVICES AND UTILITIES

1.8.1 DIVERSION OF PUBLIC SERVICES

The diversion of public services is the responsibility of the Employer and it is the intention that all public services shall have been diverted from the site or to locations where they will not interfere unduly with the Works, prior to commencement.

Nevertheless it will be the responsibility of the Contractor to take all reasonable measures to avoid causing damage to public services whether outside the confines of the Site, or buried under the Site or overhead. It will be the responsibility of the Contractor to familiarise himself and his staff with the known locations of all services passing through or over the Site.

In the event that the Contractor discovers a previously undisclosed service during the course of construction operations he shall take immediate steps to protect the installation and shall inform the Engineer of the discovery. The Engineer shall either arrange for the appropriate authorities to relocate or otherwise reinstate the service or shall instruct the Contractor to carry out the work.

1.8.2 NOTIFICATION OF DAMAGE

In the event of interruption to any service or utility as a result of accidental breakage, or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of the service or utility.

If an essential public utility service is interrupted, repair work shall be continuous until the service is restored.

1.8.3 MEASUREMENT AND PAYMENT

No measurement or payment to the Contractor shall be made in respect of public services and their relocation.

In the event that the Engineer requires the Contractor to carry out work as may be required to protect or relocate services then such works shall be measured and paid for as Daywork in accordance with the provisions of Section 10 of these Specifications.

1.9 USE OF EXPLOSIVES

1.9.1 DESCRIPTION

This work consists of the provision and utilisation of explosives required to carry out specific activities as required by the Contract in accordance with the provisions of the General Conditions and the following requirements of the General Specifications.

1.9.2 GENERAL REQUIREMENTS

1.9.2.1 Control

The Contractor shall not utilise explosives without the prior written approval of the Engineer. Such approval shall not relieve the Contractor from any of his liabilities or responsibilities to ensure that blasting operations are carried out in safe manner and in full compliance with all relevant statutory obligations.

The Contractor shall obtain all necessary permits and pay all necessary fees for the acquisition, storage and use of explosives and explosive devices. He shall submit full details to the Engineer and obtain approval in writing for each occasion when he intends to use explosives, such details to include without limitation the date and time of the blast, the size of charge, method of firing, and protective measures to be adopted.

1.9.2.2 Storage

The Contractor shall store all explosives and explosive devices in a secure location and in accordance with statutory requirements and to the approval of the Engineer.

The Contractor shall keep a current inventory of all explosives and explosive devices obtained and used and submit a monthly report to the Engineer, detailing the usage of all explosives and explosive devices by date and location.

1.9.2.3 Transport

The Contractor shall provide a properly equipped secure vehicle, which shall be maintained in good condition, for the transportation of explosives.

1.9.2.4 Personnel

The Contractor shall appoint a responsible person or persons to order and receive explosives and to be responsible for all blasting activities. The name(s) and details of experience of such person or persons shall be submitted to the Engineer for approval.

The Contractor shall only employ properly qualified workmen approved by the Engineer in the handling and firing of all charges.

1.9.2.5 Safety Procedures

The Contractor shall provide an approved system of warning the public (including road traffic) and all site personnel of an impending blast by both audible and visible means and shall ensure that the blasting area at risk to personnel is cleared of all personnel immediately prior to blasting.

The Contractor shall take all necessary measures to protect personnel and property and to prevent any fragments due to blasts from being projected in a dangerous manner.

If blasting is to be carried out in the vicinity of overhead electrical power cables the contractor shall check for stay electric currents at the blasting site prior to commencing charging. If blasting is to be carried out at locations where it is likely to cause damage to structures/properties in the vicinity, controlled blasting measures as approved by Engineer should be adopted.

1.9.3 MEASUREMENT AND PAYMENT

No separate measurement or payment shall be made in respect of compliance with the provisions of this Section of the specification. The Contractor shall be deemed to have made allowance for such compliance with there provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

1.10 PROTECTION OF THE ENVIRONMENT

1.10.1 DESCRIPTION

This work consists of the implementation of the necessary procedures required for the protection of the Environment during the execution of specific work activities as required by the Contract in accordance with the provisions of the General Conditions and the following requirements of the General Specifications.

1.10.2 GENERAL REQUIREMENTS

1.10.2.1 General

This Section of the Specification sets out limitations on the Contractor's activities specifically intended to protect the environment. The Contractor's attention is however drawn to the fact that other provisions, equally important to the protection of the environment, are included throughout these Specifications. These include, but are not limited to:

Section 1.9	Use of explosives
Sub-clause 4.1.3.9	Control of bitumen spillages;
Sub-clause 4.4.4.3 k)	Dust collection for asphalt mixing process
Section 2.3	Control and reinstatement of borrow areas and quarries.
Section 6.6	Grassing of Slopes
Section 6.7	Topsoil
Section 8	UXO Clearance
Section 9.8	Site Clean-Up

The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on site or off-site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in this document.

The Contractor shall take all measures and precautions to avoid any nuisance or disturbance arising from the execution of the Works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.

The provisions of these clauses are to be treated as relaxeable, if so required, for emergency work necessary for the saving of life or property or the safety of the Works.

1.10.2.2 Water Quality

The Contractor shall prevent any interference with the supply to or abstraction from or the pollution of water resources (including underground percolating water) as a result of the execution of the Works.

Areas where water is regularly or repetitively used for dust suppression purposes (including, without limitation, stockpiles for concrete-batching and asphalt plants) shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be re-used for dust suppression and rinsing.

All water and other liquid waste products arising on the Site shall be collected and disposed of at a location on or off the Site and in a manner that shall not cause either nuisance or pollution.

The Contractor shall not discharge or deposit any matter arising from the execution of the Works into any waters except with the permission of the Engineer and the regulatory authorities concerned.

The Contractor shall at all times ensure that all existing stream courses and drains within and adjacent to the Site are kept safe and free from any debris and any materials arising from the Works.

The Contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution, silting, flooding or erosion as a result of the execution of the Works.

The Contractor shall submit details of his temporary drainage work system (including all surface channels, sediment traps, washing basins and discharge pits) to the Engineer for approval prior to commencing work on its construction.

1.10.2.3 Air Quality

The Contractor shall devise and implement methods of working to minimise dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimise adverse impacts on air quality.

The Contractor shall utilise effective water sprays during delivery and handing of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials shall be covered with clean tarpaulins, with application of sprayed water during dry and windy weather. Stockpiles of material or debris shall be dampened prior their movement, except where this is contrary to the Specification.

Any vehicle with an open load-carrying area used for transporting potentially dust-producing material shall have properly fitting side and tailboards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards, and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extend at least 300 mm over the edges of the side and tailboards.

In the event that the Contractor is permitted to provide temporary non-bituminous surfaced roads for the use of the travelling public or uses gravel or earth roads for haulage, he shall provide suitable measures for dust palliation, if these are, in the opinion of the Engineer, necessary. Such measures may include spraying the road surface with water at regular intervals.

1.10.2.4 Noise

The Contractor shall consider noise as an environmental constraint in his planning and execution of the Works.

The Contractor shall take all necessary measure that the operation of all mechanical equipment and construction processes on and off the Site shall not cause any unnecessary or excessive noise, taking into account applicable environment requirements. The Contractor shall use all necessary measures and shall maintain all plant and silencing

equipment in good condition so as to minimise the noise emission during construction works.

1.10.2.5 Control of Wastes

The Contractor shall control the disposal of all forms of waste generated by the construction operations and in all associated activities. No uncontrolled deposition or dumping shall be permitted. Wastes to be so controlled shall include, but shall not be limited to, sewerage, all forms of fuel and engine oils, bitumen, cement, surplus concrete, surplus aggregates, gravels etc. The Contractor shall make specifies provision for the proper disposal of these and any other waste products, conforming to local regulations and acceptable to the Engineer.

In the event of any spoil or debris or silt from the Site being deposited on any adjacent land, the Contractor shall immediately remove all such spoil debris or silt and restore the effected area to its original state to the satisfaction of the Engineer.

1.10.2.6 Emergency Response

The Contractor shall plan and provide for remedial measures to be implemented in the event of an occurrence of emergencies such as spillages of oil or bitumen or chemicals.

The Contractor shall provide the Engineer with a statement of the measures he intends to implement in the event of such an emergency which shall include a statement of how he intends to provide personnel adequately trained to implement such measures. This statement shall accompany the programme to be submitted by the Contractor in accordance with the provisions of Clause 14 of the General Conditions.

1.10.3 MEASUREMENT AND PAYMENT

No separate measurement shall be made in respect of compliance by the Contractor with the provisions of this Section of the Specification. The Contractor shall be deemed to have made allowance for such compliance with there provisions in the preparation of his prices for items of work included in the Bills of Quantities and full compensation for such compliance will be deemed to be covered by them.

1.11 CONTROL AND QUALITY OF WORKS

1.11.1 FREQUENCY OF TESTS AND TEST DESIGNATIONS

Frequency of tests for major items of construction will be defined in these specifications or in the Special Provisions, however for certain items frequency of tests has been left to the discretion of the Engineer.

While deciding the frequency of tests for major items, each aspect of new construction, rehabilitation and maintenance of roads may be dealt differently, keeping in view the quantum of work.

For convenience the Frequency of tests required under these Specifications have been summarised in tabular form and are included in Clause 1.11.7 of these Specifications

1.11.2 TESTING STANDARDS

Unless otherwise specified, all tests shall be performed in accordance with the methods used by AASHTO/ASTM and shall be made by the Engineer or his designated representative.

Whenever the specifications provide an option between two or more tests, the Engineer will determine the test to be used.

Whenever a reference is made in the specifications to a specification manual, or a test designation either of the American Society For Testing and Materials, the American Association of State Highway and Transportation Officials, Federal Highway Specification, or any other recognised national organisation, and the number or other identification representing the year of adoption or latest revision is omitted, it shall mean the specification, manual or test designation in effect on the day 28 days prior to the date for submission of bids.

Whenever said specification manual or test designation provides for test reports (such as certified mill test reports) from the manufacturer, copies of such reports, identified as to the lot of material, shall be furnished to the Engineer. When material which cannot be identified with specific test reports is proposed for use, the Engineer may, at his discretion, select random samples from the lot for testing. Test specimens from the random samples, including those required for retest, shall be prepared in accordance with the referenced specification and furnished by the Contractor at his expense. The number of such samples and test specimens shall be entirely at the discretion of the Engineer. Unidentified metal products such as sheet plate, hardware, etc., shall be subject to the test requirements prescribed by the Engineer.

When desired by the Engineer and in accordance with the requirements of Clause 1.4.1 of these Specifications, the Contractor shall furnish, without charge, samples of all materials entering into the work and no material shall be used prior to approval by the Engineer. Samples of material from local sources shall be taken by or in the presence of the Engineer, otherwise the samples will not be considered for testing.

1.11.3 LINES AND GRADES

Such stakes or marks will be set by the Engineer as he determines to be necessary to establish the lines and grades required for the completion of the work specified in these specifications, on the plans and in the Special Provisions.

When the Contractor requires such stakes or marks, he shall notify the Engineer of his requirements in writing a reasonable length of time in advance of starting operations that he requires such stakes or marks. In no event shall a notice of less than 2 working days be considered a reasonable length of time.

The Engineer shall, where necessary, provide in writing the reference lines and levels and the Contractor will use these reference lines and levels for setting out.

Stakes and marks set by the Engineer on ground shall be carefully preserved by the Contractor. In case such stakes and marks are destroyed or damaged they will be replaced at the Engineer's earliest convenience. The Contractor will be charged for the cost of necessary replacement or restoration of stakes and marks which in the judgement of the Engineer were carelessly or wilfully destroyed or damaged by the Contractor's operations. This charge will be deducted from any monies due or to become due to the Contractor.

1.11.4 INSPECTION

The Engineer shall, at all times, have safe access to the work during its construction, and shall be furnished with every reasonable facility for ascertaining that the materials and the workmanship are in accordance with the requirements and intentions of these specifications, the Special Provisions, and the plans. All work done and all materials furnished shall be subject to his inspection.

The inspection of the work or materials shall not relieve the Contractor of any of his obligations to fulfil his contract as prescribed. Work and materials not meeting such requirements shall be made good and unsuitable work or materials may be rejected, not with standing that such work or materials have been previously Inspected by the Engineer or that payment therefor has been included in a progress estimate.

1.11.5 CONFORMITY WITH CONTRACT DOCUMENTS AND ALLOWABLE DEVIATIONS

Work and materials shall conform to the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown on the plans or indicated in the specifications. Although measurement, sampling and testing may be considered evidence as to such conformity, the Engineer shall be the sole judge as to whether the work or materials deviate from the plans and specifications, and his decision relating to any allowable deviations therefrom shall be final.

1.11.6 REMOVAL OF REJECTED UNAUTHORISED WORK

All work that has been rejected shall be remedied, or removed and replaced by the Contractor in an acceptable manner and no compensation will be allowed to him for such removal, replacement, or remedial work.

Any work done beyond the lines and grades shown on the plans or established by the Engineer, or any extra work done without written authority will be considered as unauthorised work and will not be paid for.

Upon order of the Engineer unauthorised work shall be remedied, removed or replaced at the Contractor's expenses.

Upon failure of the Contractor to comply promptly with any order of the Engineer made under this Item the Employer may cause rejected or unauthorised work to be remedied, removed, or replaced, and to deduct the costs from any monies due or to become due to the Contractor in accordance with Sub-Clause 39.2 of the General Conditions.

1.11.7 SAMPLING AND TESTING FREQUENCY

Table 1.1 Embankment and Subgrades : (Item No. 2.6)

Material	Test	Designation	Sampling and Testing Frequency	Reference (Item No.)
Soil	Classification	AASHTO M-145	1 per 2,000 cu-m.	2.6.2
	CBR	AASHTO T-193	1 per 2,000 m.	2.6.2
	Swelling	AASHTO T-193	1 per 200 cu-m	2.6.2
	Moisture Density (Lab) or Relative Density	AASHTO T-99 D-7049 (ASTM)	1 per 2,000 m 1 per 1,000 m	2.6.2
	Field Density	AASHTO T-191	5 per 2,000 cu-m	2.6.3.3

Table 1.2 Subbase : (Item No. 3.1)

Material	Test	Designation	Sampling and Testing	Reference (Item No.)
Aggregate	Gradation	AASHTO T-27	3 per Source plus 1 per 1000 cu-m	3.1.2.2
	Plasticity Index	AASHTO T-89 and T-90	3 per Source plus as required based on visual observation.	3.1.2.2
	CBR	AASHTO T-193	3 per Source plus as required based on variation in gradation.	3.1.2.2
	Abrasion	AASHTO T-96	3 per Source plus 1 per 500 cu-m	3.1.2.2
	Moisture Density	AASHTO T-180	1 per 1,000 M	3.1.2.2
	Field Density	AASHTO T-191	5 per layer per 2,000 sq-m laid. 3 min per layer if less than 2,000 sq-m laid.	3.1.3.4

Table 1.3 Aggregate Base Course : (Item No.3.3)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Aggregate	Gradation	AASHTO T-27	3 per Source plus 1 per 1,000 cu-m	3.3.2.1
	Plasticity Index	AASHTO T-90	3 per Source plus as required based on visual observation.	3.3.2.1
	CBR	AASHTO T-180 and T-193	3 per Source plus as required based on variation in gradation.	3.3.2.1
	Abrasion	AASHTO T-96	3 per Source plus 1 per 500 cu-m	3.3.2.1
	Sodium Sulphate Soundness	AASHTO T-104	3 per Source plus 1 per 500 cu-m	
	Fractured faces	Visual	3 per Source plus as required based on visual observation.	3.3.2.1
	Moisture Density	AASHTO T-180	1 per 1,000 m	3.3.2.1
	Field Density	AASHTO T-191	5 per layer per 2,000 sq-m laid. 3 min per layer if less than 2,000 sq-m laid.	3.3.3.3

Table 1.4 Cement Stabilised Base Course and Sub Base : (*Item No. 3.4)*

Material	Test	Designation	Sampling and Testing Frequency	Reference
Soil	Classification	AASHTO T-27 and T-89	1 per Borrow Source plus 1 per 1,000 cu-m	3.4.2.1
Mixture	Moisture Density	AASHTO T-134	1 per Soil Class.	3.4.3.3
	Pulverisation	Note (a)	1 per 300 m strip	-
	Field Density	AASHTO T-191	5 per layer per 2,000 sq-m laid. 3 min per layer if less than 2,000 sq-m laid.	3.4.3.6
	Compressive strength	ASTM D-1633	1 per Soil Class	3.4.3.3
	Wetting and Drying	AASHTO T-135	1 per Soil Class	For mix design.

Note :

a) Screening of Soil through one inch and No 4 sieves prior to mixing with cement.

Table 1.5 Lime Stabilised Base Course : (Item No. 3.5)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Soil	Classification	AASHTO T-27 and T-89	1 per Borrow Source plus 1 per 1,000 cu-m	3.5.2.1
Mixture	Moisture Density	AASHTO T-134	1 per Soil Class.	3.5.3.1
	Pulverisation	Note (a)	1 per 300 m strip	-
	Field Density	AASHTO T-191	5 per layer per 2,000 sq-m laid. 3 min per layer if less than 2,000 sq-m laid.	3.5.3.4
	Compressive strength	ASTM D-1633	1 per Soil Class	3.5.3.1
	Wetting and Drying	AASHTO T-135	1 per Soil Class	For mix design.

Table 1.6 Asphaltic Road Base and Surface Course Plant Mix : (Item No. 4.4, 4.5)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Coarse Aggregate	Abrasion	AASHTO T-96	3 per Source plus 1 per 5,000 cu-m	4.4.3.1
	Sodium Sulphate Soundness	AASHTO T-104	3 per Source plus 1 per 5,000 cu-m	
	Stripping	AASHTO T-182	3 per Source	4.5.3.3
	Fractured faces	Visual	3 per Source plus as required based on visual observation.	4.4.3.1
	Flat and Elongated Particle	BS 812	3 per Source plus as required based on visual observation.	4.5.3.3
	Specific Gravity	AASHTO-85	2 per Source for each size in Hot bins of Asphalt Plant	For use in preparation of JMF
Fine Aggregate	Sand Equivalent Or Plasticity Index	AASHTO T-176 AASHTO T-89 and T-90	3 per Source plus as required based on visual observation.	4.4.3.2 4.4.3.2
	Specific Gravity	AASHTO-84	2 per Source	For use in preparation of JMF
Bitumen	Specific Gravity	AASHTO-228	2 per Shipment	For use in preparation of JMF
	Penetration	AASHTO T-49	3 per week of plant operation. Samples taken from heating tank at staggered intervals.	4.5.3.5
Mixture	Extraction Gradation Bulk Sp.Gr. Maximum Sp. Gr. Air Voids Voids Filled W/Bitumen	AASHTO T-164 130 AASHTO T-166 Method B AASHTO T-209 AASHTO T-269 Computed Asphalt. Inst. Procedure.	} } } } 1 day's production } } }	4.5.4.2
Mixture compacted in place	Thickness	AASHTO T-230	1 per layer @100 m average interval	Note: (a, b, & c) and as per Item 4.5.4.1
	Compaction	AASHTO T-230 ASTM D2950	Minimum 5 cores per day nor less than 1 core per 100t used	4.5.4.1 (d)

Notes:

a) Test locations selected at random.

b) Test locations shall be within the same area where truck load from which T-166/T-209 samples were taken, were deposited.

c) Average of 3 or more samples shall be equal to or greater than 98 percent with not one value less than 95 percent based on laboratory compacted specimen (T-209).

Table 1.7 Concrete : (Item No. 5.1)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Course Aggregate	Gradation	AASHTO T-27	2 per Stockpile plus 1 per 1,000 cu-m	5.1.3.4
	Unit Wt.	AASHTO T-19	1 per Source plus 1 per 1,000 cu-m	For use in preparation of mix design
	Specific Gravity	AASHTO T-85	2 per Source plus 1 per 500 cu-m	For use in preparation of mix design
	Absorption	AASHTO T-85	1 per Source plus 1 per 500 cu-m	For use in preparation of mix design
	Abrasion	AASHTO T-96	1 per Source plus 1 per 500 cu-m	5.1.3.4
	Soundness	AASHTO-104	1 per Source plus 1 per 500 cu-m	5.1.3.4
	Deleterious Substance	AASHTO M-80	1 per Source plus 1 per 500 cu-m	5.1.3.4
Fine Aggregate	Gradation	AASHTO M-6	2 per Stockpile plus 1 per 800 cu-m	5.1.3.5
	Unit Wt.	AASHTO T-19	1 per Source plus 1 per 800 cu-m	For use in preparation of mix design
	Specific Gravity	AASHTO T-84	2 per Source plus 1 per 800 cu-m	For use in preparation of mix design
	Absorption	AASHTO T-84	1 per Source plus 1 per 800 cu-m	For use in preparation of mix design
	Organic Impurities	AASHTO T-21	1 per Source plus 1 per 800 cu-m	5.1.3.5
	Soundness	AASHTO-104	1 per Source plus 1 per 800 cu-m	5.1.3.5
	Fineness	AASHTO M-6		5.1.3.5
	Deleterious Substance	AASHTO M-6	1 per Source plus 1 per 800 cu-m	5.1.3.5
	Petrographic	-	1 per Source plus 1 per 800 cu-m	
Cement	Setting Time	AASHTO T-131	1 per Lot or 1000 bags	5.1.3.1
	Mortar Strength	AASHTO T-132	1 per Lot or 1000 bags	5.1.3.1
	Yield Test for Cement Content	AASHTO T-121	1 per Lot or 1000 bags	5.1.3.1
Water	Chemical Test	AASHTO T-26	1 per source	5.1.3.2

Material	Test	Designation	Sampling and Testing Frequency	Reference
Fresh Concrete Other than Class A	Compressive Strength	AASHTO T-22	1-3 batches: every batch 4-10 batches: 3 samples 11-20 batches: 4 samples >20 batches: No. batches/5	5.1.2.4 (d)
	Slump	AASHTO T-119	Every batch	5.1.2.4 (c)
Fresh Concrete Class A	Compressive Strength	AASHTO T-22	4 cylinders per 5 cu-m or part thereof (minimum)	5.1.2.4 (d)
	Slump	AASHTO T-119	Every batch	5.1.2.4 (c)

Table 1.8 Reinforcement : (Item No. 5.2)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Reinforcing Bar	Tensile Strength	AASHTO M 31M	1 Sample per 10 tonnes	5.2.2.8

Table 1.9 Prestressing Steel : (Item No. 5.4)

Material	Test	Designation	Sampling and Testing Frequency	Reference
Stressing Wire	Tensile Strength	AASHTO M 204-82	1 Sample per 10 coils or less	5.4.2.10
Stressing Bar	Tensile Strength	AASHTO M 275-79	1 Sample per 20 tonnes production	5.4.2.10
Stressing Strand	Tensile Strength	AASHTO M203-83	1 sample per 20 tonnes production	5.4.2.10

1.11.8 ALLOWABLE TOLERANCES

1.11.8.1 Roadworks

a) Thickness of Pavement Layers - The average of thickness of any pavement layer measured at five points in any length of 100 m shall not be less than 100 % nor more than 120 % of the thickness specified or ordered by the Engineer. In addition the thickness of any pavement layer measured at any point shall not be less than 98 % nor more than 125 % of the thickness specified or ordered by the Engineer.

b) Surface Regularity - The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid, steel straightedge 3 m long placed parallel to or at right angles to the centreline of the road. The maximum allowable deviation of the surface below the straightedge shall be as given in Table 1.8.1.

In addition the longitudinal slope or transverse crossfall shall not deviate from that shown on the Drawings by more than the tolerances shown in Table 1.8.1.

c) Shoulders - Shoulders shall be constructed to the same thickness, level and surface regularity requirements as for the adjacent pavement layers.

The above tolerance are summarised in the Table 1.10 following:

Table 1.10: Tolerances on Earthworks, Pavement and Bituminous Courses

Description	3 m Straight-edge(mm)	Cross-fall (%)	Longitudinal Grade in 30m (%)
Sub-grade (Granular or Stabilised)	20	± 0.5	± 0.1
Subbase (Granular or Stabilised)	10	± 0.5	± 0.1
Basecourse (Granular or Stabilised)	6	± 0.25	± 0.1
Asphaltic Base Course	6	± 0.25	± 0.1
Asphaltic Wearing Course	6	± 0.25	± 0.1

f) Cutting and Embankment Slopes - In the final trimmed slope of cuttings a tolerance of + 0.25 will be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall not be greater than 1 in 2 nor less than 1 in 2.25.

In the final trimmed slopes of embankments, a tolerance of +0.25 will be permitted, i.e. if the specified slope is 1 in 2, the acceptable slope shall not be greater than 1 in 2 nor less than 1 in 2.25.

g) Width of Cuttings and Embankments - The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured as the horizontal distance from the centreline of the road to the top of the embankment shall not be less than that shown on the Drawings or more than that shown on the Drawings plus 0.25 m.

h) Depth of Side Drains - The depth of side drains measured as the vertical height difference from the centreline of the finished pavement and the invert of the side drain shall not be less than that shown on the Drawings nor more than that shown on the Drawings plus 0.15 m.

1.11.8.2 Structures

a) Concrete Works - The construction tolerances for concrete works are as specified in sub-clause 5.1.5.16 of these Specifications

b) Reinforcement - The tolerances on the manufacture and supply of reinforcing steel are determined against theoretical weights and are as indicated in Table 1.11 below.

Reinforcing bars are evaluated on the basis of nominal weights. In no case shall the over-weight of any bar or lot of bars be the cause of rejection

The term “Lot” means all bars of the same nominal weight per linear meter contained in an individual shipping release or shipping order

Table 1.11 Reinforcement : (As Per AASHTO M-31)

Diameter of Bars	Lot under	Individual Bar under
All	3.5 %	6 %

c) Reinforced Concrete Pipes - The tolerances on the manufacture and supply of reinforced concrete pipe culverts are as specified in sub-clause 5.1.2.3.

Pipe having localised variations in wall thickness exceeding those specified shall be accepted if the three-edge bearing strength and minimum steel cover requirements are met.

Pipes having variations in the position of the reinforcement exceeding those specified above shall be accepted if the three-edge bearing strength requirements on a representative sample are met and minimum steel cover requirements are met.

1.11.9 RECTIFICATION OF EARTHWORKS AND PAVEMENT COURSES OUTSIDE OF ALLOWABLE TOLERANCES

Where any tolerances in Sub-clause 1.11.8 are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

1.11.9.1 Earthworks

Where a cutting slope is steeper, and an embankment slope is slacker, than the specified slope then the slope shall be trimmed to the specified slope. Where a cutting slope is slacker and an embankment slope is steeper, than the specified slope then the slope shall be benched and fill material placed and compacted and the slope shall be trimmed all in accordance with the requirements of Section 2.6 of these Specifications.

Where the width of a cutting is less than, and the width of an embankment more than, the specified width then the cutting or embankment shall be trimmed to the specified width. Where the width of a cutting is more than, and the width of an embankment is less than, the specified width then the embankment or cutting shall be benched and fill material placed and compacted and the slopes shall be trimmed all in accordance with the requirements of Section 2.6 of these Specifications.

Where the depth of a side drain is less than that specified the side drain shall be trimmed to the specified depth. Where the depth of a side drain is more than specified the side drain shall be backfilled with fill material compacted to a dry density of at least 95 % MDD (AASHTO T 180) up to the specified depth.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with these Specifications.

1.11.9.2 Subgrade

Where the levels or widths are out of tolerance then the full depth of the layer shall be reworked to specification. The area treated shall be at least 12.5 m long and 3 m wide or such area to be determined by the Engineer as necessary to obtain compliance with these Specifications.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or following a retest a length of at least 50 m both sides of each test and retest, failure.

1.11.9.3 Base and Subbase

Where these consist of unbound (i.e. natural or graded stone) material the full depth of the material shall be removed from the pavement and replaced to specification. The area treated shall be at least 30 m long and 3 m wide or such area to the determined by the Engineer as necessary to obtain compliance with these Specifications.

Where the courses consist of cement or lime treated material or lean concrete the full depth of the layer shall be removed from the pavement and replaced to specification. The area treated shall be at least 5 m long and the full width of the paving laid in one operation. If areas are corrected within 7 days of laying, no construction traffic or compaction plant shall use the surrounding satisfactory areas.

For bituminous bases the full depth of layer shall be removed and replaced with fresh material laid and compacted to specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation.

Where the results of the construction control tests for any of the base or subbase materials are less than that specified the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with these Specifications.

1.11.9.4 Wearing Course

These shall have the full depth of the layer removed and replaced with fresh material laid and compacted to specification. The area rectified shall be the full width of the paving laid in one operation and at least 15 m long.

Where the results of the construction control tests for the wearing course are less than that specified the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with these Specifications.

1.11.10 MEASUREMENT AND PAYMENT

No additional measurement of payment will be made for the rework or replacement of any section of the Works that has been determined not to conform to the applicable tolerances for quality or quality as detailed in these Specifications.

The Contractor shall be deemed to have allowed in his general rates and prices for the cost of complying with the requirements of Section 1.11 of these Specifications.

Notwithstanding the provisions of Clauses 1.11.8 and 1.11.9 of these Specifications, measurement and payment for earthworks and pavement works shall be made on the basis of the net cross-section ordered by the Engineer and no additional payment shall be made in respect of variation within or without the specified tolerances.

CONSTRUCTION SPECIFICATION

Section 2
Earthworks and allied Activities

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2 EARTHWORKS AND ALLIED ACTIVITIES

2.1 CLEARING AND GRUBBING

2.1.1 DESCRIPTION

This work shall consist of all clearing and grubbing necessary for the performance of the work covered by the Contract in accordance with these Specifications.

The clearing and grubbing shall consist of clearing the designated areas of all trees, down timber, snags, vegetation, rubbish and objectionable material and shall include grubbing stumps and roots and reusing or disposing of all material resulting from the clearing or grubbing. It shall also include the demolition removal and disposal of structures that obtrude into or encroach upon or obstruct the work, except where provided for otherwise.

Disposal of debris and foundations remaining after removal of houses or other structures is also considered to be included in the unit rates for clearing and grubbing and no further payment will be made under this section.

Also included in this work shall be the removal of loose pavement material, road signs, right-of-way markers, kilometre stones, guide posts and all other incidentals within the limits of construction. These items shall be removed, if so instructed by the Engineer, outside of the construction limits but within the proposed right-of-way. The Contractor shall exercise care so as not to damage these incidental items during the removal operation. All signs, markers and incidentals removed from the project shall be stacked in neat piles so they may be collected by the Employer and will become the property of the Employer.

2.1.2 GENERAL REQUIREMENTS

2.1.2.1 Preservation of Property

Attention is directed to the Contractor's obligations under law and under this Contract with regard to damage, particularly with regard to protection of property, forest, and landscape and to responsibility for damage claims.

Existing highways, improvements, facilities, adjacent property, utilities, services, and trees and plants designated for preservation shall be protected from injury or damage which could result from the Contractor's operations.

In order to reduce the risk of erosion no topsoil shall be removed from the areas outside the limits of earthworks. Any topsoil outside these limits, which is inadvertently removed during clearing and grubbing operations or otherwise, shall immediately be replaced by the Contractor at his own expense.

Trees outside the construction width but within the proposed right-of-way having a trunk girth of more than 450 mm at a point 600 mm above the ground shall not be cut down without the prior approval of the Engineer. Those trees that are not to be removed shall be protected from injury or damage resulting from Contractor's operations.

2.1.3 CONSTRUCTION REQUIREMENTS

2.1.3.1 General

Clearing and grubbing shall be performed on the areas designated by staking or on the Drawings or in the Special Provisions. If no areas are designated on the Drawings or in the Special Provisions, the areas to be cleared and grubbed will be as directed by the Engineer. Areas to be cleared and grubbed shall not normally include areas occupied by existing roadworks, but may, at the specific instruction of the Engineer, include areas occupied by cut slopes, embankment slopes and existing drainage features.

2.1.3.2 Clearing

Clearing shall consist of the removal and disposal of everything above ground level including overhanging branches except those things the Engineer directs are to be left undisturbed. The material to be cleared shall include but not necessarily be limited to trees, stumps, logs, brush, undergrowth, grass, crops, loose vegetable matter, structures (other than those structures where removal or clearance is separately specified and measured).

Outside the limits of the earthworks, and under embankments trees and stumps more than 1.5 metres in height shall be cut to a level not more than 300 mm above ground level and not less than 450 mm below the embankment slopes and everything else to ground level.

In cut areas clearing shall include the removal of stumps and roots exceeding 80 mm in diameter, to a depth of 450 mm below the finished surface except that in rounding areas at the tops of cut slopes they may be cut flush.

2.1.3.3 Grubbing

Grubbing shall be carried out on the area of embankment foundations where the embankment height is less than 1.5 metres. Grubbing shall consist of the removal and disposal of topsoil, stumps, roots, etc., to a depth of at least 150 mm below ground level and at least 450 mm below the bottom of the lowest subbase or base course of the road pavement.

Materials thus removed may be used as topsoil for slope protection if they, in the opinion of the Engineer, are suitable for this. If so, they will be measured and paid for in accordance with Section 6.7 of these Specifications, but removal and replacement of such material shall be considered incidental to clearing and grubbing and will not be measured for payment. Materials not used as topsoil shall be disposed of at locations as directed by the Engineer.

Materials under original ground level within embankment areas which are removed during the operation of the clearing and grubbing, shall be replaced by acceptable fill materials which shall be compacted to the density prescribed for layers at the depths concerned below subgrade. Such removal and replacement of materials is considered incidental to the Works of clearing and grubbing and will not be measured for payment, except in cases where the Engineer has issued a written instruction to the effect that materials deemed unsuitable by him shall be removed to depths greater than 150 mm from the original ground level, as shown on the checked cross-section sheets. All unsuitable materials shall be wasted and respread at locations specified and in a neat and orderly way as agreed by the Engineer.

Where existing embankment is to be raised or widened, all vegetation and topsoil shall similarly be completely removed from shoulders, slopes and ground under the widening before the operations of actual widening can be commenced.

Where roadway excavations are to be made, and where ditches, streams and rivers, are to be diverted, all vegetation, roots stumps and the like shall be completely removed and placed outside the excavation area concerned before the excavation works can be commenced.

At all remaining areas inside the right-of-way, the works of clearing and grubbing shall, unless otherwise instructed by the Engineer, include the levelling of obsolete dykes, terraces and ditches, the neat and complete removal of all remnants from structures and buildings, roots, stumps, untidy vegetation, rubbish, garbage and the like, to such an extent that these matters will not, in the opinion of the Engineer, obstruct future maintenance.

2.1.3.4 Ownership of Timber

The Contractor shall have the right to use unsaleable timber (or saleable timber when permission is granted in writing by the appropriate Government agency or authority) for his own purposes in connection with the Contract always provided that he has ascertained and complied with the requirements of the appropriate Government agencies or authority.

2.1.3.5 Disposal of Cleared Material

Saleable timber shall be neatly stored in an approved accessible place within or near the right of way as directed and shall be trimmed and stacked in accordance with the requirements of the appropriate Government agency.

All other timber except timber to be used and all brush, stumps, roots, logs, and other vegetation from the clearing and from the grubbing operations shall be granulated and composted for reuse on the embankment slopes, provided that, when permitted in writing by the authority having jurisdiction over the area through which the highway is being constructed, large stumps may be disposed of without granulating or composting at locations out of sight of the roadway.

Likewise, large stumps may, with the Engineer's approval, be disposed of without granulating and composting out of sight of the roadway on private land. In such cases the Contractor will be solely responsible for making the necessary agreements and paying expenses and claims arising from the use of private land.

The Contractor shall pile all material which is to be granulated and composted outside the slope lines and shall process and stockpile such material for subsequent reuse on the slopes at a time when appropriate.

All fences, buildings, structures, and encumbrances of any character, except those to be removed by others, upon or within the limits of the right of way, shall be removed by the Contractor and carefully placed on the abutting property or otherwise disposed of as indicated on the drawings or as directed by the Engineer. Materials so removed, including any existing drain or culvert pipes which the Engineer may order salvaged, shall be carefully removed and shall be the property of the Government.

The roadway and adjacent areas shall be left with a neat and finished appearance. No accumulation of inflammable material shall remain on or adjacent to the right of way.

2.1.4 MEASUREMENT

Clearing and grubbing will be paid for together as one item measured in plan (ie horizontally) on a per square metre basis. Neither the work of clearing nor grubbing disposal sites, material sites, nor imported borrow pit sites shall be paid for when such sites are outside the areas designated for clearing and grubbing and the Contractor is permitted to exercise his own option as to whether he elects to use such disposal sites or borrow pit sites. All areas to be measured for payment shall have been approved by the Engineer prior to Clearing and Grubbing operations.

Ditches, streams, ponds and depressions in the embankment areas shall be properly cleared prior to being measured for payment of embankment quantities to be filled in. Material for such fill shall be placed and compacted to the requirements as specified in Section 2.6 of these Specifications and payment will be made as embankment fill.

2.1.5 PAYMENT

This work, measured as provided above, shall be paid for at the Contract unit price per square metre for Clearing and Grubbing, which price shall be full compensation for furnishing all labour, materials, tools, equipment and incidentals necessary to do the work as well as the processing, removal, transport and satisfactory reuse or disposal of all resulting materials in accordance with these Specifications or at the direction of the Engineer.

Payment will be as follows:

Item Ref	Description	Unit of Measurement
2.1(1)	Clearing and Grubbing	Square metre

2.2 ROADWAY EXCAVATION

2.2.1 DESCRIPTION

The work shall consist of all the required excavation within the limits of the right of way except excavation otherwise defined; the removal, hauling and proper utilisation or disposal of all excavated materials and shaping of excavation and preparation of exposed surfaces of excavation on the entire length of the roadway and approaches, in accordance with these Specifications and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

Roadway excavation shall include the following:-

a. All excavated material indicated on the Drawings within the faces of the cross sections, excavation of all materials for approach roads, streets, intersections, gutters, ditches, berm ditches, drains and flumes.

b. All topsoil required to be salvaged within the limits of the highway in accordance with Section 6.7 Topsoil, except under embankment, which is included under Section 2.1 Clearing and Grubbing.

c. The removal and disposal of existing surfacing, side walks, curb or curb and gutter within the limits of construction.

d. The demolition removal and disposal of all foundations, foundation walls, basement or ground level floors, timber, rubble, masonry pipe, pipe structures and pipe culverts and box culverts within the limits of construction and not included within the limits defined for clearing and grubbing under Section 2.1, and not otherwise provided for in the Contract.

e. Excavation for removal of slides, breakages and cave-ins.

f. Excavation for stream and channel changes except where covered under Section 2.4 Channel Excavation.

g. Excavation required in cuts or under embankments below the lowest normal limit of excavation indicated on the Drawings or below ground line, for the removal of unsuitable material, and below the ground line under embankments where benching is required, or as otherwise directed.

Roadway excavation shall include the removal, hauling and proper utilisation or disposal of all excavated materials, the shaping of excavation and the preparation of exposed surfaces of excavation on the entire length of roadway and approaches, in accordance with these Specifications and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as directed by the Engineer.

In addition to the requirements of this clause, roadway excavation shall also include all ditch and temporary channel excavation, unless specifically stated elsewhere in the Contract.

2.2.2 MATERIALS REQUIREMENTS

2.2.2.1 Classification and Selection

Excavation shall be classified according to the definitions given below for common or rock. Rock excavation shall consist of igneous, metamorphic and sedimentary rock which cannot be excavated without blasting or the use of rippers, and all boulders or other detached

stones each having a volume of 0.75 cubic metres or more as determined by the physical measurements or visually by the Engineer.

2.2.2.2 Rock Excavation

Roadway Excavation classified as Rock Excavation shall include all materials to be excavated which conform to the following definition:

Rock material shall be material which cannot be ripped to an average depth of rip greater than 300 mm by a track type crawler tractor complying with the following:

(i) in good order complete with all equipment and accessories as supplied;

(ii) rated 300 BHP flywheel power or over at 2,000 rpm;

(iii) with an operating weight of not less than 37.2 tonnes;

(iv) equipped with a hydraulically operated single tine ripper compatible with the tractor used; and

(v) operated by a qualified operator in accordance with the manufacturer's recommendations and to the satisfaction of the Engineer.

In cases where it is impractical to prove rock material by the above method then rock material shall be defined as material which can be excavated only after blasting with explosives or barring and wedging or the use of a mechanical breaker fitted with a rock point in good condition and operated correctly.

If all of these methods of defining rock material prove to be impractical then the quantity of rock material, if any, shall be determined by the Engineer.

Where excavation contains individual boulders of rock material greater then 0.3 cu-m each in volume then such boulders shall be classified as rock material.

2.2.2.3 Common Excavation

Roadway excavation classified as common shall include all roadway excavation except that classified as rock.

2.2.2.4 Unsuitable Materials

Material encountered in cut areas and in the foundation of the embankment that is unsuitable for the planned use shall be excavated and disposed of as directed by the Engineer. Backfill as necessary shall be with approved material.

Normally, highly organic clays and silts, peat, soils containing large amounts of roots, grass and other vegetable matter are considered to be unsuitable.

Materials that are soft or unstable merely because they are too wet or dry are not to be classified as unsuitable unless otherwise directed by the Engineer.

Materials below the natural ground surface in embankment areas, basement material below the grading plane in excavation areas, material obtained from excavation of ditches and temporary channel excavation, and material from any other excavations within the

limits of earthworks that is unsuitable for the planned use, shall be excavated and disposed of as directed by the Engineer.

The disposal of unsuitable material may include, but not necessarily be limited to, the following:

a) Use for filling-in ditches and channels not required in the Works outside of the earthwork limits.

b) Filling-in holes, depressions, ponds, etc. outside of the earthwork limits.

c) Spread evenly in layers which shall not exceed 300 mm at locations where so directed by the Engineer

d) Removal and haulage to disposal sites outside of the right-of-way.

The Contractor shall take all necessary precautions to prevent any interference with natural drainage or irrigation flow during the operation of disposing of unsuitable material.

In sections of roads requiring pavement overlay or rehabilitation, soft spots or failed areas may be encountered which will require localised excavation down to firm material below original subgrade level. The excavation shall be squared off with neat, straight sides in order to facilitate compaction of replacement materials. Replacement material shall be either Selected Subgrade Material, or Subbase Material up to original subgrade level, which material shall be included in and paid for under Item No. 2.6. Embankment. The replacement materials above original subgrade will be determined by the Engineer and will be paid for under other applicable subbase and base course and/or pavement items as specified elsewhere in these Specifications.

All unsuitable material removed from below the natural ground surface and under or in an existing road shall be measured and paid for, except where grubbing is performed under Sub-Clause 2.1.3.3, in which case the top 150 mm of unsuitable materials removed from below the natural ground surface shall be considered incidental to clearing and grubbing and will not be measured for payment. The Engineer shall specify the levels to which unsuitable materials are to be excavated.

2.2.2.5 Suitable Materials

All materials from roadway excavation shall be used in embankment if the materials can meet the requirements as specified in these Specifications.

If the materials derived from authorised roadway excavation contain good quality material which meets requirements for selected materials or subbase, the Contractor may, if he chooses to do so, remove and stockpile this material during excavation operations for use later in the Contract. Material used in this manner and with the approval of the Engineer will be paid for under the respective items for selected materials and/or subbase material as provided for in these Specifications. Care must be taken by the Contractor not to contaminate reusable materials which may disqualify them for the intended purpose.

2.2.2.6 Structural Excavation

The description, method of measurement and payment for this item shall conform to the requirements of Item 2.5.

2.2.3 CONSTRUCTION REQUIREMENTS

All roadway excavation and embankment construction shall be performed as specified herein and in Section 2.6 Embankment, and the completed roadway shall conform to the required alignment, levels, grades, cross sections and to the tolerances specified in Clause 1.11.8 of these Specifications.

Unless otherwise indicated on plans, excavation in solid rock shall extend 200 mm below the required subgrade elevation for the entire roadway width and shall be backfilled with suitable materials as indicated on the Drawings or as directed by the Engineer.

Where provided for on the Drawings, topsoil encountered in excavation shall be removed to such a depth as the Engineer may direct. The topsoil shall be removed and stored in piles at locations designated by the Engineer in accordance with the requirement of Section 6.7 Topsoil.

All suitable excavated materials shall be used in so far as practicable in constructing the roadway. Unsuitable material and required roadway excavation in excess of that needed for construction shall be known as waste. The engineer will designate certain areas within the right-of-way at which locations material may be disposed. Disposal of waste outside areas designated by the Engineer shall be the sole financial and legal responsibility of the Contractor.

The waste shall be disposed of in such manner as to present a neat appearance and not to obstruct drainage from any highway nor to cause injury to highway Works or property.

Unsuitable material shall be excavated below subgrade level in cut and below embankment foundation level to the depth shown on the Drawings or directed by the Engineer. Where unsuitable material is excavated below the normal subgrade level or below embankment foundations or for benching under embankments the excavation shall be backfilled with suitable material and in a manner that conforms with the Section 2.6 Embankment.

All slopes shall be finished in a neat and workmanlike manner and in accordance with the tolerances specified in Clause 1.11.8 of these Specifications. Care shall be taken that no material is loosened below the required slopes. Breakages and slides shall be removed and disposed of as directed.

In cut areas, the top of the subgrade on which selected material or subbase or shoulder is to be placed shall be processed as necessary and compacted to a minimum depth of 150 mm or to such greater depth as may be instructed by the Engineer, to not less than 95% of the maximum dry density of the material as determined by AASHTO Test Method T 180. This work shall not be measured for payment but will be considered to be included in the unit price for roadway excavation.

The surface of the finished subgrade shall be neat and workmanlike and constructed to the tolerances specified in Clause 1.11.8 of these Specifications.

If the Contractor elects to obtain material by widening cuts he shall first request permission in writing from the Engineer and if written permission is granted widening of cuts will be permitted within the limits indicated, but not beyond the limits of the right of way. Such material shall be classified as borrow and will not be paid for. If widening of cuts is carried out on a written order of the Engineer the cut shall be measured and paid for as Roadway Excavation.

2.2.4 MEASUREMENT

All required, completed and accepted roadway excavation shall be measured in its original position and the volume determined in cubic metres by the average end area method as computed from the original and final cross sections to the dimensions instructed taken at 20 metre intervals or closer if so directed by the Engineer.

Measurement of rock excavated below subgrade level as required in Clause 2.2.3 of these Specifications shall be computed on the basis of excavation to the specified minimum depth below subgrade level only and no overbreak shall be included. Interim payment may be made on measured volumes of required excavation actually executed, before final shaping, provided the Contractor's intention to complete the work is clear.

Measured Roadway Excavation shall include excavation for removal of slides, breakages and cave-ins except where caused by carelessness or improper methods by the Contractor.

The Contractor shall schedule his work so that the Engineer may make adequate field surveys to determine the classification of roadway excavation being removed. The Contractor shall notify the Engineer at least 24 hours in advance of the need for survey measurement.

Excavation of temporary channel relocations at drainage structures, shall not be measured for payment. All temporary channel excavation shall be backfilled to the satisfaction of the Engineer upon completion of the drainage structure.

Measurement for relatively small volumes of Soft Spot Excavation and Replacement may be measured by the three dimensional method in the presence of an authorised representative of the Engineer.

All unsuitable material removed from below the natural ground surface and under or in an existing road shall be measured and paid for, except where Grubbing is performed under sub-clause 2.1.3.3 of these Specifications, in which case the top 150 mm. of unsuitable material from below the natural ground surface shall be considered incidental to clearing and grubbing and will not be measured for payment. The Engineer shall specify the levels to which unsuitable materials are to be excavated.

2.2.5 PAYMENT

The quantities of roadway excavation measured as specified above will be paid for at the contract unit prices per cubic metre for the various types as detailed below. Such prices shall include excavating, removal, haulage and satisfactory disposal of all roadway excavation, for shaping, dressing and completion of all surfaces and for furnishing all labour, materials, tools, equipment and incidentals to complete the work.

The above prices and payment shall be full compensation for all work involved in performing the roadway excavation completely as shown on the plans and specified in these Specifications and as directed by the Engineer.

Payment will be as follows:

Item Ref	Description	Unit of Measurement
2.2(1)	Roadway Excavation, Common	Cubic metre
2.2(2)	Roadway Excavation, Unsuitable	Cubic metre
2.2(3)	Roadway Excavation, Rock	Cubic metre

2.3 BORROW

2.3.1 DESCRIPTION

This work shall consist of the clearing and stripping of borrow pits, the excavating and hauling of materials obtained from approved sources using the material from borrow pits for constructing embankment, back fill, subgrade, shoulders and other parts of the work as required by the Contract or as directed by the Engineer.

This section applies to borrow pits outside the right of way. Borrow may also be obtained by widening cuts, widening ditches or by excavating from other sources outside the planned or authorised cross section within the right-of-way or slope easements and within the limits of the project, at locations designated and approved by the Engineer in writing.

2.3.2 GENERAL REQUIREMENTS

2.3.2.1 Borrow Pits outside the Right of Way, indicated in the Contract Documents.

If the Employer acquires or intends to acquire borrow pits outside the right of way for the purposes of the Contract such intention will be clearly stated in the Special Provisions and their locations will be indicated in the Contract Documents. Unless otherwise provided, the Contractor will not be required to pay royalties on material removed from these borrow pits for the purposes of the Contract, nor acquisition costs.

2.3.2.2 Borrow Pits outside the Right of Way not indicated in the Contract Documents.

The Contractor may open borrow pits outside the right of way other than those specifically provided by the Employer under Sub-clause 2.3.2.1, and in such cases the Contractor shall be fully and solely responsible for all expenses incurred and any legal consequences.

2.3.2.3 Safety and Public Health Requirements

The Contractor shall comply with local laws and regulations regarding public health and safety in respect for the operation of borrow pits and quarries, and in the absence of, or in addition to such laws and regulations, shall comply with the following conditions :

a) All areas being worked shall be drained and kept drained. Where a quarry or borrow pit has been excavated so that it will not drain naturally, it shall be kept pumped dry while being used.

b) The Contractor shall confine his operations solely to the areas provided or acquired by the Contractor and shall demarcate the boundary of the area and erect temporary or permanent fencing as instructed by the Engineer.

c) Where the height of any face exceeds 1 metre, the Contractor shall provide, erect and maintain at is own expense stock-proof fencing and gates to prevent unauthorised access to the top of the working face.

d) On completion of work all faces shall be neatly trimmed to a slope flatter then 1 in 4. Where this is impracticable or where the working face is to be left exposed, the edge shall be permanently fenced, as instructed by the Engineer, and measurement and payment for such fencing shall be in accordance with the requirements of Section 7.3 of these Specifications.

e) On completion of work temporary fences and all temporary structures shall be demolished and removed, and the site topsoiled and left neat and tidy.

2.3.2.4 Siting of Borrow Pits

Where borrow pits are to be opened in an area to provide a dam, fish pond or for any other use for the local residents of the area and after removal of the agreed quantities of materials, the size and location of the borrow pits should be such that they suit the local requirements and are to be approved by the Engineer.

2.3.3 CONSTRUCTION REQUIREMENTS

2.3.3.1 Site Clearance and Removal of Topsoil and Overburden

Unless otherwise instructed by the Engineer, the Contractor shall clear the sites of all borrow pits and quarries in accordance with the requirements of Section 2.1, Clearing & Grubbing, of these Specifications, but measurement shall be in accordance with this section of these Specifications.

All existing fences, trees, hedges and other features which the Engineer instructs shall not be removed or otherwise dealt with shall be protected in accordance with the requirements of Section 2.1, Clearing & Grubbing, of these Specifications.

Unless otherwise directed by the Engineer, the Contractor shall remove topsoil and/or overburden from borrow pits and quarries. The Engineer shall direct whether topsoil shall be stripped and stockpiled separately or shall be excavated and spoiled together with the overburden. If suitable the Engineer may direct that overburden be used in the Works.

2.3.3.2 Mixing, Selecting and Stockpiling of Materials

The Contractor may be required to mix the materials selected from borrow pits by bulldozing into stockpiles and/or by face loading by shovel. The stockpiles shall be formed at least six weeks before intended use for materials which are to be treated and at least three weeks before intended use for materials which are not to be treated.

The Contract shall stockpile all materials on a horizontal layer basis using a blade machine and all materials excavated shall be thoroughly mixed before loading into trucks. The direct winning and loading of materials by selective backhoe excavation is not permitted unless the material is to be mixed prior to its use in the Works.

The Contractor shall ensure that oversize material, clay, humus or other inferior material encountered in the workings is separated from the materials proposed for use in the Works and such inferior material shall be removed to spoil.

A separate stockpile shall be used for each type and grading of material.

When removing material from stockpiles, none of the underlying material shall be mixed with it, and generally at least the bottom 100 mm shall be left behind.

Should any stockpiles prove surplus to requirements the Contractor shall spread the material over the area of the borrow pit or quarry unless directed otherwise by the Engineer.

2.3.3.3 Reinstatement of Borrow Pits

On completion of work in any borrow pit or quarry the overburden and/or topsoil which has not been used in the Works shall be pushed back, spread and landscaped over the area of the borrow pit or quarry. Where topsoil has been stockpiled separately it shall be pushed back and spread over the borrow pit or quarry after landscaping, unless the Engineer has instructed that it shall be used for topsoiling in accordance with Section 6.7, Topsoil, of these Specifications.

2.3.4 MEASUREMENT

Borrow shall not be measured.

2.3.5 PAYMENT

No payment will be made to the Contractor for borrow.

Payment under the items of the work in which the borrow material is placed shall be full compensation for complying with all the requirements of Section 2.3 including the cost of searching for and finding borrow pits, for acquiring the right to occupy the sites and extract material, for the cost of any negotiation in connection with borrow pits, for the cost of obtaining right of access, for the cost of establishing and maintaining access, for any fees, licences, or royalties in connection with borrow pits, for clearing, grubbing, sloping, draining and cleaning up of pits, for hauling and excavating material from borrow pits and for all labour, materials, tools, equipment and incidentals necessary to complete the work.

2.4 CHANNEL EXCAVATION

2.4.1 DESCRIPTION

This work shall consist of excavation for channels both inside and outside the right of way, where shown on the Drawings or specified in the Special Provisions or directed by the Engineer, and shall include the re-channelling of the riverbed under or around structures, as shown on the Drawings or as directed by the Engineer. The work shall include the proper utilisation and hauling or disposal of all excavated materials, constructing, shaping and finishing all earthworks involved in conformity with the required alignment, levels, grades and cross sections.

2.4.2 MATERIALS REQUIREMENTS

Excavated materials shall be classified as laid down in Section 2.2, Roadway Excavation.

2.4.3 CONSTRUCTION REQUIREMENTS

All suitable materials removed from the excavation shall be used as far as practicable in the formation of embankments as specified under the items for embankment or shall be otherwise properly utilised or disposed of as required on the Drawings, or in these Specifications, or by the Engineer.

During construction the channel shall be kept drained as far as practicable and the work shall be constructed in a neat and workmanlike manner.

The channel shall be excavated to the alignment, levels, grades and cross sections required on the Drawings, in the Special Provisions, or by the Engineer. Excavation beyond the limits required shall not be paid for.

2.4.4 MEASUREMENT

When not otherwise specified in the Special Provisions or on the Drawings, channel excavation shall be classified and measured as roadway excavation.

Quantities of channel excavation shall be measured in cubic metres determined by average end area method computed from the original and final cross sections of the authorised and completed excavation. Interim payments may be made on measured volumes of required excavation actually executed, before final completion of shaping, provided the Contractor's intention to complete the work is clear.

When structural work is measured and paid for in accordance with Method B, as defined in Clauses 5.1.6(b) and 5.1.7(b) of these Specifications, no separate measurement or payment shall be made for channel excavation.

2.4.5 PAYMENT

Where specifically so stated in the Contract, this work, measured as provided above, shall be paid for at the Contract unit prices per cubic metre as detailed below. The payment shall be full compensation for all excavation hauling, backfilling old channels or otherwise properly using or disposing of material, for establishing and maintaining access to the

channel and for all labour, materials, tools, equipment and incidentals necessary to complete the work.

When specifically required in the Special Provisions or on the Drawings, pay items shall be as follows:

Item Ref	Description	Unit of Measurement
2.4(1)	Channel Excavation, Common	Cubic metre
2.4(2)	Channel Excavation, Rock	Cubic metre

2.5 STRUCTURAL EXCAVATION AND BACKFILL

2.5.1 DESCRIPTION

This work shall consist of the excavation for structures, including bridge abutments, piers, footings, wingwalls, concrete box culverts; constructing and removing cofferdams and sheeting; pumping, dewatering and bailing, backfilling of completed structures and disposal of excavated material. Backfill shall include the placement of backfill material in embankment in the immediate vicinity of the completed structures above the level of the original ground. The work done shall meet the requirements as specified on the Drawings.

Storm sewers and pipes shall be excavated and backfilled in accordance with Section 6.1 of these Specifications, and measurement and payment for the work will be in accordance with that section.

2.5.2 MATERIALS REQUIREMENTS

2.5.2.1 Foundation Fill Material

Material for foundation fill shall consist of suitably graded sand, gravel, or stone as shown on the Drawings or required by the Engineer, or concrete as described below.

2.5.2.2 Concrete for Foundation Fill

Concrete for foundation fill shall conform to the general requirements of Section 5.1. Concrete to be placed under water shall conform to the requirements of Section 5.1. Concrete to be used as foundation fill in dry excavation shall be made with an aggregate and cement conforming to the requirements of Section 5.1 and shall be mixed and placed in accordance with Section 5.1 except that minimum cement content shall be 250 kilograms per cubic metre.

2.5.2.3 Backfill Material

Backfill shall be approved compactable granular material and shall be free from large lumps, wood and other deleterious materials. It shall be obtained from the structural excavation if such material is approved by the Engineer as suitable. Any additional material needed shall be obtained from roadway or borrow excavation unless otherwise directed by the Engineer.

Where required on the Drawings, or instructed by the Engineer, selected porous material may be used in backfill to structures as specified in Section 5.8 of these Specifications.

2.5.2.4 Classification of Excavation

Excavated materials shall be classified as laid down in Section 2.2, Roadway Excavation, of these Specifications.

2.5.3 CONSTRUCTION REQUIREMENTS

2.5.3.1 Clearing

Prior to starting excavation operations in any area, all necessary clearing and grubbing shall have been performed.

2.5.3.2 Excavation

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross section elevations and measurement may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without the permission of the Engineer.

Trenches and foundation pits for structures and structure footings and drains shall be excavated to the lines, grades and elevations shown on the Drawings or as staked by the Engineer. The elevations of the bottoms of footings shown on the Drawings are approximate only and the Engineer may order in writing such changes in the dimension or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs and other objectionable material encountered in excavation shall be removed.

After each excavation is completed the Contractor shall notify the Engineer to that effect and no footing, bedding material or structure shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

Rock and other hard foundation material shall be cleared of all loose material and cut to a firm surface, either level or stepped or serrated, as specified or shown on the Drawings or directed by the Engineer. All seams and crevices shall be cleared out and grouted with Portland cement grout at the time the footing is placed. Excavated surfaces in hard material shall be excavated to achieve a minimum thickness of 100 mm of blinding concrete.

All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the Engineer, the foundation material is soft or otherwise unsuitable, the Contractor shall remove the unsuitable material and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the Engineer. If foundation fill material is required it shall be placed and compacted in layers not more that 150 mm thick or as directed by the Engineer. The degree of compaction shall be at least equivalent to that of the surrounding foundations, but shall not be less than 95 % of the maximum dry density of the material determined by AASHTO T180.

All excavation surfaces and surfaces of backfill material against which concrete is to be placed shall be smooth and firm and true to line and level.

2.5.3.3 Disposal of Excavated material

All excavated material so far as suitable, shall be utilised as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within a stream area, shall be finally disposed of in such a manner as not to obstruct the stream nor otherwise

impair the efficiency or appearance of the works nor is it to endanger the partly finished structure.

Excavated material suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operation.

Excavated material shall be deposited in such places and in such a manner as not to cause damage to highway, services or property either within or outside the right of way and so as to cause no impediment to the drainage of the site or surrounding area. The location of storage piles shall be subject to the approval of the Engineer who may require that the survey centre line and the transverse or hub line of any part of the structure be kept free of obstruction.

2.5.3.4 Cofferdams and Caissons

The term “cofferdam” denotes any temporary or removable structure, constructed to hold the surrounding earth, water, or both, out of the excavation, whether such structure is constructed of earth, timber, steel, concrete or any combination of these. The term includes earth dykes, timber cribs, sheet piling, removable steel shells and all bracing; and it shall be understood to include excavation enclosed by pumping wells and well points.

The cost of cofferdams is always to be included as part of the bid price for the structure.

The term “caisson”' denotes a permanent part of the substructure so constructed as to sink gradually into place as material is excavated within the area protected by its side walls.

When no provision for Caissons is shown in the Drawings it shall be the intent of the Contract that suitable cofferdams shall be provided for all excavations where cofferdams may be necessary in order to control water or to preclude sliding and caving of the walls of the excavation.

The Contractor shall submit upon request Drawings showing his proposed method of cofferdam and caisson construction. Approval of the Drawings by the Engineer will not in any way relieve the Contractor of the responsibility for the adequacy of the design for strength and stability or for the safety of the people working therein.

The interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction and removal of any required forms and the inspection of the interior and to permit pumping outside the forms.

If practicable cofferdams shall be so designed that no cross bracing shall be left in place. If this is not practicable bracing left in place shall be of structural steel. The end of such structural members that would be exposed when the structure is completed shall be boxed back at least 150 mm behind the concrete face. The resulting holes shall be completely filled with concrete.

In general, sheet piling cofferdams shall extend well below the bottom of the footing and shall be well braced and as watertight as practicable.

When foundation piles are to be driven inside a cofferdam and it is judged impracticable to dewater the cofferdam before placing a concrete seal, the excavation may be extended below the designed level to a depth sufficient to allow for swell of the material during pile driving operations. Any material that rises to a level above the design level shall be removed.

Where it is possible to dewater the cofferdam the foundation material shall be removed to exact grade after the foundation piles are driven.

Backfilling in a foundation to compensate for excavation which has been extended below the required grade shall be at the expense of the Contractor. Backfilling shall be with concrete or foundation fill material as indicated on the Drawings, or in the Specification or as directed by the Engineer.

If no material is indicated, backfilling shall be concrete of the same kind as required for the structure to be constructed in the excavation.

Unless otherwise permitted no excavation shall be made outside of caissons or cribs or cofferdams or sheet piling and the natural stream bed adjacent to the structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are in place the Contractor shall, after the foundation is in place, backfill all such excavation to the original ground surface or stream bed with material satisfactory to the Engineer.

Material deposited within the stream area from foundations or other excavations or from the filling or cofferdams shall be removed and the stream area freed from obstruction.

Caissons and cofferdams which tilt or move laterally during construction shall be corrected as necessary at the expense of the Contractor.

Unless otherwise provided cofferdams shall be removed after the completion of the sub-structure. The removal shall be effected in such a manner as not to disturb or mar the finished work. The Engineer may order the Contractor to leave any part or the whole of the cofferdam in place.

When conditions are encountered which, in the opinion of the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation or seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown in the Drawings or required by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are used and the weight is used to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal. Special anchorages such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water the cofferdam shall be vented at low water as directed.

Cofferdams shall be constructed so as to protect newly cast concrete from sudden rising of the water and to prevent damage to the foundation by erosion.

Caissons shall be constructed as provided in these Specifications and on the Drawings. Caissons shall be included in the lump sum payment for the structure if a lump sum appears in the bid items, or as otherwise provided in the Special Provisions.

2.5.3.5 Pumping and Bailing

Pumping and bailing from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through or alongside any concrete being placed. No pumping or bailing will be permitted during the placing of concrete nor for a period of at least 24 hours thereafter unless it is done from a suitable sump separated from the concrete work by a water-tight wall.

Pumping or bailing to dewater a sealed cofferdam shall not be started until at least 36 hours after final set of concrete.

Excavations shall be as dry as possible prior to and during placing concrete. Placing concrete under water will only be permitted if indicated on the Drawings or permitted by the Engineer.

2.5.3.6 Backfilling

All spaces excavated under these Specifications and not occupied by the permanent works shall be backfilled unless otherwise directed by the Engineer.

Backfill not within the embankment area shall be placed in layers not more than 150 mm in depth (loose measurement) and shall be compacted to a density of not less than 90 % of the AASHTO T180 maximum dry density.

Backfill within the embankment areas, which shall include areas on which embankments are to be constructed, shall be made with approved material placed in uniform layers not to exceed 150 mm in depth (loose measurement) and each layer shall be constructed in accordance with Section 2.6 Embankment except that mechanical tampers may be used for compaction. Each layer of backfill shall be wetted uniformly as necessary to obtain the specified dry density. Unless otherwise specified hand tamping will not be accepted.

The Contractor may not use any major earthmoving or compaction equipment, within 2 metres measured horizontally, or within 0.5 metres measured vertically of any form of structure covered by the this Section of these Specifications, which risks, in the opinion of the Engineer, damage to the structure. In such cases the Contractor shall employ equipment, to the approval of the Engineer, suitable for use in confined spaces. This clearance distance may be increased for individual structures, as indicated on the Drawings, or at the direction of the Engineer. Embankment material to be placed above natural ground level and within 2 metres measured horizontally, or 0.5 metres measured vertically of the structure, or such other clearance as shall be directed by the Engineer, shall conform to the requirements of this section of the Specifications for backfill.

In placing backfill and embankment, material shall be placed, insofar as is possible, to approximately the same height on both sides of any structure.

Backfill shall not be placed against the walls of box culverts until the top slab is placed for the required time and not less than three days whichever is greater.

No backfilling shall be placed against any structure until permission shall have been given by the Engineer. Jetting of fill or other hydraulic methods involving, or likely to involve, liquid or semi liquid pressure are prohibited.

Special care shall be taken to prevent any unduly high pressures against the structures.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.

Adequate provision shall be made for drainage and to allow for porous backfill material to be placed in accordance with Section 5.8.

Porous backfill material shall be placed where instructed, or shown on the Drawings. A sliding form or other approved means shall be used during backfilling such that the porous backfill is brought up and compacted at least 150 mm ahead of the backfill material and the

backfill material is brought up and compacted at least 150 mm ahead of the adjacent earthworks fill.

2.5.4 MEASUREMENT

2.5.4.1 General

Structural excavation and backfill shall be measured in cubic metres placed, completed and approved.

2.5.4.2 Structural Excavation

Excavation for structures in common material shall be measured by the cubic metre, calculated as the product of the net plan area of the foundation to be excavated and the average depth of the excavation. No allowance will be made for working space. The average depth shall be calculated as the difference between the original ground level, as agreed between the Engineer and the Contractor, or the formation level, whichever is the lower, and the instructed level of the underside of the blinding concrete.

Excavation in rock shall be measured by the cubic metre, calculated as the product of the average end areas measured at intervals agreed with the Engineer along the centreline of the length of the excavation and the length over which the rock is encountered. The end areas shall be calculated from levels taken on top on the rock prior to excavation and levels taken after excavation of the rock or to the levels instructed whichever is higher.

2.5.4.3 Structural Backfill

Backfill shall be measured by the cubic metre and shall include for the cost of, backfilling at any depth and complying with all the requirements of Section 2.5 of these Specifications including the cost of providing the material.

Below the level of the existing ground or road formation level, whichever is lower, backfill shall be measured as the net volume of excavation as defined in this Clause minus the volume occupied by the structure.

Between the level of the existing ground or road formation level, whichever is lower, and the level of the top of the structural faced against which backfill is to be placed, backfill shall be measured as the product of the difference between these two levels, the length of the structural face being backfilled, and the width of the backfill layer instructed to be placed (2.0 m, or such other dimension as shall have been instructed) less the instructed thickness of porous backfill layer.

Above the level of the top of the concrete face against which backfill has been placed, the cost of placing any additional backfill shall be deemed to be included in the rates included in the Bills of Quantities for the elements of construction concerned (embankment, subbase etc).

Clearing and grubbing will be measured in accordance with the requirements of Section 2.1 of these Specifications.

Replacement of unsuitable materials, where instructed by the Engineer, will conform to the requirements as specified in Section 2.6 of these Specifications, and shall be measured accordingly

For structural work measured in accordance with Method B as defined in sub-clause 5.1.6(b) of these Specifications, on a lump sum basis, no separate measurement for payment shall be made for structural excavation and backfill."

2.5.5 PAYMENT

Structural excavation and backfill shall be paid for at the Contract unit price per cubic metre as measured above.

The rate for excavation for structures in common material shall include for the cost of excavation to any depth, compaction at the foundation level of the excavation and complying with all the requirements of Section 2.5 of these Specifications.

The unit prices shall be full compensation for labour, tools, equipment, materials, haulage and incidentals necessary for the satisfactory completion of the work, including construction and removal of cofferdams and sheeting, pumping, dewatering and bailing, excavating, disposal of excavated material, removal of slides, cave-ins or silting, backfilling, all as shown on the Drawings and as directed by the Engineer.

The rate for extra over for excavation in rock material shall include for the cost of excavation to any depth and complying with all the requirements of Section 2.5 of these Specifications.

Pay items will be as follows

Item Ref.	Description	Unit
2.5(1)	Structural Excavation , Common	Cubic Metres
2.5(2)	Structural Excavation, Rock	Cubic Metres
2.5(3)	Structural Backfill	Cubic Metres

Clearing and grubbing will be paid for in accordance with the requirements of Section 2.1 of these Specifications.

Replacement of unsuitable materials, where instructed by the Engineer, will conform to the requirements as specified in Section 2.6 of these Specifications, and shall be paid for under the provisions of that Section.

2.6 EMBANKMENT

2.6.1 DESCRIPTION

This work shall consist of the construction of embankment and backfill not specified elsewhere by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with these Specifications, and to the lines, levels, grades, dimensions, and cross sections shown on the Drawings and as required by the Engineer. Selected material shall be considered as select embankment and part of the embankment section.

2.6.2 MATERIALS

Materials for embankment shall consist of suitable materials excavated from roadway excavation, channel excavation or structural excavation and from borrow. Material from borrow pits shall only be used where the Contractor has demonstrated and the Engineer agreed that there is an inadequate quantity of suitable material from excavation.

Embankment shall be constructed of materials with a CBR value not lower than the design values stated in these Specifications or on the Drawings.

These CBR values shall be for samples compacted to 90% of the maximum dry density determined by AASHTO T180, or, in the case of subgrade in selected materials, 95%. All test samples shall be soaked, in accordance with the requirements of AASHTO T193. Materials with a CBR value less than 2 shall not be considered suitable.

The term “subgrade” shall refer to the top layer of the earthworks immediately underlying the pavement structure, 150mm thick or such greater thickness as may be defined. The provisions of these Specifications applicable to “embankment” shall generally apply to subgrade in addition to those provisions specially applicable to subgrade.

Embankment materials for subgrade classified as selected materials shall be constructed to the thickness’ shown on the Drawings and shall consist of naturally occurring soil aggregate free of topsoil and all other organic matter. The soil aggregate shall consist of sound durable particles which do not breakdown under compaction or repeated wetting/drying cycles. All particles greater then 50 mm shall be hand-picked and removed from the working layer.

The subgrade material shall have a Liquid Limit, as determined by AASHTO T 89, of not greater than 40 percent and a plasticity index, as determined by AASHTO T 90, of not greater than 20 percent. The fraction passing the 0.075 mm sieve shall be more than 10 percent but not greater than 30 percent. In addition the material shall have a CBR of not less than 15 percent measured after a 4-day soak on a laboratory mix compacted to 95 percent of the maximum dry density in a moisture range of 3 percent as determined in AASHTO T-180.

Where sand embankment is specified on the Drawings, such materials shall consist of river or pit-run sand whose properties shall be in general agreement with the following requirements:

- Gradation Maximum particle size : 10 mm

  Material finer than 0.075 mm sieve : 25% maximum
- Plasticity Material shall be generally non-plastic and free from clay lumps

- CBR Strength When compacted to 95% of AASHTO T-180 density, the material shall have minimum soaked CBR of 10.

2.6.3 CONSTRUCTION REQUIREMENTS

2.6.3.1 Preparation of Foundation for Embankment

Natural ground (including slopes of existing road) situated less than 1.5 metres below the design surface of the road or side slopes shall, after proper clearing and grubbing or scarifying of existing road surface, be compacted to a depth of 150 mm, measured from original ground as shown on the cross-section sheet, to not less than 90% of the maximum dry density of the material as determined by AASHTO test method T180. Compression of existing soil which may result from this compaction will not be measured and backfilling of the corresponding volume of earth fill is considered incidental to other items of work and will not be separately paid for.

If unsuitable materials occur in some areas under the embankment or in existing embankments, such materials shall be removed to levels as directed in writing by the Engineer, the bottom of the excavation shall be compacted, as described above, and the areas backfilled and compacted layer by layer with suitable material. Fill material replacing unsuitable materials being excavated on the written instruction of the Engineer will be measured and paid for under Item No. 2.6(1), Embankment.

All compaction shall conform to the requirements in sub-clause 2.6.3.3 of these Specifications. Where an existing surface of a road is situated at subgrade level or lower, the surface shall be scarified, except where otherwise shown on the Drawings, to a depth of 150 mm, graded, spread and compacted, to the density prescribed for layers at the depth concerned below subgrade, in the full width of the new embankment. No materials shall be removed from these areas unless ordered in writing by the Engineer.

Works of compaction for preparation of foundation for embankment and preparation of subgrade in cut areas will not be measured or paid for but will be considered incidental to the works of constructing embankment. Widening of existing embankments shall be accomplished as shown on the Drawings.

2.6.3.2 Placing Embankment

Embankment shall be placed in accordance with the following requirements:

(a) General: Except as otherwise required all embankments shall be constructed in layers approximately parallel to the finished grade of the road bed. During construction of embankment, a smooth grade having an adequate crown or superelevation shall be maintained to provide drainage. Embankments shall be constructed to the required grade, and completed embankment shall correspond to the shape of the typical sections shown on the Drawings and to the tolerances specified in Clause 1.11.8 of these Specifications.

(b) Common Embankment: Common embankments shall be defined as those principally of material other than rock, and shall be constructed of approved material from designated or other approved sources.

Except as specified for embankment in swamps, common embankments shall be constructed in successive layers, for the full width of the cross section and in such lengths as are suited to the compaction and watering methods used. Prior to compaction the layers shall not exceed 200 mm in depth unless permission is granted by the Engineer.

(c) Placing over swamp ground: Embankment in or over swamps or in water shall be placed as indicated on the Drawings and as specified in the Special Provisions, and as required by the Engineer.

(d) Rock Embankment: Rock embankments shall be defined as those principally of rock, and shall be constructed of approved material from designated or other approved sources.

Except as otherwise specified rock embankment shall be constructed in successive layers for the full width of the cross section and of 0.75 metres or less in depth. When in the opinion of the Engineer, the rock sizes necessitate a greater depth of layer and the height of fill will permit, the layer depth may be increased as necessary, but in no case shall the depth of layer exceed one metre. Each layer shall be constructed by starting at one end of the section of embankment under construction and dumping the rock on top of the layer being constructed, then pushing ahead with an approved bulldozer in such a manner that the larger rock will be placed on the ground or preceding layer and the interstices between the larger stones will be filled with small stones and spalls by this operation and by the placing of succeeding layers of embankment.

The maximum dimension of any rock shall be less then the depth of the embankment layer. All oversized rock which is otherwise suitable for construction shall be broken to the required dimension and used in embankment construction or placed at the points in the embankment where the layer is of greater depth. Compensation for additional haul involved in such alternate manipulation will not be allowed. Where excavated rock is wasted the Contractor shall, at his own expense, replace the rock wasted with other suitable materials.

Except as otherwise specified, all rock fills will be covered with one or more 200 mm layers of well graded material containing no stones larger than 100 mm and the material shall be sufficient to fill all the interstices in the top of the rock fill. These layers will be constructed to the requirements for earth embankment.

Each layer of embankment shall be compacted as herein-after specified.

(e) Adjacent to culverts and bridges: Embankment within 2 metres measured horizontally, or 0.5 metres measured vertically of a structure, bridge or culvert shall be compacted in the manner prescribed for backfill in Section 2.5 Structural Excavation and Backfill. This clearance distance may be varied for individual structures, as indicated on the drawings or at the discretion of the Engineer.

Embankments placed around spill-through type abutments shall be compacted in 150 mm layers (measured before compaction) of uniform suitable material placed in such a manner as to maintain approximately the same elevation on each side of the abutment and each layer of material shall be mixed, wetted and compacted as specified herein.

Material placed adjacent to any portion of any structure shall be material free of any appreciable amount of gravel or stone particles more than 100 mm in greatest dimension and of such gradation as to permit thorough compaction.

(f) Preparation of subgrade: The surface of the finished subgrade shall be neat and workmanlike and shall have the required form, superelevation, levels, grades, and cross section. The surface shall be constructed to sufficient accuracy to permit the construction of subsequent layers of material to the thickness, surface tolerance, and compaction specified.

(g) As far as is practicable and when directed by the Engineer, the Contractor shall construct bridge approach fills as early in the contract period as possible to allow for consolidation of the embankment during the remainder of the Contract period.

(h) Where new embankment is to be compacted against existing embankments or in natural ground having a side slope of greater than 1 on 5 or where embankment is

built in half-widths, the slopes of the existing ground and old and new embankment shall, after removal of topsoil, be benched in accordance with the Drawings or as instructed by the Engineer. The material which is excavated to form benches shall either be taken to waste or if suitable used as fill.

(i) Clods or hard lumps of earth over 150 mm in greatest dimension shall be broken up before compacting the material in embankment.

(j) Where streams or ditches are to be diverted, or abandoned, their beds should be filled up to a level as directed by the Engineer. Within the limits of earthworks, such fill shall be placed and compacted to the requirements as specified in Section 2.6 of these specifications and payment will be made as embankment fill. Where this work is performed outside the limits of earthworks and unsuitable material is used, no payment will be made to the Contractor. In the case where only suitable material is available and this work is carried out outside the limits of earthworks, payment will be made as embankment fill as described above. Filling shall be performed well ahead of the construction of roadway embankments, and all other works involved such as pumping, damming etc. will be considered incidental to the works and not separately paid for. Embankment fill placed against the sides of pipe culverts shall be placed in such manner as to maintain the same elevation on both sides of the culvert.

(k) The Engineer may request the installation of settlement plates, piezometers, lateral movement stakes, inclinometers or other settlement control devices, installation of which shall be as described on the Drawings and in the Special Specification.

(l) All settlement occurring in embankment construction shall be corrected by the contractor by providing additional layers of embankment or selected material at no additional cost to the Employer except where preloading and/or waiting period are designated on the Drawings, in which case measurement and payment will be performed as described on the Drawings and in the Special Specification. The Contractor shall be fully responsible for the stability and integrity of the embankment during the Contract and Defects Liability periods.

(m) If a soil failure either occurs or becomes imminent during the construction of the embankment, the Engineer shall have the authority to suspend all embankment construction in the affected area until corrective measures can be determined and implemented. Any delay in the embankment construction schedule and any other effects caused by implementation of the above clause shall not constitute grounds on the part of the Contractor for a claim for extension of the Contract and/or financial compensation.

2.6.3.3 Compaction of Embankments Other Than Rock Embankments

Embankment (other than rock) shall be compacted in accordance with the following requirements:

(a) Before compaction, each layer shall be processed as required to bring the moisture content uniformly throughout the layer to within plus 1 and minus 2 percent of optimum moisture content as determined in AASHTO T180 or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. The material shall be so worked as to have a uniform moisture content throughout the layer. Full compensation for any additional work involved in wetting or drying embankment material to the required moisture content shall be considered as included in the contract price paid for embankment and no additional compensation will be allowed.

(b) Each layer of material shall be compacted uniformly by use of adequate and appropriate compaction equipment. The compaction shall be done in a longitudinal direction along the embankment and shall generally begin at the outer edges and progress toward the centre in such a manner that each section receives equal effort.

Hauling equipment shall be operated over the full width of each layer in so far as practicable

(c) Embankment compaction shall be carried out as follows: Embankments shall be constructed in layers of uniform thickness not to exceed 150 mm in thickness after compaction and compacted to the requirements of this section. Each layer of the embankment shall be compacted to a dry density equal to at least 90% of the maximum dry density of the material as determined by AASHTO test method T180. Density determinations shall be carried out for embankments in accordance with the requirements of AASHTO test T191 at a rate of 5 tests for every 2000 cubic metres of completed embankment or part thereof.

(d) For density results to be acceptable, four of the five densities shall be equal to or greater than the required level of compaction and all five shall be greater than the required density minus 3%, and the average of all five shall be not less than the required value.

(e) Embankments shall be maintained to the grade and cross section shown on the Drawings throughout the contract period.

(f) The Contractor shall protect the prepared subgrade from both his own and public traffic. The Contractor shall maintain the subgrade by blading, watering and rolling as frequently as necessary to preserve the subgrade in a completely satisfactory condition as specified above.

(g) The compaction of the subgrade including areas of existing road where surface layers have been removed, shall extend to a minimum depth of 150 mm or such greater depth as shall be instructed on the Drawings or by the Engineer. The compaction of subgrade shall attain not less than 95% of the maximum dry density determined by AASHTO test method T180. Density determinations shall be carried out for subgrade in accordance with the requirements of AASHTO test T191 at a rate of 5 tests per 2000 square metres of completed subgrade or part thereof, for each 150mm layer of subgrade. Acceptance criteria for subgrade densities shall be as above.

2.6.3.4 Compaction of Rock Embankment

Rock embankment shall be compacted by the passage of approved heavy equipment, including heavy vibrating rollers, until there is no visible movement of the rockfill under equipment. Compaction shall be done in a longitudinal direction along the embankment and shall begin at the outer edge and progress towards the centre.

2.6.3.5 Preparation of Subgrade Surface

The subgrade shall be shaped to correct line and level and the Contractor shall at all times ensure that the subgrade is well drained and protected against damage from public as well as construction traffic. The subgrade shall be constructed to the tolerances specified in Clause 1.11.8 of these Specifications. The surface shall be maintained in this state, with a regular light sprinkling of water to prevent a dusty condition until the pavement layers are spread.

2.6.3.6 Compaction and Trimming of Slopes

Attention is drawn to the fact that the general compaction requirements shall at any level apply to the full width of the embankment. Slopes to be covered with topsoil and grassing shall have a firm surface before topsoil is placed.

In practice it is assumed that the embankment will be constructed slightly wider that the design cross section to enable the slopes to be trimmed on completion to conform with the design cross section, thus ensuring adequate compaction of the slope faces. Where embankments are not constructed to the full width required these shall be benched and reconstructed in accordance with the provisions of sub-clause 2.3.3.3 of these Specifications.

Under no circumstances shall additional embankment material be tipped over the slopes and spread to make up a shortfall in width of embankment.

If in the opinion of the Engineer the embankment slopes do not appear to be suitably compacted, additional compaction shall be provided to the slopes as directed by the Engineer at no additional cost to the Employer.

The slopes of cuttings and embankments shall be trimmed by hand or by approved mechanical means to uniform batters as shown on the Drawings or as instructed by the Engineer prior to topsoiling and grassing where specified or instructed.

2.6.3.7 Proof rolling

All subgrade and embankment layers, cuttings, benches and original ground shall be proof rolled with a loaded scraper or truck with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed before the layer is submitted to the Engineer for approval and shall be carried out in the presence of the Engineer. All such proof rolling shall be at the Contractor's expense.

2.6.4 MEASUREMENT

2.6.4.1 Measurement of Embankment

Embankment fill, whether obtained from borrow, roadway excavation or other sources, will be measured by the cubic metre of material compacted in-place and accepted by the Engineer.

The final volume of embankment will be calculated on the basis of agreed ground cross-sections taken at 20 metres intervals or closer if so directed by the Engineer, after the completion of any advance compaction of the existing ground, and the net instructed embankment dimensions up to the final surface of the subgrade and shall be calculated by the method of average end areas. No additional measurement shall be made in respect of benching.

Volumes of topsoil on side slopes measured in accordance with clause 6.7.4 of these Specifications shall not be included in the volume of embankment fill.

Where the Engineer has issued a written instruction to the effect that unsuitable materials shall be excavated, original ground shall mean the ground at the level to which the Engineer has ordered excavations to be made, otherwise original ground shall mean the ground level as shown on the checked cross-section sheets.

The final volume of embankment fill shall not include the voids for bridges, box culverts, and pipe culverts nor the volume of any backfill to those structures placed above existing ground level. The volume of the voids for box culverts and pipe culverts shall be reckoned as the product of the cross-sectional area of the void and the overall length of the box or circular pipes. No deductions shall be made for deviations from the regular shape of the embankment due to inlets or outlets for box or pipe culverts or rip-rap slope protection.

The volume of embankment adjacent to cuts, ditches, channels, diversions, foundations, etc., which can be constructed with the materials from these excavations will not be measured or paid for until these excavations are completed and the materials brought into the embankment or satisfactorily disposed of and the adjacent embankment has been completed with materials procured by the Contractor from other acceptable sources and at his own expense.

No separate measurement or payment shall be made for benching. All costs involved in benching into an existing slope including the cutting of benches and any recompaction of material into the additional voids thus formed shall be deemed to be included in the rates included in the Bills of Quantities for Embankment measured net as defined above.

No measurement or payment will be made where materials are removed or backfilled for reasons not instructed in writing by the Engineer.

2.6.4.2 Measurement of Fill Outside Limits of Earthworks

Volumes of suitable materials used for filling-in diverted channels, ditches, ponds, streams or old borrow pits shall be measured by the cubic metre between original ground and the level to which filling has been ordered in writing by the Engineer.

Should the Contractor choose to dispose of unsuitable materials by backfilling diverted channels, ditches, ponds, etc., no measurement or payment will be made.

2.6.5 PAYMENT

Embankment, Sand Embankment and Selected Material will be paid for at the respective Contract unit prices per cubic metre, complete, compacted and accepted in place, which prices shall include all equipment, excavation and hauling of materials, tools, labour, staking and all incidentals necessary for proper execution of the work.

Payment for earth, rock embankment and selected material will be at the Contract unit price regardless of the source of material and regardless of whether the excavation of the material has been paid for under another item or not.

Where unsuitable material has been removed and paid for under item 2.2(5) Roadway Excavation, Unsuitable Material, backfill shall be placed and paid for under item 2.6(1) Embankment or 2.6(3) Selected Subgrade Material as directed by the Engineer.

Pay items will be as follows:

Item Ref	Description	Unit of Measurement
2.6(1)	Embankment	Cubic metre
2.6(2)	Sand Embankment	Cubic metre
2.6(3)	Selected Subgrade Material	Cubic metre

In the monthly estimates, partial payments may be made for embankment fill which is placed, compacted and shaped in accordance with the Drawings and these Specifications. The quantity may be estimated provisionally on the basis of the cross-sections.

2.7 REMOVAL OF EXISTING STRUCTURES

2.7.1 DESCRIPTION

This item shall consist of the satisfactory removal and disposal or salvage, wholly or in part, of all the existing structures, substructures, buildings, culverts, etc., as required.

2.7.2 CONSTRUCTION REQUIREMENTS

Existing structures upon or adjacent to the proposed road shall be removed by the Contractor, as indicated on the Drawings or as required. Where existing bridge structures may be used as a temporary crossing or detour, no part of the removal shall be performed unless otherwise indicated on the Drawings or in the Special Provisions, nor shall the structure be closed or obstructed until the new work is opened to traffic by the Engineer.

If the superstructure or any portion of the structure is deemed fit for use elsewhere, the useable portions shall be marked and removed without damage. They shall be piled neatly at an accessible point above high water level and shall become the property of the Employer.

When the Drawings provide for using the existing substructures, or part of same, as permanent parts of the new structure, only those portions indicated on the Drawings to be removed shall be removed. When no such use is contemplated, all exposed portions of the existing structures above the stream bed shall be completely removed. When the proposed structure is a bridge, and it becomes necessary to remove the portions of the existing structure below ground in order to construct the new work, such removal will be classed as excavation as provided for in Section 2.5 Excavation and Backfill for Structures.

When pipe culverts, wooden boxes or other structures with a salvage value are removed, extreme care shall be exercised in their removal and the material involved kept intact without damage. The contractor shall be held responsible for the satisfactory removal of such structures in useable condition.

Salvaged pipe culverts, wooden boxes or other structures shall be stored at approved accessible points along the project and shall become the property of the Employer.

All material which is not considered of value by the Engineer shall be removed from the right-of-way, or so disposed of upon the right-of-way as not to constitute an obstruction or a nuisance.

2.7.3 MEASUREMENT AND PAYMENT

There are no separate items in the Contract for the removal of existing drainage structures. If structures are to be removed to facilitate construction, this work shall be done and shall not be paid for directly, but shall be considered as incidental to the Contract.

The removal of the existing structures shall be done as specified on the Drawings or in these Special Provisions and shall not be paid directly, but shall be considered in the lump sum paid for the structural work.

CONSTRUCTION SPECIFICATION

Section 3
Sub-Base and Base Course

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3 SUB-BASE AND BASE COURSE

3.1 SUB-BASE

3.1.1 DESCRIPTION

This work shall consist of furnishing, placing and compacting sub-base material on a prepared and accepted sub-grade in accordance with these Specifications, to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

3.1.2 MATERIALS REQUIREMENTS

3.1.2.1 General

The sub-base materials shall be selected from borrow areas at locations suggested on the Drawings or those selected by the Contractor. The materials shall consist of naturally occurring sand or gravels that comply with the requirements given below. All materials shall be free of topsoil and all other organic matter. The materials shall consist of sound durable particles which do not break down under compaction or repeated wetting/drying cycles. All sizes greater than 80 mm shall be hand-picked and removed from the working surface.

3.1.2.2 Soil Aggregate Mixture

The grading shall conform to grading envelopes A, B, C, D or E as determined by AASHTO test method T 27 and given in Table 3.1-1 of these Specifications. The fraction of material passing the 0.425 mm sieve shall have a liquid limit, as determined by AASHTO T 89, of not greater than 35 percent and a plasticity index, as determined by AASHTO T 90, of not greater than 20. The fraction passing the 0.075 mm sieve shall be not greater than two-thirds of the fraction passing the 0.425 mm sieve. Abrasion of the coarse part of the material shall be tested in accordance with AASHTO T 96 and shall show a percentage of wear no greater than 50 percent. Shale material shall not be used for sub-base. The minimum required CBR shall be 30 percent, after 4 days soaking in accordance with AASHTO T 193, on samples compacted to 95% of the dry density determined by AASTHO T 180.

Table 3.1-1 Grading Requirements For Soil Aggregate Material

Sieve Designation	Grading A	Grading B	Grading C	Grading D	Grading E	Grading F
		Percentage by weight passing square mesh sieves				
50 mm...	100	100	-	-	-	-
25 mm....	-	75 – 95	100	100	100	100
10 mm....	30 - 65	40 - 75	50 - 85	60 - 100	-	-
2.00 mm.....	15 - 40	20 - 45	25 - 50	40 - 70	40 - 100	55 - 100
0.425 mm....	8 - 20	15 - 30	15 - 30	25 - 45	20 - 50	30 - 70
0.075 mm....	2 - 8	5 - 20	5 - 15	5 - 20	6 - 20	8 - 25

3.1.2.3 Sand Cushion

The material used for a sand cushion underneath a concrete pavement shall be coarse sand having hard and durable particles without any clay lumps or deleterious material. The percentage by weight passing the 9.5 mm sieve shall be 100% and that the passing the 0.075 mm sieve shall not exceed 10%.

3.1.3 CONSTRUCTION REQUIREMENTS

3.1.3.1 Preparation of Sub-grade

The sub-grade shall be shaped and compacted in conformity with the provisions of Section 2.2 and Section 2.6 and completed for at least 150 metres ahead of the placing of the sub-base course material and subject to the requirements of the Contract for the Engineer's approval of the sub-grade before it is covered up. Notwithstanding any earlier approval of sub-grade, any damage to or deterioration of sub-grade shall be made good before sub-base is laid.

3.1.3.2 Stabilised Sub-base

Sub-base stabilised with lime or cement shall be constructed in accordance with the requirements of Section 3.4, Cement Stabilised Base and Sub-base, and Section 3.5, Lime Stabilised Sub-base, of these Specifications

3.1.3.3 Spreading Sub-base

Sub-base shall be spread in even layers not exceeding 150 mm after compaction. Care shall be taken to prevent segregation, and oversized particles shall be hand picked from the deposited layer prior to compaction. Patches or pockets of segregated fine material shall be removed and the layer made good at the Contractor's own expense.

3.1.3.4 Watering, Rolling and Compacting

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment. Rolling operations shall begin from the outer edge of the roadbed and progress towards the centre, gradually in a longitudinal direction, except on super-elevated curves where rolling shall begin at the low side and progress toward the high side. Sub-base composed of sandy material shall be compacted by use of vibrating equipment.

Each layer shall be compacted to at least 95 percent of the maximum dry density, as determined by AASHTO T 180. During compaction, the moisture content shall be so controlled that the moisture content uniformly throughout the finished layer shall be within the limits of $\pm$2 percent of the optimum moisture content as determined in AASHTO T 180 or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Materials which do not contain sufficient moisture shall be watered prior to and during compaction to the satisfaction of the Engineer. Materials containing excess moisture shall be allowed to dry to the required moisture content prior to compaction. All costs involved in regulating the moisture content, both wetting and drying, shall be deemed to be covered by the unit price for sub-base.

Density determinations shall be carried out for each layer of sub-base constructed, in accordance with the requirements of AASHTO test T191, at a rate of 5 tests for every 2000 square metres of completed sub-base layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and all five shall be greater than the required relative density minus 3%, and the average of all five shall be not less than the required value.

The construction tolerances for Subbase shall be as defined in Clause 1.11.8 of these Specifications. Rectification of work outside the permitted tolerances shall be carried out in accordance with Clause 1.11.9 of these Specifications

3.1.3.5 Proof-Rolling

Where shown on the plans or indicated by the Engineer, the Contractor will proof-roll the compacted sub-base surface. The proof-rolling will be performed on newly completed sub-base using either a smooth wheel steel roller with a load intensity on the rear wheels of not less than 52.5 kN per linear metre width of roll, or a pneumatic-tyred roller loaded to 2.5 kN per tyre and each tyre inflated to 7 bar. Any areas which show visible movement shall be scarified and re-compacted at the contractor's expense. Any areas which have been allowed to stand for more than 24 hours prior to proof-rolling and which have not been maintained at approximately the optimum moisture content shall be watered and given at least 8 passes of the test roller before proof-rolling is carried out. The cost of this additional work in preparation for proof-rolling shall be at the contractor's expense.

3.1.3.6 Sampling

Suitable samples of the sources of sub-base materials shall be submitted to the Engineer not less than 30 days before commencing the construction and additional samples shall be furnished during construction, as required, upon request. Methods for the obtaining the materials samples for testing purposes shall conform to the requirements detailed in AASHTO T2-78 or as directed by the Engineer. The Engineer reserves the right to test the material after compaction to ensure compliance with all specified standards. Materials rejected on this basis shall be removed and replaced at the expense of the Contractor.

3.1.3.7 Maintenance

After construction is completed the sub-base shall be maintained throughout except where portions of the succeeding course are under construction thereon. Maintenance shall include drainage, rolling, shaping, and watering as necessary to maintain the finished sub-base layer in proper condition. Deficiencies in thickness, composition, construction, smoothness or density which develop during the maintenance shall be corrected to conform to the requirements specified above. Sufficient moisture shall be maintained at the surface of the sub-base layer to prevent the development of a dusty condition. This moisture level shall be achieved by a light spraying of water at appropriate time intervals.

3.1.4 MEASUREMENT

Sub-base as described in this section will be measured by the cubic metre of material compacted in place and approved. Measurements shall be based on the cross section of the sub-base shown on the Drawings and actual length measured horizontally along the centreline of the surface of the road. Sub-base stabilised with lime or cement shall be measured in accordance with the provisions of Section 3.4, Cement Stabilised Base and Sub-base, and Section 3.5, Lime Stabilised Base, of these Specifications.

3.1.5 PAYMENT

The completed work, measured as provided in the Specifications, shall be paid for at the Contract unit prices per cubic metre for sub-base or sand cushion as detailed below. Payment shall be deemed as full compensation for furnishing all materials, equipment, hauling, placing, compacting, watering, finishing and shaping and for all labour, tools and other incidentals necessary to complete the work specified.

Sub-base will not be paid for complete in place until the subsequent layer of pavement is constructed thereon. However, the Engineer may authorise payment of 75% of the quantity of sub-base on current estimates in advance of the succeeding operations, provided it has been competed in accordance with these Specifications and is satisfactorily maintained pending the placement of subsequent pavement layers.

Payment will be made under the following items:

Item Ref	Description	Unit of Measurement
3.1(1)	Sub-base	Cubic metre
3.1(2)	Sand cushion	Cubic metre

3.2 RECONSTRUCTED SUB-BASE

3.2.1 DESCRIPTION

This work shall consist of scarifying, reshaping and re-compacting the existing pavement and shoulders and reconditioning the whole width of the cross-section by the addition of approved materials to form a reconstructed layer in accordance with these Specifications and to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as directed by the Engineer.

The provision of additional soil aggregate material will be carried out in accordance with the requirements of Section 3.1 of these Specifications.

3.2.2 MATERIALS REQUIREMENTS

Additional materials required to carry out the works shall conform to the requirements detailed in Clause 3.1.2 of these Specifications, in accordance with sound engineering practice or as instructed by the Engineer.

3.2.3 CONSTRUCTION REQUIREMENTS

3.2.3.1 Scarifying and Preparation

The existing road pavement and shoulders shall be scarified to the depth shown on the Drawings or as directed by the Engineer. Care shall be exercised to prevent sub-grade soil or other materials from below the layer being scarified from being brought up and mixed with the loosened material.

The loosened materials shall then be thoroughly broken up by use of suitable approved equipment blended and mixed together with additional soil aggregate material, and shall be reshaped by motor grader to the proper cross-slope and grade. Unbroken particles too large to be properly compacted into the reconstructed layer thickness shall be either broken down further or removed from the site.

3.2.3.2 Compaction

The reconstructed layer shall be rolled and compacted in accordance with sub-clause 3.1.3.4 of these Specifications.

3.2.3.3 Surface Requirements

The reconstructed layer when finally compacted, shall present a uniform surface true to line and grade and conforming to the cross-section shown on the Drawings. The finished surface shall conform to the requirements of sub-clause 3.1.3.4 of these Specifications.

When a reconstructed layer is to carry traffic before receiving a surfacing or further pavement layer, the Contractor shall maintain the surface at his own expense and prevent ravelling by the application of additional filler and/or watering, as may be required to keep the base tightly bound and leave an excess of not more than 6 mm in thickness over the entire surface.

3.2.4 MEASUREMENT

Reconstructed Sub-base will be measured on a two dimensional square metre basis and computed as the horizontal width across the top of the reconstructed layer multiplied by the length measured horizontally along the centreline of the surface of the road.

Additional Sub-base Material required will be measured by the cubic metre of additional material compacted in place and approved. Measurements shall be based on the cross section of the sub-base shown on the Drawings, less the cross section of existing pavement materials established from site measurements giving average width and depth prior to scarifying the layer, multiplied by the actual length measured horizontally along the centreline of the surface of the road.

3.2.5 PAYMENT

Reconstructed Sub-base, measured as provided in the Specifications shall be paid for at the Contract unit price per square metre, completed and approved, regardless of the nature of materials encountered. Payment shall be full compensation for scarifying the existing pavement, mixing additional sub-base material, compacting, watering, finishing and shaping and for all labour, tools and other incidentals necessary to complete the work specified.

Additional Sub-base Material, measured as provided in the Specifications shall be paid for at the Contract unit price per cubic metre, on completion and approval of the Reconstructed Sub-base in which it has been incorporated. Payment shall be full compensation for furnishing all materials, equipment, hauling and placing additional sub-base material, and for all labour, tools and other incidentals necessary to complete the work specified.

Reconstructed Sub-base will not be paid for complete in place until the subsequent layer of pavement is constructed thereon. However, the Engineer may authorise payment of 75% of the quantity of reconstructed sub-base and additional sub-base materials on current estimates in advance of the succeeding operations, provided it has been completed in accordance with these Specifications and is satisfactorily maintained pending the placement of subsequent pavement layers.

Payment shall be as follows:

Item Ref	Description	Unit of Measurement
3.2(1)	Reconstructed Sub-base	Square metre
3.2(2)	Additional Sub-base Material	Cubic metre

3.3 AGGREGATE BASE

3.3.1 DESCRIPTION

This work shall consist of providing a base course layer composed of crushed aggregate material or other approved base course material placed and compacted on a prepared and approved sub-base in accordance with these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

3.3.2 MATERIALS REQUIREMENTS

3.3.2.1 Base Course Materials

Base course aggregate shall consist of a mixture of hard durable crushed rock particles and mineral filler which satisfies the grading limits A, B or C in Table 3.1-2 as determined by AASHTO test method T 27. The portion that passes the 0.075 mm sieve shall not be more than 2/3 of that portion passing the 0.425 mm. The coarse aggregate, defined as that material retained on the 4.75mm sieve, shall have a percentage of wear not greater than 40 percent for 500 revolutions, when tested according to AASHTO T 96. Where the coarse aggregate is produced from crushing a river source gravel, at least 90 percent of the particles shall have at least 2 crushed faces. When produced from a rock quarry, the source material shall be approved by the Engineer prior to use.

The portion passing the 0.425 mm sieve of the total mixture shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 percent, as determined in AASHTO T 90. The CBR strength of the whole mixture, as determined in AASHTO T 193, shall be no less than 80 percent after 4 days soaking, on samples compacted to 95 percent of the maximum dry density as determined in AASHTO T 180 and over a moisture range of 4 percent. Shale material shall NOT be used as base course.

If the stone used to prepare the fine material has unsatisfactory cementing qualities, it may be used provided limestone fines in an amount of 20% by mass of that proportion passing the 4.75mm sieve, are blended therewith at no additional cost to the Employer.

3.3.2.2 Mixing

Mixing of the aggregate base course material with additive to obtain the required grading shall be permitted only at the crusher site or stockpiling area but in no case shall material for base course arrive at the site not in compliance with the requirements specified in sub-clause 3.3.2.1 of these Specifications. Road mixing of additive for base course material will not be permitted under any circumstances and material arriving at the site not in accordance with the requirements of the specifications will be rejected.

Mixing of materials by the stationary plant method shall be performed in a central mixing plant. The plant shall be equipped with feeding and metering devices that will introduce the aggregate, and water into the mixer in the quantities specified. Mixing shall continue until a uniform and homogeneous mixture of aggregate and water has been obtained. After mixing, the material shall be transported to the job-site while it contains the proper moisture content and shall be placed on the roadbed by means of an approved aggregate spreader.

3.3.3 CONSTRUCTION REQUIREMENTS

3.3.3.1 Preparation of Sub-grade or Sub-base

The sub-grade or sub-base on which the base layer is to be constructed shall be shaped and compacted in conformity with the provisions of Section 2.2, Section 2.6, Section 3.1 and Section 3.2 of these Specifications and completed, and approved by the Engineer, for at least 150 metres ahead of the placing of the base course material.

3.3.3.2 Spreading Base

Base material shall be placed on the prepared sub-base and compacted to the thickness shown on the Drawings.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimise rutting or uneven compaction.

Base layers up to 150 mm of compacted thickness may be placed in one layer. Specified compacted thicknesses greater than 150 mm shall be constructed in two (or more, as required) layers of approximately equal thickness.

When base course is spread contiguous to curbs or gutters, extreme care shall be exercised not to damage the curbs or gutters. Any damage due to the construction methods or negligence on the part of the Contractor shall be rectified to the satisfaction of the Engineer at the expense of the Contractor.

In order to control base course elevations, road profile posts or some other method as approved by the Engineer shall be employed at station intervals no greater than 10.0 metres.

3.3.3.3 Watering, Rolling and Compaction

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer.

Rolling operations shall begin along the edges and overlap the shoulder at least 0.75 metre, or as close to the outer edge of the shoulder as practicable where a full width roadbed base course is specified on the Drawings, and progress toward the centre, gradually in a longitudinal direction. On super-elevated curves, rolling shall begin at the low side and progress toward the high side. The rolling operation shall continue until all roller marks are eliminated, and the whole layer is thoroughly compacted.

Each layer shall be compacted to at least 98 percent of the maximum dry density as determined by AASHTO T 180. During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of $\pm$ 2% of the optimum moisture content as determined in AASHTO test T180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of base constructed, in accordance with the requirements of AASHTO test T191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent..

Base course material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer, at the expense of the Contractor.

Any irregularities that may develop in the surface during or after construction shall be corrected by removing or loosening the surface, adding further material as required and re-compacting.

The final shaping and rolling of the shoulders to the full width shall be carried out after the base course is completed.

At the end of each day's work a construction joint shall be made in thoroughly compacted material. This joint shall be constructed normal to the centreline of the road alignment and with a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

3.3.3.4 Surface Tolerance

The construction tolerances for Aggregate Base course shall be as defined in Clause 1.11.8 of these Specifications. Rectification of work outside the permitted tolerances shall be carried out in accordance with Clause 1.11.9.

3.3.3.5 Additional Base Course Material

If, after reconstructing an existing base course layer or excavating a soft spot or localised failure in an existing base course layer, additional base course material is required, it shall be constructed and paid for under the item of Aggregate Base Course in accordance with these Specifications, unless otherwise directed by the Engineer. Any associated works such as minor excavation of the existing pavement structure squaring off of the adjoining pavement or other miscellaneous tasks shall be considered incidental to this and other items of the Contract.

3.3.3.6 Sampling

When the Contractor has set up his production of base course aggregate so as to obtain a uniform, consistent material, he shall submit suitable samples to the Engineer for approval not less than 30 days before commencing construction. Methods of sampling of materials for testing shall be carried out in accordance with the requirements of AASHTO T-2 or as directed by the Engineer.

3.3.3.7 Proof-Rolling

Where shown on the plans or indicated by the Engineer, the Contractor will proof-roll the compacted base surface. The proof-rolling will be performed on newly completed base course using either a smooth wheel steel roller with a load intensity on the rear wheels of not less than 52.5 kN per linear metre width of roll, or a pneumatic-tyred roller loaded to 2.5 kN per tyre and each tyre inflated to 7 bar. Any areas which show visible movement shall be scarified and re-compacted at the contractor's expense. Any areas which have been allowed to stand for more than 24 hours prior to proof-rolling and which have not been maintained at approximately the optimum moisture content shall be watered and given at least 8 passes of the test roller before proof-rolling is carried out. The cost of this additional work in preparation for proof-rolling shall be at the contractor's expense.

3.3.3.8 Maintenance

After construction is completed the whole of the fully prepared base shall be maintained in good order and condition. Maintenance shall include drainage, rolling, shaping, and watering as necessary to maintain the course in proper condition. Deficiencies in thickness, composition, construction, smoothness or density that develop during the maintenance operations shall be corrected to ensure the base layer conforms to the requirements of these Specifications. Sufficient moisture shall be maintained at the surface to prevent a dusty condition developing. This will be achieved by the application of a regular light spraying with water.

3.3.4 MEASUREMENT

Base course will be measured as the number of cubic metres of material complete in place and approved. Volume measurements shall be based on the cross sectional area shown on the typical roadway sections and the actual length measured horizontally along the centreline of the road.

3.3.5 PAYMENT

This work as measured above will be paid for at the Contract unit price per cubic metre, complete in place, which price shall include furnishing all materials, equipment, hauling, placing, compacting, watering, finishing, shaping, labour, tools and other incidentals necessary for the satisfactory completion of the work.

Base Course will not be paid for complete in place until the subsequent surfacing is constructed thereon. However, the Engineer may authorise payment of 75% of the quantity of base course on current estimates in advance of the succeeding operations, provide it has been completed in accordance with these Specifications and is satisfactorily maintained pending the placement of the surfacing.

Payment will be under the following item:

Item Ref	Description	Unit of Measurement
3.3(1)	Aggregate Base Course	Cubic metre

3.4 CEMENT STABILISED BASE AND SUB-BASE

3.4.1 DESCRIPTION

This work shall consist of furnishing and mixing aggregate, cement and water and spreading and compacting the mixture, all as specified in these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

3.4.2 MATERIAL REQUIREMENTS

3.4.2.1 Material

The material to be used for cement stabilised base shall be a well graded soil aggregate with not less than 30 percent retained on the 4.75 mm sieve. The fraction passing the 0.425 mm sieve shall have a plasticity index of not greater than 15 percent and a liquid limit of not greater than 40. The target UCS shall be 0.7 MPa and the minimum soaked CBR value after stabilisation shall be 80% as determined by AASHTO T193.

The material to be used for cement stabilised sub-base shall be a well graded soil aggregate with not more than 40 percent passing the 0.075 mm sieve. The fraction of material passing the 0.425 mm sieve shall have a liquid limit not greater than 40 percent and a plasticity index of not greater than 20. The minimum soaked CBR value after stabilisation shall be 30% as determined by AASHTO T193.

3.4.2.2 Cement

Cement shall conform to the requirements of Portland cement in Section 5.1 of these Specifications.

3.4.2.3 Water

Water shall be clean and free from harmful matter and may be tested in accordance with AASHTO T26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.

Furthermore water shall not contain more than 400 parts per million by weight of sulphate.

3.4.3 CONSTRUCTION REQUIREMENTS

3.4.3.1 Mix Design

The cement content of the mix shall be determined as a percentage by dry weight of soil. The actual cement content shall be determined by the Engineer on site and may be varied by him from time to time.

The strength of the cement stabilised base shall be as specified in the Special Provisions or as indicated on the drawings.

The strength of the cement stabilised sub-base shall be as specified in the Special Provisions or as indicated on the drawings.

3.4.3.2 Equipment

The equipment used for mixing the soil and cement shall be as approved by the Engineer and shall be capable of constructing the soil-cement mixture to meet the requirements specified.

3.4.3.3 Initial Testing

The Engineer will make and test trial mixes using different proportions of cement and will select mix proportions that give strengths of test cylinders, made and cured in the laboratory of not less than 110 percent of the required strength indicated in sub-clause 3.4.3.1 of these Specifications.

3.4.3.4 Mix Control

The entire operation of mixing and compacting the cement stabilised base and sub-base shall be subject to close control and frequent testing will be required as the work proceeds to ensure that the strength and density requirements are being maintained.

The mix proportions and uniformity of mixing of the soil-cement shall be such that of any 20 consecutive samples of the mixed material taken before compaction on any one day and compacted in the laboratory, the average strength shall be not less than the required strength. Not more than two of these samples shall have less than 90% of the required strength. If because of low production on any particular day less than 20 samples are taken then all samples must be up to the minimum specified standard. In particular, extra material needed to make up losses in handing and from attrition and to allow for non-uniformity of mixing shall be supplied by the Contractor at its own expense.

The Contractor shall assist the Engineer in all ways to sample soil for stabilising at least 30 days in advance of its use so that necessary adjustment to the mix design may be made. To ensure good sampling it will normally be necessary to remove overburden and stockpile sufficient soil for construction 30 days ahead at all times.

3.4.3.5 Mixing

Mixing of the soil aggregate with cement shall be accomplished by the central plant method only. The mix-in-place travelling plant method shall not be employed nor will it be permissible to blend the materials by the motor grader/windrow method.

The aggregate shall be proportioned and mixed with cement and water in a central mixing plant. The plant shall be equipped with feeding and metering devices that will introduce the cement, aggregate and water into the mixer in the quantities specified. Mixing shall continue until a uniform and homogeneous mixture of aggregate, cement and water has been obtained.

Mixed material shall be transported to the roadway in suitable vehicles and spread on a moistened sub-grade or sub-base in a uniform layer by a self-propelled or other approved spreader or where necessary, by the use of a motor grader. Not more than 60 minutes shall elapse between the start of mixing and the time of starting compaction of the cement treated mixture on the prepared sub-grade or sub-base.

3.4.3.6 Spreading and Compacting

After the cement treated mixture has been spread, the mixture shall be compacted to at least 95% in the case of sub-base, and 98% in the case of base, of the maximum density determined in accordance with AASHTO T180. Any mixture of aggregate, cement and water that has not been compacted shall not be left undisturbed for more than 30 minutes. The percentage of moisture in the completed mixture shall not vary from the optimum by more than 2 percentage points, as determined by AASHTO T180. Compaction shall be completed, the compacted surface shall be brought to the required cross section, and all irregularities shall be removed and the surface re-compacted, all within two hours of the time water is added to the mixture.

Density determinations shall be carried out for each layer constructed in accordance with the requirements of AASHTO test T191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction and the fifth shall be not less than the required relative density minus 3%.

3.4.3.7 Construction Joints

At the end of each day's work and when cement stabilised base and sub-base operations are delayed or stopped for more than 2 hours, a construction joint shall be made in thoroughly compacted material, normal to the centreline of the road alignment, with a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

Where cement stabilised base and sub-base has been finally compacted more than one hour, longitudinal joints shall be constructed by cutting vertically into the existing edge for approximately 80 mm. The face of the cut joints shall be moistened in advance of placing the adjacent base.

3.4.3.8 Curing

The completed cement stabilised base and sub-base shall be covered with an asphaltic curing seal on the same day as final compaction is performed and as soon after said compaction as practicable. The surface shall be kept moist until the seal is applied. The asphaltic curing seal shall be furnished and applied in accordance with the provisions in Section 4.1 of these Specifications. Damage to the curing seal or cement stabilised base and sub-base shall be promptly repaired by the Contractor at his own expense as directed by the Engineer

3.4.3.9 Traffic

Heavy equipment except for equipment required for constructing adjoining sections will not be permitted to drive over completed portions until curing is completed. Traffic control shall be as required by the Engineer.

3.4.3.10 Protection

The base and sub-base shall be protected as necessary to maintain the surface within the tolerances specified and to prevent failure from traffic or other causes.

3.4.3.11 Determination of Thickness

After final compaction, test holes shall be dug in the mixture to determine the thickness at intervals not greater than 100 metres. Any part of the base or sub-base which fails to meet the requirements of the Specifications or which originally having met the requirements of the Specifications subsequently suffers damage or deformation shall be rebuilt to these requirements to the full depth of the layer at the Contractor's expense. The addition of thin layers to raise the level of low areas will not be permitted.

3.4.3.12 Surface Requirements

Surface deviation in excess of 10 mm from a straight edge 3 metres long applied to the surface parallel to the centre line of the road and 12.5 mm from a template laid transversely, shall be corrected by loosening, adding or removing material, reshaping and recompacting, provided this is done within the time allowed for compaction. The level of the finished base shall not, at any point, be lower than the designed level.

The base or sub-base completed in each day's work shall be not less than the required thickness.

3.4.3.13 Acceptance

The engineer may test by generally recognised methods not mentioned herein and any test result which shows that the work does not comply with this Specification may be grounds for rejection of the work.

3.4.4 MEASUREMENT

This item will be measured as the number of cubic metres of material complete in place, and approved (no deduction will be made for the quantity of cement used). Measurement will be based on the cross section area of the base or sub-base shown in the Drawings and the actual length measured horizontally along the centre line of the surface of the road. Any cement used in excess of the specified mix proportions, whether used in order to obtain the specified strength or for any other reason will be provided by the Contractor at his own expense. Test sections shall be regarded as incidental to the work and shall not be paid for.

Cement will be measured separately as the number of tonnes of material either as the actual quantities used or as the quantity calculated from the approved mix proportions expressed as tonnes per cubic metre of compacted finished layer, whichever is the lesser.

3.4.5 PAYMENT

This work measured as provided above shall be paid for at the Contract unit price, complete in place for Cement Stabilised Base and Sub-base, which price shall not include the price of cement, but shall include all other materials; all equipment, handling, placing, mixing, compacting, all labour, tools and incidentals necessary to proper completion of the work.

The cement measured as provided above shall be paid for at the Contract Unit Price per tonne, which price shall include all purchase costs, delivery to site, storage and wastage.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
3.4(1)	Cement Stabilised Base	Cubic metre
3.4(2)	Cement Stabilised Sub-base	Cubic metre
3.4(3)	Cement for stabilising Base or Sub-base	Tonnes

3.5 LIME STABILISED BASE

3.5.1 DESCRIPTION

This work shall consist of the addition and mixing of lime with natural materials as described in Section 3.1 of these Specifications, the spreading and compacting of the treated material all as specified in these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

Following the addition and mixing in of the stabiliser the material is referred to as "treated material".

3.5.2 MATERIALS REQUIREMENTS

3.5.2.1 Natural Materials

The material to be used for stabilised base shall be a well graded soil aggregate with not more than 40 percent passing the 0.075 mm sieve. The fraction of material passing the 0.425 mm sieve shall have a liquid limit not greater than 40 percent and a plasticity index of not greater than 20 nor less than 6.

3.5.2.2 Lime

Lime for treatment of road materials shall be Hydrated Calcium Lime and, unless otherwise instructed by the Engineer, shall comply with the following requirements:

Fineness	**Hydrated lime**
Residue on 0.2 mm sieve – Maximum	1%
Residue on 0.075 mm sieve – Maximum	10%
Chemical requirements	
Free lime content – Minimum	50%
Hydrated lime content – Maximum	-

Storage and Handling - All lime shall be kept under cover and protected from moisture. Consignments shall be used in the same sequence as they are delivered. Stocks which become damaged or which are stored on the Site for more than 3 months shall not be used, and shall be replaced at the Contractor's expense.

Operators and labour shall be provided with protective clothing, masks and goggles.

3.5.2.3 Water

Water shall be clean and free from harmful matter and shall be tested in accordance with AASHTO T-26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.

Furthermore water shall not contain more than 400 parts per million by weight of sulphate.

3.5.3 CONSTRUCTION REQUIREMENTS

3.5.3.1 Mix Design

The amount of lime to be added shall be determined, as a dry weight of soil, by the Engineer following laboratory trials and site trials carried out by the Contractor.

After treatment the material shall have a CBR of at least 60 percent measured after 7 day cure and 7 day soak on the site mix compacted to 95 percent of the maximum dry density in a moisture range of 2.0 percent as determined by AASHTO T-180.

3.5.3.2 Mix-in-Place Method of Construction

The mix-in-place method may be used for the addition and mixing in of lime.

(a) Mixing equipment

The equipment for pulverising the material and mixing in the lime shall be purpose-built equipment, capable of pulverising the materials and mixing in the lime to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with Section 3.5 of these Specifications.

The equipment may be either single or multi-pass machines and shall only be acceptable if, during the site trials, it can produce material that is a uniform and intimate mixture of aggregate, lime and water that meets all the specified requirements.

The mixers shall be equipped with a device for controlling the depth of processing and mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

Mixing by grader will not be permitted.

(b) Preparation of the layer

Before the lime is applied, the material to be treated shall be spread and broken down and oversize material removed so that the maximum size of the particles is not greater than specified. The material shall first be pulverised to the required consistency by successive passes. The material shall then be shaped true to line, grade and cross-section and, if required, lightly compacted. The loose thickness shall be such as to give the specified thickness after full compaction has been carried out.

The moisture content of the layer before the addition of the lime shall be adjusted to within the range of 70% to 85% of the Optimum Moisture Content (AASHTO T-180).

(c) Spreading the lime

After the layer to be treated has been prepared to the satisfaction of the Engineer, the lime shall be uniformly spread at the specified rate over the width to be worked. If a spreader is used to spread the lime ahead of the mixer, it shall be fitted with a device to ensure a uniform and controllable rate of spread both transversely and longitudinally.

Only sufficient lime for immediate use shall be spread ahead of the mixing operation and any which, in the opinion of the Engineer, becomes defective, shall be replaced at the Contractor's expense.

Only equipment actually used in the spreading or mixing operation shall be allowed to pass over the lime, when so spread, before it has been thoroughly mixed into the material to be treated.

(d) Mixing and watering

Immediately after the lime has been spread, it shall be thoroughly and homogeneously mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a homogenous layer. The mixing machine shall be set so that it cuts at least 100 mm into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

Care shall be taken both during this and subsequent watering operations that the underlying layer is not disturbed and that no material from the underlying layer or shoulders is mixed with that being processed.

If watering is necessary to bring the mixture to the required moisture content, then this shall be done after spreading and mixing in the stabiliser. Water shall be added in a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Care shall be taken to avoid a concentration of water at any point or a flow of water over the surface.

Any part of the mixture which becomes too wet after the stabiliser has been added and before the mixture is compacted will be rejected and any such part shall be allowed to dry out until its moisture content is satisfactory and shall be retreated with fresh stabiliser and finished off in accordance with the requirements of this sub-clause.

Throughout the process of mixing in the stabiliser and water, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

3.5.3.3 Stationary Plant Method of Construction

(a) Mixing Equipment

Stationary mixing plant shall be of the power driven paddle or pan type and may be of the batch or continuous type.

If batch mixers are used, the appropriate measured amounts of material and lime shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range determined in the laboratory and site trials. Special care shall be taken with batch type paddle mixers to ensure that the lime is spread uniformly in the loading skip so that it is fed evenly along the mixing trough. With both paddle and pan mixers the lime shall be proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilised. Mixing shall be continued until the mixture has the required uniformity and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer after satisfactory trials.

If continuous mixing is used, the paddles, baffles and rate of feed of materials shall be adjusted to give uniformly mixed material.

If a spray is used for distributing water into the mixer, it shall be adjusted to give uniformity in moisture content throughout the mix.

(b) Transporting

Mixed material shall be transported to the road in suitable vehicles. Material that becomes segregated or is affected by weather shall be removed and replaced at the Contractor's expense.

(c) Laying

The mixed material shall be spread to the required width and thickness by means of a mechanical paver such that the tolerance requirements as specified in Section 3.3 of these Specifications are achieved after final compaction. Segregation shall be avoided and the layer shall be free from pockets of coarse or fine material.

3.5.3.4 Compaction and Finishing

For lime treated materials, final compaction and finishing shall be completed within 12 hours after the lime comes into contact with the material to be treated.

(a) Thickness limitations

The compacted thickness of any treated layer laid, processed and compacted at one time shall not exceed 180 mm. Where a greater thickness is required, the material shall be laid in two or more layers.

The compacted thickness of any base layer shall not be less than twice the maximum particle size of the material.

(b) Compaction requirements

The minimum density for all lime treated materials shall be 95% MDD (AASHTO T 180). The moisture content at the time of compaction shall be between 95% and 105% of Optimum Moisture Content (AASHTO T180).

Density acceptance criteria shall be as the second paragraph of sub-clause 3.3.3.6 of these Specifications.

(c) Finishing

The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material; and other surface irregularities and shall be to line and level and within the tolerances specified in Section 1.11.8 of these Specifications. If the surface fails to meet the requirements of these Specifications the Contractor shall take the action set out in Section 1.11.9 of these Specifications or such other action as the Engineer may instruct or agree.

3.5.3.5 Joints Between New and Existing Work

The forming of construction joints and the protection of previously treated or other work shall be carried out so as to produce a uniformly compacted and homogeneous layer free from ridges or other irregularities.

Full width working, without longitudinal joints, will generally be required. Half-width working may be instructed by the Engineer to pass traffic. When forming longitudinal joints, with the mix-in-place method at least 100 mm of the first laid half-width layer shall be retreated and mixed in with the second half-width layer.

When forming transverse joints, with the mix-in-place method, at least 1.0 m length of the previously laid treated work shall be incorporated into the new treated layer and the Engineer may instruct that the percentage of lime be increased at these places.

When forming longitudinal or transverse joints with the stationary plant method of construction, previous work shall be cut back to expose fully treated and compacted material.

3.5.3.6 Protection and Curing

Treated layers shall be kept continuously damp by lightly spraying with water, from completion of compaction until one of the curing systems specified below is placed.

Treated layers shall be protected within 8 hours by one of the following methods:-

(i) Completely covering the layer with clear or light coloured approved polythene sheeting of minimum thickness 0.1 mm. The sheeting shall be laid to cover the whole of the surface of the layer. At joints the sheeting shall be lapped by at least 500 mm and any damaged sheeting shall be replaced at the Contractor's expense.

The sheeting shall be securely held in contact with the layer by an approved method.

(ii) Completely covering the treated material with a layer of damp uncompacted gravel or soil material of minimum thickness 100 mm. This material, which may be that forming the next layer, shall be kept continuously damp.

(iii) Spraying the layer with a curing seal at a rate of 1.5 l/sq-m, or such other rate as shall be instructed by the Engineer, to be applied in accordance with Section 4.1 of these Specifications.

Unless otherwise instructed by the Engineer, no prime coat will be required where method (iii) is adopted and the Contractor shall comply with the requirements of Section 4.1 and 4.2 of these Specifications.

Plant used for dumping and spreading material, and the application of water or curing seal shall be approved by the Engineer and shall have individual axle loads not exceeding 6 tonnes.

Immediately prior to placing protection methods (i) or (iii) the surface of the treated layer shall be made thoroughly damp by lightly spraying with water.

The curing system shall be kept in place and intact for a minimum of 7 days after completion of compaction although small areas may be temporarily removed for the purposes of carrying out control testing but only for the minimum amount of time required for the testing.

3.5.3.7 Traffic

Traffic or equipment, other than that actually engaged in the various treatment or protection processes, shall not run over the layer being processed or compacted.

On completion of curing no traffic or equipment shall be allowed on the treated layer with the exception of that required for proof-rolling, priming or construction of the subsequent layer.

3.5.3.8 Tolerances

(a) Geometric tolerances

The treated base shall be constructed within the tolerances specified in Section 3.3 of these Specifications.

(b) Amount of lime

(i) Mix-in-place method of construction.

The average amount of lime, measured before mixing, over a length of 100 m, shall not be less than the amount ordered.

The average amount of lime in the treated material, measured at five points over a length of 100 m, shall not be less than the amount ordered.

The amount of lime, measured after mixing, shall at no point be less than 70% or more than 130% of the amount ordered.

(ii) Stationary plant method of construction

The average amount of lime in the treated material measured at five points over a length of 100 m, shall not be less than the amount ordered.

The amount of lime measured after mixing shall at no point be less than 90% or more than 110% of the amount ordered.

(iii) Determination of lime content

The lime content in mixed materials shall be determined according to Test 15 of BS 1924.

3.5.4 MEASUREMENT

For the purpose of measurement and payment no distinction shall be made between the mix-in-place and stationary plant methods of construction.

The work of providing, hauling, placing, spreading, mixing, watering, compacting and shaping the materials to be stabilised will be measured in Section 3.3 of these Specifications.

Mixing lime into the materials to be stabilised shall be measured by the cubic metre of treated material calculated as the product of the compacted sectional area specified to be treated and the length instructed.

The provision of the stabiliser shall be measured by the tonne calculated as the specified weight of stabiliser added to the material.

3.5.5 PAYMENT

The work of providing, hauling, placing, spreading, mixing, watering, compacting and shaping the materials to be stabilised will be paid in Section 3.3 of these Specifications.

For the additional work of providing and mixing-in the lime and curing the treated materials the Contractor will be paid as follows:-

Item Ref	Description	Unit of Measurement
3.5(1)	Mix in Lime	Cubic metre
3.5(2)	Lime	Tonne

The rate for lime shall include for the cost of provision, storage, handling, transport and spreading of the lime at any point on the Works and complying with the requirements of Section 3.5 of these Specifications.

The rate for mixing shall include for the cost of complying with the requirements of Section 3.5 of these Specifications including the cost of watering, provision, placing and maintenance of the curing system.

3.6 SHOULDERS

3.6.1 DESCRIPTION

This work shall consist of constructing or reconstructing supporting shoulders on both sides of the roadway in accordance with these Specifications to the lines, grades, elevations, dimensions and cross-sections shown on the Drawings and as required by the Engineer.

This work shall not be construed to include bituminous surface treatment of shoulders or grassing of soil aggregate shoulders.

3.6.2 MATERIALS REQUIREMENTS

The type of shoulder material to be used is shown on the typical roadway cross sections on the Drawings.

In the case of a shoulder consisting of crushed stone base course with a single bituminous surface treatment, materials shall meet the respective requirements of Sections 3.3 and 4.4 of these Specifications.

In the case of a soil aggregate shoulder, the upper layer of material shall consist of natural soil aggregate conforming to one of the grading envelopes A, B, C, or D of Table 3.1-1 of these Specifications. The portion of the material passing the 0.425 mm sieve shall have a liquid limit of not greater than 35 and a plasticity index of 4 to 20. The material shall have a soaked CBR value of 30% when compacted to 95% of maximum dry density as determined by AASHTO Test T 180. The lower layer of a two-layer shoulder shall consist of aggregate base material in accordance with Section 3.3 of these Specifications.

3.6.3 CONSTRUCTION REQUIREMENTS

3.6.3.1 General

The shoulder shall be constructed to the lines and levels shown on the Drawings and finished as required in the appropriate Sections of these Specifications. The work shall be carried out in conformity with the requirements for simultaneous construction of sub-base or base if such requirements are applicable. The construction shall be done in such a way that courses of material of different types are not mixed together.

3.6.3.2 Compaction

Shoulders composed of base course material shall be compacted to at least 95 percent of the maximum dry density as determined by AASHTO T 180. Soil Aggregate Shoulders shall also be compacted to 95 percent of the maximum dry density as determined by AASHTO T 180.

All shoulders shall be processed and compacted in layers not exceeding 200 mm thickness before compaction.

3.6.3.3 Surface and Thickness Tolerance

The construction tolerances for Shoulders shall be as defined in Clause 1.11.8 of these Specifications. Rectification of work outside the permitted tolerances shall be carried out in accordance with Clause 1.11.9. of these Specifications.

3.6.4 MEASUREMENT

The shoulder shall be measured as the number of cubic metres of each course separately (if courses of different kinds are required) of material complete in place, compacted and accepted. The volume shall be calculated from the required cross section as shown on the Drawings and the horizontal length of shoulder.

3.6.5 PAYMENT

If required by the typical cross section, a surface treated shoulder shall be paid for in accordance with Section 4.4 Bituminous Surface Treatment for the item of Single Bituminous Surface Treatment of these Specifications.

Soil Aggregate shoulders shall be paid for at the Contract unit price per cubic metre, complete in place, which price shall include all materials, hauling, equipment, tools, labour and incidentals necessary for satisfactory completion of the work.

If required by the typical cross section, a drain of the same material as the crushed aggregate base shall be constructed beneath the shoulder. Payment for this crushed aggregate drain shall be made in accordance with Section 3.3, Aggregate Base, pay item for Aggregate Base Course of these Specifications. No additional payment shall be made for forming this drain under Section 3.3 or Section 3.5 of these Specifications.

Payment will be under the following item:

Item Ref	Description	Unit of Measurement
3.6(1)	Soil Aggregate Shoulder	Cubic metre

CONSTRUCTION SPECIFICATION

Section 4
Bituminous Works

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4 BITUMINOUS WORKS

4.1 BITUMINOUS PRIME COAT

4.1.1 DESCRIPTION

This work shall consist of the preparation for and application of a bituminous prime and blotting material to a previously prepared and untreated surface viz:; earth sub-grade, waterbound base course, crushed aggregate base course, cement or lime stabilised base course, top of roadway shoulders, concrete bridge deck, etc. in accordance with these Specifications and in close conformity with the lines shown on the Drawings or established by the Engineer.

4.1.2 MATERIALS REQUIREMENTS

4.1.2.1 Bituminous Materials

Bitumen shall conform to the requirements given in AASHTO M20-70 for the particular grades stipulated in these Specifications. Bitumen shall be designated by its penetration value (e.g. 60-70 pen).

Cut back bitumens shall be of the rapid curing type or the medium curing type and shall conform to AASHTO designations M81-75 and M82-75 respectively. Cut back bitumen shall be described by its kinematic viscosity value at 60 ^{0}C. (e.g. RC 250, MC 70).

The prime coat shall be a medium or slow curing cutback bitumen conforming to the requirements of AASHTO M82 or a slow setting cationic emulsified bitumen conforming to the requirements of AASHTO M208. Application temperatures shall be as follows:

Type and Grade	Application Temperature
MC - 30	30 - 90°C
MC - 70	50 - 100°C
SC - 70	50 - 100°C
CSS – 1	25 - 55°C

The prime coat or bituminous curing seal for a cement stabilised base shall be either medium curing cutback grade MC 70 or MC 30 conforming to the requirements of AASHTO M 82. The medium curing cutback grade MC 30 will be recommended if it is found that medium curing cutback grade MC 70 cannot penetrate the base. However, if medium curing cutback grade MC 30 is not available on the market, grade MC 70 may be blended with kerosene in proportions approved by the Engineer.

4.1.2.2 Sources of Supply

a) General - Bituminous materials will be accepted at the source of shipment subject to the following conditions.

- The Supplier shall conduct laboratory tests of all materials intended for shipment to the Contractor and certify that the material meets the contract specifications.
- Before loading, the Producer shall examine the shipping container, remove all remnants of previous cargoes which might contaminate the material to be loaded and certify that it was clean and free of contaminating material when loaded.

- The Contractor shall furnish with each shipment two copies of the delivery ticket. The delivery ticket shall contain the following:

Consignee _____	Designation _____
Project Number _____	Date _____
Grade _____	Loading Temp. _____
Net Litres _____	
Specific Gravity at 15^0 C _____	
Net weight _____	
Identification No.	
(Truck, Car, Tank, etc,) _____	

- The Contractor, or the Supplier as his agent, shall deliver to the Resident Engineer a certification signed by an authorised representative of the supplier to cover the quality and quantity of the material and the condition of container for each shipment. The certification shall be essentially in the following form and may be stamped written or printed on the delivery ticket.

"This is to certify that this shipment of _____ Tonnes/ litres of_____
bitumen meets all contract specification requirements of the project, and the shipping container was clean and free from contaminating material when loaded:

Producer _____
Signed _____"

- Failure to sign the certification will be cause to withhold use of the material until it can be sampled, tested and approved.

b) Acceptance procedures for bituminous materials: The following acceptance procedure for bituminous material will apply. The Contractor shall provide delivery tickets and certifications as set out in a) above. Acceptance samples of bituminous materials shall be obtained in accordance with AASHTO T40, at the applicable point of acceptance as defined herein:

- Bituminous materials used in direct application on the road: Acceptance samples shall be obtained under the supervision of the Engineer from the conveyances containing the bituminous material at the point of delivery. Single samples shall be taken of each separate tank load of bituminous material delivered, at the time of discharge, into distributors or other conveyances on the project.
- Bituminous materials initially discharged into storage tanks on the project: Acceptance samples shall be obtained from the line between the storage tank and the distributor on the asphalt mixing plant after each delivery. A single acceptance sample shall be taken after a sufficient period of circulation of such bituminous material has taken place to ensure samples representative of the total material then in the storage tank.

As soon after sampling as practicable, the acceptance sample shall be delivered by the Engineer to the nearest authorised laboratory for tests to determine compliance. Final acceptance of bituminous materials shall be determined on the basis of the acceptance sample test results compliance with the applicable specification requirements.

Bituminous material which deviates from the specification requirements shall be removed and replaced or otherwise corrected by and at the expense of the contractor.

4.1.2.3 Bituminous Materials - Storage and Handling

The bituminous materials storage area and heating station shall be kept neat and tidy. The storage area shall be cleared of vegetation and where bituminous material is stored in drums these shall be stacked on their sides and only in small quantities with gaps between each stack to reduce fire risk.

Bitumen distributors and boilers shall be kept clean at all times. When changing the grade of bituminous material and at the end of each day's work, all boilers and distributors shall be thoroughly cleaned out with a solvent. The flushings from boilers and distributors shall not be poured over the area indiscriminately, but shall be led by drainage channels to disposal pits, care being taken that flushings do not find their way into stormwater ditches or streams.

All boilers, pre-heating pits, tools, and plant shall be kept scrupulously clean.

When filling the bitumen distributor from the boilers or bulk containers, the bituminous material shall be passed through a filter of fine wire gauze.

On completion of the Works the disposal pits and drainage channels shall be filled in, topsoiled and the site left clean and tidy in accordance with the requirements of Section 9.9.of these Specifications.

4.1.2.4 Blotting Material

Blotting material shall be approved clean dry sand or stone screenings free from any cohesive material. It shall contain not more than 15 percent retained on a 6.3 mm sieve and shall contain no organic matter.

4.1.3 CONSTRUCTION REQUIREMENTS

4.1.3.1 Preparation of Bituminous Materials

The bitumen shall be heated to the specified temperature in tanks so designed as to avoid local overheating.

When carried in bulk containers, records of bitumen temperature and time, in a manner acceptable to the Engineer, shall be kept. Any bitumen not conforming to the requirements of this sub-clause may be rejected by the Engineer as unsuitable for use in the Works. The minimum pumping temperatures, the range of spraying temperatures and the maximum heating temperatures of cut-backs, penetration grade bitumens and emulsions are given in Table 4.1.1

Table 4.1.1 Temperature Ranges for Handling Bituminous Materials

Bituminous Material	Temperatures (°C) *			
	Minimum Pumping	Spraying		Maximum Heating
		Slot-jets	Atomising jets	
Cut-back RC 30	10	35 - 45	-	50
Cut-back RC 70	25	55 - 65	-	70
Cut-back RC 250	45	80 - 90	-	90
Cut-back RC 800	60	100 -115	-	120
Cut-back RC 3000	80	125 -135	-	135
Cut-back MC 30	10	35 - 45	50 – 60	65
Cut-back MC 70	25	55 - 65	70 – 85	85
Cut-back MC 250	45	80 - 90	90 – 110	110
Cut-back MC 800	60	100 - 115	120 – 135	135
Cut-back MC 3000	80	125 - 135	135 –150	150
Bitumen 400/500	95	140 - 150	160 – 170	170
Bitumen 280/320	100	150 -160	160 – 170	170
Bitumen 180/200	105	155 - 165	160 – 170	170
Bitumen 80/100	115	160 - 170	160 – 170	170
Bitumen 60/70	115	160 - 170	160 – 170	170
Emulsion K1-70	15	75 - 85	75 - 85	95
Emulsion K1-60 **	-	-	-	95

* These spraying temperatures are for guidance only since the optimum spraying temperature depends on the temperature/viscosity relationship of the bituminous material.

** The minimum pumping and spraying temperatures for K1-60 shall be in accordance with the manufacturer's recommendations.

For slot-jets the viscosity for spraying shall be 70 to 100 centistokes and for atomising jets 35 to 60 centistokes.

No bituminous material shall be heated above the maximum temperature given in Table 4.1.1 and any that is overheated shall be removed from the Site and disposed of by the Contractor.

The rates of application of bituminous material specified or instructed by the Engineer refer to volumes of bitumen corrected to 15.6 °C using the Standard Petroleum Measurement Table (ASTM D 1250).

4.1.3.2 Weather Limitations

Prime coat shall be applied only when the surface to be treated is dry or slightly damp when the surface temperature in the shade is above 13 ^{0}C and rising, or above 15 ^{0}C if falling and when the weather is not foggy or rainy.

4.1.3.3 Equipment

a) Bitumen Distributor - The bitumen distributor tank shall be calibrated and the pump pressure/application rate determined before spraying so that the correct distributor travel speed can be calculated once the application rate is decided upon. The transverse distribution and the actual application rate shall be checked by placing 200 mm x 100 mm cotton pads at 250 mm spacings across the sprayed width and ensuring that the transverse variation is less than 10%.

Before any bitumen distributor is approved for use on the Works, the calibration of the instruments and measuring equipment shall be checked in a series of field tests at locations directed by the Engineer. Up to five (5) separate field test runs may be directed at various nominal application rates chosen to each pass at least 200 litres of bitumen material through the spray bar.

The bitumen distributor shall be truck mounted and shall have sufficient power to maintain uniform speeds for the proper application of the bitumen. The truck shall be equipped with an accurate tachometer showing the driver the speed of the truck in metres per minute.

The bitumen distributor will have a useable tank capacity of at least five thousand (5,000) litres and will be equipped with gas or oil fired burners or other satisfactory means for reheating the full contents of the tank. The bitumen distributor shall be capable of spraying material at uniform, controlled rates both transversely and longitudinally, from 0.2 litre per square metre with a tolerance of five (5) percent, over spray or under spray, in widths from 0.6m to 7.5m in increments of approximately 0.1m. All spray nozzles on the bitumen distributor shall be at an angle of 15^{o} to 30^{o} to eliminate any interference from adjacent sprays. The spray bar height shall be adjusted to give an exact double lap spread, i.e. one nozzle should spray to the centre of the adjacent nozzle. This must be checked in detail, by shutting every second nozzle and seeing that the sprays just meet with no overlap. The bitumen distributor shall be maintained in sound mechanical condition. The Engineer may direct further field tests at any time during the progress of the work and if such tests reveal unsatisfactory spraying accuracy, the distributor may be rejected for further use on the road.

The bitumen distributor shall be fitted with a hand-held, manually operated bar fed by a flexible line for use on areas too small to be satisfactorily sprayed with the main bar.

b) Road Broom - Rotary road brooms shall be drawn, tractor mounted or self propelled and shall have a broom core width of not less than 1.8 m.

4.1.3.4 Preparation of Surface

Immediately prior to applying bituminous material all loose dirt and other objectionable material shall be removed from the surface with a power broom and/or blower as required. If the Engineer so orders, the surface shall be lightly bladed and re-compacted immediately prior to the application of bituminous material, in which case brooming or blowing will not be required. When so ordered by the Engineer a light application of water shall be made just before the application of bituminous material.

4.1.3.5 Application of Bituminous Material

As soon as possible after the surface to be sprayed has been prepared as specified in sub-clause 4.1.3.4 of these Specifications and approved by the Engineer, the prime coat shall

be sprayed on to it at the specified rate. Spraying shall be carried out not later than 12 hours after the surface has been prepared unless otherwise approved by the Engineer. The quantity of bituminous material used shall give complete and uniform coverage of the surface with a minimum of run-off. Should the specified rate of spray appear to be incorrect, the Contractor shall immediately stop spraying, inform the Engineer and amend the spray rate as instructed.

The edge of the area shall be marked out with a line or string or wire pegged down at intervals not exceeding 15 m on straights or 7.5 m on curves.

Bituminous material shall be sprayed from a pressure distributor and no hand spraying shall be permitted except in small areas, or to make good a defective area caused by a blocked nozzle.

The nozzles shall be arranged to give a uniform spray and shall be tested prior to spraying by discharging on to suitable material (such as building paper, metal sheets, etc.) or into purpose made troughs. Testing shall not take place on the road, and any bitumen spilt onto the ground shall be cleaned off.

If during spraying, a nozzle becomes blocked or develops a defect, the spraying shall be immediately stopped, and any area incompletely sprayed shall be made good with a hand spray, and the machine repaired before further spraying is commenced.

When commencing and stopping spraying, sheets of building paper or metal at least 1 m wide shall be spread across the full width of the road to be sprayed to give a clean sharp edge.

The metal sheet used for stopping and starting work shall be cleaned after each run and the troughs used for testing shall be cleaned at the end of each day's work.

During spraying all curbs, road furniture, culvert headwalls, trees and the like which are liable to be disfigured by splashing of bituminous material shall be protected, and any such feature which is accidentally marred by bituminous material shall be cleaned off with a suitable solvent or made good.

4.1.3.6 Application of Blotting Material

Blotting material shall be used unless otherwise directed by the Engineer. If, after the application of the prime coat, the bituminous material fails to penetrate within the time specified or if the road must be used by traffic, blotting material shall be spread in the amount required to absorb any excess bituminous material and to protect the primed surface.

Blotting material shall be spread so that no wheels or tracks are able to travel in uncovered wet bituminous material.

4.1.3.7 General Precautions for Handling Bituminous Materials

Since cutback bitumen is flammable, extreme care must be exercised during the heating process.

Care shall be taken in transporting emulsified bitumen to avoid separation of the mixture. Drums or small containers of emulsified bitumen shall be rolled five times to each side every week and before pouring into the bitumen distributor. Emulsified bitumens shall not remain in the bitumen distributor holding tank overnight. Generally, it is desirable that an

opened container of emulsified bitumen be completely used; if not used completely, the container shall by tightly sealed in order to prevent separation of the mixture.

4.1.3.8 Tolerances

The rate of application of bituminous material across the full width of each spray run shall not vary by more than ± 10% of the rate ordered and the average rate of bituminous material for each single run of the spray truck shall be at least equal to the rate ordered. Tray tests shall be taken at the commencement of priming operations. Calculations based on dipping of spray trucks shall be made before and after every run to check application rates.

When the actual rate of application of bituminous material exceeds or is less than the rate ordered, the Engineer will direct that the work will be made good or will be allowed to remain, subject to such conditions as may be further directed by the Engineer.

4.1.3.9 Control of Bitumen Spillages

The Contractor shall take all measures necessary to prevent the spillage of extraneous bitumen on or adjacent to the Site. In particular, deposits of bitumen resulting from the clearing of bitumen spray bars shall not be permitted. Any bitumen spillages on the site shall be removed and disposed of by means approved by the Engineer.

4.1.4 MEASUREMENT

Bituminous prime coat shall be applied to the full width of the top of the completed and approved base course layer, including shoulders where shoulders are constructed of base course material, and on all other areas receiving surface treatment or asphalt pavement in accordance with the Drawings or as otherwise directed by the Engineer.

Bituminous prime coat shall be measured by the area in square metres sprayed in accordance with the Drawings at the instructed rate of application in litres/sq-m, corrected to 15.6 ^{o}C .

Blotting material shall not be measured for payment but will be considered to be included in the unit price for bituminous prime coat.

The actual litres of bituminous prime coat sprayed shall be recorded and corrected to 15.6^{o}C to determine the actual rate of application. When the actual application rate, corrected to 15.6 ^{o}C is less than 90% of the specified application rate the actual shortfall in litres shall be measured and an adjustment to the payments will be applied.

4.1.5 PAYMENT

Bituminous prime coat will be paid for at the Contract unit price per square metre of area measured as provided for in Clause 4.1.4 of these Specifications for each type of bituminous material, complete and approved in place, and shall include for the cost of providing, hauling and spraying the prime coat at the instructed application rate, blotting material, and complying with the requirements of Section 4.1 of these Specifications.

When the actual application rate, corrected to 15.6 ^{o}C is less than 90% of the specified application rate a deduction of the actual shortfall in litres at the Contract unit price per litre of the corresponding type of bituminous prime material will be applied.

Payment shall be made under the following item :

Item Ref	Description	Unit of Measurement
4.1(1)	Bituminous Prime Coat	Square metre
4.1(2)	Cost of Bituminous Prime Material Type ……. (Deduction for reduced application rate - provisional)	Litre
Etc		

4.2 BITUMINOUS SURFACE TREATMENT

4.2.1 DESCRIPTION

This work shall consist of a single (SBST) or double (DBST) bituminous surface treatment layer involving the application of a bituminous material followed by an aggregate cover specified, on the completed and approved pavement in accordance with these Specifications and in close conformity with the lines shown on the Drawings or established by the Engineer.

4.2.2 MATERIALS REQUIREMENTS

4.2.2.1 Bituminous Materials

Bituminous materials used in surface treatments shall be one of the types and grades listed in the following table and approved by the Engineer.

Designation	Type of Material
60 - 70	Bitumen
80 - 100	Bitumen
RC - 250	Cutback Bitumen, Rapid Curing
RC - 800	Cutback Bitumen, Rapid Curing
RC - 3000	Cutback Bitumen, Rapid Curing
RS - 2	Emulsified Bitumen
CRS - 2	Cationic Emulsified Bitumen
CRS - 3	Cationic Emulsified Bitumen

The materials shown above shall be in compliance with AASHTO designations M20-70, M81-75, M140-82 and M208-81, as applicable, and shall be supplied in accordance with the requirements specified in sub-clause 4.1.2.2 of these Specifications. The general precautions outlined in sub-clause 4.1.3.7 of these Specifications shall be applicable. The minimum pumping and spraying temperatures and the maximum heating temperatures for the various types and grades of bitumen shall be in accordance with Table 4.1.1 of these Specifications or as otherwise instructed by the Engineer. Bitumen shall only be cut back on site if so instructed and approved by the Engineer.

4.2.2.2 Additives

Bitumen additives shall be used if and when directed by the Engineer. Prior approval must be obtained from the Engineer regarding the type of additive to be used.

4.2.2.3 Rubberised Bituminous Material

Rubberised bituminous material shall not be used, unless required under the Special Provisions.

4.2.2.4 Aggregates

Aggregates for bituminous surface treatments shall consist of clean, dry, hard durable crushed stone or crushed gravel free from dust, clay, dirt and other deleterious matter. Aggregates shall meet the quality requirements of AASHTO M80 except as altered herein.

All aggregates shall be mechanically screened to remove dust and small particles. Where bitumen or cutback bitumen is used, aggregates shall be precoated. Where emulsified asphalt is used, only washed aggregates will be allowed.

When subjected to the coating and stripping test, AASHTO test method T182, the aggregates shall have a coated area of not less than 95%. Aggregates which do not meet this requirement may be used for bituminous surface treatments provided an approved chemical additive or wetting agent is used to create a water resistant film.

When crushed gravel is used to produce sealing aggregate, not less than 75 percent by weight of the particles shall have at least two fractured faces. The minimum size of stone to be crushed to produce sealing aggregate shall be at least four times the maximum size of the sealing aggregate.

The aggregates shall have a percentage of wear not exceeding 35 when tested for abrasion resistance by AASHTO Method T96 and, when subjected to five alternations of the sodium sulphate test for soundness (AASHTO Test Method T104) shall have a weighted loss not greater than 12%. The flakiness index, as determined by British Standard 812, shall not exceed 33%.

Aggregate sizes to be used in the various applications of surface treatment shall be as follows:

(a) Single Bituminous Surface treatment (SBST)

Average Least Dimension 12.5 mm

(b) Double Bituminous Surface Treatment (DBST)

First layer, 19.0 mm

Second layer , 12.0 mm

(c) Shoulders

Shoulders shall be surface treated when indicated on the Drawings or directed by the Engineer. The two types of surface treated shoulders are as follows:

SBST shoulder, 19.0 mm or 12.5 mm.

DBST shoulder, 19.0 mm for first layer, 9.5. mm for second layer.

The above-mentioned '"nominal sized' aggregates shall comply with the following gradation requirements using AASHTO Test Method T27:

Nominal Size Of Material	Percent by Weight Passing AASHT0 sieve Sizes							
	37.5 mm	**25.0 mm**	**19.0 mm**	**12.5 mm**	**9.5 mm**	**4.75 mm**	**2.36 mm**	**1.l8 mm**
25.0mm	100	90-100	0-45	0-10	0-5	-	0-2	0-0.5
19.0mm		100	90-100	0-30	0-8	-	0-2	0-0.5
12.5mm			100	90-100	0-40	0-8	0-2	0-0.5
9.5mm				100	90-100	0-30	0-8	0-2

In all cases the percentage passing the 0.075 mm sieve shall not exceed 0.5% by weight.

4.2.2.5 Pre-Coated Aggregates

Aggregates shall be pre-coated to improve adhesion to the bitumen. The precoating material may be diesel, kerosene, cut back bitumen, fuel oil, tar, or other materials approved by the Engineer. Pre-coating material shall be thinly and evenly applied to all aggregate particles, such that they are fully coated, but do not contain excess material. A fine pressure spray may be used against a regulated stream of aggregates falling from a conveyor belt or from a bin, or mixing can be carried out in the pugmill of an asphalt mixing plant. The aim of the operation is to obtain an aggregate that is free from dust, and yet remains a free flowing material that can be applied with aggregate spreaders. The coating shall be such that no material will drip from a freshly coated particle of aggregate held between the fingers. Aggregates that are excessively pre-coated and are wet on the surface shall be left to dry out. The pre-coating material, the rate of application, the method of mixing and the mixing plant shall be subject to the approval of the Engineer.

Aggregate shall not contain excessive moisture to cause uneven distribution of the pre-coating material and shall not be used in the work until the moisture has evaporated and the pre-coating material has adhered effectively to the aggregate.

Pre-coated aggregate shall not be stock-piled for any period longer than is necessary for moisture to dry out. When there is a visible coating of dust on the particles the Engineer may direct that portions of the stock-pile be pre-coated again.

The Contractor may run the aggregate through a drier beforehand, so that no moisture is retained on the aggregate particles upon pre-coating, and arrange for the pre-coated material to be immediately loaded into trucks to be carried to the spreaders without the need of stock-piling.

4.2.2.6 Stockpiling of Aggregates

Stockpiling of aggregate will be permitted only where agreed by the Engineer. A separate stockpile shall be made for each nominal size of aggregate at each location.

The site of the stockpile shall be cleared of all vegetation and debris, graded and drained, and where the Engineer deems it necessary, the area shall be surfaced with a 100 mm layer of approved stone or rock.

Unless otherwise approved by the Engineer each stockpile shall be built at least 2 metres high by tipping in layers not more than one metre deep over the whole area of the stockpile. The Contractor shall supply any planking or other material required in connection with movement of vehicles over and about the stockpiles.

The bottom 50 mm layer of the aggregate stockpile or any contaminated aggregate shall not be used in the work.

4.2.2.7 Material Application Rates

The application rates for both aggregate and bitumen to be used for the initial field trials shall be determined as follows:

(a) Aggregate

A preliminary value of the aggregate quantity to provide for a thickness equal to the average least size dimension with 20% voids is as follows:

A (kg/sq-m) = 0.8 F x G x H where

F is the Wastage Factor 1.07 for 9.5mm and 12.5mm aggregate

1.02 for 19.0mm and 25.0mm aggregate

G is the Bulk specific gravity (AASHTO test Method T85) and

H is the Average Least Dimension (mm)

The above equation assumes voids in the loose aggregate to be 50%. Control tests shall be carried out to determine the loose density according to AASHTO T19 and the loose voids content determined as follows:

V = 1 – J / G where

V is the loose voids content

J is the loose unit weight (t/cu-m.)

G is the Bulk specific gravity

The final design aggregate quantity shall then be calculated as:

A (kg/sq-m) = (1 - 0.4 V) F x G x H

The design quantity shall be checked by packing the aggregate one stone thick on a sample tray and by field trials.

(b) Bitumen

The theoretical bitumen application rates for each layer to embed the aggregate to about 70% of its average least size dimension can be determined from the following formula:

B (litres/sq-m) = (0.4 x H x V x T) + S where

B is the theoretical “cold" bitumen application rate for each layer.

T is the Traffic factor (0.70 - 0.75)

R is the Residual bitumen factor

S is the Surface texture correction for first layer only.

= -0.1 to -0.3 litre/sq.m., for black flushing surface;

= nil for smooth surface, good priming;

= +0.1 to +0.3 litre/sq.m., for absorbent and rough surfaces.

For double surface treatment, the theoretical bitumen quantities for each layer shall be added together and converted to “hot”' rates at the spraying temperature (ASTM D1250-56). For warm season construction, 60% of this combined rate shall be applied for the first layer and 40% for the second. For cool season construction, 50% of the combined rate shall be applied for the first layer and 50% for the second layer.

The design application rates for double surface treatment may be checked by method C.14 given in the Asphalt Institute Manual Series MS-13 “Asphalt Surface Treatments”.

The final design quantity shall be determined by field trials. The actual quantity to be used in the work shall be as directed by the Engineer.

4.2.3 CONSTRUCTION REQUIREMENTS

4.2.3.1 Equipment

a) Bitumen Distributor

The bitumen distributor shall be as specified in sub-clause 4.1.3.3 (a) Bituminous Prime Coat of these Specifications

b) Aggregate Precoating and Loading Unit

Pre-coating and loading equipment, producing dust free aggregates, may be of the type and operations as described in the following:

The equipment is mounted on a truck, consisting of an aggregate scraper, spiral wheel elevator, tilting ram, rotating drum with ruff wheel and screen, belt conveyor, suction type pre-coating material feed and pre-coating jets.

The aggregate is fed into a rotating drum where the aggregate is cleaned of dust particles by the help of a drum-mounted screen. A fine pressure spray of pre-coating material is then applied against a regulated stream of clean aggregates falling from the conveyor belt. The pre-coated material is loaded into trucks and transported to the spreaders.

c) Aggregate Spreaders

Aggregate shall be spread by self-propelled mechanical spreaders, or other approved systems.

Mechanical aggregate spreaders or box type spreaders mounted at the rear of spreader trucks shall be capable of spreading the aggregate uniformly over variable widths from 0.5m to 3.5m at the rates specified.

d) Road Brooms

The road brooms shall be as specified in sub-clause 4.1.3.3 (b) Bituminous Prime Coat of these Specifications

e) Rollers

Rollers shall be self-propelled, pneumatic tyred, multi-wheeled rollers having an unballasted mass not less than 8 tonnes and tyres of equal size. Rear wheels shall be offset relative to the front wheels to give overlapping tyre paths and complete coverage for the effective width of the roller. Rollers will be capable of providing a wheel load from 1,000kg to 1,500kg per wheel with a maximum tyre pressure of 6 Bar.

4.2.3.2 Weather Limitations

No spraying shall be carried out on a wet pavement, while rain appears imminent or during high winds.

The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or pavement or any conditions which he considers may affect the work adversely.

4.2.3.3 Application of Bitumen

Bitumen shall be sprayed from a pressure distributor in accordance with the requirements of sub-clause 4.1.3.5 of these Specifications. No hand-spraying will be permitted other than for those areas too small to be sprayed by the main bar.

The spraying temperature of the bitumen material shall be as stipulated in Section 4.1 of these Specifications. Application rates shall be as determined in sub-clause 4.2.2.7 of these Specifications and as approved or as directed by the Engineer.

The distributor shall be dipped and the temperature taken before and after every run and the actual '"hot"' application rate determined and checked against the specified rate. The actual rate shall not vary more than ± 5% from the specified rate. Bitumen shall not be held at temperatures within the spraying range for periods exceeding eight hours. Any bitumen which has been heated for an excessive period of time or which has been overheated shall be rejected. Spray rates shall be checked by dipping the distributor tank immediately before and after each spray run and the application rate checked.

All surplus aggregate from the first layer shall be removed before spraying for the second layer.

Bitumen shall be applied over the full width of the carriageway, that is, the total width of both traffic lanes. Spraying half width or partial width will only be carried out with the approval of the Engineer.

When half width spraying is permitted, the bitumen distributor shall be operated in the opposite direction to the first layer when spraying for the second layer and the centre joint shall be offset 300 mm. Spraying shall cease immediately if any defect develops in the spraying equipment and it shall not recommence until the fault has been rectified.

4.2.3.4 Application of Cover Aggregate

Sufficient aggregate to cover the proposed area to be sprayed shall be in trucks at the site of the work before any spraying is allowed to commence.

All trucks shall be weighed on portable scales prior to spreading to enable aggregate quantities and application rates to be checked. Alternatively the contents of each truck shall be water-levelled before spreading commences and the remaining contents, if any, after spreading is completed shall be measured to determine the exact volume used from which the aggregate application rate can be determined.

As the binder soon cools to road temperature and loses its viscosity to adhere to the aggregate, it is desirable to spread the aggregate within one minute of spraying. A maximum of 3 minutes will, however be allowed. Before commencing, sufficient aggregate shall be loaded into spreader trucks, or to replenish the mechanical spreader, to cover the full spray run.

The transverse distribution of aggregate and application rate shall be checked before laying by determining the aggregate amount on 0.5 m square papers across the spreading width and checking it against the design value. The rate shall not vary by more than ± 10%. Hand brooming and hand spotting of areas deficient in aggregate shall be carried out immediately after spreading and excess heaps or rills removed before rolling. A light spread to give a complete cover of one stone thickness with some hand spotting is preferable to a heavy spread. Tray tests shall be taken, at least once per spray run, to check rate of spread of aggregate.

The average least size dimension of the cover aggregate shall be determined regularly and the aggregate application rate changed accordingly (see sub-clause 4.2.2.7).

4.2.3.5 Rolling and Brooming

The pneumatic tyred rollers complying with the requirements of sub-clause 4.2.3.1 of these specifications shall be used to roll the aggregate into the binder. Rolling shall commence immediately after spreading and continue, in conjunction with drag brooming, until the aggregate is well embedded in the binder and a uniform surface is obtained. At least 4 passes of the roller over all parts of the surface shall take place and in the first layer may be followed by 2 passes of a steel wheeled roller not exceeding 8,000 kg to make a smooth surface without any crushing of the aggregate for the second layer.

Rolling shall continue until the aggregate is bound properly to the binder. If satisfactory embedment does not occur, then further rolling shall be carried out the following day. When the binder has hardened to the stage that not more aggregate can be pressed into it by rolling, all loose aggregate shall be removed by sweeping.

If the Engineer considers that the adhesion of the binder to the aggregate is unsatisfactory, he shall reject the work and direct that no further work be carried out until the conditions improve.

4.2.3.6 Control of Traffic

The Contractor shall strictly regulate the traffic over the finished work to protect the freshly laid aggregate from disturbance from its embedded position. The Contractor shall be fully responsible for any damage arising there from.

4.2.3.7 Single Bituminous Surface Treatment Margins (SBST)

When shown on the drawings or directed by the Engineer a margin of single bituminous surface treatment will be required at the edge of the carriageway.

Single bituminous surface treatment will be constructed on the shoulders of an asphalt paved road or of a double bituminous surface treatment (DBST) pavement or as directed by the Engineer. Aggregate sizes for the aforementioned SBST applications shall be as specified in sub-clause 4.2.2.4, aggregates, of these Specifications.

The shoulder treatment will be constructed at the same time as and as part of the first layer of the DBST and all requirements of the clauses controlling construction of DBST shall apply equally to construction of SBST.

4.2.3.8 Tolerances

The final average overall width of the surface dressing measured at six equidistant points over a length of 100m shall be at least equal to the width specified or instructed. At no point shall the distance between the centre line of the road and the edge of the surface dressing be narrower than that instructed by more than 15 mm.

The rate of application of bitumen across the width of each spray run shall not vary by more than ± 5% of the rate ordered and the average rate of bitumen for each single run of the spray truck shall be at least equal to the rate ordered. Calculations based on dipping of spray trucks shall be made before and after every run to check application rates.

When the actual rate of application of bitumen exceeds or is less than the rate ordered, the Engineer will direct that the work will be made good or will be allowed to remain, subject to such conditions as may be further directed by the Engineer.

4.2.3.9 Control of Bitumen Spillages

The Contractor shall take all measures necessary to prevent the spillage of extraneous bitumen on or adjacent to the Site. In particular, deposits of bitumen resulting from the clearing of bitumen spray bars shall not be permitted. Any bitumen spillages on the site shall be removed and disposed of by means approved by the Engineer.

4.2.4 MEASUREMENT

Bituminous surface treatments shall be measured by the area in square metres of each seal coat placed as specified on the Drawings at the instructed rate of application in litres/square metre, corrected to 15.6 ^{o}C.

The actual litres of bitumen sprayed for each coat shall be recorded and corrected to 15.6^{o}C to determine the actual rate of application. When the actual application rate, corrected to 15.6 ^{o}C is less than 95% of the specified application rate the actual shortfall in litres shall be measured and an adjustment to the payments will be applied.

Sealing Aggregate shall be measured by the cubic metre of each nominal size for each class calculated as the product of the area in square metres covered as specified on the Drawings and the reciprocal of the instructed rate of application in square metres/cubic metre or the actual rate of application in square metres/cubic metre whichever calculation gives the lower volume.

Additives used in accordance with sub-clause 4.2.2.2 of these Specifications shall be measured by the number of litres of each type used at the rate instructed or the actual litres used whichever is the lesser.

4.2.5 PAYMENT

Bituminous Surface Treatment shall be paid for at the Contract unit price per square metre of area for each seal coat measured in accordance with Clause 4.2.4 of these Specifications and shall include for the cost of preparation of the surface to receive bitumen, providing, hauling and spraying the bitumen at the instructed application rate and complying with the requirements of Sections 4.1 and 4.2 of these Specifications.

When the actual application rate of bitumen, corrected to 15.6 oC is less than 95% of the specified application rate a deduction of the actual shortfall in litres at the Contract unit price per litre of bitumen will be applied.

Sealing Aggregate will be paid for at the Contract unit price per cubic metre of each type of aggregate measured in accordance with Clause 4.2.4 of these Specifications and shall include for the cost of providing, hauling, spreading and rolling the aggregate at any instructed application rate, all haulage as necessary and in compliance with the requirements of Sections 4.1 and 4.4 of these Specifications.

No additional payment will be made for precoating of aggregate, if directed by the Engineer, but will be considered as incidental to the surface treatment work.

Payment will be made for the use of bitumen additive, if directed by the Engineer, at the Contract unit price for each type of additive measured in accordance with Clause 4.2.4 of these Specifications.

Payment shall be made under the following items :

Item Ref	Description	Unit of Measurement
4.2(1)	Bituminous Seal Coat, 19mm	Square metre
4.2(2)	Bituminous Seal Coat, 12mm	Square metre
4.2(3)	Sealing Aggregate, 19mm	Cubic metre
4.2(4)	Sealing Aggregate, 12mm	Cubic metre
4.2(5)	Cost of Bitumen, Grade……. (Deduction for reduced application rate – provisional)	Litre
4.2(6)	Bitumen Additive Specify Type (provisional)	Litre

4.3 BITUMINOUS TACK COAT

4.3.1 DESCRIPTION

This work shall consist of furnishing and applying bituminous material to a previously prepared and approved surface, prior to the application of an asphaltic base or surface course, in accordance with these Specifications and to the width and area required by the Engineer.

4.3.2 MATERIALS REQUIREMENTS

The tack coat shall be one of the following bituminous materials:

Designation	Type of Material	Application Temperature (°C)	Residual Bitumen Application (litres/sq-m)
RC-70	Rapid Curing Cutback Bitumen	50 – 100	0.1 - 0.3
RC-250	Rapid Curing Cutback Bitumen	80 – 100	0.1 - 0.3
CRS-2	Rapid Setting Cationic Emulsified Bitumen	20 – 70	0.1 - 0.3

The materials shown above shall be in compliance with AASHTO M71 and M208-81, as applicable, and shall be supplied in accordance with the requirements specified in sub-clause 4.1.2.2 of these Specifications. The general precautions outlined in sub-clause 4.1.3.7 of these Specifications shall be applicable.

4.3.3 CONSTRUCTION REQUIREMENTS

4.3.3.1 Equipment

The equipment shall be as specified in Section 4.1 Bituminous Prime Coat of these Specifications.

4.3.3.2 Cleaning Surface

When, in the opinion of the Engineer it is necessary, the full width of surface to be treated shall be cleaned with a power broom or power blower to remove loose dirt and other objectionable material. The surface to be treated shall be dry.

4.3.3.3 Application of Bituminous Material

Immediately after cleaning the surface, bituminous material shall be applied by means of a distributor, in accordance with the provisions of sub-clause 4.1.3.5 of these Specifications at the rates and temperatures shown in Clause 4.3.2 of these Specifications and directed by the Engineer. The tack coat shall be applied only when the surface is dry unless otherwise directed by the Engineer.

The surface of structures and trees adjacent to the areas being treated shall be protected in such manner as to prevent their being spattered or marred with bitumen. No bituminous material shall be discharged into a borrow pit or gutter. The Engineer may direct that emulsions shall be diluted with clean water in order to control the rate of spread. This shall be done at the Contractor's expense.

The surface course shall not be placed over the tack coat until it is in a proper condition of tackiness to receive it. Tack coat shall be applied only so far in advance of surface course placement as is necessary to obtain this proper condition of tackiness. Until the surface course is placed, the Contractor shall protect the tack coat from damage.

4.3.4 MEASUREMENT

Bituminous tack coat shall be measured by the area in square metres instructed to be sprayed at the instructed rate of application in litres/m2, corrected to 15.6 oC

The actual litres of bituminous tack coat sprayed shall be recorded and corrected to 15.6oC to determine the actual rate of application. When the actual application rate, corrected to 15.6 oC is less than 90% of the specified application rate the actual shortfall in litres shall be measured and an adjustment to the payments will be applied.

4.3.5 PAYMENT

Bituminous tack coat will be paid for at the Contract unit price per square metre of area instructed to be sprayed for of each type of bituminous material, complete and approved in place, and shall include for the cost of providing, hauling and spraying the tack coat at the instructed application rate, and complying with the requirements of Section 4.3 of these Specifications.

When the actual application rate, corrected to 15.6 oC is less than 90% of the specified application rate a deduction of the actual shortfall in litres at the Contract unit price per litre of the corresponding type of bituminous tack coat will be applied.

Payment shall be made under the following item :

Item Ref	Description	Unit of Measurement
4.3(1)	Bituminous Tack Coat	Square metre
4.3(2)	Cost of Bituminous Tack Coat Type ……. (Deduction for reduced application rate - provisional)	Litre
Etc.		

4.4 GENERAL REQUIREMENTS FOR ASPHALTIC ROADBASE AND SURFACE COURSES

4.4.1 DESCRIPTION

4.4.1.1 General

This work shall cover the general requirements that are applicable to all types of asphaltic bases and surfacing irrespective of gradation of mineral aggregate, kind and amount of bituminous material, or use. Deviations from these general requirements are indicated in the specific requirements as set forth in the respective sections for each type.

The work shall consist of one or more courses of plant-mixed asphaltic material constructed on a prepared and accepted sub-grade, sub-base, base course or other roadbed in accordance with these Specifications and the specific requirements of the type under Contract, and in conformity with the required lines, levels, grades, dimensions and typical cross section.

4.4.2 GENERAL REQUIREMENTS

4.4.2.1 General Composition of Mixtures

The asphaltic material shall be composed basically of coarse mineral aggregate, fine mineral aggregate, filler, and bituminous material. The several mineral constituents shall be sized, uniformly graded, and combined in such proportions that the resulting blend meets the grading requirements for the specific type under the contract. To such composite blended aggregate shall be added bitumen within the percentage limits set in the specifications for the specific type.

4.4.2.2 Formula for Job Mix

Before starting work, the Contractor shall submit to the Engineer a proposed job-mix formula, in writing, for the mix proposed to be supplied for the project. The formula so submitted shall stipulate for the mixture a single definite temperature at which the mixture is to be emptied from the mixer, and for mixtures to be laid hot, a single definite temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the general composition and temperature limits. The Engineer shall then set the job mix. In setting the job mix, the Engineer, at his discretion, may use the submitted formula, in whole or in part. In any event, the job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of bitumen to be added to the aggregate, a single temperature at which the mixture is to be emptied from the mixer, and a single temperature at which the mixture is to be delivered on the road, unless the mixture is to be laid cold.

4.4.2.3 Applications of Job-Mix Formula and Allowable Tolerances

All mixes furnished shall conform to the Job-mix formula set by the Engineer and be within the ranges of tolerance given below.

(a) Asphaltic Base Course

For Aggregates:

Passing sieves 10 mm and larger	± 7%
Passing sieves between 10 mm and 0.075 mm	± 4%
Passing 0.075 mm sieve	± 1%
For Bitumen	± 0.30%
For Resulting Mix	
Temperature of mixture when emptied from mixer	± 11° C
Temperature of mixture at delivery on road	± 11° C

(b) Asphaltic Surface Course

For aggregates:

Passing 4.75 mm Sieve and Larger	± 5%
Passing 2.36 mm and 1.18 mm Sieves	± 4%
Passing 0.600 mm to 0.150 mm Sieves	± 3%
Passing 0.075 mm Sieve	± 1%
For Bitumen	± 0.3%
For Resulting Mix	
Temperature of mixture when emptied from mixer	± 11° C
Temperature of mixture at delivery on road	± 11° C

Each day as many samples of the materials and mixture shall be taken and tested as the Engineer considers necessary for checking the required uniformity of the mixture. When unsatisfactory results or changed conditions make it necessary, the Engineer may establish a new job mix.

Should a change in a material be encountered or should a change in a source of material be made, a new job-mix formula shall be submitted to the Engineer and approved before the mix containing the new material is delivered to the construction site.

Job mixes will be rejected if they are found to have voids or other characteristics that would require a bitumen content greater or less than the specified range to obtain the specified mix.

4.4.3 MATERIALS REQUIREMENTS

4.4.3.1 Coarse Mineral Aggregate

Coarse aggregate (retained on the 4.75 mm sieve) shall be crushed stone, or crushed gravel, and unless otherwise stipulated, shall conform to the quality requirements of AASHTO M80. Only one source of coarse aggregate shall be used except by written permission from the Engineer.

The crushed aggregate shall also meet the pertinent requirements of Section 2.1 of AASHTO M147-6S and not less than 75 percent by weight of the particles retained on the 4.75 mm sieve shall have at least two fractured faces and 90 percent one or more fractured faces.

The abrasion loss (AASHTO T96) shall not exceed 40 percent. Any aggregates liable to polish shall not be used for the coarse aggregate fraction. The coarse aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion the resultant mixture will meet the gradation required for the composition of the mix.

4.4.3.2 Fine Mineral Aggregate

Fine aggregate (passing the 4.75 mm sieve) shall consist of natural sand, stone, screenings, or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mixture. The sand equivalent, tested in accordance with AASHTO T176, shall be greater than 50.

4.4.3.3 Mineral Filler

Filler material for asphaltic materials shall conform to the requirements in AASHTO MI7.

When the Strength Index as determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test is less than 75%. Either 1 to 2 per cent of hydrated lime or 2 to 4 per cent of Portland cement by weight may be added to the mix.

Where mineral filler is added to the asphaltic mix it shall not be measured and paid for, but will be considered incidental to the Asphaltic Pavement item.

Hydrated lime and Portland cement shall be properly stored to prevent the lime and cement becoming moist. Lime or cement that is partially hard and contains lumps shall not be used and must be removed from the site.

4.4.3.4 Bituminous Materials

Bituminous material used in asphaltic courses shall be bitumen with penetration grades of 60-70 of 80-100 only and shall conform to the requirements given in AASHTO M20-70 for the particular grades stipulated in these Specifications. Bitumen shall be designated by its penetration value (e.g. 60-70 pen).

The bituminous materials shall be supplied in accordance with the requirements specified in sub-clause 4.l.2.2 of these Specifications. The general precautions outlined in sub-clause 4.1.3.7 of these Specifications shall be applicable. The minimum pumping and spraying temperatures and the maximum heating temperatures for the various types and grades of bitumen shall be in accordance with Table 4.1.1 of these Specifications or as otherwise instructed by the Engineer. Bitumen shall only be cut back on site if so instructed and approved by the Engineer.

4.4.4 CONSTRUCTION REQUIREMENTS

4.4.4.1 Weather Limitation

Asphaltic materials shall be placed only when the surface is dry, when the weather is not rainy and when the prepared roadbed is in a satisfactory condition; provided, however that

the Engineer may permit, in case of sudden rain, the placing of asphaltic materials then in transit from the mixing plant, if they are laid within the correct temperature range and the surface on to which they are to be placed is free from pools of water. Such permission shall in no way relax the requirements for quality and smoothness of surface, nor relieve the contractor of its responsibilities for the subsequent performance of the constructed asphaltic layer.

4.4.4.2 Progress of work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour, to ensure progress at a rate greater than or equal to 60% of the capacity of the mixing plant.

4.4.4.3 Plant and Equipment-Requirements for all mixing plants

The mixing plant, which may be either a batching plant or a continuous mixing plant shall have a capacity sufficient to provide a continuous supply of asphaltic mixed materials to the on-site paving construction works when such construction works are being performed at normal operating speeds and to the specified thicknesses. All plant used by the Contractor for the preparation of asphaltic mixes shall conform to all of the requirements below, except that the requirement to provide weighing scales shall apply only where weigh-batching is used; and in addition any batch mixing plants shall conform to the special requirements under sub-clause 4.4.4.4, and any continuous mixing plants shall conform to the special requirements under sub-clause 4.4.4.5 of these Specifications. When the Contractor has completed the installation of the mixing plant, he shall inform the Engineer who shall check the completeness and verify the calibration of the mixing plant before permitting the asphaltic pavement work to commence. The Contractor shall submit his work and equipment schedule to the Engineer for approval.

a) Uniformity - The asphalt mixing plants shall be so designed, coordinated and operated as to produce a mixture within job-mix tolerances.

b) Plant scales and weighhouse - scales for any weighbox or hopper may be either of the beam or springless dial type and shall be of a standard make and design accurate to within one-half of 1% of the maximum load required. A weigh house shall be provided.

When scales are of the beam type, there shall be a separate beam for each size of aggregate. There shall be a “tell-tale” dial attached that shall start to function when the load being applied is within 50 kilograms of that desired. Sufficient vertical movement shall be provided for the beams to permit the "tell-tale” dial to function properly. Each beam shall have a locking device designed and so located that the operation of the beam can easily be suspended or re-activated. The weighing mechanism shall be balanced on knife-edges and fulcrums and shall be so constructed that it can not easily be thrown out of alignment or adjustment.

When springless dial scales are used, the end of the pin pointer shall be set close to the face of the dial and be of a type that is free from errors due to excessive parallax. The scale shall be provided with adjustable pointers for marking the weights of each material weighed into the batch. The scales shall be substantially constructed, and any unit that loses its adjustment easily shall be replaced. All dials shall be located so that they are in full view of the operator at all times.

Scales for the weighing of asphaltic material shall conform to the specifications for scales for aggregate except that each beam scale shall be equipped with a tare beam and a full capacity beam. The value of the minimum graduation in any case shall not

be greater than 1 kilogram. Dial scales for weighing the asphaltic material shall not have a capacity of more than twice the weight of the material to be weighed and shall read to the nearest pound or half kilogram. Beam scales shall be equipped with a "tell-tale" device that will start to function in this case when the load being applied is within 5 kilograms of that required.

Scales shall have been approved by the Engineer prior to use and shall be checked as often as the Engineer may deem necessary to ensure their continued accuracy.

The Contractor shall provide and have on site at all times not less than ten 25 kilogram weights to allow regular testing of all scales.

c) Equipment for the preparation of bitumen - Tanks for storage of bitumen shall be capable of heating the material under effective and positive control at all times, to a temperature within the range specified. The heating shall be accomplished by steam coils, electricity, or other means such that no flame shall come in contact with the heating tank. The circulating system for the bitumen shall be of adequate size to ensure proper and continuous circulation during the entire operating period. Suitable means shall be provided either by steam jackets or other insulation, for maintaining the specified temperature of the bitumen in the pipe lines, meters, weigh buckets, spray bars, and other containers or flow lines. The storage tank capacity shall be sufficient for at least 1 day's operation. Bitumen may be partially heated in the tanks and brought to the specified temperature by means of booster heating equipment between the tanks and the mixer.

d) Feeder for drier - The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the drier so that uniform production and uniform temperatures are obtainable.

e) Drier - A rotary drier of approved design for drying and heating the mineral aggregate shall be provided. The drier shall be capable of drying and heating the mineral aggregate to the specified temperature and at the required rate.

f) Screens – Mixing plant screens capable of screening all aggregate to the specified sizes and proportions and having normal capacities slightly in excess of the full capacity of the mixer, shall be provided. The screens shall be readily exposable for inspection by the Engineer.

g) Bins - The plant shall include storage bins adequately protected from the weather of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least three compartments and shall be arranged to ensure separate and adequate storage of appropriate fractions of the aggregate, not including mineral filler. Each compartment shall be provided with an overflow pipe that shall be of such size and at such location as to prevent any backing up of material into other bins. Bins shall be so constructed that representative samples can readily be obtained, and the aggregate level observed.

h) Bitumen control unit - Satisfactory means either by weighing or metering, shall be provided to obtain the proper amount of bitumen in the mix within the tolerance specified for the job-mix.

The metering device for use with mixing plants for the addition of bitumen shall be a rotating, positive displacement, bitumen metering pump, with a satisfactory spray nozzle arrangement located at the mixer. The metering device shall provide the designated quantity of bitumen for each batch. For continuous mixing plants, the operating speed of the pump shall be synchronised with the flow of aggregate in the mixer by an automatic locking control, and the device shall be easily and accurately

adjustable. Means shall be provided for checking the quantity or rate of flow of bitumen into the mixer. An accuracy within ± 1% of the specified amount is required.

j) Thermometric equipment - An armoured thermometer reading from 35 ^{0}C to 205 ^{0}C shall be fixed in the bitumen feed line of the mixing plant at a suitable location near the discharge valve at the mixer unit.

The plant shall be further equipped with an approved dial scale mercury activated thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.

For better regulation of the temperature of the aggregate, replacement of any thermometer by an approved temperature - recording apparatus may be required by the Engineer, and he will further require that daily temperature charts be maintained and handed over to him.

k) Dust collector - The plant shall, be equipped with a dust collector so constructed as to waste or return uniformly to the elevator all or any part of the material collected.

The dust collector shall also ensure that the any resulting emission from the mixing plant conforms to the requirements of Section 1.10, Protection of the Environment of these Specifications.

l) Control of mixing time - The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it at a constant time interval unless changed at the direction of the Engineer. The time of mixing shall be considered as the interval between the time the bitumen is spread on the aggregate and the time the same aggregate leaves the mixing unit.

When bitumen is applied by a spray system, the mixing time shall begin with the start of the bitumen spray. When the bitumen is not applied by a spray system, a minimum dry mixing period of five seconds shall precede the addition of the bitumen to the mix.

m) Field laboratory - The Contractor shall provide a field laboratory in accordance with the requirements of the Section 9.1 of these Specifications.

n) Safety requirement - Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be placed at all points required for accessibility to all mixing plant operations. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and round the truck loading space. This space shall be kept free from drippings from the mixing platform. Flexible pipe connections carrying hot bitumen shall be shielded.

4.4.4.4 Plant and Equipment - Special requirements for Batching Plants

a) Weigh box or hopper - The equipment shall include a means for accurately weighing each bin size of aggregate in a weigh box or hopper, suspended on scales, ample in size to hold a full hatch without hand raking or running over. The weigh box or hopper shall be supported on fulcrums and knife-edges so constructed that they will not easily he thrown out of alignment or adjustment. All edges, ends and sides of weighing hoppers shall be free from contact with any supporting rods, columns or other equipment that will in any way affect the proper functioning of the hopper. There shall also be sufficient clearance between hoppers and supporting devices to prevent accumulations of foreign materials. The discharge gate of the weigh box

shall be so hung that the aggregates will not be segregated when dumped into the mixer and shall close tightly when the hopper is empty so that no material is allowed to leak into the batch in the mixer during the process of weighing the next batch.

b) Mixer - The batch mixer shall be an approved twin pugmill type, adequately heated, and capable of producing a continuous uniform mixture within the job-mix tolerances. It shall be of such design as to permit visual inspection of the mix. The mixer capacity shall not be less than 1,000 kilogram per batch. The discharge gate of the mixer shall be controlled by an approved time-lock that can be set and adjusted to measure individually the mixing time for the several materials entering the mix, and will not release the gates until the total specified time has elapsed.

The mixer shall be equipped with a sufficient number of paddles or blades with proper arrangement to produce a properly and uniformly mixed batch. The clearance of blades from all fixed and moving parts shall not exceed the maximum allowable particle size in the mix plus 2mm unless otherwise approved by he Engineer.

4.4.4.5 Plant and Equipment - Special requirements for Continuous Mixing Plants

a) Gradation control unit - The plant shall include a means for proportioning accurately each bin size of aggregate either by weighing or by volumetric measurement.

When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the materials drawn from each respective bin compartment. The orifice shall be rectangular, of dimensions about 200 mm by 225 mm with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided for each gate to show the respective gate opening in centimetres.

b) Weight calibration of aggregate feed - The plant shall include provision for a calibration of the gate openings by means of weight test samples so that each of the materials fed out of the bins through individual orifices may be bypassed satisfactorily to suitable test boxes, each bin material being confined separately. The plant shall be equipped to handle conveniently such test samples weighing not less than 150 kilograms combined weight of samples from all bins, and not less than 50 kilograms for any one bin sample.

c) Synchronisation of aggregate and bitumen feed - Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be accomplished by interlocking mechanical means or by a positive method satisfactory to the Engineer. The bitumen storage and the aggregate bins shall be provided with signal devices and controls that will warn of low levels.

d) Mixer - The plant shall include a continuous mixer of an approved twin pugmill type, adequately heated, capable of producing a continuous uniform mixture within the job-mix tolerances. The paddles shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The clearance of the paddles from all fixed and moving parts shall not exceed the maximum allowable particle size in the mix plus 2mm unless otherwise approved by the Engineer. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and charts shall be provided by the manufacturer giving the rate of feed of aggregate per minute, at plant operating speed.

Determination of the mixing time shall be by a weight method using the following formula (the relative weights shall be determined for the particular job mix by tests made by the Engineer):-

$$\text{Mixing time seconds} = \frac{\text{Pugmill dead capacity in kilograms}}{\text{Pugmill output in kilograms per second}}$$

e) Hopper - The mixer shall be equipped with a hopper at the discharge end, of such size and design that no segregation of mix occurs. Any elevator used for loading mixture into vehicles shall have an equally satisfactory hopper.

4.4.4.6 Plant and Equipment

Equipment for Hauling and Placing

a) Trucks - Trucks for hauling asphaltic material shall have tight, clean, and smooth metal trays that have been sprayed with soapy water, fuel oil, paraffin oil, or lime solution to prevent the mixture from adhering to the trays. The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather and all covers shall be securely fastened. Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer be removed from the work until such conditions are corrected. When necessary, in order that the asphaltic material shall be delivered on the road at the specified temperature, truck trays shall be insulated to maintain workable temperature of the mixed materials.

The number of trucks available for hauling asphaltic materials shall be sufficient to supply the paving machine on the road continuously without any interruptions to the laying procedure when spreading the asphaltic materials at normal speed and the required thickness.

b) Spreading and finishing equipment - The equipment for spreading and finishing shall be approved mechanical, self powered paving machines, capable of spreading and finishing the asphaltic material true to the lines, grades, levels, dimensions and cross sections.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the asphaltic material evenly in front of adjustable steering devices and shall have reverse as well as forward travelling speeds.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of asphaltic material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the asphaltic materials without dragging or marring.

The term “screed" includes any cutting, crowding, tamping, compaction or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, dragging or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor forthwith.

c) Small tools - The Contractor shall provide suitable means for keeping all small tools clean and free from accumulations of asphaltic material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any asphaltic material that may have been dumped and not spread.

4.4.4.7 Preparation of Existing Surface

Where local irregularities in the existing surface would otherwise result in an asphaltic layer more than 75 mm thick after compaction, the surface shall be brought to uniform contour by patching with an asphaltic material to be approved by the Engineer and thoroughly tamping or rolling it until it conforms with the surrounding surface. The mixture used shall be the same as that specified for the next layer, unless the size of the largest aggregate in the mixture precludes this, in which case the Engineer will decide the mixture to be used.

Where the existing pavement is broken or shows instability, the unsuitable material shall be removed and disposed of as directed by the Engineer and replaced with the same asphaltic material as specified for the succeeding pavement layer, compacted to the specified standard and to the elevation of the adjacent surface.

Where the existing surface course is stabilised or constructed of asphaltic materials or Portland cement concrete, and if the edge of the course has become eroded, disintegrated, or broken, the edges shall be trimmed back, the debris removed and disposed of, and the space backfilled with an asphaltic material or with gravel or similar approved material, and then compacted, as directed by the Engineer.

The surface upon which the asphaltic material is to be placed shall be swept thoroughly and cleaned of all loose dirt and other objectionable material immediately before spreading the asphaltic materials.

Before spreading the asphaltic material upon a Portland cement concrete surface all longitudinal and transverse joints shall be cleaned out and filled with an approved sand asphalt mix. Cracks shall be similarly treated as directed by the Engineer. Wherever possible the cleaning out shall be to a depth of 40 mm or more and the sand asphalt shall be thoroughly compacted in joints and cracks to a level which will not be more than 5mm below the surface.

If instructed by the Engineer a tack coat shall be applied in accordance with Section 4.3 of these Specifications. If the Engineer considers an additional tack coat is required prior to laying the asphaltic material or between successive layers of the asphaltic material, due to solely to the Contractor's method of working, then such tack coat shall be at the Contractor's expense.

4.4.4.8 Preparation of Bituminous Materials for use in Asphaltic Mixes

The bituminous materials shall be prepared in accordance with the requirements of sub-clause 4.1.3.1 of these Specifications.

The bitumen shall be heated to the specified temperature in tanks so designed as to avoid local overheating and provide a continuous supply of bitumen to the mixer at a uniform temperature at all times.

4.4.4.9 Preparation of Mineral Aggregate

The mineral aggregates for the mixture shall be dried and heated before being placed in the mixer. Flames used for drying and heating shall be adjusted properly to avoid injury to the aggregate and to avoid forming a coating of soot on the aggregate. The aggregates shall be dried and heated so that they are mixed at the following temperatures:

125 °C - 165°C	when using 80/100 bitumen
130 °C - 170°C	When using 60/70 bitumen.

When using other bituminous materials the aggregate temperature shall be determined by the Engineer.

The aggregate, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with bitumen. The fraction of aggregate deposited in any bin shall not contain more than 10% of material outside the specified size limits for that bin.

4.4.4.10 Preparation of Mixture

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The bitumen shall be measured or gauged and introduced into the mixer in the amount determined by the Engineer. The proper amount of bitumen shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregate are coated uniformly. The total mixing time shall be set by the Engineer and regulated by a suitable locking means. For a continuous mixing plant, the mixing time shall be determined from the formula in sub-clause 4.4.4.5, item d), of these Specifications and may be regulated by fixing a minimum-time gauge in the mixer unit and/or by other mixing unit adjustment.

4.4.4.11 Transportation and Delivery of Asphaltic Material

The asphaltic material shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of sub-clause 4.4.4.6, item a) of these Specifications. Loading and transporting shall be such that spreading, compaction and finishing shall all be carried out during daylight hours unless satisfactory illumination is provided by the Contractor.

Each vehicle shall be weighed after loading at the mixer and a record shall be kept of the gross weight, tare and net weight of each load.

4.4.4.12 Spreading and Finishing

Upon arrival at the point of use, the asphaltic shall be spread and struck off to the grade, elevation, and cross-section shape intended, either over the entire width or over such partial width as may be practicable. Asphalt pavers conforming to the requirements of sub-clause 4.4.4.6, item b) of these Specifications shall be used for this purpose. The asphalt

material shall be laid upon an approved surface and only when weather conditions are considered suitable by the Engineer.

Any deposited asphalt material in which the temperature drops below the final allowable temperature for the completion of compaction before compaction is carried out shall be rejected.

In narrow strips, areas of widening, deep or irregular sections, turnouts or driveways where it is impractical to spread and finish the asphalt material by use of a paver, the Contractor shall use approved spreading equipment or acceptable hand methods as directed by the Engineer.

On areas where, in the opinion of the Engineer, the use of spreading equipment is considered impractical the asphalt material shall be dumped on steel boards then spread, raked and levelled by hand to provide the correct weight or uniform thickness of material without segregation. Asphalt materials shall not be applied faster than they can be properly handled, spread and compacted with the equipment available on site.

4.4.4.13 Compaction of Asphalt Material

a) General - Immediately after the asphalt material has been spread and struck off, the surface shall be checked and any inequalities adjusted. The asphalt material shall then be thoroughly and uniformly compacted by rolling. Each layer shall be rolled as soon after being placed as the material will support the roller without undue displacement or cracking.

b) Minimum Compaction Equipment Requirements - Generally, with each paver, two steel wheeled tandem rollers and one pneumatic tyred roller will be required.

All rollers shall be self propelled, capable of being reversed without creating faults in he newly laid asphalt layer and equipped with power steering, dual controls allowing operation from either the right or left side, water tanks, sprinkler systems and coco-mats to ensure even wetting of rolls or tyres. The Contractor shall supply to the Engineer for each type of roller a calibration chart showing the relationship between depth of ballast and weight and giving the tare weight of the roller. Each roller shall be in good condition and worked by a competent and experienced operator.

Steel wheeled tandem rollers shall weigh not less than 8 tonnes and each tandem roller used for final compaction (finish rolling) shall have at least one roll capable of applying a minimum rolling pressure of 3.5 kilograms per mm of roll width.

Pneumatic tyred rollers shall be of an approved type having not less than seven wheels fitted with smooth tread compactor tyres of equal size and construction capable of operating at inflation pressures up to 9 Bar. Wheels shall be equally spaced along both axle lines and arranged so that tyres on one axle line track midway between those on the other with an overlap. Each tyre shall be kept inflated to the specified operating pressure such that the pressure difference between any two tyres shall not exceed 0.3 Bar. Means shall be provided for checking and adjusting the tyre pressures on the job at all times. For each size and type of tyre used the Contractor shall supply to the Engineer charts or tabulations showing the relationship between wheel load, inflation pressure and tyre contact pressure, width and area. Each roller shall be equipped with a means of adjusting its total weight by ballasting so that the load per wheel can be varied from 1,500 to 2,500 kilograms. In operation the tyre inflation pressure and the wheel load shall be adjusted, as required by the Engineer, to meet the requirements of each particular application. In general the compaction of any asphaltic layer with a pneumatic tyred roller shall be accomplished with contact pressures as high as the material will support.

c) Procedure - Rolling of the asphalt material shall consist of six separate operations as follows:

(1)	transverse joints	(4)	initial or breakdown rolling
(2)	longitudinal joints	(5)	second or intermediate rolling
(3)	edges	(6)	finish rolling

The first rolling of all joints and edges, the initial or breakdown rolling and the final or finish rolling shall all be done with the steel wheeled tandem rollers. The second or intermediate rolling shall be done with the pneumatic tyred roller except on small operations as noted above.

Rolling shall start longitudinally at the sides and proceed toward the centre of the pavement except that on superelevated curves rolling shall begin at the low side and progress toward the high side. Successive passes of the roller shall overlap by at least one-half of the width of the roller and alternate passes shall not terminate at the same point. For initial rolling the drive roll should be nearest the paver.

The speed of the rollers shall not exceed 4 kilometres per hour for steel wheeled rollers and 6 kilometres per hour for pneumatic tyred rollers and shall be at all times slow enough to avoid displacement of the hot mix. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh asphalt material applied where required. Care shall be exercised in rolling operations not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the asphalt material is still in a workable condition and until all roller marks are eliminated. Initial compaction shall be completed before the temperature of the asphalt material drops below 110°C.

To prevent adhesion of the asphalt material to the roller, the wheels shall be kept properly moistened, but excess water will not be permitted.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until compaction has been completed and the asphalt material has cooled to ambient temperature.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor.

Along curbs, headers, manholes, and similar structures and at all places not accessible to the roller, thorough compaction shall be secured by means of hot hand tampers or with mechanical tampers giving equivalent compaction. Each hand tamper shall weigh not less than 10 kilograms and shall have a tamping face area of not more than 25,000 square mm.

The surface of the asphalt material after compaction shall be smooth and true to the detailed cross section, shape and grade and within the tolerances specified. Any asphalt material that become loose and broken, mixed with dirt, or which are defective in any way, shall be removed and replaced with fresh hot asphalt material, which shall be compacted immediately to conform with the surrounding area. Any area of 0.1 m2 or more showing an excess or deficiency of bitumen shall be removed and replaced. All high spots, high joints, depressions, and honeycombs shall be adjusted as directed by the Engineer.

4.4.4.14 Joints

Both longitudinal and lateral joints in successive pavement layers shall be staggered so as not to be one above the other. Longitudinal joints shall be arranged so that the longitudinal joint in the top layer shall be at the location of the line dividing the traffic lanes. Lateral joints shall be staggered a minimum of 250 mm and shall be straight.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the layer. No asphalt material shall be placed against previously rolled material unless the edge is vertical or has been cut back to a vertical face. A brush coat of hot bitumen shall be applied just before additional asphaltic material is placed against the previously rolled material.

Spreading shall be as nearly continuous as possible and rollers shall pass over the unprotected end of freshly laid asphalt material only when authorised by the Engineer. In all such cases provision shall be made for a properly bonded and sealed joint with the new surface for the full depth of the layer as specified above.

Before placing asphalt materials against them, all contact surfaces of curbs, gutters, headers, manholes etc. shall be given a thin uniform coating of hot bitumen and the joints between these structures and the surface asphalt material shall be effectively sealed by the subsequent spreading, finishing and compaction operations.

When the wearing course is placed adjacent to curbs to form an asphalt gutter it shall be sealed with bitumen for a distance of 300 mm from the curb. The seal shall be evenly applied to the surface by means of hot irons or squeegees so that the surface voids are completely filled and no excess bitumen remains on the surface. The required drainage pattern shall be maintained.

4.4.4.15 Surface Test of the Pavement

The surface shall be tested by a crown template and 3 metre straight edge, furnished by the Contractor, applied respectively at right angles and parallel, to the centreline of the road. The Contractor shall designate one of its employees to use the template and straight edge under the direction of the Engineer in checking all surfaces. The crown template shall conform to the typical cross section shown or the Drawings.

The variation of the surface from the testing edge of the crown template and the straight edge between any two contacts points with the surface shall be within the tolerances as defined in Clause 1.11.8 of these Specifications.

Tests for conformity with the specified crown and grade shall be made immediately after initial compaction, and variations shall be corrected by removing or adding asphalt material as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the compacted layer shall be checked again and any irregularity of the surface exceeding the above limits and any areas defective in texture or composition shall be corrected as directed by the Engineer. All such remedial work including the removal and replacement of materials if so directed by the Engineer shall be at the Contractor's expense.

The edges of the pavement shall be straight and true to the required lines. Any excess material shall be cut off square after final rolling, and disposed of by the Contractor in a manner acceptable to the Engineer.

4.4.5 MEASUREMENT AND PAYMENT

All work prescribed above shall be measured and paid for as provided in the respective sections of these Specifications for each type of pavement. The quantity measured and paid for shall be the quantity scheduled, plus any approved additional work or the actual quantity used and certified whichever is the lesser.

4.5 ASPHALTIC CONCRETE SURFACING

4.5.1 DESCRIPTION

This work shall consist of a surfacing of dense graded asphaltic concrete, constructed on a prepared base in accordance with these Specifications and the lines, levels grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

All the provisions of Section 4.4, "General Requirements for Asphaltic Road Base and Surface Courses" shall form a part of these Specifications unless otherwise stipulated herein.

The surfacing shall consist of one or two layers of the thickness shown on the Drawings. The top layer shall be denoted as the wearing course and the lower layer as the binder course.

This work shall also consist of constructing asphaltic concrete overlays of one or multiple layers on a previously tack-coated existing bituminous surface as well as providing a bituminous levelling course where necessary as directed by the Engineer.

4.5.2 GENERAL REQUIREMENTS

4.5.2.1 General Composition of the Mixture

The design of asphalt concrete mixtures shall be undertaken by the Contractor in accordance with sub-clause 4.4.2.3 of these Specifications. The design of mixtures shall be carried out in a materials testing laboratory approved by and under the supervision of the Engineer.

The mixture shall consist of mineral aggregate, filler (1-2% of lime or 2-4% of cement if necessary according to the Engineer) and the bitumen. The total mineral aggregate shall have a job mix grading within the limits shown in Table 4.5-1. Gradations outside the limits specified must have the approval of the Engineer.

In addition to meeting the job mix formula in section 4.4, laboratory samples shall be prepared according to the Marshall method (AASHTO T245) using 75 blows to compact the sample. The samples shall be of approved material to the gradation and bitumen content stated and shall have the following characteristics. The strength Index shall be determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test.

- Marshall Stability (kN) not less than 7.0 kN.
- Marshall Flow not less than 2 mm nor greater than 4.
- Air Voids in Mix: Wearing 3-5%; Binder 4-7%.
- Voids in mineral aggregate: 14-10%.
- Voids filled with bitumen: Wearing 65-80%; Binder 55-75%.
- Strength Index: minimum 75%.

The selected job mix shall conform to the guidelines outlined in Table 4.5.1 below. Asphaltic concrete for levelling courses shall follow the same mix requirements of the

lowest layer of asphaltic concrete pavement or overlay (usually binder course) as shown on the plans or directed by the Engineer.

During the preparation of the job mix design, the Engineer may instruct the Contractor to adjust the cold bin openings or revise the proportions of the aggregates or add filler or additive or change the source of materials in order to obtain the most suitable formula, if the Engineer considers that such revision is necessary.

Table 4.5.1 Job Mix Requirements

Mix Classification	1	2	3	4
Course	**Binder**	**Wearing**	**Wearing**	**Wearing**
Thickness (mm) Max.	75	60	45	60
Min.	35	30	25	30
25mm	100	-	-	-
19mm	90-100	100	100	100
12.5mm	-	-	-	-
10.0mm	55-82	60-83	75-95	70-90
Total % by weight 4.75mm	35-57	40-65	53-72	50-70
Passing (including 2.36mm	23-40	30-50	35-53	35-50
Filler) Sieve Size 1.18mm	15-33	20-40	24-43	-
0.600mm	10-26	15-35	19-35	18-29
0.300mm	6-20	10-25	14-27	13-23
0.150mm	3-13	7-17	9-18	8-16
0.075mm	1-7	4-9	5-10	4-10
Bitumen content by total weight of mixture. Percentage by weight found by analysis.	3.5 -5.5	4.0-6.6	4.0-7.0	3.5-7.0

4.5.3 MATERIALS REQUIREMENTS

The materials shall conform to the requirements of Clause 4.4.3 of these Specifications with the additional requirements noted below.

4.5.3.1 Bituminous Materials

Bituminous materials for asphalt concrete shall be bitumen with penetration grades 60/70 or 80/100 only.

4.5.3.2 Bitumen Additive

The provisions of sub-clause 4.2.2.2 of these Specifications shall apply.

4.5.3.3 Coarse Mineral Aggregates

Coarse aggregates shall consist of crushed stone produced from rock or boulders, the minimum size of which shall be at least four times the maximum size of the final crushed stone. The coarse aggregate shall be free from clay, silt, organic matter, or other deleterious substance.

The coarse aggregates shall be tested in accordance with British Standard 812 to determine the Flakiness Index and the Elongation Index. When so tested the Flakiness Index and the Elongation index shall not exceed 35 percent.

When subjected to Coating and Stripping Tests, AASHT0, Test Method T182 the aggregates shall have a coated area of not less than 95 percent.

4.5.3.4 Combined Mineral Aggregates

The mineral aggregates when-combined in the proportions required by the job-mix formula shall have a Sand Equivalent of not less than 50 as determined by AASHT0 Test Method T 176.

4.5.3.5 Mixture

The Bitumen shall be extracted from samples in accordance with AASHT0 Test Method T 164. After concentration of the extracted bitumen solvent solution to approximately 200 millilitres the contained mineral particles shall be removed in a centrifuge. This removal shall be considered satisfactory when the ash content (by ignition) of the recovered bitumen is not greater than 1% by weight. The bitumen shall be recovered from the solution in accordance with AASHT0 Test Method T 170.

Bitumen recovered from samples shall have a penetration of at least 70% of the penetration of the bitumen before mixing and ductility of at least 400 mm, when tested in accordance with AASHT0 Test Methods T 49 and T 51 respectively.

4.5.4 CONSTRUCTION REQUIREMENTS

4.5.4.1 Tolerances

a) The temperature of the aggregates shall be so controlled that the temperature of the mixture on being discharged from the mixing plant is between 135 and 160 ^{0}C. The Contractor shall select the minimum temperature which will ensure the aggregates are properly dried, and which enables him to deliver the mixture to the paver at or slightly above the required temperature.

b) The temperature at which bitumen is fed into the mixer shall be between 0 and 15^{o}C lower than the temperature of the heated aggregates.

c) The temperature at which the asphalt material is spread on site shall not be less than 145°C, or such temperature as directed by the Engineer so that adequate compaction is obtained.

d) The asphalt material shall be compacted as soon as it will bear the weight of a roller without causing undue lateral displacement or "picking up" of the material. The density of the asphalt material after compaction shall be not less than 98 percent of the Marshall Density as determined from daily compacted samples. The density shall be checked by 100 mm. diameter cores made with an approved core drill, at a rate to be determined by the Engineer, but not less frequently than five cores per day whenever asphaltic material is constructed, nor less than one core per one hundred tonnes of asphalt material used on site.

e) The average thickness of the compacted asphalt pavement laid in any one day shall not be less than the thickness shown on the Drawings. The minimum thickness at any one point shall not vary by more than 5 mm below the specified thickness.

f) Pavement Samples - The Contractor shall, after final rolling and before opening the surface to traffic, cut samples from the finished work for testing. Samples shall be not less than 250 mm x 250 mm, except that, for measurement of the field density only, cores with a minimum diameters of 100 mm cut by an approved coring machine will be acceptable. Samples shall be taken of the asphalt material for the full depth of the pavement layer from the locations directed by the Engineer.

Samples for analysis and other tests shall be taken from the surface layer when the Engineer so directs and shall in any case be taken whenever a substantial change is made in the job mix formula.

Where samples have been taken from the surface layer, fresh asphaltic material shall be placed, thoroughly compacted and finished to the satisfaction of the Engineer.

g) The surface of the finished pavement shall be tested for evenness by the Engineer using a 3.5 metre straight edge. The surface will be considered acceptable providing the deviation from the straight edge, placed either longitudinally or transversely, does not exceed 3 mm between two contact points.

Pavement surfaces not conforming to this tolerance may be rejected by the Engineer. Rejected areas shall be removed and repaved at the Contractor's own expense.

h) The joints of an asphaltic concrete wearing course shall be sawn joints.

4.5.4.2 Control and Testing

The Contractor shall provide a fully equipped laboratory in accordance with the requirements of Section 9.1 of these Specification.

The Engineer shall be responsible for directing all sampling and testing and will be provided, by the Contractor, with an adequate number of skilled technicians to do this work.

The following test results and records of tests carried out on each day's production together with the exact location of each day's production in the finished work are required :

1) Temperature of asphalt materials when sampled at the plant and on the road.
2) Density of laboratory mix (Marshall Density).
3) Compacted density and percentage compaction of surface course.

4) Marshall Stability and Flow, and Strength Index.

5) Asphalt content and aggregate grading of mix.

6) Air voids in mix.

4.5.4.3 Protection of the Pavement

Sections of the newly finished work shall be protected from traffic of any kind until the asphalt material has cooled to approximately ambient air temperature. Traffic shall not normally be permitted on the newly laid surface less than 6 hours after completion of pavement, except with the approval of the Engineer.

4.5.5 MEASUREMENT

Asphaltic concrete to be used as a binder course or wearing course, of thicknesses specified in the Contract Drawings, shall be measured on a cubic metre basis, the dimensions of which shall comprise the thickness and width specified on the typical cross section and the length of completed and accepted construction, measured horizontally, and, where appropriate, along the centre-line of the road. Side road intersections, curve widenings, fillets and other smaller areas required to be paved shall also be measured on a cubic metre basis. Pavement thickness must be within the limit specified in sub-clause 4.5.4.1 e). Additional measurements for payment will not be considered for thickness greater than those specified.

Asphaltic concrete to be used in levelling courses, patching, pothole repair or other remedial works not easily measured on a dimensional basis shall be measured by the number of metric tonnes used in the works as ordered by the Engineer. The material shall be weighed after mixing at the batch plant and the weight of mixture shall be controlled by triplicate load delivery tickets from the truck scales at the batch plant.

Measurement of variation of bitumen content shall be by the litre calculated as the product of the difference, corrected to 15.6oC, between the nominal bitumen content and the bitumen content instructed by the Engineer, and the weight of compacted mix to which the variation applies, calculated from the volume determined in accordance with Clause 4.5.5 of these Specifications.

Additives used in accordance with sub-clause 4.2.2.2 of these Specifications shall be measured by the number of litres of each type used at the rate instructed or the actual litres used whichever is the lesser.

4.5.6 PAYMENT

Asphaltic Concrete for levelling, measured as provided for in clause 4.5.5 of these Specifications, shall be paid for at the Contract unit price per tonne, complete in place, which price shall include all material, labour, equipment, tools, cleaning and preparation of the area to be levelled or patched, removal of deleterious material or loose existing asphalt and all incidentals necessary for the satisfactory completion of the work.

Asphaltic Concrete for Wearing Course or Binder Course shall be paid for at the respective Contract unit prices per cubic metre, complete in place, which prices shall be complete compensation for all aggregates, mineral fillers, bitumen, crushing, heating and mixing

plant, all equipment necessary for placement, tools, labour and incidentals necessary to complete the work.

With the approval of the Engineer, payment will be made at the Contract unit price bid, regardless of the design mix bitumen content finally determined and agreed on the site, provided said bitumen content is within the range specified in sub-clause 4.5.2.1 of these Specifications.

When the actual bitumen content is less than the specified application rate, and outside the range as per Table 4.5.1, a deduction of the actual shortfall in litres at the Contract unit price per litre of bitumen will be applied for works accepted for payment by the Engineer.

Payment will be made for the use of bitumen additive, if directed by the Engineer, at the Contract unit price for each type of additive measured in accordance with Clause 4.5.5 of these Specifications.

Payment shall be made under the following items :

Item Ref	Description	Unit of Measurement
4.5(1)	Asphaltic Concrete Levelling Course	Tonne
4.5(2)	Asphaltic Concrete Wearing Course	Cubic metre
4.5(3)	Asphaltic Concrete Binder Course	Cubic metre
4.5(4)	Cost of Bitumen, Grade……. (Deduction for reduced application rate – provisional)	Litre
4.5(5)	Bitumen Additive Specify Type (provisional)	Litre

4.6 COLD ASPHALT

4.6.1 DESCRIPTION

This work shall consist of the general requirements for the manufacture and placement of a cold, plant mixed asphaltic material suitable for cold placement and /or for stockpiling for subsequent use.

The cold asphalt shall be suitable for use as asphaltic road base and surface courses, for levelling course and for patching in accordance with the specific requirements for each type under the contract and in conformity with the required lines, levels, grades and dimensions and typical cross sections and as required by the Engineer.

The relevant provisions of Section 4., Bituminous Works as they relate to the individual components and methods of placement shall form a part of these Specifications unless otherwise stipulated herein.

4.6.2 GENERAL REQUIREMENTS

4.6.2.1 General Composition of the Mixture

The cold asphalt, often referred to as “premix” or “coldmix”, shall be produced from a mixture of mineral aggregates (including mineral filler) which is mixed cold to a workable condition suitable for stockpiling and/or immediate spreading and compaction.

4.6.2.2 Manufacture

Cold asphalt shall be manufactured in an approved stationary mixing plant or approved mobile mixing plant, or by mixing in place, if approved in accordance with the requirements of sub-clause 4.6.4.2 of these Specification

4.6.3 MATERIALS REQUIREMENTS

4.6.3.1 General

The materials shall conform to the requirements of Section 4, Bituminous Works, of these Specifications with the additional requirements noted below.

4.6.3.2 Bituminous Materials

Bituminous materials for cold asphalt shall be a fluxed bitumen or a cutback bitumen or a bitumen emulsion as follows:

a) Fluxed Bitumen

Fluxed bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of a bitumen fluxing agent (e.g. diesel fuel oil)

b) Cutback bitumen

Cutback bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of bitumen cutter of an approved type (eg, kerosene, avtur)

c) Bitumen emulsion

Bitumen emulsion shall be a slow setting, cationic emulsion (CSS) of a type which complies with the specified requirements of AASHTO M208.

4.6.3.3 Bitumen Additive

The provisions of sub-clause 4.2.2.2 of these Specifications shall apply.

4.6.3.4 Coarse Mineral Aggregates

Coarse aggregates shall consist of crushed stone produced from rock or boulders or crushed gravel particles larger than 2.36 mm in size. The aggregate shall be clean, hard, angular, durable and free from clay or other aggregations of fine material, silt, soil, organic matter, or other deleterious substance.

The requirements for coarse aggregates of sub-clauses 4.4.3.1 and 4.5.3.3 of these Specifications shall apply

4.6.3.5 Fine Mineral Aggregates

Fine aggregate (passing the 4.75 mm sieve) shall consist of natural sand, stone, screenings, or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mixture. The sand equivalent, tested in accordance with AASHTO T176, shall be greater than 50.

4.6.3.6 Mineral Filler

Filler material for asphaltic materials shall conform to the requirements in AASHTO MI7 and shall generally consist of finely ground particles of limestone, hydrated lime, Portland cement, fly-ash or other approved non-plastic material.

When the Strength Index as determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test is less than 75%. Either 1 to 2 per cent of hydrated lime or 2 to 4 per cent of Portland cement by weight may be added to the mix.

Hydrated lime and Portland cement shall be properly stored to prevent the lime and cement becoming moist. Lime or cement that is partially hard and contains lumps shall not be used and must be removed from the site.

4.6.4 CONSTRUCTION REQUIREMENTS

4.6.4.1 Mix Proportions

The grading of the combined mineral aggregates shall be such as to comply with the requirements of Table 4.6.1 of these Specifications

The aggregate grading curve shall not exhibit any sharp irregularities and shall lie smoothly within the grading limits shown in Table 4.6.1

In addition to meeting the above requirements the shape of the lower portion of the grading curve (material smaller than 2.36 mm) shall be such that nowhere shall the percentage passing consecutive sieve sizes vary from at or near one limit to at or near the opposite limit.

Table 4.6.1 Combined Mineral Aggregate Grading Limits

Sieve Size (mm)	Percent passing by mass (%)
26.50	100
19.00	76 - 100
13.20	60 – 85
9.50	45 – 70
4.75	30 – 50
2.36	19 – 35
600 :	7 – 18
300 :	4 – 12
150 :	1 – 7
75 :	0 – 6

The residual binder content in the mix shall be between 5 percent and 7 percent by mass of the mix. The actual binder content employed in the mix shall be approved before manufacture of the mix commences.

During manufacture and placement the Engineer shall obtain samples of any carry out tests on the mix produced in accordance with the general requirements for sub-clause 4.5.4.2 of these Specifications.

4.6.4.2 Mixing Procedure

Cold asphalt shall be manufactured as follows:

(a) in a rotary drum mixer (e.g. concrete mixer), or

(b) in a single or twin shaft pugmill mixer, or

(c) mixed in place (subject to Engineer's approval)

Mixers shall be of an approved type and shall be capable of providing a consistently uniform mixing of the aggregates, the filler and the binder.

Aggregates shall be handled and stored in a manner that prevents contamination and effectively minimises segregation.

Filler shall be handled and stored in a manner that ensures it remains dry and in a free flowing state at all times.

Bituminous materials shall be stored in containers that effectively prevent contamination.

Except for mixes employing a bitumen emulsion binder, the aggregates shall be preheated to remove any surface moisture.

Materials shall be batched by weight, unless otherwise approved in which case volume batching will be carried out only using approved gauging boxes.

When rotary drum mixers or pugmill mixers are employed the aggregates and filler shall be deposited in the mixer and given a “dry” mixing run prior to the addition of the bitumen binder.

The mixing time shall be such as to ensure that the aggregates and the filler are uniformly coated with the bitumen binder. Over mixing, resulting in stripping of the binder coating shall not be allowed to occur.

When the mix-in-place process is approved, the bitumen binder shall be sprayed on to the surface of the combined aggregates. The constructional plant employed for this operation and the mixing procedure adopted shall be such as to provide a uniform distribution of he bitumen binder throughout the aggregate and ensure even coating of the individual aggregate particles.

If the bitumen binder is a bitumen emulsion care shall be taken to ensure that the above requirements are met whilst still retaining the property of rapid breaking of the emulsion.

4.6.4.3 Preparation of the Pavement

Prior to the placement of the cold asphalt the surface of the existing pavement shall be dried and thoroughly broomed and/or otherwise treated to remove all loose material and any adhering foreign matter.

Any depressions or uneven areas on the surface shall be tack coated in accordance with Section 4.3 of these Specifications and brought to the general level of the surface by means of a corrective layer of the cold asphalt. The corrective layer shall be compacted to the requirements of sub-clause 4.6.4.5 of these Specifications.

4.6.4.4 Tack Coat

The whole area upon which the cold asphalt is to be spread shall be given a light, even tack coat of rapid setting bitumen emulsion of a type which complies with the requirements of Section 4.3 of these Specifications.

The emulsion coat shall be finely applied using a spray bar. The rate of application shall be between 0.3 and 0.6 litres per square metre or as otherwise directed by the Engineer.

Warming of the bitumen emulsion or dilution with water prior to application (in order to facilitate spraying) shall be undertaken with extreme care at the Contractor’s risk.

The tack coat shall be allowed to “break” prior to spreading the mix.

4.6.4.5 Spreading, Compaction and Finishing.

Cold asphalt shall be spread in uniform layers not exceeding 65 mm compacted, unless specifically directed otherwise. The layers shall be spread by means of hand spreaders or approved mechanical spreaders for larger areas.

Spreading of cold asphalt will not be permitted if the pavement is wet.

Initial compaction of the cold asphalt shall be undertaken using an approved steel wheel roller having a mass of not less than 8 tonnes, or an approved vibratory roller. Subsequent compaction shall be undertaken using an approved self-propelled pneumatic tyred roller having a mass of not less than 10 tonnes.

The finished surface of the cold asphalt shall be given a light sprinkling of an approved mineral filler. The quantity of filler provided shall be just sufficient to ensure that the finished surface will not be tacky and pick up under traffic.

4.6.4.6 Tolerances

The surface of the finished cold asphalt shall be tested for evenness by the Engineer using a 3.5 metre straight edge. The surface will be considered acceptable providing the deviation from the straight edge, placed either longitudinally or transversely, does not exceed 3 mm between two contact points.

Cold asphalt surfaces not conforming to this tolerance may be rejected by the Engineer. Rejected areas shall be removed and replaced at the Contractor's own expense.

Where the cold asphalt is required to be placed within a defined alignment and dimensional tolerances these shall be as specified on the drawings or in the relevant sections of the Specifications

4.6.4.7 Storage of Cold Asphalt

Cold asphalt which has been manufactured using a fluxed bitumen binder may be stored for future use. The mix shall be stored on clean, hard-surfaced areas and sheltered from sun and wind, preferably covered with a suitable tarpaulin. The stored cold asphalt shall be heaped so as to minimise the exposed surface area. The exposed surfaces shall be lightly compacted (smoothed) to further minimise the loss of volatiles.

Prior to use, the outer “crust” of the stockpiled material shall be removed and discarded or otherwise softened by the application of bitumen fluxing agent or bitumen cutter.

4.6.5 MEASUREMENT

Cold asphalt shall be measured on a cubic metre basis, the dimensions of which shall comprise the thickness and width specified on the typical cross section and the length of completed and accepted construction, measured horizontally, and, where appropriate, along the centre-line of the road.

Additives used in accordance with sub-clause 4.2.2.2 of these Specifications shall be measured by the number of litres of each type used at the rate instructed or the actual litres used whichever is the lesser.

4.6.6 PAYMENT

Cold asphalt, measured as provided for in clause 4.6.5 of these Specifications, shall be paid for at the Contract unit price per tonne, complete in place, which price shall be complete compensation for all aggregates, mineral fillers, bitumen, crushing, heating and mixing plant, and shall include all material, labour, equipment, tools, cleaning and preparation of the area to be levelled or patched, removal of deleterious material or loose existing asphalt and all incidentals necessary for the satisfactory completion of the work.

With the approval of the Engineer, payment will be made at the Contract unit price bid, regardless of the mix bitumen content finally determined and agreed on the site, provided said bitumen content is within the range specified in sub-clause 4.6.4.1 of these Specifications.

Payment will be made for the use of bitumen additive, if directed by the Engineer, at the Contract unit price for each type of additive measured in accordance with Clause 4.6.5 of these Specifications.

Payment shall be made under the following items :

Item Ref	Description	Unit of Measurement
4.6(1)	Cold Asphalt (fluxed)	Cubic metre
4.6(2)	Cold Asphalt (cutback)	Cubic metre
4.6(3)	Cold Asphalt (emulsion)	Cubic metre
4.6(4)	Bitumen Additive: Specify Type (provisional)	Litre

4.7 REPAIR OF BITUMINOUS WORKS

4.7.1 DESCRIPTION

This work shall consist of the repair to bituminous pavements that can be performed economically and is not sufficiently extensive to require resurfacing, rehabilitation or reconstruction. Repairs such as patching and crack sealing may be carried out prior to subsequent resealing or reconstruction.

Repair work will be carried out in accordance with these Specifications and in close conformity with the lines shown on the Drawings or established by the Engineer.

4.7.2 GENERAL REQUIREMENTS

4.7.2.1 Types of Surface to be Repaired.

The bituminous pavement to be repaired may be a sprayed seal, slurry seal, asphalt road base or wearing course or bitumen macadam and the repairs necessary may involve the repair of defects in the surfacing, the pavement or in the sub-grade layers.

4.7.2.2 Types of Defect

The types of defects to be repaired in accordance with the requirements of this particular Section of these Specifications include pavement cracking, pot holes, edge breaks, large depressions and pavement failures. These types of defects are described as follows:

a) Cracks

A bituminous surface may exhibit a number of types of cracking, resulting from various causes. Cracking may range from that which is not visible from a moving vehicle, to wide, clearly visible cracking and may be of a number of types which are described in the AUSTROADS Publication “A Guide to the Visual Assessment of Pavement Condition”.

b) Pot Holes

Pot Holes are localised areas where the wearing surface has cracked and has been removed and the underlying pavement has continued to be lifted out under traffic action. The pot hole may or may not be accompanied by distortion of the adjacent surface.

c) Edge Breaks

Edge Breaks are those areas of the edge of a bituminous surface which have fretted or broken away from the main pavement layer along the shoulder.

d) Large Depressions

Large depressions are locally depressed areas in the pavement surface which result from the poor compaction at sites such as bridge abutments and service trenches.

e) Pavement Failures

These are areas where the pavement layer has cracked and there is substantial deformation of the area resulting from poor compaction, defective or inadequate depth of pavement material, poor sub-grades and/or the ingress of moisture.

4.7.3 MATERIALS REQUIREMENTS

Materials used for patching shall generally be the corresponding materials from which the original layer has been constructed and shall conform to the requirements of the appropriate Sections on Sub-base and Base Courses and Bituminous Works of these Specifications

4.7.4 CONSTRUCTION REQUIREMENTS

4.7.4.1 Basic Patching Procedures

Where excavation of the pavement is necessary the sides of the area to be patched must be trimmed vertical, the depth of the hole just being sufficient to remove the unsuitable material. To ensure the hole does not trap moisture it may be necessary to slop the bottom of the excavation towards one corner and dig a mitre drain to the outer pavement edge.

Selected materials or crushed rock used for backfill must be at optimum moisture content to facilitate compaction and all such materials shall be compacted in layers not exceeding 100 mm thick. Compaction shall be carried out by means of appropriate mechanical compactors.

The amount of material used must be such that the patch, when compacted is flush with the surrounding pavement surface. If the patch is to be left unsealed for some time, the final surface should be left slightly above the surrounding surface to enable a final trim to be carried out prior to sealing.

Prior to application of any bituminous surfacing the patched area must be swept clean of dust and loose stones. The surfacing shall then be applied using materials as far as practicable, similar to those in the original surface in accordance with the requirements of Clause 4.7.3 of these Specifications and in such a manner that it will have similar texture and colour as the surrounding area.

4.7.4.2 Seal Patching

If a patch involving excavation beyond the existing seal is to be made the existing seal shall be stripped for at least 75mm beyond the perimeter of the excavated area.

Priming, Primersealing and Sealing of the patched area shall be carried out in accordance with the requirements of the corresponding Sections of these Specifications.

Equipment to be used shall be of such a size as is appropriate for the size of patches to be repaired and the hand operated spray equipment, brooms, compaction equipment and other tools and equipment shall be approved for use by the Engineer.

4.7.4.3 Asphalt Patching

Patching of asphalt courses shall be carried out using cold asphalt materials incorporating cutback bitumen or bitumen emulsion in accordance with the requirements of Section 4.6 Cold Asphalt of these Specifications.

The general procedures described in sub-clause 4.7.3.1 for basic patching shall be applied for the use of cold asphalt in place of the selected materials of crushed rock.

Prior to the placement of cold asphalt material the squared and trimmed sides and base of the hole shall be lightly primed or tack coated

4.7.4.4 Repair of Specific Defects

a) Cracks

Cracks wide enough to be treated shall be cleaned out with compressed air and then filled with an unmodified bituminous material such as cutback bitumen or bitumen emulsion having a viscosity low enough to enable it to be poured or worked into the cracks. Care shall be taken to ensure that the cutback bitumen or bitumen emulsion does not bridge across the crack at the surface. A squeegee or rubber wiper should be used to enable the binder to penetrate the cracks.

Light sanding or gritting as directed by the Engineer shall be carried out on the treated area to prevent traffic picking surplus bitumen.

b) Pot Holes

Pot holes to be repaired shall be squared, with the edges trimmed vertical and all loose material removed before reinstatement. Shallow holes shall be reinstated with cold asphalt materials whilst deeper holes shall be repaired using selected materials or crushed rock with the lop layer only of cold asphalt materials.

c) Edge breaks

Loose material shall be removed from the shoulder in the area of the edge break prior to the application of any bituminous material. The edge of the area to be repaired shall be marked with a string line and a straight edge shall be used to form a vertical edge for the patch. Edge breaks shall be patched using cold asphalt which shall be compacted to conform with the level of the adjacent bituminous surface and sanded or gritted to prevent picking up under traffic.

d) Large Depressions

The area to be treated shall first be cleaned by brooming or blowing clean with compressed air prior to the application of a light tack coat. The depression shall then be filled with cold asphalt material, compacted and sanded or gritted to prevent picking up under traffic.

d) Pavement Failures

The defective pavement and /or subgrade material shall be removed until sound material is reached. The hole then shall be refilled and compacted in accordance with the requirements of sub-clause 4.7.3.1 using the materials appropriate to the layers being repaired.

4.7.5 MEASUREMENT

Repairs to bituminous surfaces shall be measured by the area in square metres of each type of repair carried out in accordance with the Drawings or as directed by the Engineer.

Blotting material and other material used for patching shall not be measured for payment but will be considered to be included in the unit price for each type of patching.

Repairs to bituminous surfaces will be paid for at the Contract unit price per square metre of area measured as provided for in Clause 4.7.4 of these Specifications for each type of repair, complete and approved in place, and shall include for the cost of providing and placing all materials required and complying with the requirements of Section 4.7 of these Specifications.

4.7.6 PAYMENT

Payment shall be made under the following item :

Item Ref	Description	Unit of Measurement
4.7(1)	Repair of Cracking	Square metre
4.7(2)	Repair of Pot Holes	Square metre
4.7(3)	Repair of Edge Breaks	Square metre
4.7(4)	Repair of Depressions	Square metre
4.7(5)	Repair of Pavement Failure	Square metre
Etc		

CONSTRUCTION SPECIFICATION

Section 5
Structures

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5 STRUCTURES

5.1 CONCRETE

5.1.1 DESCRIPTION

This work shall consist of the construction of all or portions of structures of Portland cement concrete, of the required class or classes, with or without reinforcement, and with or without admixture, constructed in accordance with these Specifications and the lines, levels, grades, and dimensions shown on the Drawings, and as required by the Engineer.

Concrete shall consist of a mixture of Portland cement, water, and coarse and fine aggregate with or without admixture.

5.1.2 GENERAL REQUIREMENTS

5.1.2.1 Definitions

Batch	One load or charge of a mixing plant or transit mixer
Characteristic Strength (f'_c)	The Compressive strength of the concrete at age 28 days as specified in the documents. This characteristic strength shall be exceeded by at least 95% of the concrete as assessed by standard tests.
Cover	The distance between the outside of the reinforcement and the nearest permanent surface of the member excluding any surface finishing material
Lot	An identifiable quantity of concrete from which samples are taken, and about which decisions are made on the basis of tests carried out on specimen cylinders made from the samples. A lot shall consist of batches of concrete of the same Class, produced and placed in an essentially uniform and continuous manner. Any separately identifiable portion of a structure placed in one operation shall be considered a lot
Mean Strength	The arithmetic average of the compressive strengths achieved by two or more specimen cylinders
Sample	A portion of fresh concrete drawn from a batch and from which specimen cylinders are made. All sampling shall be carried out in accordance with AASHTO T-141
Specimen Cylinder	A single concrete cylinder, 100 mm in diameter x 200 mm in length or 150 mm in diameter x 300 mm in length in accordance with AASHTO T-23 made from a sample for the purpose of testing
Standard Deviation	A statistical measure of the variation from the mean strength of the specimen cylinders
Target Strength (f'_t)	The compressive strength of the concrete at age 28 days selected for design of the mix as provided for in sub-clause 5.1.2.3

5.1.2.2 Quality of Concrete

(a) Classes of Concrete - The classes to be used for the various structures and structure components shall be as designated in Table 5.1.1:

Table 5.1.1 Classes of Concrete

Class of Concrete	Ultimate Compressive Strength at 28 days on cyl. 150 x 300 mm	Structures and Components
A1	45 MPa	Prestressed concrete for precast concrete beams and piles, or any other precast components. Prestressed concrete for cast-in-situ prestressed structures.
A2	40 MPa	Reinforced concrete for deck slabs.
B1	32 MPa	Reinforced concrete for beams, piers, abutments and run-on slabs (approach slabs), bridge curbs and pedestrian sidewalks, wingwalls and counterfort walls, road sign posts, pedestrian bridges, precast square or tubular piles. Reinforced concrete for standard box culverts, headwalls for pipe and box culverts and small irrigation structures. Reinforced concrete for road curbs, gutters and barriers.
B2	32 MPa	Reinforced concrete for massive components such as gravity walls and barriers and pile caps.
B3	32 MPa	Reinforced concrete for standard pipe culverts. Reinforced concrete for fence posts.
D	20 MPa	Reinforced concrete for various drainage and road furniture components: lined ditches, manholes, post foundations, guide posts, kilometre stones, etc.. Concrete slope protection, and all unreinforced concrete components.
E	not specified	Blinding concrete (lean concrete) for blinding beds under foundations and run-on slabs.

(b) Constituents of the concrete mix - The concrete shall conform to the requirements for the particular class as set out in Table 5.1.2. The proportion by dry weight of coarse to fine aggregate, which will normally be approximately 2 to 1 may be varied between 1.5 to 1 and 3 to 1, with the agreement of the Engineer provided the quality of the concrete is thereby improved.

The minimum quantity of cement permitted will be as set out in Table 5.1.2 even though the strength of mixes containing these quantities may exceed the minimum required for the particular classes. The Contractor will design the concrete mixes and submit his proposals for the approval of the Engineer.

Table 5.1.2 Composition of Concrete

Class of Concrete	Minimum Cement Content (kg/m3)	Maximum W/C Ratio	Slump (mm)	Coarse Aggregate AASHTO M 43
A1	390	0.44	0 - 100	No. 67 (19.0 mm - 4.75 mm)
A2	380	0.46	50 - 100	No. 67 (19.0 mm - 4.75 mm)
B1	362	0.49	50 - 100	No. 67 (19.0 mm - 4.75 mm)
B2	362	0.49	50 - 100	No. 467 (37.5 mm - 4.75 mm)
B3	362	0.49	50 - 100	No. 7 (12.5 mm – 4.75 mm)
D	350	0.49	50 - 100	No. 67 (19.0 mm - 4.75 mm)
E	307	0.58	50 - 100	No. 357 (50.0 mm - 4.75 mm)

The air content for concrete Class A1, A2, B1, B2 and B3 shall not be more than 4, +/- 1 percent.

(c) Grading of aggregates - The grading of the aggregates shall be within the limits as specified in sub-clauses 5.1.3.4 and 5.1.3.5. Once the appropriate gradings have been determined and approved they shall not be varied without the permission of the Engineer.

(d) Water cement ratio - The ratio of free water to cement for saturated surface dry aggregate shall be in accordance with the table above.

(e) Workability - The concrete shall be of suitable workability for full compaction to be obtained. The slump as measured by AASHTO test method T 119 shall be not greater than 100 mm for a non-vibrated concrete sample.

5.1.2.3 Trial Mixes

The Contractor shall prepare trial mixes having workability, strength, and surface finish as criteria, to satisfy the Engineer regarding these qualities. The trial mixes shall be made and compacted in the presence of the Engineer, using the same type of plant and equipment as will be used for the works.

The trial mixes shall be made for each class of structural concrete A1, A2, B1, B2, B3 and D. For each class of structural concrete the design tests shall consist of:

Type of tests	Age	Number of specimens tested
Compressive strength	3 days	9
	7 days	9
	28 days	9
Flexural strength	3 days	9
	7 days	9
	28 days	9

and workability control tests by measurement of the slump.

All these tests shall be carried out in accordance with the requirements of AASHTO test specifications T 22, T 23, T 97, T 119, T 126 and T 141. The compressive strength shall be measured on diameter 150 mm x height 300 mm cylinder specimens and the flexural strength on 150 mm x 150 mm x 500 mm prismatic specimens.

From the same mix as that from which the test specimens are made, the workability of the concrete shall be determined by the slump test in accordance with AASHTO test specification T 119 or other method approved by the Engineer. The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours the sides of the mould shall be struck and the surface examined in order to satisfy the Engineer that an acceptable surface can be obtained with this mix.

A trial mix for a particular class shall be acceptable when the strengths of each specimen from three sets of three specimens made from different batches, cured and tested after the age specified, in a laboratory approved by the Engineer, and when the slump tested on the concrete from the same batches, are not below the particular requirements specified in Table 5.1.3.

Table 5.1.3 Trial Mix Characteristic Properties

Concrete	Minimum compressive strength (MPa)			Minimum flexural strength (MPa)			Slump (mm)
	3-day	7-day	28-day	3-day	7-day	28-day	non vibrated
A1	16.8	27.3	42	2.7	3.4	4.3	0 – 100
A2	16.8	27.3	42	2.7	3.4	4.3	50 – 100
B1	12	19.5	30	2.3	3.0	3.7	50 – 100
B2	12	19.5	30	2.3	3.0	3.7	50 – 100
B3	12	19.5	30	2.3	3.0	3.7	50 – 100
D	8	13	20	1.9	2.4	3.0	50 – 100

The flexural strength is expressed as the modulus of rupture MR = K $\sqrt{f'_c}$, with K=0.7 to 0.8, and f'_c in MPa.

When a proposed mix has been approved, no variations shall be made in the mix proportions, or in the type, size, grading zone or source of any of the constituents without the consent of the Engineer, who may require further trial mixes to be made before any such variation is approved.

Until the results of trial mixes for a particular class have been approved by the Engineer, no concrete of the relevant class shall be placed in the works.

When the Contractor intends to purchase factory-made precast concrete units, trial mixes may be dispensed with provided that evidence is given to satisfy the Engineer that the factory regularly produces concrete that complies with these Specifications. The evidence shall include details of mix proportions, water-cement ratios, slump and strengths obtained at 3, 7 and 28 days.

5.1.2.4 Quality Control Testing

a) General - All concrete used in the Works shall be subject to sampling and testing strictly in the manner prescribed in AASHTO Testing Specifications T-22, T-23, T-97, T-126, T-119 and T-141 and in accordance with the requirements as detailed in these Specifications.

b) Equipment - The Contractor shall furnish at his own expense an adequate supply of steel moulds conforming to AASHTO T-23 for test specimens on any site where concrete is being placed and a curing tank of adequate size for storing and curing specimens prior to testing.

The Contractor shall also provide at each site where concrete is being placed an Abrams cone conforming to AASHTO T-119 for the measurement of slump of fresh concrete.

c) Rejection of Wet Concrete - Workability control tests, by measurement of the slump of the fresh concrete, shall be carried out using the Abrams cone according to AASHTO T 119. One slump test, or more as directed by the Engineer, shall be carried out on every batch of concrete produced, and the test shall not be deemed to have been carried out unless witnessed by the Engineer or his representative.

Before any concrete is placed in the Works it shall be visually checked by the Engineer as specified above and shall be liable for rejection if it is defective in any of the following ways:

The slump is outside of the range specified in Table 5.1.3. If placement is delayed for a significant period, the slump shall be rechecked prior to placement.

The appearance, colour or cohesiveness of the batch is significantly different from other batches of the same mix

d) Sampling - Samples shall be taken from separate batches of concrete selected at random during the placing operation. Two cylinders (minimum) shall be cast from each sample in purpose-made steel moulds conforming to AASHTO T-23 and identified as a matched set. Each cylinder shall be identified with the batch and/or lot as directed by the Engineer and a written record made of the location of each batch within the structure. In addition, for precast concrete, the cylinders shall be so marked that they can be readily identified with the corresponding structural unit at all times.

i) Concrete other than Class A

The minimum rate of sampling is defined in Table 5.1.4

Table 5.1.4 Sampling Frequency for 28 Day Strength Tests

No of Batches	No. of Samples
1 - 3	Every Batch
4 - 10	3
11 - 20	4
More than 20	(Number of batches) / 5

ii) Class A1 and A2 Concrete

For each element cast in one continuous operation the minimum rate of sampling shall be:

4 cylinders per 5 Cu-m or part thereof

Additional cylinders as directed by the Engineer at the Contractor's expense if post-tensioning of the element is to be combined with pre-tensioning

e) Additional Sampling

i) Initial Testing

Where the information supplied in sub-clause 5.1.2.3 of these Specifications does not permit determination of standard deviation based on previous field testing for each Class of concrete, the frequency of initial sampling shall be increased above that shown in Table 5.1.4 at the Contractor's expense. The actual increase in initial sampling shall be at the Engineer's discretion.

ii) Early Stripping and/or Loading

Any request by the Contractor for early removal of forms (Refer to sub-clause 5.1.5.9 of these Specifications) or for early application of significant loads to the structure shall be given in writing to the Engineer prior to placing concrete. The Engineer shall determine the number of additional cylinders required for early testing at the Contractor's expense.

iii) Further Construction prior to 28 day testing.

If concrete is to be placed over or adjacent to and connected with a previous section prior to 28 day testing and acceptance, the Engineer may order additional sampling and early age testing at the Contractor's expense. Any approval by the Engineer to proceed with construction shall not remove the Contractor's responsibility to satisfy acceptance criteria specified in sub-clause 5.1.2.5 of these Specifications.

f) Handling and Curing of Specimen Cylinders

i) Concrete Other than Class A

The specimens intended for the 28-day tests shall be kept in their moulds at a temperature as close as possible to 20^{o}C during the first 24 hours after casting.

Cylinders shall not be moved for a period of 24 hours after casting unless absolutely necessary and with the approval of the Engineer. They shall be removed from the moulds after 24 hours, placed into sealed casings and transported to the laboratory as quickly as possible. Cylinders shall be handled with care, transported without bumping or vibrating, and placed in standard curing conditions within 36 hours, in accordance with AASHTO T-126.

Cylinders shall be kept under water until they are tested. They shall be wiped, but not dried, just before testing.

Where cylinders are temporarily stored at the site of the Works they shall be stored in lime saturated water at a temperature as close as practical to 27^{o}C

The specimens for the 3-day and 7-day tests shall always be stored near the structure, adequately protected and maintained by the Contractor, so that their thermal and hygrometric history is comparable to that of the structure.

ii) Class A1 and A2 Concrete

Specimen cylinders shall be cured under conditions identical with those of the concrete they represent (refer also to sub-clause 5.4.3.7 of these Specifications) for the initial curing period.

After this initial curing the cylinders shall be stored and cured under standard conditions as for other than Class A1 and A2 concrete in accordance with the above requirements.

g) Testing of Specimen Cylinders - Concrete cylinders shall be tested at an approved testing laboratory on the designated dates in accordance with the requirements of AASHTO T-22.

A minimum of two matched cylinders shall be tested at 28 days. The test result of a sample shall be the average of all cylinder tests from the sample, except where abnormal test results are identified as set out below.

Where the range of test results exceeds the limits given in Table 5.1.5, the history of the cylinders shall be examined and their condition reported to the Engineer by the testing laboratory. The cylinders shall be retained in the laboratory for at least 14 days to permit further examination.

Table 5.1.5 Maximum Difference in Compressive Strengths for a Matched Set

No of Matched Cylinders from a Sample	Difference in Strength Maximum - Minimum (MPa)
2	2.0
3	3.0

Test Results of individual cylinders shall be excluded from the assessment of strength for the purposes of acceptance or rejection under the following conditions:

- Where, in the opinion of the Engineer, a low test result can be attributed to an obvious defect in the cylinder or test procedure.
- Where test results from a matched set exceed the range set out in Table 5.1.5, the low test result shall be excluded even when no defect in the cylinder or procedure is obvious.

When any test result is excluded by the above criteria, the Engineer and the Contractor shall check that the manufacture, storage and testing of cylinders is being correctly carried out.

5.1.2.5 Acceptance or Rejection of Concrete

a) General - The results of the quality control tests shall be in accordance with the mix property requirements, as specified in Table 5.1.4 of these Specifications. The results shall be submitted to the Engineer as soon as they are available.

b) Plasticity - Concrete not meeting the slump requirements shall not be placed in the work. The workability and texture of the mix shall be such that it can be placed in the works without the formation of hollow spaces or gaps or retention of air or water bubbles, and such that on removal of the formwork a smooth, uniform, dense surface is presented. If it appears impossible to get the specified workability with the original mix design approved by the Engineer, the Contractor shall submit to the Engineer's approval mix adjustments. Admixtures for increasing the workability will be permitted only when specifically approved by the Engineer.

c) Monitoring of Target Strength - If the average strength of three consecutive samples is less than $0.5(f'_c + f'_t)$ the Contractor shall submit to the Engineer as a matter of urgency proposals to upgrade the mix and/or procedures to achieve the approved target strength.

Where a significant amount of concrete is to be placed in a four week period, monitoring shall include early age testing (typically 7 days) and a comparison of cylinder strengths with previously measured strength gain results.

d) Acceptance or Rejection of Hardened Concrete on the Basis of Strength - Subject to the concrete meeting all the requirements of these sub-clauses of the Specifications it will be accepted or rejected on a statistical basis using the results of 28 day tests as set out as follows:

Concrete in a lot shall be rejected if any of the following apply:

- Any sample strength (average of two or more matched cylinders) is less than 0.9 times the specified characteristic strength
- The average strength of three consecutive samples from the lot is less than the specified characteristic strength

In addition, where 10 or more samples of a particular Class of concrete are tested in four consecutive weeks or less, all the concrete represented by these samples shall be rejected if the average strength of all the tests for that Class of concrete over that period is less than $0.5(f'_c + f'_t)$

The standard deviation shall be calculated from the tests from that period and compared with the value used to calculate the target strength. If the standard deviation from the test results is significantly greater than that used in calculating the target strength, the Engineer may withdraw approval for the mix (refer sub-clause 5.1.2.3).

e) Consequences of Unsatisfactory Strength Results - When the results of 7-day tests give strengths below those specified, the Contractor shall not place any further concrete until the cause of the low results has been ascertained and until he has taken such steps to ensure that the production of concrete complies with the Specifications.

The Engineer may also suspend the work and / or direct the Contractor to take corrective action to improve the mix quality on the basis of the 3-day compressive strength test results. In such a case the Contractor shall immediately cease placing the concrete in question but may elect to wait until the results of the 7-day test are available before implementing corrective measures, at which time the Engineer will review both the 3-day and 7-day test results, and may direct immediate implementation of whatever corrective measures he judges are necessary. Rectification of unsatisfactory concrete work involving the complete removal and replacement of the concrete shall not be based on the results of 3-day compressive strength tests alone unless the Contractor and Engineer mutually agree on the rectification.

If the 28 day results are not satisfactory, the structure or part of the structure shall be subject to additional quality control testing including dynamic non-destructive testing, such as loading tests or concrete hammer testing, and compressive strength testing on core drilled samples, according to a schedule approved by the Engineer. The cost of the 28-day strength tests, core drilling and testing, dynamic non-destructive testing and load test, including all supplies and use of specialised staff, shall be carried by the Contractor.

The final decision on acceptance, rectification or rejection of the structure or part of the structure shall be the Engineer's responsibility if the results of the additional testing are not satisfactory.

Where hardened concrete has been rejected, the Engineer may order any of the following alternatives, at the Contractor's expense

i) The rejected concrete, and any portion of the structure built on the rejected concrete, shall be removed and replaced to satisfy the requirements of these Specifications.

ii) The rejected concrete may remain in place and additional works, approved by the Engineer, shall be undertaken to achieve adequate strength and / or durability.

The rejected concrete may remain in place and the Contractor shall agree to a reduction in the scheduled payment rate for the quantity of concrete rejected equal to the supply cost of the concrete on site per Cu-m as determined by the Engineer.

5.1.3 MATERIALS REQUIREMENTS

5.1.3.1 Portland Cement

Cement shall conform to the requirements of AASHTO Standard Specification M85. The use of high alumina cement is not allowed. Cement shall conform to Type I unless specifically otherwise stated in the Special Provisions, or on the Drawings.

Supply of cement shall be submitted for approval before use, with respect to origin and quality. Subsequent deliveries shall be also subject to quality control testing as work proceeds.

Approval of origin and quality shall be given only on presentation of test results showing that the cement factory proposed is able to supply a product which will consistently meet the physical and chemical qualities specified. Quality control tests shall be made on each cement delivery, in order to determine the following characteristics :

a) specific gravity,

b) specific surface by means of air permeability,

c) heat loss,

d) hot and cold expansion properties,

e) compressive strength at 3, 7 and 28 days,

f) setting time,

and periodically determination of carbonate, alkali and chloride contents.

All these tests shall be carried out in accordance with a procedure agreed by the Engineer.

When cement is stored for long periods, the Engineer shall be entitled to ask for a renewal of quality control tests, restricted to heat loss, setting time and mechanical resistance.

Manufacturer's test certificates shall be submitted to the Engineer on request.

Unless otherwise permitted by the Engineer, the product of only one mill and one brand shall be used on the project for each type of Portland cement used in the project.

The Contractor shall provide suitable means of storing and protecting the cement against dampness that shall be subject to the approval of the Engineer. The Contractor shall store consecutive deliveries of cement separately and shall ensure that cement is used in chronological order of delivery. The Engineer may reject cement which is more than eight weeks old or which has become partially set or which contains lumps of caked cement. The use of cement reclaimed from discarded or used bags will not be permitted.

5.1.3.2 Water

Water used in mixing and curing concrete shall be subjected to approval of the Engineer and shall be clean and free from oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to concrete or steel. Generally, water that is suitable for drinking is satisfactory for use in concrete.

Whenever there is a reason to suspect that water proposed for use in concrete is not suitable, it shall be tested and approved before it may be used.

Water shall be tested by methods described in AASHTO T26, and shall not contain concentrations of dissolved solids, chlorides expressed as Cl, and sulphates expressed as $S0_4$ in excess of the following limits:

Application	Concentrations in ppm		
	Dissolved Solids	Cl	SO_4
Non-reinforced concrete	2,000	2,000	1,500
Reinforced Concrete	2,000	1,000	1,000
Prestressed Concrete	2,000	500	1,000

Water which contains a high content of suspended solids shall be allowed to stand in a settling basin before use. The turgidity of water shall not exceed 2,000 ppm.

In case of doubt concerning the quality of the water, verification can be made by comparing the influence of the water on the setting time of the cement, and the qualities of resistance of the concrete mix, one made with the water submitted for approval and the other with distilled water. Resistance to compression after 28 days using the water proposed shall not be less than 90 % of the resistance of the sample mixed with distilled water.

5.1.3.3 Admixtures

Admixtures or any other additions shall not be used without the written approval of the Engineer.

Admixtures, if specified or permitted, shall conform to the requirements of AASHTO Standard Specification M 194. Any delivery of admixtures shall be accompanied with a certificate of origin stating the date of manufacturing and the limit date of use. The admixture formulation shall contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Admixtures containing calcium chloride, fluorides, sulphites and nitrates and/or other chlorides in excess of 0.5 percent by weight of admixture shall not be used.

All admixtures shall be used in accordance with the instructions of the manufacturer. Permission to use the admixture may be withdrawn at any time if unsatisfactory results are obtained.

The Contractor shall submit samples and technical details of any admixtures he proposes to use to the Engineer, at least 35 days prior to the date of commencement of construction of the particular structure, or portion of structure, on which he intends to use such admixtures. Trial mixes incorporating the proposed admixture shall be made by the Contractor and shall be approved by the Engineer before use in the Works. Any approval or otherwise given under this Clause shall in no way relieve the Contractor of his obligations to produce concrete with the specified strength and workability, as required under this Contract.

5.1.3.4 Coarse Aggregate

a) General - Coarse aggregate shall consist of clean, hard, durable rounded natural aggregates or crushed rock. It shall comply with the requirements of AASHTO M80, Coarse Aggregate for Portland Cement Concrete, in respect of bulk density, unit mass, water absorption, stability, soundness, material finer than 75 microns, deleterious materials, sulphur content, physical properties and particle shape. If required, aggregate shall be washed to satisfy these requirements.

   The coarse aggregate shall have a Los Angeles abrasion coefficient, after 500 revolutions, below 35 % (AASHTO T-96) and a water absorption capacity < 5 % (AASHTO T-85).

   The aggregates shall include as few as possible of flat and elongated particles. The testing for checking the amount of particles with an incorrect shape shall be carried out either by determining the average volumetric coefficient of the aggregate, or by any other equivalent method approved by the Engineer.

   The coarse aggregate for use in concrete structures shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that, if such materials are present in injurious amounts, the coarse aggregate may be used with a cement containing less than 0.6 percent alkalies calculated as sodium oxide or with the addition of the material that has been shown to prevent harmful expansion due to alkali-aggregate reaction.

b) Grading - Coarse aggregate shall conform to the requirements prescribed in AASHTO M43 for the grading specified.

   The Contractor shall provide the Engineer with grading figures to indicate the average grading of the aggregate proposed, which shall be the basis for acceptance. These grading figures shall be known as the “Submitted Grading”. Alternatively, the Contractor may submit a sample, the grading of which shall be the basis for acceptance. This sample shall be known as the “Submitted Sample”.

If the Contractor chooses to blend two or more aggregates to provide the submitted grading, or the submitted sample, the proportions shall be nominated.

The coarse aggregate shall be selected so that the maximum particle size is no more than 75% of the minimum clear space :

(a) between reinforcing bars,

(b) or between reinforcing bars and formwork,

(c) or between any other restrictions in the space that the concrete must occupy in the work.

5.1.3.5 Fine Aggregate

Fine aggregate shall consist of either a sand resulting from the crushing of the rock used for the fabrication of coarse aggregates with a Los Angeles abrasion coefficient lower than 35 % at 500 revolutions (AASHTO T 96) and a water absorption capacity lower than 5 % (AASHTO T 84), or a natural river sand. The use of marine sand is not allowed.

Fine aggregate shall conform to all the requirements of AASHTO Standard Specification M6.

5.1.3.6 Reinforcement

All reinforcement shall comply with the requirements of Section 5.2 of these Specifications.

5.1.3.7 Jointing Materials

a) Joint Fillers - Non-extruding and resilient types shall conform to the requirements of AASHTO Standard Specification M 153 or M 213

Bituminous type filler shall conform to the requirements of AASHTO Standard Specification M 33.

b) Joint Primer - Joint priming compound shall be Expandite No. 3 or other approved primer.

c) Joint Sealing Compound - Horizontal joint sealing material shall be Expandite Pli-astic hot poured rubber-bitumen sealing compound Grade 99 or other approved compound. Vertical or inclined joint sealing material shall be Expandite Plastijoint bituminous putty or other approved compound.

5.1.3.8 Curing materials

a) Burlap - The burlap used for curing shall be made from jute or hemp and at the time of using shall be in good condition, free from dirt, clay or any other substances that interfere with its adsorptive quality. It shall not contain any substance that would have a deleterious effect of the concrete. Burlap shall be of such quality that it will absorb water readily when dipped or sprayed and shall weigh not less than 240 grams per square metre when completely dry.

b) Sand - Sand shall be clean, sharp and free from any clay balls or any other deleterious matter.

c) Liquid membrane forming compounds - Liquid membrane forming compounds shall conform with the requirements of AASHTO Standard Specification M 148. Any liquid membrane forming compound is subject to the Engineer's approval. All requests for approval must be accompanied by a test report, the test having been carried out by a specialised laboratory establishing the efficiency of the product under hazardous conditions: at 40°C and with a humidity of 55 %, the coefficient of efficiency of the product shall not be less 85 % after 6 hours and 80 % after 24 hours. Furthermore the product shall not adversely affect the bond of coatings nor insulation, or the bond of waterproofing systems to be applied to the concrete. A certificate of origin and directions for use shall be submitted with every delivery.

5.1.3.9 Mould Oil

Mould oil shall be a petroleum distillate free from water, bituminous and other insoluble residues. It shall be a non-staining paraffin oil.

5.1.3.10 Mortar

Any mortar used in conjunction with concrete work shall be a 1 : 3 : 5 mix mortar, conforming to Sub-Clause 5.4.2.12, unless otherwise indicated.

5.1.4 MATERIALS REQUIREMENTS

5.1.4.1 General

Equipment and tools necessary for handling materials and performing the work, and satisfactory to the Engineer as to design, capacity, and mechanical condition, shall be at the site of the work before work is started.

If any equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or other satisfactory equipment substituted or added at the discretion of the Engineer.

5.1.4.2 Batching plant and equipment

a) General - All material in the mix shall be proportioned wholly by weight. Batching plants shall include bins, weighing hoppers, and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. Batch containers shall be watertight.

Provision satisfactory to the Engineer shall be made for batching other components of the mix, at the batching plant or at the mixer as may be necessary. The batching plant may be either of stationary or of mobile type. It shall be always properly levelled within the accuracy required for the proper operation of the weighing mechanisms.

b) Bins and hoppers - Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means or control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing an overload of the several materials from the hopper shall be provided.

Weighing hoppers shall be constructed so as to discharge fully.

c) Scales - The scales for weighing aggregates and cement shall be of either the beam type or the springless-dial type. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten 25 kilogram weights shall be available for checking accuracy. All exposed fulcrums, crevices, and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and up to 25 kilograms overload. All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard sacks considered to weigh 50 kilograms net. When measured by weight a separate, satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper. Satisfactory methods of handling shall be employed.

Batching shall be so conducted as to result in the weights of material required, within tolerances of 1% for cement and 2% for aggregates.

5.1.4.3 Mixers

a) General - All concrete shall be mixed in batch mixers. It may be mixed at the site of construction, at a central plant, or in transit. Each mixer shall have attached to it in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum.

b) Mixers at site of construction - Mixers at the site shall be approved drum-type capable of combining the aggregate, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage, and a water measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged. The discharge lever shall lock automatically until the batch has been mixed the required time after all materials are in the mixer. Suitable equipment for discharging the concrete into hoppers or buckets shall be provided. The mixer shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

c) Central Plant Mixers - These mixers shall be of approved drum type capable of combining the aggregate, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixers shall be cleaned at suitable intervals. They shall be examined daily for changes in interior condition. The pick up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

d) Truck or transit mixers - These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated

mixing speeds. The transit mixer shall have a watertight revolving drum suitably mounted and shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity and without segregation.

The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 80% the gross volume of the drum.

The agitating speed of the drum shall not be less than two or more than six revolutions per minute.

The gross volume of agitator bodies expressed in cubic metres shall be supplied by the mixer manufacturer.

Upon approval by the Engineer, open-top, revolving-blade truck mixers may be used in lieu of agitating trucks for transportation of central plant mixed concrete.

Except when intended for use exclusively as agitators truck mixers shall be provided with a water measuring device to measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

5.1.4.4 Transport of Batched Materials

a) Non-agitator Trucks - Bodies of non-agitating equipment shall be smooth, watertight, metal containers equipped with gates that will permit control of the discharge of the concrete. Covers shall be provided when needed for protection against the weather.

The non-agitating equipment shall permit delivery of the concrete to the site of the work in a thoroughly mixed and uniform mass with a satisfactory degree of discharge.

b) Dry batching - For mixing at the site of construction, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers adequate in design and construction to carry properly the batch required. Partition separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or while being dumped.

Cement in original shipping containers may be transported on top of the aggregates. The number of sacks of cement required for each batch shall be placed on the aggregates for that batch. Sacked cement shall be emptied into the aggregates prior to dumping into the mixer.

Batches shall be delivered to the mixer separately and intact. Each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material form one batch compartment into another.

5.1.4.5 Formwork

Formwork shall include all temporary or permanent moulds for forming the concrete. All formwork shall be of wood or metal and shall be built mortar-tight and rigid enough to maintain the concrete position during placing, compaction, setting, and hardening.

Formwork for exposed surfaces shall be made of dressed lumber of uniform thickness with or without a form liner of an approved type or shall be of metal sufficiently rigid in itself with

no surface blemishes that will impair the quality of the concrete surface finish. No rusty or bent metal forms shall be used. Formwork shall be chamfered on all sharp edges and shall be given a bevel in the case of all projections.

Rough lumber may be used for surfaces that will not be exposed in the finished structure.

All lumber shall be sound, free from warps and twists, sap, shakes, large or loose knots, wavy edges or other defects affecting the strength or appearance of the finished structure.

The shape, strength, rigidity, watertightness and surface smoothness of reused formwork shall be maintained at all times. Any warped or bulged lumber must be resized before being reused. Formwork which is unsatisfactory in any respect shall not be reused.

Internal ties shall be so arranged as to permit their removal to a depth of at least 25 mm from the concrete face without injury to the concrete. No permanently embedded metal shall have less than 25 mm cover to the finished concrete surface.

Formwork shall be so constructed that easy cleaning out of any extraneous material inside the formwork can be achieved without disturbing formwork already checked and approved by the Engineer.

Formwork shall be treated with approved non-staining oil or saturated with water at the discretion of the Engineer before placing concrete. Form oil will only be used after the approval of the Engineer has been given. The Engineer may require trials to be carried out before approval is given for the use of a particular form oil, to ascertain that the form oil proposed by the Contractor will not discolour or injure the finished concrete face in any way.

5.1.4.6 Falsework and Centering

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads coming upon it without significant settlement or deformation. The Contractor shall submit to the Engineer calculations and drawings related to the falsework, and shall not commence construction without the Engineer's prior approval.

Falsework that cannot be founded on solid footings must be supported by ample falsework piling which shall be spaced, driven, and removed in a manner approved by the Engineer.

Arch centering shall be so constructed as to permit its being lowered gradually and uniformly.

5.1.4.7 Compacting Equipment

High frequency internal vibrators of either the pneumatic, electric or hydraulic type shall be used for compacting concrete in all structures and where practicable in precast units. The vibrators shall be of a type approved by the Engineer, with a minimum frequency of 8000 impulses per minute and shall be capable of visibly affecting a properly designed concrete with a 20 mm slump over a circular area of 450 mm radius.

5.1.5 CONSTRUCTION REQUIREMENTS

5.1.5.1 General

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the work. All construction, other than concrete, shall conform to the requirements prescribed in other sections for the several items of work entering into the complete structure.

5.1.5.2 Limitations on Mixing and Placing Concrete

a) General - Concrete shall be mixed only in amounts required for current use.

The Contractor shall be responsible for producing a concrete of the required consistency. Should it prove impracticable to finish centrally mixed concrete properly before it has become too stiff, the Engineer may require that the concrete be mixed at the site of the work.

b) Visibility - No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

c) Temperature and Evaporation - No concrete shall be placed in the Works under the following conditions:

- The temperature of the concrete is less than 10^{o}C or exceeds 35^{o}C
- In the Engineer's opinion, the ambient air temperature is likely to be greater than 45^{o}C during placement or within 2 hours subsequent to placement.

If the ambient air temperature measured at the point of placement is likely to exceed 35^{o}C during placing and finishing operations, the Contractor shall take practical precautions, approved by the Engineer, to ensure that the temperature of the concrete does not exceed the permitted maximum so that concrete can be placed and finished without defects, otherwise it shall be rejected.

Typical precautions include the following:

- Placing the concrete at a time of day when the ambient temperature is lower than the maximum.
- Providing early curing for freshly finished concrete

Other precautions which should be considered are shown in Table 5.1.6

When the evaporation rate during the intended casting period is expected to be high as a result of the combination of high temperature, high humidity and high winds suitable measures shall be taken to minimise evaporation losses from the freshly placed concrete as described in Table 5.1.6.

Table 5.1.6 Precautions for Hot Weather Concreting

At the Mixer	At the Site
Shading aggregate stockpiles	Shading the work area
Painting water tanks white	Erecting wind breaks
Insulating or burying delivery lines	Minimising the time for placing and finishing
Insulating drums of transit mixers	Use of evaporation retarding curing oil
Adding crushed ice to replace mixing water (in part) or chilling water	Cooling the formwork by dampening with water sprays
Injecting liquid nitrogen into the mixer	

5.1.5.3 Foundations

Preparation of foundations shall conform to the details as shown on the Drawings in accordance with the requirements of Section 2.5 Structural Excavation and Backfill of these Specifications. The elevations of the bottoms of footings as shown on the Drawings are approximately only and the Engineer may order further excavation as necessary to obtain satisfactory foundations.

Pile foundations shall be constructed in accordance with the provisions set out in Section 5.3 of these Specifications and as shown on the Drawings.

5.1.5.4 Formwork, Falsework and Centring

Before concrete is placed the Engineer shall inspect all formwork, falsework and centring and no concrete shall be placed until the Engineer has inspected and approved such formwork, falsework and centring. Such approval shall not relieve the Contractor of any of his responsibility under the Contract for the successful completion of the structure.

5.1.5.5 Reinforcement

The Engineer shall inspect and approve all reinforcement in place in accordance with the requirements of Section 5.2 Reinforcement of these Specifications, before concrete is placed. An experienced steel fixer shall be present while all concrete is placed to ensure that no reinforcement becomes displaced during placing and if it does to reposition such reinforcement before placing continues.

5.1.5.6 Mixing Concrete

a) Plant mixing at the site of construction - Job-site mixers shall be operated at a drum speed of not less than 15 nor more than 20 revolutions per minute. The batched materials shall be so charged into the drum that a portion of the water shall enter in advance of the cement and aggregates and the water shall continue to flow into the drum for a minimum time of 5 seconds after all the cement and aggregates are in the drum. Mixing time shall be measured from the time all materials except water are in the drum and shall in the case of mixers having a capacity of 1 cubic metre or less not be less than 50 seconds nor more than 70 seconds.

In the case of dual drum mixers, the mixing time shall not include transfer time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein. Any concrete mixed less than the specified minimum time shall be discarded and disposed of by the Contractor at his own expense.

The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic metres as shown on the manufacturer 's guaranteed capacity standard rating plate on the mixer.

Retempering concrete by adding water or by other means will not be permitted. Concrete which is not of the required consistency at the time of placement shall not be used.

The amount of admixture to be added, if any, shall be approved by the Engineer.

b) Central plant mixing - In addition to the requirements of Sub-Clause 5.1.4.3, central plant mixers which have a capacity of not less than 2 cubic metres nor more than 5 cubic metres and mixers having a capacity greater than 5 cubic metres, shall permit a minimum mixing time of 90 seconds and 120 seconds respectively; provided a mixing analysis and tests of the job materials indicates such produced concrete is equivalent in strength and uniformity to that attained in a) above.

Mixed concrete shall be transported from the central mixing plant to the site of work in agitator trucks or, upon written permission of the Engineer, in non-agitator trucks. Delivery of concrete shall be so regulated that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete in place to harden partially, and in no case shall such an interval exceed 30 minutes.

The interval between introduction of water into the mixer drum and final discharge of the concrete from the agitator shall not exceed 45 minutes. During this interval the mixture shall be agitated continuously.

Uniformity shall be satisfactory if samples from the one-quarter and three-quarter points of the load do not differ by more than 30 mm in slump.

c) Truck mixing - Truck mixers may be used for complete mixing at the batch plant and as truck agitators for delivery of concrete to job sites or they may be used for complete mixing of the concrete at the job site. They shall either be a closed watertight revolving drum or an open top revolving blade or paddle type.

The amount of mixing shall be designated in number of revolutions of the mixer drum. When a truck mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolution of the drum or blades at the rate of rotation designated by the manufacturer of the equipment as the "mixing speed". Such designation shall appear on a metal plate attached to the mixer. If the batch is at least one cubic metre less than guaranteed capacity, the number of revolutions at mixing speed may be reduced to not less than 50. Mixing in excess of 100 revolutions shall be at the agitating speed. All materials, including the mixing water, shall be in the mixer drum before actuation the revolution counter which will indicate the number of revolutions of the drum or blades.

When wash water (flush water) is used as a portion of the mixing water for the succeeding batch, it shall be accurately measured and taken into account in determining the amount of additional mixing water required. When wash water is carried on the truck mixer, it shall be carried in a compartment separate from the one

used for carrying or measuring the mixing water. The Engineer will specify the amount of wash or flush water, when permitted, and may specify a “dry" drum if wash water is used without measurement or without supervision.

When a truck mixer is used for complete mixing at the batch plant, mixing operation shall begin within 30 minutes after the cement has been added to the aggregate. After mixing, the truck mixer shall be used as an agitator for transporting concrete at the speed designated by the manufacturer of the equipment as agitating speed. Concrete discharge shall be completed within 45 minutes after the addition of the cement to the aggregates. Each batch of concrete delivered at the job site shall be accompanied by a time slip issued at the batching plant, bearing the time of departure therefrom. When the truck mixer is used for the complete mixing of the concrete at the job site, the mixing operation shall begin within 30 minutes after the cement has been added to the aggregates.

The rate of discharge of the plastic concrete from the mixer drum shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

5.1.5.7 Placing Concrete

a) General - All concrete shall be placed within the times specified in sub-clause 5.1.5.6. Concrete shall be placed in such a manner as to avoid segregation and the displacement of reinforcing bars and shall be spread in horizontal layers when practicable. Concrete shall be placed where necessary inside forms by hand shovels and in no instance shall vibrators be so manipulated to transport concrete inside formwork.

Care shall be taken to prevent mortar from spattering on forms and reinforcing steel and from drying ahead of the final covering with concrete. Where spattering has occurred, the forms and steel shall be cleaned with wire brushes or scrapers before concrete is placed around steel, or in forms, which have been spattered.

Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

Troughs, pipes, or short chutes used as aids in placing concrete shall be positioned in such a manner that segregation of the concrete will not occur. All chutes, troughs, and pipes shall be kept clean and free from coating of hardened concrete of mortar.

Concrete shall not be dropped freely over a vertical distance of more than 1.5 metres.

Concrete shall be placed continuously throughout each section of the structure or between indicated joints if shown on the Drawings or as directed by the Engineer. If, in an emergency, it is necessary to stop placing concrete before a section is completed, bulkheads shall be placed as the Engineer may direct and the resulting joint shall be deemed a construction joint, the treatment for which is given in sub-clause 5.1.5.7, item g, below.

No concrete shall be placed or considered for payment without the prior written authorisation by the Engineer to proceed with the pouring of concrete. Such authorisation shall be obtained in triplicate form at least 24 hours prior to the scheduled work.

b) Concrete Columns - Concrete in columns or bents shall be placed in one continuous operation unless otherwise permitted by the Engineer.

c) Concrete slab and girder spans - Concrete in T-Beam or deck girder spans having spans of 12 metres or less shall be placed in one continuous operation unless otherwise stated on the Drawings. Concrete preferably shall be deposited by beginning at the centre of the span and working from the centre toward the ends.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise stated on the Drawings.

Concrete in girders spanning more than 12 metres may be placed in two operations, the first operation being the placing of concrete in the girder stems to the bottom of the slab haunches or the bottom of the slab whichever is applicable. Shear keys shall be provided for by inserting oiled timber blocks to a depth of about 40 mm in the fresh concrete at the top of each girder stem. A sufficient number of blocks shall be removed as soon as the concrete has set sufficiently to retain its shape. A period of at least 24 hours shall elapse between the completion of placing concrete in the girder and the commencement of placing concrete in the slab. Immediately before placing concrete in the slab, the top surface of the previously placed concrete shall be hammered with a sharp hand tool until the aggregate is exposed, cleaned and a small quantity of neat cement slurry added. The Contractor shall check all falsework for shrinkage and settlement and shall tighten all wedges to ensure minimum deflection of all formwork.

d) Walls, piers etc. - Where walls, piers, columns, struts, posts and other such structural members allow horizontal construction joints, concrete shall not be placed on top of other concrete which has not been allowed to set for 12 hours or more.

Work shall not be discontinued within 450 mm of the top of any face, unless provision has been made for a coping less than 450 mm thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

e) Culverts - The slabs of box culverts shall be placed for their full depth in one mass or layer and allowed to set not less than 12 hours before any additional work is done on them. For culverts of exceptional length under high embankment details of construction joints are shown on the Drawings. The entire length of slabs between indicated construction joints shall be placed for their full depth or layer and allowed to set for not less than 12 hours before any additional work is done on these lengths.

Before concrete is placed in sidewalls, bottom slabs shall be cleaned of all shavings, sticks, sawdust and other extraneous material.

The Contractor shall submit to the Engineer for approval his proposals for pouring culvert walls before commencing culvert construction. Concrete shall not be placed in layers more than one metre high relative to the concrete already placed. Placing concrete shall proceed in a systematic manner.

f) Placing concrete under water - Concrete shall not be placed in water except with the approval of the Engineer and with his immediate supervision; and in this case the method of placing shall be as defined in this section.

Concrete placed in water shall be Class B2 with 10 percent by weight extra to the amount of cement approved by the Engineer for normal Class B2 concrete. To prevent segregation, it shall be carefully placed in a compact mass, in its final position, by means of a tremie tube or pipe, or a bottom-dump bucket and shall not be disturbed after being placed. Special care must be exercised to maintain still water at the point

of placement. Concrete shall not be placed in running water. The method of placing concrete shall be so regulated as to produce approximately horizontal surfaces.

Concrete seals shall be placed in one continuous operation. When a tremie tube or pipe is used, it shall consist of a tube or pipe not less than 250 mm in diameter. All joints in the tube shall be watertight. The means of supporting the tremie tube shall be such as to permit free movement of the discharge end over the entire tip of the concrete and to permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie tube shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tremie tube shall be kept full.

When concrete is placed with a bottom-dump bucket, the bucket shall have a capacity of not less than one-half cubic metre and the top of the bucket shall be open. The bottom door shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when empty be withdrawn slowly until well above the concrete. The slump of the concrete used shall be maintained between 100 and 200 mm.

Dewatering shall proceed only when the concrete seal is considered strong enough to withstand any pressures to be exerted upon it. This time will be decided by the Engineer.

All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, jetting, chipping or other means that will not injure the seal unduly.

g) Construction joints - A concreting schedule shall be prepared for each completed structure and the Engineer shall approve the locations of construction joint on this concreting schedule. These locations shall not be altered, unless in case of emergency, when construction joints shall be positioned as directed by the Engineer.

At horizontal construction joints, gauge strips 20 to 30 mm square shall be placed inside the forms along all exposed surfaces to give the joints straight lines. Before placing fresh concrete, the surfaces of all construction joints shall be hammered with a sharp hand tool until the aggregate is exposed, cleaned and a small quantity of neat cement slurry added. At the same time forms shall be checked to see that they are tight against the concrete already in place. Concrete in substructures shall be placed in such manner that all horizontal construction joints will be truly horizontal.

Where vertical construction joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic. Special care shall be taken to avoid construction joints through wing walls.

h) Compaction of Concrete - Concrete shall be placed and consolidated by methods that will not cause segregation of the aggregates and will result in a dense homogeneous concrete which is free of voids and rock pockets. All concrete shall be placed while fresh and before it has taken initial set. Re-tempering any partially hardened concrete with additional water will not be permitted.

Mixed concrete, after being deposited, shall be consolidated until all voids are filled and free mortar appears on the surface. The concrete shall be placed as nearly as possible in its final position, generally in horizontal layers not more than 400 mm thick, except in the manufacture of prestressed concrete elements. The use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted.

For prestressed concrete elements the concrete shall be built up to the full depth of the section and the concrete face moved forward progressively.

With the exception of concrete placed as pipe culvert headwalls and endwalls, slope paving and aprons, and concrete placed under water, all concrete shall be consolidated by means of high frequency internal vibrators within 15 minutes or appropriate period of time approved by the Engineer after it is deposited in the forms.

The vibrators shall not be attached to or held against the forms or the reinforcing steel. The vibrating shall be done with care and in such manner that displacement of reinforcement steel is avoided. When concrete is inaccessible for adequate consolidation by other means, external vibrators shall be used and the forms shall be sufficiently rigid to resist displacement or damage.

The following conditions will apply when using internal vibrators:

- The number of vibrators to be used by the Contractor shall be not less than one for each 4 Cu-m of concrete placed per hour, with a minimum of 2 vibrators to be provided at any time.

- Vibrators shall be inserted vertically at successive positions not more than 450 mm apart and in a manner which ensures compaction of the concrete around the reinforcing steel and any other embedded fixtures, and into all parts of the forms.

- Vibration shall continue at each position until air bubbles cease to emerge from the concrete. The vibrators shall then be withdrawn slowly so as to avoid leaving a "pocket" or void in the concrete.

- Care shall be taken to ensure that newly placed concrete is vibrated into any fresh concrete adjacent to it to provide a homogeneous concrete mass.

- Vibration shall not be applied either directly or through reinforcement to any concrete which has taken its initial set.

Where external form vibrators are used for the manufacture of precast items, the number, type, spacing and method of support of the vibrators shall be approved by the Engineer. Internal vibration shall always be used in conjunction with external form vibration.

i) Marine and other Aggressive Environments - Concrete deposited against sea water or ground water containing sulphate concentrations shall be with 10 percent by weight extra to the amount of cement for the normal practice approved mixed design, mixed for a period of not less than 2 minutes. The water content of the mixture shall be controlled control and regulated so as to produce concrete of maximum impermeability.

No construction joints shall be formed between levels of extreme low water and extreme high water as determined by the Engineer. Between these levels sea water shall not come in direct contact with the concrete for a period of not less than 30 days. The original surface, as the concrete comes from the forms, shall be left undisturbed. The clear distance from the face of in-situ concrete to the nearest face of reinforcement steel shall not be less than 100 mm.

5.1.5.8 Curing

All concrete surfaces shall be kept wet for at least 7 days after placing. Bridge deck and sidewalk slabs shall be covered with wet burlap immediately after final finishing of the surface. This material shall remain in place for the full curing period or may be removed and replaced with sand when the concrete has hardened sufficiently to prevent marring. In both cases the materials shall be kept thoroughly wet for the entire curing period. All other surfaces if not protected by forms, shall be kept thoroughly wet, either by spraying water or by the use of wet burlap until the end of the curing period. If wood forms are allowed to remain in place during the curing period, they shall be kept moist at all times to prevent openings at joints.

The Contractor's proposals for the use of liquid membrane curing compound shall be subject to the approval of the Engineer, according to the requirements of sub-clause 5.1.3.8 Curing materials, item c). White pigmented liquid membrane, shall be used only on the top surfaces of bridge decks or on surfaces not exposed to view in the completed work. Clear curing compounds shall be used on other surfaces.

5.1.5.9 Removal of Formwork and Falsework

a) General - Formwork shall be constructed such that the side forms of members can be removed without disturbing the soffit forms and, if props are to be left in place when the soffit forms are removed, the props shall not be disturbed during striking. All formwork shall be removed without damage to the concrete.

b) Time of removal - Forms and falsework shall not be removed without the approval of the Engineer. The Engineer's approval shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the same time as the forms and in no case shall any portion of the wood forms be left in the concrete.

   Forms used on exposed vertical faces shall remain in place for periods that shall be determined by the Engineer.

   Falsework and forms under slabs, beams, girders, and arches shall remain in place for 14 days after the day on which placing of concrete was completed. When high early strength cement is used, forms for all structures may be removed after less than 14 days but only with the written approval of the Engineer who will decide the time for removal as a result of tests. Formwork and falsework for the whole of suspended span bridges and other special structures shall remain in place until such time as the Engineer will decide after all concrete has been poured.

c) Patching - As soon as the forms are removed, all wire or metal devices used for securing the formwork which project from or appear on the surface of the finished concrete shall be removed or cut back at least 25 mm from the finished surface of the concrete. All holes and pockets so formed shall be filled with cement mortar mixed in the same proportions as the fine aggregate to cement of the concrete mix used for that particular section of the structure, after the surface to be patched has been thoroughly cleaned and wetted to receive the patch.

d) Cause for rejection - Excessive honeycombing shall be sufficient to cause rejection of portions of the structure containing this honeycombing. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure at his own expense.

5.1.5.10 Finishing Concrete

All concrete surfaces exposed in the completed work shall comply with the requirements of c) below except where the Drawings indicate otherwise.

a) Concrete decks - Immediately after placing concrete, concrete decks shall be struck off with templates to provide proper crowns and shall be finished smooth to the correct levels. Finish shall be slightly but uniformly roughened by brooming. The finished surface shall not vary more than 3 mm from a 3 metre straightedge placed parallel to the centreline of the roadway and 3 mm from a transverse template cut to the true cross section of the road way.

b) Curb and sidewalk surface - Exposed faces of curbs and sidewalks shall be finished true to lines and grades. The curb surface shall be wood floated to a smooth but not slippery finish. Sidewalk surfaces shall be slightly but uniformly roughened by brooming.

c) Ordinary finish - An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holes left by form ties have been filled, and any minor surface defects have been repaired. The surface shall be true and even free from depressions or projections.

   The concrete in bridge seats, caps, and tops of walls shall be struck off with a straightedge and floated to true grade. Under no circumstances will the use of mortar topping for concrete surfaces be permitted.

d) Rubbed finish - After the removal of forms the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in patching to have thoroughly set. A medium coarse carborundum stone shall be used for rubbing a small amount of mortar on the face. The mortar used shall be composed of cement and fine aggregate mixed in the same proportions as those used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time. The final finish shall be obtained by rubbing with a fine carborundum stone and water until the entire surface is of a smooth texture and uniform colour.

   After the final rubbing has been completed and the surface dried, burlap shall be used to remove loose powder. The final surface shall be free from unsound patches, paste, powder and objectionable marks.

   All surfaces on the superstructure visible to the eye of a passing motorist or pedestrian such as interior and exterior parapet surface, barrier, hand railing, abutment, pier and walls should comply with the finish requirements of paragraph d) "Rubbed Finish".

5.1.5.11 Loading

No superstructure load shall be placed upon finished bents, piers, or abutments until the Engineer so directs but in no case shall any load of any kind be placed until the Contractor has completed curing. The Contractor shall not place any temporary loads on deck slabs. Bridge deck slabs shall be opened to traffic only when so directed by the Engineer and generally not sooner than 28 days after the placing of the concrete has been completed.

Concrete shall at no time be subjected to a combination loading including its own weight and a live load which will induce a compressive stress in it exceeding 0.33 of its compressive strength at the time of loading or of the specified 28 day strength. The assessment of the strength of the concrete and the stress produced by the loads shall be subject to the agreement of the Engineer.

5.1.5.12 Backfill to Structures

All spaces which have been excavated and the volumes of which are not occupied by the concrete structure shall be backfilled and compacted with acceptable material in accordance with the provisions of Section 2.5 of these Specifications or as directed by the Engineer, but not before the damp proofing has been applied onto the concrete surfaces which remain permanently in contact with the ground, in accordance with Section 5.7 Damp proofing and Waterproofing of these Specifications.

5.1.5.13 Cleaning up

Upon completion of structure and before final and acceptance, the Contractor shall remove all falsework, falsework piling etc., down to 0.5 metres below the finished ground line. Excavated, or useless materials, rubbish etc., shall be removed from the site and the site shall be left in a neat and presentable condition satisfactory to the Engineer.

5.1.5.14 Approach Slab

Reinforced concrete bridge approach slabs shall be constructed to the lines, elevations and dimensions as shown on the Drawings or as directed by the Engineer.

Concrete for approach slabs shall be as designated in sub-clause 5.1.2.2 of these Specifications and described in these Specifications. Steel reinforcement shall be deformed bars conforming to the requirements of Section 5.2 of these Specifications.

5.1.5.15 Repair of Existing Reinforced Concrete Bridge

Repairing or rehabilitation works of deteriorated parts of the existing bridges may be required. Types of repair works and the locations of the bridges to be repaired are shown on the Drawings. The types of repair may be classified as follows:

Type 1 : Bracing Improvement at Pile Bent

The details and adequacy of temporary bracing to be provided to the existing piles shall be approved by the Engineer.

Demolition of the deteriorating bracing shall be handled with care in such a way not to cause any damage to the existing embedded steel bars and the existing piles. The exposed reinforcement steel shall be cleaned to remove rust and other deleterious materials. After cleaning, the reinforcement may be left exposed for not more than 3 days.

Bracing shall be cast using Class B1 concrete with Type III cement and the method of placing concrete shall be in accordance with sub-clause 5.1.5.7 of these Specifications.

Once the concrete has already been placed, the speed of vehicles running over the bridge shall be restricted, upon the instruction of the Engineer, so as to lessen the possible vibration being imparted to the newly-cast members.

The temporary bracing provided shall be removed not less than 7 days after placing of concrete.

Type 2 : Repair of Spalling Surface

The honeycombed or spalling surface area shall be chiselled off, and unsound concrete shall be removed until sufficiently strong concrete is found. A concrete surface pre-treatment method using wire brush or steel-wire broom may be used. The treated surface shall then be filled with non-shrink mortar.

Type 3 : Improvement of Pile surface

Unsound concrete forming part of the pile surface shall be removed, pre-treated and filled with concrete Class A. Concrete shall be made of Type III cement.

Type 4 : Crack Repair

Cracks present on the structures shall be repaired by chipping off concrete along the crack pattern as shown on the Drawings and sealing the pre-treated area by non-shrink mortar.

Type 5 : Transverse Expansion Joint Improvement

After removal of the existing joint filler, the expansion joint shall be cleaned and filled with new joint filler. Sealant of half the gap-width thick shall be used with the full-depth primer along both sides, and debonding material (e.g. masking tape) laid underneath. The materials used for the repair shall conform to clause 5.10.2 of the Specifications. The repairing work should be carried out in such a way that the traffic suffers minimum disturbance.

The defective part of the existing pile or column, including 0.30 m. extension from both ends shall be properly pre-treated and cleaned before the casting or strengthening reinforced concrete sleeve is commenced. Concrete Class A1 with Type III Cement shall be used. sub-clause 5.1.5.7 of these Specifications shall be followed to ensure good quality concrete.

5.1.5.16 Construction Tolerances

The construction tolerances for concrete works shall be as follows:

(a) Setting out:

spread footings, pile caps, pier columns and stems, pier heads	: ± 10 mm,
horizontal alignment of pier columns and stems	: ± 10 mm,

(b) Dimensions:

length of concrete members (beams & slabs):	
overall length up to 6 m	: - 0 and + 5 mm,
overall length over 6 m	: - 0 and + 15 mm,
distance between beams, columns, walls, etc..	: ± 10 mm,
width, depth & thickness (beams & slabs)	: - 0 and + 5 mm,

out-of true: deck slab surfaces shall not have an out-of-true greater than 5 mm under a 1 m straightedge and 10 mm under a 3 m straightedge,

(c) Shape:

squareness (difference in diagonal lengths)	: 10 mm,
straightness or bow (deviation of intended line)	
for length up to 3 m	: 12 mm,
for length from 3 m to 5	: 15 mm,
for length over 5 m	: 20 mm,

(d) Verticality:

plumb alignment for pier columns or stems, and walls	: ± 10 mm,

(e) Elevation:

top of driven piles	: ± 10 mm,
top of blinding concrete	: ± 10 mm,
top of pile caps, footings, pier columns, beams and deck slabs	: ± 10 mm,
top of bearing pedestals	: ± 5 mm.

5.1.6 MEASUREMENT

Unless specified otherwise, concrete shall be measured by the number of cubic metres of each class of concrete complete in place and accepted. In computing quantities the dimensions used shall be those shown on the Drawings or ordered in writing by the Engineer, but the measurement shall not include any concrete used for the construction of temporary works or which is included in other billed items. No deduction from the measured quantity shall be made for drainage openings, pipes less than 300 mm in diameter, conduits, chamfers, reinforcement bars and supports, wire mesh, expansion joints except expansion joint recesses in precast work, water stops, pile heads embedded in concrete.

The quantities of reinforcing steel and other items as shown in the Contract Documents which are included in the completed and accepted structure shall be measured for payment as described for the separate items listed in the Bill of Quantities.

Formwork, scaffoldings and surface finishes shall not be measured separately but shall be deemed to be an integral part of the concrete items.

Concrete piles shall be measured by linear metre in accordance with the provisions of Clause 5.3.4 of these Specifications.

Prestressed Concrete Deck Units shall be measured by individual unit in accordance with the provisions of Clause 5.4.4 of these Specifications

Grouting of ducts for prestressing tendons shall not be measured separately but shall be deemed to be an integral part of the prestressed concrete unit.

5.1.7 PAYMENT

This work measured as described in sub-clause 5.1.6(a) above for the class or classes of concrete specified shall be paid for at the Contract unit price per cubic metre of concrete as

detailed below. The payment shall be full compensation for furnishing and placing all materials, including all trial mixes of concrete including related material testing, labour, tools, equipment, forms, scaffoldings, casting, finishing and incidentals thereto including the provision and construction of drainage falls and system, weepholes and pockets, any pipes less than 300 mm in diameter, and furnishing and placing of joint fillers and miscellaneous metal devices unless they are covered by other items in the Contract.

Concrete Piles will be paid for in accordance with the provisions of Clause 5.3.5 of these Specifications

Prestressed Concrete Deck Units will be paid for in accordance with the provisions of Clause 5.4.5 of these Specifications

Reinforcing steel and prestressing steel including all works related thereto will be paid for in accordance with the terms laid down in Section 5.2 and Section 5.4 respectively.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
5.1(2)	Concrete Class A2 (40 MPa – 19mm)	Cubic metre
5.1(3)	Concrete Class B1 (30Mpa – 19mm)	Cubic metre
5.1(4)	Concrete Class B2 (30Mpa – 37.5mm)	Cubic metre
5.1(5)	Concrete Class D (20Mpa – 19mm)	Cubic metre
5.1(6)	Concrete Class E (50mm)	Cubic metre

5.2 REINFORCEMENT

5.2.1 DESCRIPTION

This work shall consist of furnishing and placing reinforcement bars of the grade, type, and size shown in accordance with these Specifications, and in conformity with the requirements shown on the Drawings.

5.2.2 MATERIALS REQUIREMENTS

5.2.2.1 Bar Reinforcement

Bars for concrete reinforcement shall conform to the material properties specified in AASHTO M 31M, Deformed and plain billet-steel bars for concrete reinforcement, Grades 300 and 400. Deformed bars shall be of Grade 400, plain round bars shall be of grade 300. Bars shall be of diameters 6 mm, 8 mm, 10 mm, 12 mm, 16 mm, 20 mm, and 25 mm, unless otherwise agreed by the Engineer.

5.2.2.2 Wire and Wire Mesh

Wire shall conform to the requirements of AASHTO Standard Specification M 32 -Cold Drawn Steel Wire for Concrete Reinforcement.

Wire mesh shall conform to the requirements of AASHTO Standard Specification M 55 - Welded Steel Wire Fabric for Concrete Reinforcement.

5.2.2.3 Bar Mat Reinforcement

Bar mat reinforcement for concrete shall conform to the requirements of AASHTO Standard Specification M 54 - Fabricated Steel Bar or Rod Mats for Concrete Reinforcement.

5.2.2.4 Binding Wire

Unless otherwise permitted by the Engineer all intersecting bars shall be tied together and the ends of the tying wire turned into the main body of the concrete.

Reinforcement binding wire shall conform to an international standard acceptable to the Engineer.

5.2.2.5 Standards

The AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, provides specifications in both Imperial and equivalent metric units. Therefore, steel manufactured to Imperial sizes may be substituted, subject to the approval of the Engineer, for steel designated in metric units, provided the sizes are equal or larger, or that the equivalent cross sectional area of steel is provided, with the requirement that all other necessary properties meet the specifications.

5.2.2.6 Bar Lists

When so required by the Engineer, copies of a list of all reinforcement steel shall be furnished to the Engineer at the site of the work before the placing of reinforcement steel is begun. Furnishing such lists to the Engineer shall not be construed to mean that the lists will be reviewed for accuracy. The Contractor shall be wholly and completely responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel in accordance with the details shown on the Drawings and as specified by the Engineer.

5.2.2.7 Ordering Material

The Contractor shall submit the name of the proposed supplier (or suppliers) of the reinforcement and necessary information concerning the supplier as soon as possible to the Engineer for his approval.

Copies of orders placed shall be submitted to the Engineer.

The manufacturer shall submit all requested relevant data on the steel, i.e. breaking strength, yield strength, characteristics on elongation, chemical composition etc., to the Engineer for his approval.

No steel shall be delivered without a certificate guaranteeing the yield stress.

Reinforcing steel shall be shipped in standard bundles. Each bundle shall be tagged and marked at the mill showing the name of the mill and the melt or heat number.

If purchased in small lots from a dealer, reinforcement may be accepted at the discretion of the Engineer, upon proof that it meets the requirements of these Specifications.

The steel shall be stored and marked in a way that later enables identification of the steel corresponding to each certificate.

5.2.2.8 Tests

Tension and bend tests shall be required from the Contractor in addition to the tests carried out by the manufacturer and specified above.

The Contractor shall cut out samples as directed by the Engineer.

The samples shall be tested according to the Engineer's instructions by an approved Testing Institution. Expenses incurred in connection with cutting out and transport and testing of the samples shall be born by the Contractor. Approximately one sample shall be tested from each 10 tonnes of reinforcement delivered to the site.

5.2.3 CONSTRUCTION REQUIREMENTS

5.2.3.1 Inspection, Protection and Storage

Each bundle of steel shall be tagged at the mill with an identifying mill tag showing the name of the mill and the melt or heat number. The Contractor shall also make available for review, when requested by the Engineer, a copy of the certified mill test report for each heat and size of reinforcing steel showing physical and chemical analysis.

Reinforcement for structures shall be handled and stored in a manner that will prevent bending out of the desired shape and the unnecessary accumulation of dust, oil and paint. All reinforcing steel shall be stored under cover and protected from the weather, and no reinforcing steel shall be stored in direct contact with the ground nor with water.

Before concrete is placed, the reinforcement to be embedded shall be free of mortar, oil, dirt, loose mill scale and loose rust, and other coatings of any character that would destroy or reduce the bond.

5.2.3.2 Cutting and Bending

Bars shall be cut and bent cold to the dimensions indicated and with equipment and methods approved by the Engineer.

Stirrups and tie bars shall be bent around a pin having a diameter not less than two times the minimum thickness of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness except for bars larger than 30 mm in which case the bends shall be made around a pin of eight bar diameters. Hooks shall conform to American Concrete Institute Standard Building Code Requirements for reinforced concrete (ACI 318), Section 906, or as shown on the Drawings.

Reinforcement shall conform accurately to the dimensions shown on the Drawings. Bars shall not be bent and straightened in a manner that will injure the material. In particular it shall not be authorised to straighten back deformed bars which have been previously bent. Bars with kinks or improper bends shall not be used.

All reinforcement bars shall be sheared; flame cutting will not be permitted unless approved by the Engineer.

5.2.3.3 Placing, Supporting, and Fastening

All bar reinforcement shall be placed, supported, and secured before the beginning of concreting operations. The reinforcement shall be checked and approved by the Engineer before placement of concrete begins. The minimum spacing of bars shall not be less than 1.33 times of the maximum particle size of the coarse aggregate. Laying or driving bars into the concrete after placement will not be permitted. All horizontal reinforcement shall be supported on metal supports or mortar blocks of approved shape with tie wires embedded in them made out of Portland cement and sand in the ratio of 1 to 3 by weight. Supports that are in contact with the external face of the concrete will all be mortar blocks. The use of small stones or wood blocks will not be permitted. The reinforcement shall be held securely in place at the exact position and at the exact spacing as indicated on the Drawings by the use of wire ties at bar intersections, supports and spacer blocks.

Wire ties shall be securely tied and folded so that they do not project beyond the planes formed by the reinforcing bars. The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Engineer.

The concrete cover shall be in accordance with the requirements of the AASHTO LRFD Bridge Design Specifications, Section 5, Table 5.12.3-1, unless otherwise indicated in the Drawings.

5.2.3.4 Splicing

Reinforcement shall be furnished in the lengths indicated on the Drawings. Lap splicing except where shown on the Drawings will not be permitted without written approval from the Engineer, and if additional lap splices are used the additional weight occasioned by such lap splices with not be included in the measurement of reinforcement for payment.

All splices shall have a lap length of not less than 40 diameters of the bars for tensile reinforcement and 32 diameters for compressive reinforcement or as shown on the Drawings. Lap splices shall generally be located at points of minimum tensile strength. Except where otherwise shown on the Drawings lap splices shall be made with the bars placed in contact and wired securely together.

Welding of reinforcing steel shall not normally be permitted and shall only be done if detailed on the Drawings or approved in writing by the Engineer. Before the Engineer will approve of welding, the Contractor shall submit such samples as the Engineer may require for testing and make allowance for the time elapsing before test results are available.

Welding of reinforcing steel, if permitted, shall conform to the Structural Welding Code AWS DI.4 of the American Welding Society and applicable special provisions and shall only be done where shown, specified, or permitted by the Engineer. Every welder shall posses a welding certificate issued by an internationally recognised authority acceptable to the Engineer.

5.2.3.5 Substitutions

Substitution of different size bars will be permitted only with specific authorisation by the Engineer. If steel is substituted, it shall have a cross sectional area equivalent to the design area or larger.

5.2.3.6 Working Drawings

The Contractor shall provide, in the case of substitutions, at his own expense and to the approval of the Engineer, Working Drawings of all reinforcement accompanied by bending schedules and copies of orders placed for bars.

5.2.4 MEASUREMENT

The quantity of reinforcement to be measured under this section shall be the computed weight in tonnes of material used and accepted as shown on the Drawings provided that the quantity shall not include the reinforcement in any item of work for which the basis of payment includes the reinforcement. In computing the weight to be measured, the theoretical weights of bars of the cross section shown on the Drawings or authorised, shall be used. These weights are given in Table 5.2.1.

Table 5.2.1 Unit Mass of Reinforcing Bars

Bar Size (mm)	6	8	10	12	16	20	25
Weight (kg/m)	0.222	0.394	0.617	0.888	1.578	2.466	3.853

The computed weight shall not include the extra material incurred when bars larger than those specified are used, or the extra material necessary for splices when bars shorter

than those specified are used with the permission of the Engineer, or the weight of any devices used to support or fasten the reinforcement in correct position.

The computed weight shall include the extra material necessary for splices when bars longer than 12 m are used.

Spirals that form an internal part of anchorages shall not be measured. They shall be included in the cost of the prestressing reinforcement.

5.2.5 PAYMENT

Bar reinforcing steel, placed as shown on the Drawings or as directed by the Engineer, will be paid for at one Contract unit price per tonne of reinforcement for the particular Bill Item listed below, which price shall include furnishing all labour, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing the bar reinforcing steel, complete in place.

Full compensation for furnishing all tie wires, blocks, chairs, dowel caps, debonding and other supporting devices shall be considered as included in the Contract unit price paid for reinforcement and no separate payment will be made therefore.

Full compensation for furnishing and testing sample splices, and furnishing access facilities to permit the Engineer to perform the tests, shall be considered as included in the Contract unit price paid per tonne for the bar reinforcing steel involved and no additional compensation will be allowed.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
5.2(1)	Grade 300 Plain Reinforcing Bar	Tonne
5.2(2)	Grade 400 Deformed Reinforcing Bar	Tonne
5.2(3)	Wire Mesh Reinforcement	Tonne

5.3 DRIVEN PILES

5.3.1 DESCRIPTION

This work shall consist of furnishing and driving precast reinforced concrete, precast prestressed concrete, or timber piling in accordance with these Specifications and in conformity with the requirements on the Drawings or elsewhere in the Contract Documents.

5.3.2 MATERIALS REQUIREMENTS

5.3.2.1 Precast Reinforced Concrete Piles

a) General - Piles shall be constructed, in accordance with the details shown on the Drawings, of concrete classes specified, proportioned, mixed and placed in accordance with the provisions of Section 5.1, Concrete of these Specifications.

The pile shall be straight such that a line stretched from tip to butt on any face will not be more than 1/1000 of the length of the pile from the face of the pile at any point.

b) Formwork - Forms for precast concrete piles shall conform to the general requirements for concrete formwork as described in Section 5.1 of these Specifications. Forms shall be accessible for compacting the concrete. Side forms may be removed at any time not less than 24 hours after completion of the placing of concrete but the entire pile shall remain supported for at least 7 days and shall not be subjected to any handling stress until the concrete has been in place for 21 days or such reduced time as the Engineer may decide as a result of tests.

c) Reinforcement - Reinforcement shall comply with the provisions of Section 5.2 of these Specifications and shall be positioned as shown on the Drawings. Main reinforcing bars shall be supplied in one complete length and, should this prove impracticable, effectively spliced by a method approved by the Engineer.

d) Pile shoes - Shoe bases where used shall consist of "chilled hardened" high duty cast iron, free from sand, honeycombing or porous places, air holes or other defects. Straps shall be of mild steel or wrought iron cast into the base and shall run continuously through it. All shoes shall be fitted to the reinforcement as shown on the Drawings.

e) Casting - The piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycomb or other defect.

Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screeded off, and the top surfaces finished to a uniform, even texture similar to that produced by the forms.

f) Finish - When removed from the forms piles shall present true, smooth, even surfaces free from any surface blemishes, and true to the dimensions shown on the Drawings.

g) Curing - Concrete piles shall be covered with wet burlap immediately after placing is completed and shall be kept continuously wet for at least 7 days.

h) Handling - When raising or transporting precast concrete piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile or cracking of the concrete. No concrete pile shall be lifted otherwise than by slinging from the lifting holes, the positions of which shall be as directed or approved by the Engineer. Piles damaged in handling or driving shall be replaced. Concrete piles shall be so handled at all times to prevent breaking or chipping the edges.

i) Driving - Piles shall not be driven until 28 days have elapsed from the time of casting or such reduced time as the Engineer may decide as a result of tests.

5.3.2.2 Precast Prestressed Concrete Piles

a) General - Piles shall be constructed in accordance with the details shown on the Drawings, of prestressed concrete as specified proportioned, mixed and placed in accordance with the provisions of Section 5.4 Prestressed Concrete of these Specifications.

The pile shall be so straight that a line stretched from tip to butt on any face will not be more than 1/1000 of the length of the pile from the face of the pile at any point.

b) Formwork - The formwork shall be sufficiently rigid not to deform during the placing and compaction of the concrete and shall be sufficiently tight to prevent loss of water from the concrete.

The casting bed shall be adequately supported to prevent any settlement that might cause cracking of the concrete. If the pile is to be stressed on the casting bed, provision shall be made for the elastic shortening of the concrete under prestress and for the transfer of dead weight after stressing.

All rubbish shall be removed from the interior of the forms before concrete is placed. The faces of the formwork in contact with the concrete shall be cleaned and treated with form oil approved by the Engineer.

Side forms shall be removed as soon as possible after the concrete has set to avoid shrinkage cracks. The pile will not be moved until after the pile has been stressed. All formwork will be removed in such a way as to ensure no damage is done to the concrete.

c) Prestressing Steel - All prestressing steel shall comply with the provisions of Section 5.4 of these Specifications. All prestressing steel shall be free from loose mill scale, loose rust, oil, grease, or other harmful matter at the time of fixing and of placing concrete. Steel shall not be pitted.

All prestressing steel shall be stored in a suitable weather-proof shed and protected from dampness.

Coils of prestressing wire or strand shall be obtained from the manufacturer in sufficiently large diameters to ensure the wire or strand running off the coils is straight.

Wires, strands, or bars shall be accurately positioned and maintained in position, both vertically and horizontally as shown on the Drawings.

All cutting to length and trimming of ends shall be done by suitable mechanical means. Care shall be taken if flame cutters are used with the Engineer's permission, to ensure that the flame does not come into contact with other stressed wires or strands and that

overheating of the wire or strand to be cut does not occur where the wire or strand is to be stressed.

d) Reinforcement - Ordinary reinforcement steel shall be in accordance with the provisions set out in Section 5.2 Reinforcement of these Specifications and positioned as shown on the Drawings.

e) Casting - The piles shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a pile free from any air pockets, honeycomb or other defect.

Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be slightly overfilled, the surplus concrete screeded off and the top surfaces finished to a uniform, even texture similar to that produced by the forms.

f) Tensioning Procedure - Tensioning shall be carried out only in the presence of the Engineer unless prior permission has been granted the Contractor by the Engineer to proceed without the supervision of the Engineer.

As used here the work “tendon” shall be defined as any single prestressing element used to apply prestressed forces to the concrete. For pretensioning this shall be each strand or straight wire.

All tendons to be stressed in a group shall be brought to a uniform tension of approximately 500 kilograms per tendon prior to being given their full tension. After this initial stressing the group shall be stressed to a total tension as required on the Drawings by means of hydraulic jacks or other approved appliances equipped with gauges graduated to read directly to one percent of the total load applied, and calibrated to measure accurately the stress induced in the steel. The induced stress shall be measured by elongation of the tendons and checked by gauge pressure. The results obtained shall be within five percent of each other.

Means shall be provided for measuring the elongation to an accuracy of one millimetre in twenty metres of length between jacking heads. In the event of apparent discrepancies of more than five per cent between stresses indicated by gauge pressure and elongation, the entire operation shall be checked carefully and the source of error determined and corrected before proceeding further.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the tendons.

g) Curing - Curing of the concrete shall be commenced prior to the formation of surface shrinkage cracks and as soon as the concrete has hardened sufficiently to prevent injury.

The pile shall be covered with wet burlap or membrane curing compound as an interim measure to elevated temperature curing.

Precast, pretensioned members shall be cured continuously, until the concrete strength, as indicated by compressive tests on 300 mm x 150 mm diameter cylinders has reached the “Release Strength”. Curing then may be interrupted for a time interval of not more than two hours for removal of the piles from the casting bed to a curing area. Curing operations shall then be resumed for an additional 48 hours.

h) Release - For precast pretensioned members the tendon stress shall be maintained between anchorages until the concrete has reached a compressive strength equal to the "Release Strength "specified on the Drawings as determined by compressive tests on 300 mm x 150 mm diameter cylinders. After strength requirements are attained, the tension in the tendons shall be gradually and simultaneously released and the tendons cut off as required in such a way as to prevent shock. It shall be the Contractor's responsibility to transfer the prestress safely and to the Engineer's satisfaction in all respects.

When elevated temperature curing is used, the release of stress shall be prior to the beginning of temperature reduction. Piles shall remain protected until there is a differential of temperature inside the curing jacket and air temperature of not more than 8 ^{0}C.

i) Finishing - At the ends of piles a recess shall be cut around each tendon to allow cutting off the tendon and filling the recess with grout so that the cover to the end of the tendon is not less than 20 mm.

Piles shall present true, smooth, even surfaces free from any surface blemishes and true to the dimensions shown on the Drawings.

5.3.2.3 Timber Piles

a) General - Unless otherwise required by the Drawings or by these Specifications, timber piles may be of any species of timber that will withstand driving and support the loads imposed. The minimum diameter at the centre of the pile, that is midway between tip and butt shall not be less than the dimension shown on the Drawings. Sawn timbers used as piling shall conform to the dimensions shown on the Drawings.

Piles shall be of sound wood, straight grained free from decay, unsound knots, splits, shakes or any other defects. Piles shall be peeled of all bark and a straight line from the centre of the butt to the centre of the tip shall lie entirely within the body of the pile.

b) Treatment - Where treated piles are called for on the Drawings they shall be pressure treated with creosote or creosote coal tar solutions in accordance with the methods defined by the American Wood-Preservers' Associations Treatment Standards.

c) Storage and Handling - The method of storing and handling shall be such as to prevent injury to the piles. Special care shall be taken to prevent breaking the surface of treated piles and cant-hooks, dogs, or pike-poles shall not be used. Any cuts or breaks which may result from the use of chains shall be given three brush coats of hot creosote oil of approved quality and hot creosote oil shall be poured into all bolt holes.

5.3.2.4 Auger Press Piles

Unless otherwise shown on the Drawings, auger press piles shall be precast prestressed concrete piles of hollow square or circular cross sections. All piles specified on the Drawings as predrilled shall be installed by semi auger press technique. They shall be auger pressed to a depth approximately 4 to 5 m above the specified pile tip elevation. They, then, shall be driven to the required pile tip elevation.

Excavated material shall be removed from the site at the Contractor's expense.

5.3.3 CONSTRUCTION REQUIREMENTS

5.3.3.1 Preparation for Driving

(a) Abutments - Abutment piles shall be driven from a working surface that extends up to the underside of the pile cap and out to the finished slopes around the abutment. The working surface shall form part of the permanent embankment, and shall be constructed to the relevant specifications in Section 2.6 of these Specifications. Under no circumstances will the Contractor be permitted to complete this part of the embankment after the piles have been driven.

(b) Pile Cushions - The heads of all concrete piles shall be protected by cushions of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a helmet which in turn supports a shock block of timber or other suitable material.

(c) Splicing Piles - Full-length piles shall be used where practicable. In exceptional circumstances splicing of piles may be permitted. The method of splicing shall be as shown on the Drawings or as approved by the Engineer.

5.3.3.2 Methods of Driving

a) General - Reinforced concrete piles may be driven using a drop hammer, single or double acting steam hammer, or a diesel hammer. The Contractor will provide a suitable hammer of sufficient weight and/or energy capable of installing each pile to the required penetration and to control the hammer and/or energy to ensure that no pile is damaged during driving.

In case the required penetration cannot be obtained by the use of a hammer complying with the above minimum requirements, the Contractor shall provide a heavier hammer, or resort to jetting at his own expense.

b) Leaders - Pile driver leaders shall be of approved design and constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to ensure support to the pile during driving. Except where piles are driven through water, the leaders shall be of sufficient length so that the use of a follower will not be necessary. Inclined leaders shall be used in driving batter piles, and shall provide sufficient lateral support for the pile so that no undue stresses are induced in the pile during driving.

c) Follower - The driving of piles with a follower shall be avoided if practicable and shall be done only with written permission of the Engineer. When a follower is used, it shall be fabricated from steel of approved type and size, and one pile from each group of 10 shall be a long pile driven without the follower and shall be used as a test pile to determine the average load carrying capacity of the group. Expenses incurred in connection with the testing of piles shall be born by the Contractor.

d) Water Jets - When water jets are used, the number of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 7 kilograms per square centimetre pressure at 20 mm jet nozzles. Before the desired penetration is reached, the jets shall be withdrawn and the piles shall be driven with the hammer to secure the final penetration.

e) Accuracy of Driving - Piles shall be driven with a deviation of not more than 1^0 from the vertical or from the batter shown on the plans. After driving, the positions of the pile heads shall not deviate by more than 80 mm from the positions shown on the Drawings. The centre of gravity of any row of piles shall be within 50 mm from its theoretical position in any direction.

f) Defective Piles - The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, will not be permitted. Any pile damaged by reason of internal defects, or by improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer:

- A second pile or piles shall be driven adjacent to the defective pile.
- The pile shall be built up or extended or a sufficient portion of the footing extended to properly embed the pile as approved by the Engineer.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again to their previous elevations.

g) Cutting Off Piles - Piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Drawings. Precast Concrete piles may be cast the full length of the reinforcing bars, provided that the concrete is cut off to expose the reinforcement steels as shown on the Drawings after the piles have been driven.

All cut-off lengths of piling shall become the property of the Contractor. Cut-off lengths of piling may be incorporated in the work if approved in writing by the Engineer, otherwise pile cut- off lengths shall be disposed of to the satisfaction of the Engineer

5.3.3.3 Determination of Bearing Capacity of Pile

a) General - All piles shall be driven to such depths or sets as may be required to obtain the necessary allowable bearing value. The Engineer will decide on the criteria for when this value has been achieved, based on load tests or the driving records. He will choose a factor of safety dependent on the uniformity of the foundation conditions, but the required ultimate load will generally be two and a half times the working load for loading tests, or three times or more the working loading when determining the final set of the pile according to the specified driving formula.

b) Test Piles - The lengths of piles shown on the Drawings are based on information that it has been possible to obtain from a site investigation prior to the driving of test piles.

If no lengths of piles are shown on the tender drawings the required pile size and length will be determined by the Engineer following completion of the additional soil investigation to carried out by the Contractor prior to the driving of test piles.

Before the driving criteria are finally settled, the Contractor shall construct to the lengths specified by the Engineer such pilot piles as may be found necessary and these piles shall be driven in the positions and to the set specified by the Engineer, who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of pilot piles throughout the full depth of driving, as specified in (e) below.

Based on the results of the pilot piles, the Engineer will choose one or more locations for pile loading tests that shall be carried out prior to driving production piles

c) Static Load Tests - The Engineer may require one or more static loading tests at each bridge location. At the start of the Project, the Contractor shall therefore submit to the Engineer detailed drawings of the equipment and arrangement he intends to use for loading tests. The equipment shall be designed to apply loads in smooth increments up to at least 3 times the working load specified in the drawing. If the Contractor proposes to use tension piles for the load reaction, such tension piles shall be of the same type and size as the permanent piles and shall be driven in the location of permanent piles. Loads for the load test shall not be applied until 10 days or such time as directed by the Engineer have elapsed since the driving of the piles.

Tension piles will require strengthening with extra steel to carry the tension loading. The Contractor shall submit drawings to the Engineer showing the extra reinforcement and method of transferring the load between the piles and loading frame. A minimum of 3 pile diameters clear distance shall be allowed between the test pile and tension piles.

No particular payment will be made for any additional length supplied, cast or driven, or for any additional reinforcement of such piles that may be required for their use as tension piles, nor for any resumed driving that may be ordered by the Engineer, during or after the test, due to the piles having moved, or for repair of any damage caused during the test, such costs being considered incidental to load tests and paid for the structure itself.

Piles selected by the Engineer for static load test shall be tested as follows:

- The test load shall be applied by a method approved by the Engineer and shall be measured within the accuracy of 2 percent. Settlements shall be measured within an accuracy of 0.2 mm.
- The test load shall be applied in the increments of 25 percent of the working load of the piles.
- The load after each increment shall be kept constant until the rate of settlement does not exceed 0.2 mm per hour.
- The amount of settlement shall be recorded before the next increment of load.
- The full test load shall maintain on the test pile not less than 48 hours.
- The load shall be reduced in stages equal to those in which it was applied.
- The amount of recovery shall be recorded before the next decrement of load.
- The Contractor shall, within 24 hours of the completion of the test, submit to the Engineer for each pile tested graphs showing load and settlement plotted above and below a common base line of time; settlement and recovery plotted vertically against a base line of load.
- The ultimate bearing capacity of the pile shall be defined as that load where the gross settlement begins to exceed 1 mm per tonne of additional load, or which cause a gross settlement of 25 mm, whichever occur first.

d) Dynamic Load Tests - In addition to the static load test mentioned above, the Engineer may require one or more piles to be tested by the dynamic load test conforming to ASTM D4945.

This item of work requires a dynamic load to be applied by a pile hammer to a driven pile (restrike) or to a pile being driven, while transducers obtain measurements for predicting the static capacity of the pile. The dynamic load shall be applied to the pile by a pile hammer that is operating at its normal operating level. Waiting periods may be necessary so that soil set-up and relaxation characteristics can be determined.

The Contractor shall notify the Engineer of his intent to drive piles at least three days prior to the installation of the first pile and shall supply a his pile driving schedule. The Engineer shall determine if a test is to be performed or if some pile driving experience at the proposed site is to be obtained before a decision can be made. The Engineer will establish data for the tests and will also determine the location of all piles to be dynamically load tested.

The hammer selected for driving the test pile shall be used for driving all test piles. If the Contractor subsequently finds it necessary to use a different hammer, the Engineer will determine if an additional dynamic load test is necessary. Any such test shall be completed at no additional cost.

After the dynamic testing measurements have been obtained and analysed and the report in terms of ultimate capacity of piles has been submitted to the Engineer, the Engineer will provide instructions and guideline for driving the piles.

e) Driving Records - A record of all piles installed shall be kept by the Contractor and a copy of the record of each day's work shall be given to the Engineer within 24 hours. The record shall contain the following information:

- Date of Driving
- Date of Casting and Identification Number
- Location of Pile
- Length of Pile and Cross Section
- Ground Level before Driving
- Estimated Tip Elevation (as shown on the Drawings)
- Actual Tip Elevation after Driving
- Number of Blows for each 300 mm Penetration from Start of Driving
- Number of Blows for each 100 mm penetration from last 1.0 m
- Hammer Type, Weight and Rated Energy
- For Drop Hammer, the Actual Drop Height
- Details of Interruptions to Driving
- Details of Re-driving
- Details of condition of Pile Head

On completion of piling, the Contractor shall deliver to the Engineer a drawing recording the final depths of all piles relative to project elevations.

f) Driving Formula - To interpolate bearing capacities of piles between load test locations, or at locations where load tests have not been carried out, the ultimate capacity of piles may be calculated from the formula as shown on the Drawings.

In the event no formula is given in the Drawings, an acceptable pile driving formula can be used, subject to the Engineer's approval.

The working load of pile shall be calculated by applying the safety factor of 3.

5.3.4 MEASUREMENT

The unit of measurement for all types of piling will be the linear metre of pile furnished, driven and accepted in the structure. The pay lengths of the satisfactorily driven piles will be measured from the tip to the cut-off.

Cut off lengths will not be measured for payment. Load tests will be measured by number completed and accepted.

When concrete piles are extended, the length of the extension from the cut-off to the top of the extension shall be considered as concrete piling and will be added to the original length for measurement.

The cut-off elevation will be considered to be the level at the bottom of the pile cap whether the pile head is extended or not. If after driving of test piles or completing the pile tests for a particular structure the Contractor desires for his own convenience of pile rig utilisation to drive the other piles of the particular structure, before their tip elevations have been calculated and agreed upon, he may apply in writing to the Engineer to do so. The Engineer may approve this application provided that the Contractor agrees to re-drive the piles so driven at a later date if the calculated pile tip elevations fall lower than the elevations to which the piles were driven or, if the piles were over-driven to a lower elevation than those calculated from the pile load test, to accept payment to the pile tip elevation established by the pile load tests.

In the case of extending the pile bent above the lateral braced beam, the cut-off elevation will be considered to be at the bottom elevation of the braced beam if the Contractor chooses the option to cut-off piles at this level. The concrete and reinforcing steel in the braced beam as well as in the extended piles will in this case be ensured and paid for under unit rates specified in Section 5.1 of these Specifications.

The quantities of steel reinforcement required in concrete piling, including the length extending into pile caps, footings or braced beams, will not be paid for separately but will be considered as included in the Contract unit price per linear metre for concrete piles, unless otherwise specified by the Engineer.

5.3.5 PAYMENT

Reinforced concrete piles (RC) and prestressed concrete piles (PSC), of specified cross sectional dimensions, shall be paid for at the respective Contract unit prices per linear metre, complete in place, which prices shall include all materials, including reinforcement, hardware, furnishings, formwork, driving, jetting, in-place casing and in-fill material or pre-auger, cutting off, splicing, welding, coupling, and all related equipment including rigs, cranes, boilers, hammers, jets, leads and tools as well as labour and incidentals necessary for the satisfactory completion of the work.

Static and dynamic load tests on piles, completed and accepted, shall be paid for at the Contract unit price for each, which price shall include all equipment jacks, kentledge, frames, supports, precise measuring apparatus, survey instruments, miscellaneous tools, labour and incidentals necessary for the proper execution of the test.

No payment will be made for unauthorised, defective, unsound or unsatisfactorily driven piles or for any costs incurred by the Contractor for such piles.

Pay items will be as follows:

Item Ref	Description	Unit of Measurement
5.3(1) – 5.3(3)	RC Pile, _____mm x _____mm	Metre
5.3(4)	PSC Pile, _____mm x _____mm	Metre
5.3(5)	Timber Pile, _____mm x _____mm	Metre
5.3(6) – 5.3(8)	Static Load Test on RC Pile ____mm x _____mm	Number
5.3(9)	Static Load Test on PSC Pile	Number
5.3(10)	Static Load Test on Timber Pile	Number
5.3(11) – 5.3(13)	Dynamic Load Test on RC Pile ____mm x _____mm	Number
5.3(14)	Dynamic Load Test on PSC Pile	Number
5.3(15)	Dynamic Load Test on Timber Pile	Number

Partial payment for reinforced or prestressed piles, when acceptable to the Engineer and either delivered and stored or manufactured at the Contractor's camp near the project, may be allowed on the terms set forth in the Contract, but in no case shall be more than 75% of the unit price applicable for the pay item.

5.4 PRESTRESSED CONCRETE

5.4.1 DESCRIPTION

This work shall consist of the furnishing, transportation, storage and placing of prestressed concrete, stressed by pretensioning or post tensioning methods. It shall be in accordance with the details shown on the Drawings and as specified herein, also the work shall conform to the applicable requirements of Section 5.1 of these Specifications.

5.4.1.1 Definitions

Post tensioning is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned after the concrete is placed.

Pretensioning is defined as any method of prestressing concrete in which tensioned reinforcement is tensioned before the concrete is placed.

Prestressing reinforcement is defined as any reinforcement to which prestress is applied by post tensioning or pretensioning.

Non-prestressing reinforcement is defined as any reinforcement to which no prestressing tension is applied externally.

5.4.2 MATERIALS REQUIREMENTS

5.4.2.1 Cement

Cement shall conform to sub-clause 5.1.3.1, Portland Cement of these Specifications.

5.4.2.2 Water

Water shall conform to sub-clause 5.1.3.2, Water of these Specifications.

5.4.2.3 Admixtures

Admixtures or any other additions shall not be used except with the written approval of the Engineer.

The Contractor shall submit specifications and samples of any admixtures or additive that he proposes to use, to the Engineer at least 28 days before the commencement of construction or manufacture of the particular structure on which he intends to use such admixtures.

Any tests the Engineer may require on concrete mixes on account of the Contractor's proposal to use additives shall be carried out at the expense of the Contractor.

5.4.2.4 Coarse Aggregate

Coarse Aggregate shall conform to sub-clause 5.1.3.4, Coarse aggregate of these Specifications.

5.4.2.5 Fine Aggregate

Fine aggregate shall conform to AASHTO Standard Specification M 6.

5.4.2.6 Reinforcement-General

Non-prestressing reinforcement shall conform to the requirements of Section 5.2 Reinforcement of these Specifications.

Prestressing Reinforcement shall be high tensile strength steel wire, or high tensile strength steel strand, or high tensile strength steel bars.

5.4.2.7 Prestressing Reinforcement

High Tensile Strength Steel Wire - High Tensile Strength Steel Wire shall conform to the requirements of AASHTO M204 Uncoated Stress-Relieved Wire for Prestressed Concrete.

High Tensile Strength Steel Strand - High Tensile Strength Steel Strand shall conform to the requirements of AASHTO M203 Uncoated Seven-Wire Low Relaxation Stress-Relieved Strand for Prestressed Concrete. Strand shall be delivered in coils of sufficiently large diameter to ensure that it pulls off straight. They shall be stored clear of the ground and protected from the weather and any other potentially harmful effects.

High Tensile Strength Steel Bars - High Tensile Strength Steel Bars for prestressed concrete shall conform to AASHTO M275 Uncoated High Strength Steel Bar For Prestressing Concrete.

Prestressing reinforcement may be subject to such testing to prove its compliance with these Specifications as the Engineer may require. All coils of strand shall be capable of being identified with test certificates.

Copies of all manufacturer's test certificates shall be made available prior to the supply of any prestressing reinforcement

5.4.2.8 Voids

Non-circular voids shall be made from cellular polystyrene Grade SL to AS 1366.3

Circular voids shall be made from galvanised steel with a minimum wall thickness of 1.0 mm. The ends shall be sealed to stop the entry of water and grout into the voids.

5.4.2.9 Testing of Prestressing Reinforcement

Tensile tests shall be carried out on samples of wire and strand as required hereunder:

High Tensile Strength Steel Wire - Unless otherwise agreed upon between the manufacturer and the Engineer, one test specimen shall be taken from each 10 coils or less in a lot or batch.

High Tensile Strength Steel Strand - At least one specimen for test shall be taken from each 20 tonnes production lot of finished strand. Test specimens shall be cut from the outside end of reels or either end of coils of strand. Any specimen found to contain a wire joint should be discarded and a new specimen obtained.

The specimens shall be tested to determine compliance with the requirements of the relevant AASHTO Specifications.

5.4.2.10 Anchorage Assemblies

End anchorages shall be specially designed for prestressed concrete and must have been used on other similar work and thus have demonstrated proper functioning and durability for this purpose. The Engineer has the right to test to destruction one anchorage for each span or in the case of single span bridges, two anchorages. The anchorage shall be capable of holding the prestressing steel at a load of not less than 95% of the specified minimum tensile strength of the prestressing steel.

5.4.2.11 Mortar for Keyways

Mortar for filling in or between prestressed concrete members shall be of the following mix unless otherwise required in the Drawings, the Special Conditions, or by the Engineer:

Portland Cement	3 parts by weight
Sand	5 parts by weight
Water	1 part by weight maximum

The sand shall conform to the requirements of AASHTO Standard Specification M 45.

The mortar shall be mixed with the least amount of water necessary to produce a crumbly mix that is not plastic and can be placed to the satisfaction of the Engineer by being driven and/or tamped compactly into place to prevent any shrinkage.

5.4.2.12 Grout for Anchor Bolt Holes

Grout for anchor bolt holes shall be composed of one part of Portland Cement and up to one part of sand (passing a 0.600 mm sieve) by volume and sufficient water to make a grout that will flow freely. Grout shall be mixed only in quantities required for immediate use. That which is not used within 45 minutes of mixing shall be rejected. Retempering of grout will not be permitted.

5.4.2.13 Grout for Duct and Bonding Steel

Unless otherwise directed or approved by the Engineer as a result of grouting trials, the grout shall:

- consist of Portland Cement complying with all the requirements of AASHTO M85 and water conforming to AASHTO T 26.
- have a water/cement ratio as low as possible consistent with adequate workability and under no circumstances exceeding 0.45.
- not be subject to bleeding that exceeds 2 percent of the volume 3 hours after mixing nor an overall maximum of 4 percent. Bleeding shall be measured at 30 degrees C in a glass cylinder of internal diameter about 100 mm and a height of grout of about 100 mm. The cylinder shall be covered during the test to prevent evaporation.
- be introduced by grouting equipment that shall be capable of completing continuous grouting of one duct in no more than 20 minutes. Under normal conditions, grouting shall be accomplished within 20 calendar days following the installation of tendons.

5.4.2.14 Concrete

Concrete for all prestressing elements shall be Class A1 concrete conforming to the requirements of Section 5.1of these Specifications and the requirements specified below.

The Contractor shall develop his own mix designs which shall be submitted to the Engineer for approval. The use of cement other than Type 1 for the purpose of producing high strength at an early date shall be subject to the approval of the Engineer. The maximum size of aggregate for use in the manufacture of prestressed concrete shall be 19 mm.

5.4.2.15 Enclosures

All enclosures or ducting shall be metallic, corrugated and shall be mortar- tight. Adequate means, to the Engineer's approval, shall be employed to ensure that their locations are maintained exactly throughout the concreting operation. Enclosures or ducting shall be flexible enough to allow it to conform to the curved lines of the prestressing cables and yet rigid enough so that it does not sag between points of support in the formwork before and during the placing of concrete. The ducts or sheathings shall be 22 or 28 gauge galvanised or bright spirally wound or longitudinally seamed steel strip with flexible or semi-rigid seams and strong enough to maintain their shapes under such forces as will come upon them. The design shall be such that there shall be no leakage of cement paste into the space to be occupied by the steel.

The size of the duct shall follow the manufacturer’s recommendation, but shall be a minimum of 6 mm larger in internal diameter than the bar, cable, strand, or group of wires that they enclose. Ducts shall be provided with pipes or other suitable connections for the injection of grout under pressure, after the prestressing operations have been completed. Unless indicated on the Drawings 10 mm diameter vent and drainage holes shall be provided at all high and low points on cable profiles.

5.4.2.16 Moulds for Prestressed Concrete Work

Moulds shall be made of metal and shall be substantial enough so that they shall not deflect beyond the tolerance limits during casting. Chamfers shall be straight and true to shape and line.

Core for forming transverse holes in the finished work, or other forming devices which would restrict longitudinal strains in the member shall be loosened so that concrete shrinkage or thermal movements are not restrained.

Moulds shall be kept clean of adhering slurry so that surfaces as cast are smooth. Water, dirt, tie wires, sawdust and other foreign matter shall be removed from the formwork prior to casting.

Seals shall be fitted to prevent loss of cement past through joints in the formwork.

5.4.3 CONSTRUCTION REQUIREMENTS

5.4.3.1 General

The Contractor shall provide a technician skilled in the use of the system of prestressing to be used, who shall supervise the work and give the Engineer assistance as the Engineer may consider necessary.

The Contractor shall provide all equipment necessary for the construction and the prestressing. Prestressing shall be done with approved jacking equipment. If hydraulic jacks are used they shall be equipped with accurately reading pressure gauges. The combination of jack and gauge shall be calibrated and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devises shall be furnished so that the jacking forces may be accurately known.

All of the applicable requirements of Clause 5.1.5 Construction Requirements of these Specifications shall be complied with except as may be modified herein or in the Special Provisions. Prestressed concrete shall be formed, stressed, placed, cured, and protected at shops, manufacturing plants and locations approved by the Engineer, where the fabrication of such members may be properly inspected and controlled.

5.4.3.2 Plan of Operation

The Contractor shall prepare, check and submit to the Engineer complete detailed shop Drawings and schedules showings:-

- Contractor's alternative designs if the submission of alternatives is approved.
- Contractor's details of proposed manufacture and construction.
- Sequence of operations proposed.
- Dimensions and complete descriptions of all devices, joints, bearings, and anchorages not specified or detailed in the Contract Documents.

Concrete shall not be cast prior to the Engineer's approval of the Contractor's Drawings of concrete mixtures, of form work, of method of application of prestressing forces, of methods of placing, of curing, of protecting, of handling and of erecting members. Any alternative to the design in the Contract Documents, shall be subject to the Engineers approval before manufacture or construction.

The Contractor shall inform the Engineer not less than 3 days in advance of the probable date of commencement of manufacture and the dates when tensioning of steel, casting of units and transfer of stress will be undertaken for the first time.

5.4.3.3 Enclosures

Enclosures for prestressed reinforcement shall be accurately placed at locations shown on the Drawings or approved by the Engineer.

5.4.3.4 Placing Steel

All steel elements shall be accurately placed in the position shown on the Drawings and rigidly held during the placing and setting of the concrete.

Distances from the forms shall be maintained by stays, blocks, ties, hangers, or other approved supports. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be used.

Wires, wire groups, cables, and any other prestressing elements shall be straightened to insure proper positioning in the enclosures.

Suitable spacers shall be provided, if required, to hold the wires or cables in place in true position in the enclosures in such a way that there is space around each wire or cable to enable it to be surrounded by grout.

5.4.3.5 Pretensioning Method

The prestressing elements shall be accurately held in position and stressed by jacks. Stressing shall be applied to produce the stresses required in the wires immediately after the anchorage as shown on the Drawings or as directed by the Engineer. Suitable allowances shall be made for friction in the jacks and for slip and yield in the grips or anchorages. A record shall be kept of the jacking forces and the elongations produced thereby and the minimum age in hours of the concrete in the line at the time the tendons were released.

Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor shall end anchors be released, until the concrete has attained a compressive strength of at least 75% of the ultimate compressive strength obtained when testing standard cylinders and cured in the manner identical to the curing of the members. The elements shall be cut or released in such an order that eccentricity of prestress will be a minimum.

5.4.3.6 Post-Tensioning Method

Stressing shall be applied to produce the stresses required in the wires immediately after the anchorage as shown on the Drawings or as directed by the Engineer. Suitable allowances shall be made for friction in the jacks and cable ducts and for slip and yield in the grips or anchorages.

The tensioning process shall be conducted so that the tension being applied and the elongation may be measured at all times. A record shall be kept of gauge pressures and elongations at all times and the minimum age in hours of the concrete in the unit at the time the stressing took place. Prestressing forces shall not be applied to the concrete until it has attained strength as specified above for the pretensioning method.

5.4.3.7 Curing

Curing shall comply with the requirements in Section 5.1 of these Specifications.

A steam curing process may be used as an alternative to water curing. The casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. Two to 4 hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to from 4 to 6 hours. Water curing methods shall be used from the time the concrete is placed until steam is first applied.

The steam shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 220 C per hour until the maximum temperature has been reached the maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 220 C per hour until the temperature has been reached 100 C above the temperature of the air to which the concrete will be exposed. The maximum curing temperature shall be from 600 C to 670 C.

If the Contractor elects to cure by any other special method, the method and its detail shall be subject to the approval of the Engineer.

5.4.3.8 Grouting

Post tensioned steel shall be bonded to the concrete by grouting as soon as possible after stressing unless noted otherwise on the drawings. When, in the opinion of the Engineer, such grouting is impracticable, the grouting shall take place as soon as is practicable and in any case not later than 28 days after stressing of the tendons in any cable duct is completed. All prestressing reinforcement enclosures and ducts shall be free of dirt, loose rust, grease, and other deleterious substances. The duct shall be flushed out with clean water and compressed air first. Grout shall be placed within 45 minutes of mixing. Grout shall be placed under a pressure of at least 7.0 kilograms per square centimetre, the injection shall be continuous and include a system for recirculating the grout if actual grouting is not in progress.

Grout shall be allowed to flow from these intermediate drainage points until its consistency is similar to that of the grout injected, after which the openings shall be firmly closed one after the other in the direction of flow. On completion of injection the pressure shall be held by the closing of a valve on the grouting pipe or by other means until the grout has set. Should any wastage or subsidence of grout occur the vent openings shall be topped up with grout and if required by the Engineer a further topping up shall take place after 2 or 3 days. Voids around the fittings shall be filled flush.

5.4.3.9 Unbonded Tendons

Where sheathing of pre-tensioned strand is required to prevent bond over a specified length, it shall consist of plastic tubing or other material, of a quality, diameter and thickness such that the bond shall be effectively prevented. This sheathing shall be fastened to the tendon in such a manner that the efficiency of the bond break shall not be impaired by the entry of cement mortar.

5.4.3.10 Acceptance of Precast Units

The acceptability of precast units shall be determined by inspection and the results of test herein specified. Members may be rejected on account of failure to meet any of the requirements of the Contract.

Members shall comply with the following tolerances:

- **Length**

  The overall length of any unit shall not vary by more than 0.06% from the specified length with a maximum variation of 20 mm. Centre-to-centre spacing of holes for transverse bars shall not vary by more than 10 mm from the specified position as measured from the transverse centre line of the unit.

- **Location of Tendons and Reinforcing Steel**

Tendon pattern plates	± 2 mm
Cover to tendons and reinforcement	± 5 mm
(includes cover to internal voids)	
Tendons between pattern plates	± 5 mm

- **Void Location**

Vertically measured from the soffit	± 10 mm
Transversely measured from the	± 5 mm
longitudinal centre line of the units	

- **Out of Square**

  On any transverse cross-section the adjacent faces shall not be out of square by more than 5 mm per metre or 5 mm overall, whichever is the greater. On any longitudinal cross-section the slope of the end face shall not deviate from that specified by more than 15 mm per metre, to a maximum of 12 mm overall.

- **Hog**

  The hog values of similar units which are to be used in the same span shall be within a maximum range of 20 mm for units up to 20 m long and a maximum range of 25 mm for units over 20 mm long for units of the same age.

- **Bow**

  At any section, the longitudinal centre line shall not deviate in the transverse direction from a straight line joining the centre points of the ends of the units by more than 10 mm bow for units up to 15 m long, 12 mm for units over 15 m to 20 m long and a maximum 17 mm bow for units over 20 m long.

  Notwithstanding these tolerances, the dimensions and side bow of deck units shall be such that each unit will fit between two parallel vertical planes space 610 mm apart for units up to 20 m long and between two parallel vertical planes spaces 615 mm apart for units longer than 20 m.

- **Twist**

  With one end cross-section taken as a reference the rotation of any cross-section shall not exceed 5 mm per metre for the edge being checked.

5.4.3.11 Void Formers

The void formers shall be restrained so that the tolerances limits given above are achieved. No damage to voids shall occur during casting operations. Void formers shall not be secured to the tendons.

The restraint systems for void formers shall be approved prior to placing any concrete.

Precautions shall be taken to prevent occurrence of cracks over the voids but any cracks shall be sealed with an approved liquid epoxy compound.

5.4.3.12 Handling, Transport and Storage

Prestressed concrete shall be handled, stored and transported in accordance to the requirements of these Specifications in addition to the requirements stated on the Drawings.

Precast prestressed concrete shall not be moved from the casting position until the concrete has attained a compressive strength of 75% of the specified 28 day strength, nor transported until it has developed a strength of 85% of the specified 28 day strength.

The prestressed concrete deck units shall, at all times during handling, transport and storage be kept in such a position that the lifting loops are uppermost. The method of handling and storage shall be such as to avoid the danger of fracture by impact, undue bending, twisting and whipping. Units shall be moved only while fully suspended. In no case shall they be move by dragging across the terrain.

Units are provided with lifting loops in the top face of each unit. The units shall be lifted only by these lifting loops and no other means of lifting shall be used at any stage of handling.

Cranes shall work within their rated capacity. The Contractor shall make available for inspection by the Engineer the crane manufacturer's load charts for the cranes that are proposed for erection with details of counterweight, jib length and rigging.

Units shall be transported only after all inspections, required by the Engineer, have been satisfactorily completed. Units shall be supported in such a manner that no damage will be incurred by the units. Units shall be supported on two level timber bearers of minimum dimensions 100 mm x 100 mm placed within 1000 mm from their ends. Units shall not rest on any support at locations between the approved support points.

5.4.3.13 Marking of Prestressed Members

Each prestressed member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement.

5.4.3.14 Testing of Prestressed Beams

When directed by the Engineer one or more beams shall be subjected to a loading test. The Contractor shall obtain the prior approval of the Engineer to the detailed arrangements for the testing. A beam that is to undergo testing shall be supported at its design points of bearing and the upward deflection due to the prestressing force measured relative to a line joining these points.

Equal loads shall then be applied at the third points in ten equal increments, the total being sustained for 5 minutes. The beam shall then be unloaded.

The mid-span deflection relative to the reference line shall be measured for each increment of load. The load deflection curve plotted from these values must show no appreciable variation from a straight line. The Drawings shall show, or the Engineer shall direct, the loads to be applied and the corresponding deflections that must not be exceeded.

Any beam which fails to satisfy the Engineer under the prescribed test shall be rejected and all other beams cast in the same line as the rejected beam shall also be rejected unless tested at the Contractor's expense and found satisfactory.

The Contractor shall supply to the Engineer record sheets of the tests showing date of test, the loads, deflections, and load deflection curves, calculated values of “E”, and the strength of the concrete at release as indicated by the relevant cube test results.

The tests are to be carried out on units selected by and in the presence of the Engineer after he has agreed the method of testing and form of records. The cost of such tests and records shall be included in the unit prices.

5.4.3.15 Erection of Deck Units

Where units are to be bedded on cement mortar, a mortar seating strip shall be prepared on the substructure immediately before erection of the units. An approved bonding agent shall be added to the mortar which shall have the consistency of mortar used in bricklaying. The mortar strip shall be laid to the widths and thicknesses shown on the Drawings and shall provide an even seating for the ends of the units.

Immediately following the placement of the mortar seating strip and before the mortar sets, the deck unit shall be seated on the substructure in the position shown on the Drawings. Any excess mortar shall be struck off.

All holding down bolt holes and transverse prestressing holes shall be carefully aligned during placing of the units. The alignment of the holes for the transverse stressing bars shall be checked by inserting trial mandrels into the holes as erection proceeds.

Deck units shall be installed with a gap between units that is to be filled with mortar before transverse stressing. A minimum gap of 10 mm shall be maintained by wedging, where necessary.

The longitudinal joint between the deck units shall be sealed at the base of the joint with a leak proof compressible seal. Compressible packer shall also be used to enclose each of the holes for stressing bars. The cells formed shall extend the full depth of the units and shall be at least 250 mm wide. The space between the units shall then be filled with mortar to form a dense waterproof joint. The water cement ratio of the mortar shall be such to produce a consistency that allows the mortar to be puddled into the joint without being free flowing.

The completed joints shall be filled with sound mortar throughout, and any porous, honeycombed or defective areas shall be cleaned out and made good before transverse prestressing is carried out.

Transverse prestressing shall be not be carried out until the cement mortar joints have reached the compressive strength nominated on the Drawings. Before inserting transverse stressing bars into the units any grease or protective coating film shall be removed with a solvent such as petrol. Kerosene or diesel fuel shall not be used.

Transverse stressing bars shall be carefully threaded through the holes in the deck and barrier units taking care not to damage the treads on the ends of the bars. Nuts, washers and anchor plates shall be assembled as shown on the Drawings.

Each span shall be transversely prestressed by applying a transverse prestressing force to each end of the transverse stressing bars. The magnitude of the transverse prestressing force shall be measured by means of a pressure gauge and by the extension of the transverse stressing bar caused by the prestressing force. The extension shall be measured by means of a Vernier scale fixed to the jack. Should there be more than 10 % variation between the calculated and measured extension, transverse prestressing shall be discontinued until the reason for the difference has be ascertained.

The expected extension for a 29 mm diameter bars is 3.1 mm per metre length of the bars manufactured from steel with a modulus of elasticity of 170,000 MPa.

After prestressing,, the transverse stressing bars shall be grouted in cast holes. Grout shall be poured down one or more of the gaps in the mortar above the transverse stressing bars until the grout is force up all the remaining gaps and until it emerges from the drilled hole in the bearing plated on the outside of the kerb units'.

Holding down bolts at the ends of the deck units , complete with nut and washer, shall be inserted in a cored hole and held about 150 mm above its final position. Cement grout having a thick creamy consistency shall be poured around the bolt, so that, when the holding down bolt is pushed firmly to its final position, the cored holes in the substructure and the holes in the prestressed units shall be completely filled. Any excess grout shall be struck off level with the top of the deck units.

Nuts on the holding down bolts should be screwed down using a short spanner to just nip the washer. Excessive force in tightening the nuts shall be avoided. The square recess in the top of the units shall be filled with a compressible filler.

The gaps between the ends of the deck units and the abutment end wall shall be filled with cement mortar packed tightly into the joint.

The lifting loops shall be cut off flush with the top surface of the deck unit and the exposed strand coated with epoxy.

Any protruding transverse stressing bars shall be cut off using a metal cutting disc to give the cover shown on the Drawings. Immediately before the recess is to be filled, the surface of the recess shall be painted with an approved wet-to-dry epoxy. Anchorage recesses shall be filled with cement mortar prepared to a firm consistency and hammered into the recess. The mortar surface shall be finished flush with the unit surface with a steel trowel.

5.4.3.16 Measurement

The quantity of precast prestressed structural members to be measured shall be the actual number of each installed in place, completed and accepted. The quantities of other items such as joint filler and sealant, concrete sidewalks, barriers, curbs and railing, piers, abutments, piling, approach slabs and/or bearing units shall be measured for payment as described in relevant sections of these Specifications.

5.4.4 PAYMENT

Precast prestressed structural members shall be paid for at the Contract unit price each, complete in place, which price shall include concrete, reinforcement and prestressing steel, enclosures for prestressing steel, anchorages, plates, nuts, spirals, grouting, falsework, shoring, formwork, all equipment, labour and incidentals necessary to the satisfactory completion of the work.

For precast concrete girders and other superstructure units the payment shall also include transporting, lifting, launching, erection in place and all temporary works incidental to the work.

Pay items will be as follows:

Item Ref	Description	Unit of Measurement
5.4(1) - 5.4((16)	PSC Deck Unit – Length – Type (to be defined)	Number
5.4(17) - 5.4(20)	PSC Super T Unit – Length – Type (to be defined)	Number
5.4(21)	Transverse stressing bars	Number

Partial payment for precast prestressed structural members, when acceptable to the Engineer and either delivered and stored or manufactured at the Contractor's camp near the project, may be allowed on the terms set forth in the Contract, but in no case shall be more than 75% of the unit price applicable for the pay item.

5.5 STEEL STRUCTURES

5.5.1 DESCRIPTION

This work shall consist of the construction of all or portions of steel structures constructed in accordance with the requirements of these Specifications and the lines, levels, grades, and dimensions shown on the Drawings, and as required by the Engineer.

This work shall include the preparation of the detailed design and shop drawings, the supply of materials, the manufacturing and the shop assembly, the transport to the site, the site assembly and erection, testing and quality control.

5.5.2 GENERAL REQUIREMENTS

The Steel Structures shall be designed and constructed in accordance with the relevant Codes and Standards indicated in these Specifications, Codes and Standards, in particular the AASHTO, ASTM, AS and AWS Standards.

Prior to the commencement of the works, the Contractor shall prepare and submit for the Engineer's approval:

a) the structural analysis and the shop drawings indicating in detail the fabrication, assembly and erection requirements, material lists and material properties, welded and bolted connection details, not less than sixty (60) days before fabrication commences,

b) all manufacturer's catalogues, detailed technical data, specifications and installation instructions for all components and items, not less than thirty (30) days before fabrication commences,

c) a detailed fabrication schedule indicating all the stages of the fabrication in shop of the components, as well as the shop pre-assembly program,

d) a detailed construction plan indicating the proposed methods, sequences, standards, etc., to be adopted.

5.5.3 MATERIALS REQUIREMENTS

5.5.3.1 General

All materials shall be new and of the best quality of the specified type. They shall meet the requirements of the relevant standards.

All materials and equipment necessary for the construction shall be supplied by the Contractor. A statement of the origin of all materials and equipment intended to be used on the site shall be submitted by the Contractor within a period of sixty (60) calendar days from the date of acceptance of the tender. This statement shall include statements of the characteristics of the materials and equipment, the standard of performance, test performance, and the reasons for their selection.

Samples shall be submitted to the Engineer for all materials that may be subject to acceptance tests. Acceptance samples shall be kept as reference to be compared with the materials delivered on site as the works proceed.

The Contractor shall provide proof of the origin and quality of the materials. In particular the Contractor shall provide the manufacturer's mill certificates (including the chemical analysis) and test results (including mechanical properties) for all components used in the steel structure works. Any modification of the origin and quality of materials shall not be permitted without the Engineer's authorisation, and the Contractor shall submit proof that the proposed material is equal or better than that specified, including detailed description, tests reports and past performance data.

The storage of materials on bare ground is prohibited. The Contractor shall provide storage areas, with a suitable surfacing, large and resistant enough to preclude any pollution of the materials throughout the duration of the works. The Engineer shall be entitled to inspect the storage areas and the way the materials are stored in the Contractor's shop, as it deems necessary.

5.5.3.2 Acceptance Tests

Materials shall be normally accepted based on the manufacturer's certificates and test results.

However, in order to complete the acceptance tests as far as he deems necessary, the Engineer will be entitled to stipulate complementary acceptance tests as well as methods of testing. Those complementary acceptance tests shall be carried out in a suitable laboratory under the control of the Engineer or his representative.

Rejected lots shall be immediately moved aside and labelled to avoid any risk of confusion. They shall be taken away from the site by the Contractor within 48 hours following their rejection.

The Engineer shall be entitled to inspect the materials in the Contractor's shop, as he deems necessary.

5.5.3.3 Structural Steel

The structural steel shall be:

(a) shapes and plates for main bridge components, as main girders, cross girders, deck plates, bearing plates, connection elements (splices, shim plates, etc..), etc..: AASHTO M 270 Grade 50, with a minimum yield point strength of 345 MPa and a tensile strength of min. 450 MPa, or similar,

(b) shapes and plates for secondary components, as railings, expansion joints, angles for concrete edge protection, etc..: AASHTO M 270 Grade 36, with a minimum yield point strength of 250 MPa and a tensile strength of 400-550 MPa, or similar,

(c) pipes for steel piles, if required: ASTM A 252, Grade 2, or similar,

(d) closure plates for closed end piles, if required: AASHTO M 183/M183M, with a minimum yield point strength of 250 MPa and a tensile strength of 400-550 MPa, or similar,

(e) steel H-piles, if required: AASHTO M 183/M183M, as above,

(f) sheet piles, if required: AASHTO M 202 with a minimum yield point strength of 270 MPa and a tensile strength of 485 MPa, or AASHTO M 223, Grade 42 (minimum yield point 42,000 psi) or Grade 50 (minimum yield point 50,000 psi), or similar.

5.5.3.4 Bolts, Nuts and Anchor Bars

High strength steel bolts shall be plain bolts conforming to AASHTO M 164M, Types 1 and 2 (or ASTM A 325 M, Types 1 and 2). Nuts for high strength steel bolts shall be Class 8S heavy hex. nuts conforming to AASHTO M 291M.

Standard bolts shall be non-galvanized bolts conforming to ASTM A 307, grade B. Nuts for standard bolts shall be Class A heavy hex. nuts conforming to AASHTO M 291.

Steel for threaded or non-threaded anchor bars shall conform to the requirements of AASHTO M183/M183M. Nuts for threaded anchor bars shall be Class A heavy hex. nuts conforming to AASHTO M 291.

5.5.3.5 Electrodes for Welding

The electrodes for welding shall suit the grade of steel to be welded. In particular the characteristics of the metal of the welding rods shall be at least equivalent to those of the structural steel.

5.5.4 CONSTRUCTION REQUIREMENTS

5.5.4.1 General

The works shall be of first class quality, in accordance with the requirements of the Codes and Standards specified in these Specifications. The steel works shall be carried out in such a manner as to ensure a satisfactory coordination with the other works.

5.5.4.2 Fabrication

The Engineer shall be entitled to carry out inspection visits, as frequently as the Engineer deems necessary, to the Contractor's shop, for checking the preparation, fabrication, shop assembly and manufacturing of the structural steel works.

All shapes, plates and pipes shall be within tolerances specified in relevant standards, true to shape and free from winding, accurately straightened, planed or shaped as necessary and without damaging the material. Straightening may be carried out by mechanical means or by application of a limited amount of local heating with a temperature of the heated area not exceeding 690 degrees C. The plates which are to be bent, folded, or pressed shall be heated in an oven. However cold bending or cold pressing will be allowed for parts having a thickness less than 9 mm, or when the radius does not exceed 50 times the plate thickness. Care shall be taken not to damage or discolour the exterior surface.

Welded or bolted connections shall be as shown on approved shop drawings.

Flame cutting shall be accurately made with guides as necessary, and without damaging the metal. Edges for welding shall be properly prepared.

Flame cutting of holes for bolts shall not be permitted. No hole shall be off of its theoretical position by more than d/10, d being its diameter. The diameters of the holes for bolts shall be conform to the AISC requirements. Oblong holes for site adjustment shall be as shown on approved shop drawings. Splices shall be permitted only where and as shown or in accordance with the approved shop drawings. Contact surfaces of bearing plates shall be ground or milled as necessary for maximum effective bearing. Stiffening angles and plates

shall be accurately ground to fit. Drift pins, when used, shall not distort the work or enlarge the holes.

5.5.4.3 Manufacturing Tolerances

For all parts the manufacturing tolerance, expressed in millimetres, on their length L expressed in metres, shall be as follows:

$2\sqrt[3]{L}$	if $L < 8$ m
0.5 L	if $8\ m \leq L < 14$ m
7	if $L \geq 14$ m

The tolerance, expressed in millimetres, on the deviation from theoretical tracing of any structure or part of structure, is L + 0.1 L (L being the length of the structure or part of structure in question, expressed in millimetres).

Members shall be preferably shop assembled so that the site welded or bolted connections can be reduced. Surfaces of metal in contact shall be cleaned before assembling. Parts to be finally site assembled shall be pre-assembled in shop with temporary fastening, two by two or entirely, as necessary, in order to test the assembly feasibility and to verify the lengths, camber, and edge cuttings for site welding. The Contractor shall submit for the Engineer's agreement the schedule for shop pre-assembly, at the beginning of the fabrication works.

5.5.4.4 Welding

Welding shall be performed only by qualified welders with a recognised international welding qualification, or approved by Engineer. Any welder who fails to meet the welding standards shall be replaced. In the absence of references the Engineer will organise testing of the ability of the welders, at the Contractor's expense.

All welding shall conform to the AWS standards and AISC standards.

Welds shall be sufficient, adequate and suitable to perform the structural requirements, and subject to approval by the Engineer. Weld shall be executed taking all measures necessary to avoid distortion and stresses set up by heat and shrinkage. The sequence in which the various welds are to be made shall be precisely followed.

The welding operations shall be carried out with thoroughly dry electrodes, and sheltered from rain and wind. Welded joints shall be free from porosity, cracks or holes, and shall be finished to match adjacent surfaces. Great care shall be taken when an interrupted weld is resumed, or when two separate welds are joined, in order to avoid pits. The deposit of the weld seam shall not cause grooving of the steel material. The weld surface shall be regular and as smooth as possible. If necessary it shall be thickened or ground in order to remove all traces of loss of thickness, discontinuity, overlap, and excessive swelling. All cracked welds shall be repaired. All traces of cinder and slag shall be removed from weld spot and seams. All welds that will be exposed in the finished work shall be ground to a smooth uniform finish suitable for paint finish.

The control of welding shall strictly conform to the requirements of ANSI / AWS DI.1-84 and particularly to Chapter 6 - Inspection. The welds shall be controlled as follows :

(a) butt welds :

visual inspection = 100 % of the length

ultrasonic testing = 100 % of the length, except as otherwise specified by the Engineer

(b) fillet welds and bevel groove welds:

visual inspection = 100 % of the length

magnetic particle or penetrant testing = 100 % of the length.

Complementary milling may be ordered by the Engineer if it deems it necessary. All defective welds shall be removed and welded again at the expense of the Contractor.

Acceptance of welds shall be carried out prior to any painting work.

5.5.4.5 Transport, Handling and Storage

The Contractor shall use handling, storage, packing and shipping procedures that will prevent damage or loss of products.

Platform or flatbed trucks or trailers shall be long enough to receive the longest parts. Fragile parts shall be appropriately stiffened and protected with metal bracing or wood. Small parts shall be placed in boxes. All parts shall be firmly secured to avoid their displacement during transport. All parts shall be handled with care to avoid damaging the paint work. Loading, transporting, unloading shall be performed so that the steel is always kept clean.

Steel material stored on site shall be protected from corrosion.

The Engineer shall be entitled to reject seriously damaged parts, which shall be replaced at the Contractor's expense.

5.5.4.6 Site Assembly and Erection

Temporary bracing shall be used wherever necessary and shall be designed to support all loads to which the structure may be subjected during erection, including wind and seismic loads, and loads or forces due to equipment and operation thereof, transport, and stored materials. Such bracing shall be left in place as long as may be required for safety.

As erection progresses, the work shall be welded or bolted sufficiently to take care of all dead load, wind and erection stresses. The members forming parts of a completed frame or structure shall be aligned and adjusted accurately before being fastened. Fastening of splices of compression members shall be done after the abutting surfaces have been brought completely into contact. No bolting or welding shall be done until as much of the structure as can be stiffened thereby has been aligned properly. Bearing surfaces and surfaces that are to be in permanent contact shall be cleaned before the members are assembled.

Drifting done during assembly shall be only such as to bring parts into position, and not sufficient to enlarge the holes or disturb the metal. If any hole must be enlarged, it shall be reamed. The standard bolting procedure shall include the following steps:

(i) initially, tighten the bolts and nuts enough to maintain the integrity of the work,

(ii) then, after final alignment and truing, re-tighten all bolts and nuts for full and tight bearing,

(iii) finally, before being permanently concealed, re-check and tighten the bolts as necessary. In bolted assemblies, the threads shall be blocked by welding or any equivalent method, if subject to tensile forces. Two washers shall be used for each bolt. The threaded portion of a bolt shall never be subject to shear. Bolts fitted methods shall conform to the requirements of the AISC, American Institute of Steel Construction.

Field welding shall conform to the requirements specified herein, except as applicable to strictly shop welding procedures.

Corrections of minor misfits by moderate use of drift pins and a moderate amount of reaming, chipping or cutting will be permitted and shall be provided as part of erection work. Any errors which prevent proper assembly of parts by these measures, or which require correction or adjustment, shall be immediately reported to the Engineer, and such corrections and adjustments shall be made as necessary and only by means approved by the Engineer. Cutting or alterations other than approved shall not be permitted.

The Contractor shall take all necessary measures to ensure a perfect protection of works that would corrode or be stained in course of erection and during painting operations. Protective measures shall include construction of platforms, positioning of layers of sand, tarpaulins, etc.

5.5.4.7 Quality Control

The Contractor shall systematically check the quality of the materials and workmanship throughout the contract period. The controls are summarised in the table below:

Table 5.5.1 Control Checks for Structural Steelwork

Type of Work	Type of Test	Frequency	Results Required for Acceptance	Corrective Measures
1. Structural steel 2. Bolts & nuts 3. Anchor bars 4. Electrodes	1. Chemical analysis 2. Mechanical properties	For each delivery	Conformity to Standards	Rejection: Materials to be replaced
Individual units	1. Visual inspection 2. Measurement of dimensions	All units	Conform to tolerances	Rejection: Work to be done again
Welding	1. Visual inspection 2. Ultrasonic, etc..	100% of weld length, as indicated above	Satisfactory appearance and test results	Milling check; weld to be removed and re-welded

The results of all check tests shall be recorded in registers to which the Engineer shall be given access at any time. In addition the Engineer is entitled to have a certain number of checks carried out at his own expense. In case of conflict with the results of the Contractor's tests the Engineer may order changes in the Contractor's testing method.

5.5.5 MEASUREMENT

The quantity of structural steel for steel structures to be measured under this section shall be the computed weight in tonnes of material, complete in place and accepted, as shown on the Drawings.

In computing the weight to be measured, either the theoretical weight of members of the dimensions shown on the Drawings, or authorised, shall be used when available, or a unit weight of 7.850 tonne per cubic metre shall be used. No deduction shall be considered for holes for bolts. No additional weight shall be considered for welds. Bolts, nuts, washers and anchor bars shall not be measured.

5.5.6 PAYMENT

The structural steel for steel structures, placed as shown on the Drawings or as directed by the Engineer, will be paid for at the Contract unit price per tonne of steel for the particular Bill Item listed below, which price shall include furnishing all labour, materials, tools, equipment, quality control and incidentals, and for doing all the work involved in furnishing, fabricating, transporting, assembling and erecting the steel structures, complete in place.

Full compensation for furnishing and placing bolts, nuts, washers and anchor bars, and for furnishing electrodes, shall be considered as included in the Contract unit price paid for structural steel and no separate payment will be made.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
5.5(1)	Structural Steel, Grade 50	Tonne
5.5(2)	Structural Steel, Grade 36	Tonne

5.6 RAILING

5.6.1 DESCRIPTION

This work shall consist of furnishing, fabrication and erection of pipe, aluminium and concrete railings for bridges and incidental structures, all as indicated on the Drawings and required by these Specifications.

5.6.2 MATERIALS REQUIREMENTS

5.6.2.1 Steel Pipe Railings

Unless another grade and quality has been shown on the drawings, the steel pipe shall conform to the standard specified below.

a) Wrought Iron Pipe shall conform to the requirements of ASTM Designation A 72, Standard Weight.

b) Malleable castings shall conform to ASTM Designation A 47, Grade No. 35018.

c) Mortar and Grout shall conform to the provisions of Section 5.4 of these Specifications.

d) Galvanising of all pipe railing and fittings shall be carried out unless otherwise specified in accordance with Specification AASHTO M 111 or ASTM A 123.

e) Painting, where required, the number of coats and the type of paint will be as specified on the Drawings.

5.6.2.2 Aluminium Railing

a) Aluminium alloy pipe (6061-T6) shall conform to ASTM Specification B 241, Alloy GS-IIA, Condition T 6.

b) Aluminium alloy castings shall conform to ASTM Specification B 108, Alloy SG 70 A, Condition T 6 except for rail caps. As an alternative rail caps may conform to ASTM Specification B 26, Alloy SG 70 A, Condition T 6. All posts shall have an 80 grit finish on flange faces and all rail cap castings shall have an 80 grit finish on all exterior surfaces. All castings exhibiting shrinkage cracks will be unacceptable.

c) Aluminium alloy shims (1100-0) shall be made from sheet or plate conforming to ASTM Specification B 209, alloy 990 A, Condition 0.

d) Anchor bolts, nuts, and washers for attaching railing post castings to concrete shall be aluminium alloy or structural steel as shown on the Drawings. If steel is used, it shall be given as heavy a coating of galvanising as practical or may be non-corrosive metal as required on the Drawings, in these Specifications or as approved by the Engineer.

5.6.2.3 Concrete Railing

Concrete shall be Class B1 as specified in Section 5.1 of these Specifications. Reinforcement shall conform to the requirements of Section 5.2 of these Specifications.

The surfaces of all railing and posts shall receive a rubbed finish as described in sub-clause 5.1.5.8, item d) of these Specifications and as directed by the Engineer.

5.6.3 CONSTRUCTION REQUIREMENTS

5.6.3.1 Storage and Handling of Materials

Pipe, railing, fittings, and incidental parts shall be carefully handled and stored on blocking, racks or platforms so as not to be in contact with the ground and shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter. Surfaces to be painted shall be carefully protected both in the shop and in the field. Threads shall be carefully protected from injury.

5.6.3.2 Connections

The component parts of pipe railings shall be connected with screw threads unless otherwise specified on the Drawings. Rails and posts shall be connected with tees, crosses and ells. Fittings for railings on slopes shall be levelled to fit the required grades. Screw thread fittings shall be coated with red lead and oil, and the threads shall engage for a minimum distance of 20 mm. Expansion shall be provided by omitting threads on one side of fittings at designated posts. Where the rails are continuous through two or more posts threads may be omitted between the rail and the fittings, but the rails must be pinned at each post. Individual rail sections shall be connected with screw thread couplings between posts and couplings shall be staggered where two or more strings are required. Where welding of component parts is permitted, the details must be in accordance with the Drawings or as approved by the Engineer.

The connections between the posts or rails and the structure shall be as follows:

(a) Where railings are to be connected to steel or metal structures, the connection shall be with flanged plates or castings, and the fittings shall be bolted rigidly to the structure in accordance with the detailed Drawings.

(b) For connecting railings to concrete, the posts shall be set in approved sockets or sleeves, unless otherwise specified. The posts shall be fixed in these holes with grout as shown on the Drawings. Base plates shall be provided to cover all holes. Posts may be otherwise connected to concrete by means of flanges, plates or castings which in turn shall be fastened to the concrete by bolts cast in or anchored in drilled holes.

5.6.3.3 Erection

The Contractor shall provide for the erection of pipe railing by suitable fabrication in the shop. Where railing is fitted between concrete posts, provision shall be made to allow the installation of same.

Where aluminium alloy come into contact with concrete or other metals, except non-corrosive anchor bolts, washers and nuts, the contacting surface shall be thoroughly coated with an approved caulking compound or shall be separated by an approved insulating shim as indicated on the Drawings. Omission of this detail from the Drawing will not be considered as permission to omit the approved coating, or approved shims from the work. Cast aluminium alloy caps with set screws shall be furnished and installed on all exposed open ends of rails.

Railings shall be fabricated and erected as indicated on the Drawings, and rails shall be parallel to the grade of the road.

All exposed surfaces shall be thoroughly cleaned in an approved manner as a final operation under this project.

Concrete railings shall be constructed to the line and grade shown on the Drawings. Unless otherwise specified, all railing posts shall be plumb. Railings shall not be placed on a structure until centering or falsework has been removed and the Engineer approves the railing to be installed.

5.6.3.4 Working Drawings

The Contractor shall furnish for the approval of the Engineer working Drawings for the particular type of railing to be installed.

5.6.4 MEASUREMENT

For structural work measured in accordance with Method A, as defined in sub-clause 5.1.6(a) of these Specifications, this work shall be measured as the actual number of linear metres of railings of each of the particular types specified on the Drawings, satisfactorily completed and accepted.

For structural work measured in accordance with Method B, as defined in sub-clause 5.1.6(b) of the Specifications, on a lump sum basis, there shall be no separate measurement for railings

5.6.5 PAYMENT

For structural work paid for in accordance with Method A, as defined in sub-clause 5.1.7(a) of these Specifications, this work measured as provided above will be paid for at the Contract unit price per linear metre of railings unless otherwise stipulated in the Specifications.

The price and payment shall constitute full compensation for furnishing all railings, posts and fittings including delivery, erection and finishing, and for all labour, equipment, tools and incidentals necessary for the completion of the work.

Pay Items will be:-

Item Ref	Description	Unit of Measurement
5.6(1)	Railing (type to be stated)	Linear metre

[Further serial numbers in brackets may be used for each different type].

5.7 DAMP PROOFING AND WATER PROOFING

5.7.1 DESCRIPTION

This work shall consist of damp proofing or waterproofing of concrete surfaces. The type of covering shall be as indicated on the Drawings or stipulated in these Specifications. The methods are briefly described as follows:

(a) Damp proofing - Damp proofing is designated as tar or bitumen and consists of one prime coat and two seal coats.

(b) Membrane Waterproofing - This covering consists of a prime coat and three mop coats and two layers of fabric and mortar for protection, all as later described herein.

(c) Thin Membrane Waterproofing - This consists of a two part, solvent free, spray applied polyurethane reactive coating used for waterproofing of concrete bridge decks.

5.7.2 MATERIALS REQUIREMENTS

Materials for damp proofing and waterproofing shall conform to the following:

(a) Primer: Primer to be used with bitumen shall conform to AASHTO M 116, Asphalt Primer Used in Roofing, Damp-proofing, and Waterproofing. Primer to be used with tar shall conform to AASHTO M 121, Creosote Primer Used in Roofing, Damp-proofing and Waterproofing.

(b) Tar: Tar to be used for mop or seal coats shall conform to the following:

(1) Coal tar pitch heated to free flowing but not to exceed 150 degrees C: AASHTO M 118, Coal-Tar Bitumen Used in roofing, Damp proofing, and Waterproofing, Type II.

(2) Rubberised tar heated to free flowing but not to exceed 120 degrees C: ASTM D 2993.

(3) Emulsified coal-tar pitch: ASTM D 3320.

(c) Bitumen: Bitumen to be used for mop coat shall conform to AASHTO M 115, Asphalt Used in Damp-proofing and Waterproofing , Type III.

(d) Waterproofing fabric: Waterproofing fabric saturated with tar or bitumen (depending on the material specified for prime and mop coats) shall conform to AASHTO M 117, Bitumen Saturated Cotton Fabrics Used in Roofing and Waterproofing.

(e) Mortar: Mortar material for the protective course shall be composed of one part of Portland cement and three parts of sand, unless otherwise provided. The sand shall conform to AASHTO M 45, Aggregate for Masonry Mortar.

(f) Joint Fillers: Filler for use in horizontal joints in waterproofing work shall be straight refined oil bitumen conforming to the following requirements:

Flash point	Not less than 232^0 C.
Softening point	48^0 C. to 54.4^0 C
Penetration	At 0^0 C., 200 grams, 1 minute, not less than 15
	At 25^0 C. , 100 grams, 5 seconds, 50 to 60.
	At 46^0 C. , 50 grams, 5 seconds, not more than 300.
Loss on heating	At 163^0 C. , 50 grams, 5 hours, not more than 0.5%

Ductility At 25^0 C. , 5 centimetres per minute, not less than 85.

Total bitumen (soluble in carbon disulphide) : Not less than 99.5%.

(g) Materials for thin membrane waterproofing:

The materials for thin membrane waterproofing shall be submitted by the Contractor to the Engineer's approval. The material for the reactive coating may consist of a two part, liquid applied, pigmented polyurethane elastomer which is spray applied in one coat in two passes.

Other materials used in conjunction with the reactive coating may be:

- a single component, moisture curing primer, applied at a coverage rate of 75-150 g/m^2,
- a tack coat system which could be:

  either a solvent free, moisture curing polyurethane, thinned with 30 % toluene, delivered to site ready to use, applied at a coverage rate of 70-90 g/m^2, a quartz, dry sand of particle 0.5-1.3 mm, applied immediately to the wet polyurethane, and a cationic bitumen emulsion, applied at a coverage rate of 0.15 - 0.60 litres per m^2, only applied immediately prior to the laying of wearing course,

  or a high polymer modified bitumen emulsion, applied at a coverage rate of 0.5-0.8 litres per m^2, and a quartz, dry sand of particle size 0.3 to 0.7 mm, applied after an interval of 30 to 45 minutes to the bitumen emulsion.

5.7.3 CONSTRUCTION REQUIREMENTS

5.7.3.1 General

Fabric shall be stored in a dry, protected place. The rolls shall not be stored on their ends. Bituminous materials in containers shall be kept closed when not in use.

Damp proofing or membrane waterproofing shall not be applied until all provisions for curing of concrete and repairing of defective concrete surfaces have been complied with. The use of liquid membrane curing compound shall not be authorised for concrete surfaces on which damp proofing will be applied. All concrete surfaces shall be reasonably smooth and free from projections and holes.

The concrete surfaces shall be dry for at least 10 days after completion of curing.

Immediately before the application of damp proofing or waterproofing, the surfaces shall be thoroughly cleaned of dust and loose materials.

When necessary, the Engineer will require the surfaces to be scrubbed with water and a stiff brush, after which all surfaces shall be allowed to become thoroughly dry before application of materials.

5.7.3.2 Damp proofing

Care shall be taken to confine all bitumen to the areas to be covered, and special care shall be taken to prevent disfigurement of any other parts of the structure by dropping or spreading of materials. The cured, cleaned and dry surfaces shall be painted as follows:

i) Apply damp proofing in dry weather,

ii) Apply primer to surface at the rate of not less than 0.5 litre/m^2, and allow it to dry. The materials may be either brushed or spread on.

iii) After the prime coat has thoroughly dried, apply two seal coats by brush only at the rate of approximately 13 kg/10 m^2 of surface per coat. When necessary the seal coat material may be heated, but not in excess of 65 degrees C. Apply prime coat and seal coats uniformly, fully covering the surface, and thoroughly work them into the surface. Make the total of the final two seal coats approximately 2 mm thick. Allow seal coats to harden before allowing contact with water or backfill material.

5.7.3.3 Membrane Waterproofing

The cured, cleaned and dry surfaces shall be painted with a prime coat and covered with mop coats and layers of fabric alternately and then with a protective cover of mortar, all as described below:

The surfaces shall first be painted with a primer, either by spraying or brushing. The amount of the primer coat shall be not less than one-half litre for each square metre of surface. The primer shall be applied so as to give a uniform coating. The priming coat shall be applied 24 hours in advance of applying any mop coats, and shall be allowed to become thoroughly dry before the first mopping is applied. The primer shall not be heated.

After the prime coat has dried as specified above, the mop coats shall be applied.

Bitumen shall be heated to a temperature between 1500 C and 1750 C. Arrangements shall be made to apply the heat indirectly. The heating kettles shall be equipped with thermometers.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed, so that water will run over and not against or along the laps.

The first strip of fabric shall be of half width; the second shall be full width, lapped the full width of the first sheet; and the third and each succeeding strip shall be full width and lapped so that there will be at least two layers of fabric at all points and three layers with laps not less than 50 mm wide at edges of strips. All laps at ends of strips shall be at least 300 mm.

Beginning at the low point of the surface to be waterproofed, a section about 200 mm wide and the full length of the surface shall be mopped with the hot bitumen or tar, and there shall be rolled into it, immediately following mopping, the first strip of fabric, of half width, which shall be carefully pressed into place so as to eliminate all air bubbles and obtain close conformity with the surface. This strip and an adjacent section of the surface of a width equal to slightly more than half the width of the fabric being used shall then be mopped with hot bitumen or tar, and a full strip and a full width of fabric shall be rolled into this, completely covering the first strip and pressed into place as before. The forward or upgrade half of this second strip and an adjacent section of the concrete surface shall then be mopped with hot bitumen or tar and the third strip of fabric “shingled” on so as to lap the first strip not less than 50 mm. This process shall continue until the entire surface is covered, each strip of fabric lapping at least 50 mm over the second strip below. The entire surface shall then be given a final mopping of hot bitumen.

The completed waterproofing shall be a firmly bonded membrane composed of two layers of fabric and three moppings of bitumen or tar. Under no circumstances shall one layer of fabric touch another layer at any point or touch the surface, as there must be at least three complete moppings of bitumen.

In all cases, the mopping on concrete shall cover the surface so that no grey spots appear, and on cloth it shall be sufficiently heavy to complete conceal the weave. On horizontal surfaces not less than 49 litres of bitumen or tar shall be used for each 10 square metres of finished work, and on vertical surfaces not less than 60 litres shall be used. The work shall be so regulated that, at the close of a day's work, all cloth that is laid shall have received the final mopping of bitumen or tar. Special care shall be taken at all laps to see that they are thoroughly sealed down.

At the edges of the membrane and any points where it is punctured by such appurtenances as drains or pipes, it shall be flashed in a manner suitable to the Engineer, to prevent water from getting between the waterproofing and the waterproofed surface.

All flashing at curbs and against girders, spandrel walls, etc., shall be done with separate sheets lapping the main membrane not less than 300 mm. Flashing shall be closely sealed either with a metal counter-flashing or by embedding the upper edges of the flashing in a groove poured full of joint filler.

Joints which are essentially open joints, but which are not designed to provide for expansion, shall first be caulked with oakum and lead wool and then filled with hot joint filler.

Expansion joints, both horizontal and vertical, shall be provided with sheet copper or lead in “U” or "V" form in accordance with the details, and after the membrane has been placed, the joint shall be filled with hot joint filler. The membrane shall be placed at expansion joints as detailed on the Drawings.

At the ends of the structure, the membrane shall be carried well down on the abutments and suitable provision made for all movement.

Care shall be taken to prevent injury to the finished membrane by the passage over it of men or equipment, or by throwing any material on it. Any damage that may occur shall be repaired by patching. Patches shall extend at least 300 mm beyond the outermost damaged portion, and the second ply shall extend at least 70 mm beyond the first.

A protection course of 50 mm cement mortar shall be constructed over membrane waterproofing where specified or shown on the Drawings. This course shall be reinforced at its mid-point with wire mesh. The top surface shall be trowelled to a smooth, hard finish, true and accurate to required grade.

The construction of the protection course shall follow the construction of the membrane waterproofing so closely that the latter will not be exposed without protection for more than 24 hours.

The mortar protection course will be subject to the same requirements for curing, and defective work as stipulated for concrete work. The requirements of Sections 5.1 and 5.4 of these Specifications will apply for mortar and of Section 5.2 of these Specifications for wire mesh.

Loading or filling will not be allowed on the mortar until the entire surface has been cured.

5.7.3.4 Thin Membrane Waterproofing

The thin membrane waterproofing system shall be installed in accordance with the code of practice requirements and the manufacturer’s instructions, and as directed by the Engineer. The application should not be made if rain is imminent.

The two part, solvent free, pigmented polyurethane elastomer is machine mixed on site in the correct proportions and spray applied in one coat in two passes at a nominal coverage rate of 3 kg/m^2. This will give a thickness of 2.9 mm on flat surfaces. After the waterproofing membrane has cured for at least four hours, the first tack coat system described above shall be applied and allow to dry; the cationic bitumen emulsion and the wearing course may be laid a minimum of 12 hours after application of the membrane. Alternatively, after the waterproofing has cured at least two hours, the second tack coat system can be applied. The wearing course may be laid a minimum of two hours after sanding.

Quality control checks shall be made on site in accordance with the manufacturer's data sheets.

5.7.4 MEASUREMENT

The quantity to be measured shall be the number of square metre of damp proofing, membrane waterproofing and thin membrane waterproofing completed and accepted in place.

5.7.5 PAYMENT

The work measured as provided above shall be paid for at the Contract unit price per square metre for "Damp proofing", "Membrane waterproofing" or "Thin Membrane Waterproofing" as detailed below. The payment shall be full compensation for damp proofing and waterproofing completed and accepted in place, including furnishing and placing of all materials, bituminous or other, cotton fabric or felt, protective mortar course, joint fillers, and all tools, labour and incidental work to complete the work in accordance with the Contract.

Pay Items shall be as follows:

Item Ref	Description	Unit of Measurement
5.7(1)	Damp proofing	Square metre
5.7(2)	Membrane Waterproofing	Square metre
5.7(3)	Thin Membrane Waterproofing	Square metre

5.8 POROUS BACKFILL MATERIAL

5.8.1 DESCRIPTION

This work shall consist of placing porous backfill material and other accessories in order to facilitate the drainage function as shown on the Drawings against the rear faces of abutments, wingwalls, against box culverts, headwalls, retaining walls, including drains, and all structures requiring porous backfill material in accordance with these Specifications, as shown on the Drawings or as directed by the Engineer.

5.8.2 MATERIALS REQUIREMENTS

Porous backfill material shall be hard, durable clean gravel or crushed rock or sand and shall be free from organic material, clay balls and other deleterious substances. Laterite or concretionary materials shall not be used.

Sand used for porous backfill material shall conform to the following grading requirements.

Sieve Designation	Percentage by weight passing square mesh sieves (AASHTO T 27)
	Type A
10 mm	100
4.75 mm	95 – 100
1.18 mm	45 – 80
0.300 mm	10 – 30
0.150 mm	2 – 10

Gravel and crushed rock shall conform to one of the following grading requirements:

Sieve Designation	Percentage by weight passing square mesh sieves (AASHTO T 27)			
	Type B	Type C	Type D	Type E
50 mm	100	-	-	-
37.5 mm	70 – 100	100	-	-
25 mm	55 – 85	75 – 100	100	-
19.5 mm	50 – 80	60 – 90	70 – 100	100
10 mm	40 – 70	45 – 75	58 – 75	-
4.75 mm	30 – 60	30 – 60	35 – 65	45 – 80
2.00 mm	20 – 50	20 – 50	25 – 50	30 – 60
0.425mm	10 – 30	10 – 30	15 – 30	20 – 35
0.075 mm	0 – 2	0 – 2	0 – 2	0 – 2

Where one or more of the gradings shown above are indicated on the Drawings or other Contract Documents, material conforming to the gradings indicated shall be used, otherwise the Contractor may select any one of the above gradings.

5.8.3 CONSTRUCTION REQUIREMENTS

5.8.3.1 Underdrains to Structures

Trenches for underdrains shall be excavated, the pipes installed and the trenches backfilled with porous backfill material according to the dimensions and details shown on the Drawings and in accordance with Section 6.2 of these Specifications.

5.8.3.2 Behind Structures

Porous backfill material shall be placed in layers in conjunction with the adjacent fill and compacted as specified in sub-clause 2.5.3.6 Backfilling of these Specifications. Any fill material removed for placing the porous backfill material will be at the expense of the Contractor.

5.8.4 MEASUREMENT

This work shall be measured net, to the dimensions instructed.

5.8.5 PAYMENT

The work measured as provided above shall be paid for at the Contract unit price per cubic metre for "Porous Backfill Material", which price shall be full compensation for all labour, material, equipment, tools and incidentals necessary to furnish and place the materials.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
5.8(1)	Porous Rock Backfill Material	Cubic metre
5.8(2)	Porous Sand Backfill Material	Cubic metre

5.9 EXPANSION MATERIALS IN BRIDGES

5.9.1 DESCRIPTION

The work shall consist of furnishing and installation of reinforced elastomeric expansion joints, including premoulded and elastic joint filler, watertight expansion joint, sealing material, bitumen paper pad, plain bearing strip, plain and laminated bearing pad, pot bearing, restraining devices, reinforced concrete plinth, supporting stress calculations and incidentals, all as indicated on the Drawings and required by these Specifications.

5.9.2 MATERIALS REQUIREMENTS

5.9.2.1 Premoulded Expansion Joint Filler

Non-extruding and non-bituminous resilient types shall be in accordance with AASHTO M 153.

Non-extruding and resilient bituminous types shall be in accordance with AASHTO M 213.

Preformed bituminous type filler shall be in accordance with AASHTO M 33.

5.9.2.2 Joint Sealing Materials

Joint Primer - Joint priming compound shall be Expandite No.3 or other approved primer.

Joint Sealing compound - Horizontal joint sealing material shall be Expandite Pli-astic hot poured rubber-bitumen sealing compound Grade 99 or other approved compound. Vertical or inclined joint sealing material shall be Expandite Plastijoint bituminous putty or other approved compound.

5.9.2.3 Tarpaper or Bitumen Paper Filler

These will be used only when specified. A three-ply roofing paper will be required and shall be of a type approved by the Engineer.

5.9.2.4 Elastomeric Bearing Pads

Elastomer for bearing and expansion joint construction shall be made of approved materials and they shall have excellent resistant to ageing, weathering, oil, chemical and ozone attack, and not propagate flame.

Bridge bearings shall be multiple laminated layers of elastomeric material, separated by steel plates, bonded by vulcanisation to the elastomeric material, conforming to the requirements of bearing schedule as shown on the Drawings and to the requirements of AASHTO M251, Laminated Elastomeric Bridge Bearings, or other internationally recognised standard of practice approved by the Engineer.

Bridge bearings shall be supplied only by manufacturers having at least 5 years experience of producing this product.

The Contractor shall furnish to the Engineer certification by the Manufacturer that the elastomer conforms to the Standards requirements. The certification shall be supported by a certified copy of the results of tests, performed by the manufacturer upon samples of elastomer to be used in the pads, covering all requirements. However, low temperature tests shall not be required.

5.9.2.5 Epoxy Resin

Two component epoxy resin adhesive for use as protective or skid resistant overlay on Portland cement concrete surface and bridge deck shall generally be in accordance with AASHTO Standard Specification M200. The epoxy system to form an epoxy mortar levelling pad for bridge bearing as required by the Drawings shall be approved by the Engineer.

5.9.2.6 Water Stop

Waterstop material shall be approved in writing by the Engineer before being used in the works.

5.9.2.7 Pot Bearing

All pot bearings shall be of the types as shown on the Drawings, consisting of a circular elastomer pad made of chloroprene or natural polyisoprene totally enclosed by a steel pot with 100 percent virgin polytetrafluoroethylene sheet, lubricated with special silicone grease against homogeneous high grade stainless steel plate of at least 1.5 mm thickness to form surface roughness of less than 1 micron, which constitute sliding surfaces and rotation for the sliding bearings. Pot bearing shall be supplied by a manufacturer having at least 10 years experience of producing this product.

Bearing design and installation details to be used in the work shall be such that:

- the bearings are conveniently accessible for periodic inspection and maintenance.
- the bearings are easily replaceable, if necessary, without closure to traffic.
- the levels of bearings shall be adjustable to compensate for any excessive differential settlement of the structures. It shall be done with the minimum interference to highway operation. The adjustment of bearing levels may be done by injection of silicone rubber (siloprene) between the pot and the rubber plate, in which case injection channels and devices must be provided with a non-return valve. A more conventional method of adjustment by inserting or removal of liners (shim plates) between the top plate of the bearing and the superstructure or other means shall be subject to the approval of the Engineer.

5.9.2.8 Reinforced Elastomeric Expansion Joint

a) General Requirements - The expansion joints to be installed shall satisfy the following functional requirements.

- To withstand all traffic loads and resist a minimum 1 N/mm^2 truck tyre pressure.
- To accommodate movements of the bridge due to shrinkage, creep, temperature without creating unacceptable stresses in the joints or other parts of the structure.

- To have smooth riding quality not causing any inconvenience to the road users nor causing skidding hazard. The width of longitudinal expansion grooves at traffic surface shall not be more than 30 mm.
- Not generating excessive noise or vibration nor causing any damage during the passage of vehicles at a speed of 80 km/hr.
- To be tightly sealed not allowing any seepage of water and collection of debris.
- To be easy to install, inspect and maintain and all parts liable to wear must be easy to replace.
- The certified licences of building supervisory authorities or certificates of authorised laboratory shall be submitted by the Contractor to the Engineer for approval. Each unit of expansion joint must be marked with the manufacturer's trade mark and type.
- The expansion joints installed shall be maintenance free and should last for 5 years after opening to traffic.

b) Elastomer - The elastomer shall be composed of two different material qualities to give better performance and long life, i.e. mechanically high quality for abrasion proof surfaces and soft inner parts for shearing force resistance.

Elastomer parts must possess, according to their functions, the minimum properties required by AASHTO M 251.

c) Steel Plates - The steel used for all construction parts shall be accompanied by a manufacturer's certificate. Unless otherwise specified, the yield strength of steel plate shall be 2,400 kg/sq-cm. All edges of the steel plates shall be carefully treated in order to prevent notch effects. The exposed parts of anchorage units shall be sufficiently protected against corrosion.

5.9.3 CONSTRUCTION REQUIREMENTS

5.9.3.1 Storage and Preparation

Expansion joint materials and bearing materials delivered to the bridge site shall be stored, under cover, on platforms above the surface of the ground. It shall be protected at all times from injury, and when placed it shall be free from dirt, oil, grease or other foreign substance.

Premoulded material shall be used in as large pieces as possible. Small areas of 0.25 square metre or less shall be made of one piece, where a single piece may be used for each pour. The material shall be cut to a neat accurate edge with a sharp tool. Rough or ragged edges will not be permitted. The material shall be placed so that it will be securely held in the form and well-fastened to one face of the concrete. Care must be taken to ensure straight lines at the joint.

5.9.3.2 Expansion Joints

a) General - Expansion joints except in the case of premoulded filler shall be formed by placing a temporary joint form, shaped to the section, of a type of material approved by the Engineer. Care shall be taken in removing these forms so that the concrete is not chipped or broken. The size of the gap shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements agreed with the Engineer.

The position of all bolts cast into concrete and all holes shall be accurately determined from templates.

The mixing, application and curing of all proprietary materials shall comply with the manufacturers requirements.

All joints shall be constructed according to physical details shown on the Drawings.

b) Prevention of damage - During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and the supports to which they are being fixed.

When one half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular where strongbacks or templates are used to locate the two sides of a joint they shall not be fixed simultaneously to both sides. Screw threads shall be kept clean and free from rust.

Ramps shall be provided and maintained to protect all expansion joints from vehicular loading. Vehicles shall cross the joints only by means of the ramps until the Engineer permits their removal.

5.9.3.3 Epoxy Mortar Nosings

Epoxy mortar nosings shall be formed under the direction of a competent supervisor experienced in the use of the material. The work shall be carried out preferably in dry weather. The air temperature around the joint shall be not less than 10°C.

Concrete surfaces to which the nosings are applied shall be dry, sound and free from laitance. Before application of the priming coat, loose material and dust shall be removed by an air jet, tested to ensure that no oil is carried over from the compressor.

Unless otherwise described in the Drawings or these Specifications surfacing shall be carried across the joint and then cut back to accommodate the nosing. The cutting shall be done with a diamond saw to give a clean edge throughout the depth of the material to be removed. Masking material provided to prevent surfacing materials adhering to the deck where nosings are to be formed shall be adequately located to prevent displacement by the paving machine.

A priming coat of unfilled epoxy resin composition shall be well worked in by brush to all surfaces with which the nosings will be permanently in contact at a uniform rate of not less than 250 grams per square metre. The mortar shall then be applied as quickly as possible while the priming coat is still tacky.

The composition and mix proportions of the epoxy mortar shall be submitted for the Engineer's prior approval. Aggregate shall be either silica sand, calcined bauxite or other approved synthetic or natural aggregate of suitable grading. The particle size distribution shall be that which produces a mortar with adequate workability and minimum void volume. Aggregates shall be clean and completely dry.

Whichever type of aggregate is used, the epoxy mortar components shall be thoroughly mixed in a suitable mechanical mixer. The sequence, duration and temperature of mixing shall be in accordance with the manufacturer’s instructions.

The mortar shall be placed in position within the time recommended by the manufacturer. It shall be well worked against the primed surfaces and trowelled flush with the adjacent

road surface to form a dense mortar to the profiles described in the Drawings or these Specifications.

Epoxy mortar shall generally be compacted in courses of thickness not exceeding 50 mm. Where an underlying course is more than 1 hour old it shall, unless otherwise agreed by the Engineer, be primed with an unfilled epoxy resin priming coat before placing the next course.

Traffic shall not be permitted to run on the mortar until the Engineer's agreement has been obtained.

5.9.3.4 Bearing Pads

Bearing pads shall be horizontally installed to appropriate setting as directed by the Engineer or as shown on the Drawings. When they are set on their beds of neat cement grout, the grout shall be allowed to harden and cure before girders are erected.

The bearing pads shall be maintained in their correct position during the placing of the bridge deck. After the deck has been completed, each bearing and the area around it, shall be left clean.

5.9.3.5 Water Stops

Waterstops where used shall form continuous watertight joints.

5.9.4 MEASUREMENT

Joint filler and joint sealant shall be separate components of one item, varying only with the dimension of the joint required by the Drawings. Measurement of joint filler and sealant shall be two-dimensional on a square metre basis, measured vertically from the top of the joint sealant to the bottom of the joint filler and in horizontal direction for the width of the span. Each thickness of joint material required shall constitute a separate item.

Reinforced elastomeric type expansion joint at bridge abutments as shown on the Drawings shall be measured in linear metre along the surface of the joint installed and accepted by the Engineer.

Expansion joint for pedestrian bridges as shown on the Drawings shall be separate components of one item, measured in linear metre along the width of joint installed and accepted by the Engineer.

Plain elastomeric bearing strip and laminated bearing pads of the type shown on the Drawings shall be measured in linear metre and as a number respectively of the size and type installed and accepted by the Engineer.

Pot bearing of types, sizes and performances as indicated on the Drawings shall be measured as a number of bearing installed and accepted by the Engineer.

5.9.5 PAYMENT

Expansion materials for bridges will be paid for in accordance with the following:

The joint filler and joint sealant measured as provided above shall be paid for at the unit rate price for particular thickness of joint material. Payment made shall be full compensation for furnishing and placing of all materials, labour, tools, equipment and incidental necessary to complete the works as prescribed and to the satisfaction of the Engineer.

The reinforced elastomeric type expansion joint at bridge abutments measured as provided above shall be paid for at the unit rate price for particular size of movement. Payment made shall be full compensation for furnishing and installation of all materials including stainless steel stud, nut, anchorage unit, sealing compound, epoxy mortar nosing, labour, tools, equipment and incidentals necessary to complete the works as prescribed and to the satisfaction of the Engineer.

The expansion joint for pedestrian bridge measured as provided above shall be paid for at the unit rate price for particular width of joint indicated. Payment shall be full compensation for furnishing and installation of all materials including continuous watertight expansion joint, epoxy paint, asphalt paper strip, debonding agent, primer, hot poured sealant, labour, tools, equipment and incidental necessary to complete the works as prescribed and to the satisfaction of the Engineer.

Plain elastomeric bearing strip and laminated bearing pad measured as provided above shall be paid for at the unit rate price for particular type and size. Payment shall be full compensation for furnishing and installation of all materials including non-shrink or cement based mortar pad, reinforced concrete plinth, dowels, anchor unit, restraining devices, upper and lower plate, labour, tools, equipment and incidentals necessary to complete the works as prescribed and to satisfaction of the Engineer.

Pot bearing installed at bridge piers and abutments measured as provided above shall be paid for at unit rate price for particular type, size and performance. Payment made shall be full compensation for furnishing and installation of material including upper and lower anchor plates, dust guard, movement indicator, dowels, anchorage unit, non-shrink or cement based mortar pad, reinforced concrete plinth also metallic settlement indicator at each pier and abutment, labour, tools, equipment and incidentals necessary to complete the works as prescribed and to the satisfaction of the Engineer.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
5.9(1.1)	Joint Filler and Sealant, _____mm thick	Square metre
5.9(2.1)	Reinforced Elastomeric Expansion Joint _____ mm movement	Metre
5.9(3.1)	Expansion Joint, _____ mm movement (Pedestrian Bridge)	Metre
5.9(4.1)	Plain Elastomeric Bearing Strip, _____mm x _____mm	Metre
5.9(5.1)	Laminated Bearing Pad _____mm x _____mm x _____mm	Metre
5.9(6.1)	Pot Bearing Type _____	Number
	(sizes and type of particular item shall be described)	

5.10 CONDUITS, FITTINGS AND BOXES

5.10.1 DESCRIPTION

This work shall consist of the furnishing and installation of all the conduits fittings, pull and junction boxes, conduit expansion joints and incidental parts necessary to provide for future lighting or operation of structures. The type, size and location of conduits, fittings and boxes will be as indicated on the Drawings.

5.10.2 MATERIALS REQUIREMENTS

5.10.2.1 Metallic Conduit, Fittings and Boxes

Conduit shall be formed of mild steel without laminations due to slag breaks, blisters or pockets, and without cinders or other foreign matter. Conduit shall have a circular cross-section, with uniform wall thickness to permit the cutting of clean, true threads. All seams shall be completely and thoroughly welded.

The conduit shall be galvanised on the outside by one of the three methods of hot dip galvanising, sherardising or electro-galvanizing, and the inner surfaces shall be protected in a like manner by a thick coating of enamel. All mill scale shall be removed before pickling and conduit shall be thoroughly cleaned and dried after pickling is completed. Galvanising shall be done under controlled temperatures. The zinc coating and enamel coating, if used, shall have an even, smooth appearance and be of uniform quality. Conduits shall be capable of standing five dips in the Preece Copper Sulphate test for galvanised coating ASTM Designation A-239-40.

The conduct seam and coating shall withstand being bent cold at minimum temperature of 150 C. under slowly applied pressure through 900 to a radius six times the outside diameter of the conduit with the seam on the outside of the bond, without developing cracks or opening the weld and without cracking or flaking the coating.

All conduit fittings without exception shall be made from the same material and shall have the same coating as specified for conduit. The test for the continuity of coating shall be the same as specified for conduit. One coupling shall be furnished with each length of conduit or bend.

Pull or junction boxes shall be made of sheet steel of cast iron in accordance with the Drawings and/or these Specifications. Sheet steel boxes shall have sharp, straight edges and continuous electric welded seams. A 10 mm flange, turned in, shall be used to take a rubber gasket and shall be drilled and tapped for an approved number of 5 mm brass machine screws. If box is to be encased in concrete, the cover shall extend 10 mm beyond dimensions of the box and shall be drilled to match tapped holes in flange of same. When boxes are completely exposed, the cover shall conform to the outside dimensions of the box. All holes for conduit entrances into sheet steel boxes shall be drilled. Sheet steel boxes shall be galvanised in the same manner as for conduit.

5.10.2.2 Asbestos Cement Conduit, Fittings and Boxes

Asbestos Cement Conduit shall consist of an intimate mixture of asbestos fibre and cement. The fibre shall be carefully selected and graded and shall be so interspersed with the cement as to serve effectively as an aggregate and reinforcement to the resultant mass. The fibre and cement shall be dispersed in water, formed into a thin web having a

width equal to the full length of the finished section and wrapped on a smooth cylindrical mandrel under continuously applied pressure to produce a conduit having a dense, uniform and homogenous structure.

Conduit shall have an inside diameter not smaller than nominal sizes indicated by the manufacturer. All fittings shall be of the same material as used for straight conduit and shall possess the same characteristics. The inner surface shall be free from obstructions, rough or flaky areas as gauged by the ability to freely pass a ball of a diameter 5 mm less than the nominal size of the conduit with which the fitting is used.

The bore shall be straight as gauged by the ability to freely pass a 1 metre long mandrel 5 mm less in diameter than the nominal size of the duct.

The conduit shall not contain free alkali or any other material in sufficient quantities to contribute in any greater degree to the corrosion of the lead sheath, lead alloy sheath, rubber covered or waterproofed cables than the water and soils ordinarily encountered in underground work.

Pull or junction boxes shall be built of sheet material identical in composition with the used for the conduit. All corners shall be square, all edges true and all joints strongly braced and fastened as recommended by the manufacturer. Edges shall be waterproofed with a waterproofed joint sealing compound recommended by the conduit manufacturer and approved by the Engineer, and a gasket shall be used under all covers.

5.10.3 CONSTRUCTION REQUIREMENTS

5.10.3.1 General

The size of each conduit shall be such that the sum of the areas of the cross-section of all conductors, including insulation and protective coverings, shall be not greater than 30 per cent of the inside area of conduit, except that no conduit encased in concrete or installed underground shall be less than 50 mm, inside diameter, and no conduit smaller than 20 mm inside diameter shall be used except for fixture hangers.

All conduit sizes and conduit layout shall be approved by the Engineer before installation, and the Contractor shall submit data on the layout for the exact makeup, overall diameter, and cross-sectional areas of the actual conductors he intends to use and the sum of the areas of the conductors in each conduit.

Bends shall be of long sweep, free from kinks and of such easy curvature as to permit the drawing in of conductors without injury. The radius of curvature of inner edge of bends shall not be less than ten times the inside diameter of the conduit except as may be otherwise noted on the Drawings or in these Specifications. Conduits shall be not flattened or distorted. The total angle of all bends between any two boxes or fittings shall not exceed 90 degrees.

All conduits used on a contract shall be the product of one manufacturer.

Exposed conduit runs shall be parallel to or at right angles to walls, slabs, girders and in locations giving greatest accessibility for painting and least accumulation of dirt. All exposed conduit runs shall be attached to steel, masonry, concrete or timber by galvanised malleable iron or galvanised steel straps, clamps or hangers of an approved type, held at not less than two points by galvanised steel bolts or lag screws. The runs shall be supported at not greater than 3 metre centres on horizontal runs, unless otherwise specified and not less than 50 mm clear of the supported members. Conduits mounted on structural steel members shall be securely clamped to prevent rattling and wear.

All ends of conduits installed during construction, or for future use, shall be closed against the introduction of foreign material by the use of standard pipe or bush caps. All conduits shall be installed so that they will drain and necessary holes for this purpose shall be made as directed.

All conduit risers in railing posts shall, unless otherwise shown on the Drawings terminate 20 mm below the top surface of the post. The risers shall be accurately placed so that they may be located for future use.

All conduits installed underground shall have a concrete envelope which shall afford a 70 mm cover beyond the maximum dimension of the conduit. Class B2 concrete shall be used.

Excavation for the encasement shall be carefully done, sidewalls trimmed to line an bottom of trench graded, so that the envelope will be uniform, and there will be no pockets or low points in the conduit run. All backfill shall be carefully tamped to conform to the requirements of Section 2.5 of these Specifications, unless otherwise specified, and care shall be taken not to injure concrete envelope or conduit.

All conduits, boxes, etc., to be encased in concrete must be accurately placed and rigidly held in position so that no variation from line or grade occurs when concrete is placed.

Conduits, fittings and boxes shall be stored under cover and above ground.

Upon completion of the conduit installation, the system shall be cleared in the presence of the Engineer before any conductors are installed. Immediately prior to the installation of conductors in any run, the conduits comprising that run shall again be checked. Any and all obstructions shall be removed to the approval of the Engineer.

The Contractor shall install and leave in place a No.10 iron wire in all conduit runs installed for future use.

The Contractor shall furnish work drawings of A1 size (594 mm x 840 mm), in duplicate, for the Engineer's preliminary examination. After work drawings have been accepted by the Engineer and revisions made, the Contractor shall furnish additional copies as may be requested.

5.10.3.2 Metallic Conduits, Fittings and Boxes

Conduits runs shall be with as few couplings as standard lengths will permit. Screw couplings shall be used. All cuts shall be made with the hacksaw and reamed clear of fins or burrs with a reamer.

Conduit shall have threaded ends coated with red or white lead and of sufficient length so that they will butt squarely and tightly in the coupling. Long running threads will not be permitted. Conduits shall be installed so as to be continuous and watertight between boxes and/or equipment.

Where conduits cross expansion joints in the structure, or where otherwise specified, they shall be provided with expansion fittings of an approved type. The electrical continuity of the conduit which runs across the expansion fittings shall be assured by approved fittings and bare No.8 copper wire.

Pull boxes shall be used wherever necessary to facilitate the installation of the conductors. Conduits entering into cast iron pull boxes or enclosures shall be threaded into hubs on

same. Conduits entering into sheet steel boxes or enclosures shall be secured with two lock nuts and the projecting ends shall be equipped with an approved insulating bushing.

All surfaces of conduit, boxes, fittings, etc., in contact with concrete encasement shall be painted one coat of approved paint.

5.10.3.3 Asbestos-Cement Conduits, Fittings and Boxes

Conduits shall be cut with a saw, and all ends shall be accurately tapered or otherwise finished, depending on type of conduit and coupling specified. Tools recommended by the conduit manufacturer shall be used, and finished ends shall be equal to those supplied by the manufacturer. All ends shall be smoothed of burrs or fins. Standard bends shall be used wherever possible, and special bends shall preferably have a radius not less than that of standard bends. All special conduit shall be accurately dimensioned and manufactured.

All joints shall be sealed with a waterproof joint sealing compound recommended by the conduit manufacturer and approved by the Engineer.

Expansion couplings shall be of a type designed and manufactured by the conduit manufacturer. They shall be sized to fit the conduit run in which they are to be used and of length as indicated on the Drawings. Expansion couplings shall be placed not more than 16 metres apart where an exposed conduit run, between boxes or terminals, is equal to or more than 22 metres. One expansion coupling shall be used on all exposed runs less than 33 metres between boxes or terminals. Expansion couplings on conduit runs encased in concrete shall be placed as indicated on the Drawings.

Exposed conduit shall be supported by approved hangers at not more than 3 metre centres. Hangers shall be of a type that permits movement of the structure. Expansions couplings shall be rigidly secured to the structure.

Appropriate safety measures shall be implemented by the Contractor for protection of labour when working with asbestos products.

5.10.4 MEASUREMENT

This item will not be measured, and payment shall be made on a lump sum basis.

5.10.5 PAYMENT

This work shall be paid for at the Contract lump sum price for the item “Furnishing and Installation of Conduits, Fittings and Boxes”, complete in place, including all working drawings, conduits, fittings, pull and junction boxes, fixings, conduit expansion joints and incidentals, excavation, concrete encasement, backfill, tamping, galvanising, painting, tools labour, equipment and incidentals necessary to complete the work.

Pay item shall be as follows:

Item Ref	Description	Unit of Measurement
5.10(1)	Furnishing and Installation of Conduits, Fittings and Boxes	Item

5.11 PAINTING METAL STRUCTURES

5.11.1 DESCRIPTION

This work shall consist of, unless otherwise provided in the Contract, the preparation of the metal surfaces, the application, protection and drying of the paint coatings and the supplying of all tools, tackle, scaffolding, labour and materials necessary for the entire work.

5.11.2 MATERIALS REQUIREMENTS

5.11.2.1 General

The Contractor shall submit for the Engineer's approval the origin and characteristics of the paints which shall be used for protection of the metal structures against corrosion.

The selection of the paints to be used shall take into consideration:

- the guarantee requested against corrosion (6 years, category Ri 1 according to the French Standard NF T 30-071, or to similar standards),
- the guarantee requested against blistering and peeling (5 years),
- the guarantee requested against degradation of colour (non uniform, 5 years),
- the guarantee requested against degradation of the paint film (non uniform, 3 years),
- the compatibility between the paint and the steel materials, as well as the compatibility of each coat of paint with the next one (prime coat and undercoat, undercoat and finish coat).

The Contractor shall select, preferably, paints that are approved by an independent quality control organisation.

The Engineer will be entitled to order preliminary approval tests carried out on samples of the paints, in a laboratory of his own choice; sampling, transport and testing shall be at the Contractor's expense.

All paints shall be supplied by the same manufacturer, unless otherwise authorised by the Engineer.

5.11.2.2 Prime Coat (Shop or Field Coat)

The prime coat of paint for ungalvanized ferrous metal shall be either a shop coat of a two-pack, solvent based inorganic zinc silicate primer (for new steelwork); or a field coat of a two-pack, zinc-rich polyamide cured epoxy primer (organic primer for rehabilitation of existing steel structure). Either coating shall be applied to achieve a minimum dry film thickness of 75 microns.

Galvanized surfaces shall not be coated unless specified otherwise in the Drawings.

Aluminium or aluminium alloy surfaces shall not be coated unless specified otherwise in the Drawings.

5.11.2.3 Finish Coat (Field Coat)

Unless noted otherwise on the Drawings, the paint to be used for the finish coat shall consist of a two-pack micaceous iron oxide pigmented polyamide cured epoxy. It shall be applied in two coats to achieve a minimum dry film thickness of 250 microns.

5.11.3 CONSTRUCTION REQUIREMENTS

5.11.3.1 Cleaning of Surfaces

Surfaces of metal to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil or grease and other foreign substances. Unless cleaning is to be done by sand blasting, all weld areas, before cleaning is begun, shall be neutralised with a proper chemical, after which it shall be thoroughly rinsed with water.

Three methods of cleaning are provided herein. The particular method to be used shall be specified by the Engineer. However, only the sandblasting method shall be used for cleaning the structural steel used for bridge decks.

5.11.3.2 Hand Cleaning

The removal of rust, scale and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle or wood fibre brushes shall be used for removing loose dirt.

5.11.3.3 Sandblasting

All structural steel used for the bridge decks shall be cleaned by sandblasting. The sandblasting shall remove all loose mill scale and other substances down to the bare metal. The steel surfaces shall be blasted to approval and not less than to the preparation grade Sa 2□ conforming the last issue of the Swedish Specification Svensk Standard SIS 05 59 00 “Pictorial surface preparation standards for painting steel surfaces”. Furthermore the steel surface shall meet the index of roughness specified, by the paint manufacturer, for the type of paint and the conditions of application.

Oil and grease shall be removed by solvent cleaning before sand or grit blasting. Sand or steel grit blasting shall be carried out with compressed air-equipment. Compressed air shall be dry and without oil traces; for this purpose the equipment shall be fitted with separators and valves. Sand or grit blasting shall proceed only when the relative humidity is less than 80 %. Blast products shall be removed from the surface of blast cleaned steel by air pressure and vacuum cleaning; brush cleaning only shall not be considered as satisfactory.

Special attention shall be given to cleaning of corners and re-entrant angles. Before painting, sand adhering to the steel in corners and elsewhere shall be removed. The cleaning shall be approved by the Engineer prior to any painting, which shall be done as soon as possible before rust forms.

5.11.3.4 Flame Cleaning

Flame cleaning shall not be used on the inside surfaces of closed members unless approved respirators and other safety equipment specified by the Engineer are supplied and used.

Where approved by the Engineer, flame cleaning shall be carried out in accordance with the following:

i) Oil, grease and similar adherent matter shall be removed by washing with a suitable solvent. Excess solvent shall be wiped from the work before proceeding with subsequent operations.

ii) The surface to be painted shall be cleaned and dehydrated (free of occluded moisture) by the passage of oxyacetylene flames which have an oxygen to acetylene ratio of at least one. The inner cones of these flames shall have a ratio of length to port diameter of at least 8 and shall be not more than 3.7 mm centre to centre. The oxyacetylene flames shall be traversed over the surfaces of the steel in such manner and at such speed that the surfaces are dehydrated; and dirt, rust, loose scale in the form of blisters or scabs, and similar foreign matter are freed by the rapid, intense heating by the flames. The flames shall not be traversed so slowly that loose scale or other foreign matter is fused to the surface of the steel. The number, arrangement and manipulation of the flames shall be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.

iii) Promptly after the application of the flames, the surfaces of the steel shall be wire brushed, hand scraped wherever necessary, and then swept and dusted to remove all free materials and foreign particles. Compressed air shall not be used for this operation.

iv) Paint shall be applied promptly after the steel has been cleaned and while the temperature of the steel is still above that of the surrounding atmosphere, so that there will be no recondensation of moisture on the cleaned surfaces.

5.11.3.5 Number of Coats and Colour

All steel shall be painted with one prime coat, and with not less than two other coats of finishing paint. The number of coats and the thickness of each coat shall be submitted by the Contractor to the Engineer's approval. The total dry film thickness of all applied coatings shall not be less than 325 microns.

The colour of each coat shall be as specified or determined by the Engineer. The coats shall be sufficiently different in colour to permit detection of incomplete application.

5.11.3.6 Weather Conditions

Paint shall not be applied when the air is misty, or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work. If shall not be applied upon damp surfaces.

Material painted under cover in damp weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting shall not be done when the metal is hot enough to cause the paint to blister and produce a porous paint film.

5.11.3.7 Areas in Contact with Concrete

Areas of steelwork in contact with concrete in the completed structure shall receive the surface preparation and applied coatings as that employed on adjacent exposed areas for a minimum distance of 50 mm from the exposed surface. Areas further than 50 mm from the exposed surface shall receive the same surface preparation and primer but coatings applied after the primer may be reduced in build to give a total minimum dry film thickness for all coatings of 150 microns.

5.11.3.8 Shear Studs

Shear studs shall receive the same surface preparation as adjacent areas of steelwork and primed to achieve a total dry film thickness of 50 microns.

5.11.3.9 Surfaces to be bolted

The faying surfaces of friction-type bolted connections shall be treated as follows:

- Abrasive blast clean to Class 2 ½
- Surface profile 25 to 65 microns
- Apply one coat of inorganic zinc primer with a minimum dry film thickness of 75 microns

The faying surfaces of bearing-type bolted connections shall receive the same treatment as the adjacent steelwork.

5.11.3.10 Application

a) Mixing of Paint - Paint shall be factory-mixed except as provided in this section. All paint shall also be field mixed before applying in order to keep the pigments in uniform suspension. Zinc rich paints shall be continually agitated in the pot by an approved method during application.

b) Stripe Coats - The following provision shall apply to application of both undercoat and finish coat: To secure a maximum coating on edges of plates or shapes, bolt heads and other parts subjected to special wear and attack, the edges shall first be striped with a longitudinal motion and the bolt heads with a motion rotary of the brush, followed immediately by the general painting of the whole surface, including the edges and bolt heads.

c) Field Painting - When the erection work is complete including all bolting and straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign material shall be removed as specified under 5.12.3.1 to 5.12.3.4.

As soon as the Engineer has examined and approved all field bolts, the heads of such bolts, all welds and any surfaces from which the prime coat or the undercoat has become worn off or has otherwise become defective, shall be cleaned and thoroughly covered with one coat of prime coat paint.

The application of the finish coat shall be deferred until adjoining concrete work has been placed and finished. If concreting operations have damaged the paint, the surface shall be re-cleaned and repainted.

The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the structure and also all other portions of the structure, against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

d) Brushing - When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

e) Spraying - Power spraying equipment shall apply the paint in a fine, even spray without the addition of any thinner. The Contractor shall follow the manufacturer's recommendations with regard to the adjustment of the painting equipment (nozzle orifice and pressure), the weather conditions required during application and the interval of time between the coats.

Paint, when applied with spray equipment, shall be immediately followed by brushing when necessary to secure uniform coverage and to eliminate wrinkling, blistering and airholes.

f) Removal of Paint - If the painting is unsatisfactory to the Engineer, the paint shall be removed and the metal thoroughly cleaned and repainted.

g) Thinning Paint - Paint as delivered in containers when thoroughly mixed is ready for use. If it is necessary to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators, and liquid shall not be added nor removed unless permitted by the Engineer.

h) Painting Galvanised Surfaces - Painting of galvanised surfaces shall be as directed in writing by the Engineer.

i) Shop Protective Treatment - Unless otherwise specified, steelwork shall be given one coat of approved primer paint after it has been accepted by the Engineer, either in shop before it is shipped from the plant (for new steelworks), or in the field (for rehabilitation of existing steel structures). The prime coat must be applied within maximum two (2) hours after the blasting and dust freeing. If the time elapsed since the start of blasting exceeds this limit, brushing and dust freeing must be repeated. Priming shall proceed only when the relative humidity is less than 80 %.

Structural steel that is to be welded shall not be painted before welding is complete. Steel that is to be field welded shall be given one coat of boiled linseed oil or other approved protective coating after shop welding and shop fabrication is completed.

Surfaces of iron and steel castings, either milled or finished, shall be given one coat of paint.

With the exception of abutting joints and base plates, machine-finished surfaces shall be coated as soon as practicable after being approved before removal from the shop.

Erection marks for the field identification of members and weight marks shall be painted upon surfaces areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry, and in any case not less than 24 hours after the paint has been applied.

j) Quality Control - The control of the paint work shall include a verification of the quality of the blasting and surface roughness, the quality of the paint applied, and the thickness of the various paint coats. The dry film thickness shall be measured in place with a calibrated magnetic film thickness gauge.

5.11.4 MEASUREMENT

The quantity of work done under this item shall be measured as the number of square metres painted and accepted, unless otherwise specified. The surface shall be calculated without reduction or addition for bolt holes, contact surfaces, welds, and cross-sectional ends.

5.11.5 PAYMENT

Painting work measured as described above shall be paid for at the contract unit price per square metre of paint, completed and accepted, unless otherwise specified. The payment shall be full compensation for the work, materials, labour and equipment, including furnishing of paint material, cleaning of surfaces and application of paint.

Pay Item shall be as follows:

Item Ref	Description	Unit of Measurement
5.11(1)	Shop protective treatment of Metal Structures	Square metre
5.11(2)	Field protective treatment of Metal Structures	Square metre

5.12 FOUNDATION INVESTIGATION

5.12.1 DESCRIPTION

This work shall consist of the conducting of foundation investigations for structures including all investigations, sampling and testing necessary to determine as accurately as possible the bearing capacity of the soil (for shallow and deep foundations), the settlement and consolidation parameters, and the depths of the piles as specified on the Drawings or in accordance with the requirements of the Engineer.

5.12.2 GENERAL REQUIREMENTS

5.12.2.1 Site Operations

Prior to the preparation of the detailed designs and construction drawings, the Contractor shall carry out a detailed foundation investigation of each bridge site.

The foundation investigation shall include.

(a) borings with SPT tests or pressuremeter tests, including undisturbed and disturbed sampling , or dynamic penetration tests,

(b) laboratory testing including:

- water content (ASTM D4683-87),
- specific gravity (ASTM D854-91, AASHTO T100-90),
- grain size distribution [ASTM D422-63(90), AASHTO T88-90],
- liquid limit and plastic limit (ASTM D4318-84, AASHTO T90-87),
- wet unit weight and dry unit weight, void ratio and porosity,
- soil classification,
- undrained direct shear test (ASTM D3080-90, AASHTO T236-84),
- unconfined compression test (ASTM D2166-91, AASHTO T208-90),
- consolidation test (ASTM D2435-90 or D4186-89, AASHTO T216-83),
- oedometer test, pH and SO4 content.

The depth of the borings may be determined based on the results of the foundation investigation available, but it shall not be sufficient for obtaining the information required for the foundation design.

SPT tests should be taken at 1.5 m intervals and water levels recorded at time of the site investigation. Detailed bore logs shall be recorded by an experienced engineering geologist or geotechnical engineer employed by the Contractor and shall be submitted to the Engineer together with the surveyed location and existing ground level of each bore hole.

The results of the soils testing shall also be submitted to the Engineer.

5.12.2.2 Programme and Scope

The programme for the foundation investigation shall be submitted by the Contractor for the Engineer's approval but will not comprise less than one borehole at each bridge abutment with sampling and SPT (or similar) testing, plus one borehole at each pier where multi-span bridges are to be constructed.

5.12.3 MEASUREMENT

Measurement for foundation investigations will be by the actual number of bridge sites at which investigations have been carried out and results provided and accepted by the Engineer and is deemed to include all site work and laboratory testing activities

5.12.4 PAYMENT

Payment for the foundation investigations carried out and accepted by the Engineer will be at the Contract unit price for each bridge site specified in the Drawings and shall be full compensation for all labour, materials, equipment and incidentals necessary to complete the investigations, including completing all borings, materials testing and reporting, all to the satisfaction of the Engineer.

Payment shall be made under the following heading

Item Ref.	Description	Unit
5.12.(1)	Foundation Investigation for Bridges	Number

5.13 SURVEY

5.13.1 DESCRIPTION

This work shall consist of the carrying out of site surveys to be used by the Engineer for completion of the foundation and sub-structure designs for bridges and to provide setting out details for culverts.

5.13.2 GENERAL REQUIREMENTS

5.13.2.1 Scope of Work

The scope of the surveys proposed by the Contractor at each site will be submitted to the Engineer and approved prior to the commencement of these activities.

5.13.3 SURVEY REQUIREMENTS

5.13.3.1 Box Culverts

The Contractor shall carry out detailed topographic survey of each box culvert site to enable the preparation of an existing site layout drawing with 0.5 m contours, detailing the existing road alignment and levels, and position and levels of the existing stream channel and any other relevant local features such as irrigation structures, houses, property fences or boundaries and any other permanent reference marks.

The Contractor shall provide at each site permanent reference and recovery marks to enable accurate location and control of construction of the new structure in accordance with the requirements of sub-clause 9.4.3.3 of the General Specifications. These marks shall be accurately identified and tabulated on the completed survey drawings of each site

5.13.3.2 Bridges

The Contractor shall carry out survey of each bridge site as detailed above in sub-clause 5.14.3.1 of these Special Provisions.

Where a realignment of the road is required, adequate survey of the existing road and adjacent area shall be carried out to enable section of realignment proposed to be accurately shown on the drawings, in particular in relation to its connections to the existing road.

5.13.4 DESIGN REQUIREMENTS

5.13.4.1 Box Culverts

The construction of box culverts shall be in accordance with Drawings, the relevant provisions of the General Specifications and the provisions of Clause 2.2.3 of Part A of these Special Provisions.

The Contractor may propose to use precast box culverts in place of the insitu box culverts shown on the Drawings as provided for under Section A, Clause 2.2.3 of these Special Provisions in which case it shall submit to the Engineer the detailed designs and construction drawings for consideration.

These designs and drawings shall be in accordance with the relevant design codes as specified in sub-clause 5.14.2.2 of these Special Provisions and shall be submitted with a written request that shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change.

This request and all details specified above shall be submitted to the Engineer no later than period specified in sub-clause 5.14.4.3 of these Special Provisions.

5.13.5 MEASUREMENT

Measurement for survey will be by the actual number of bridge and box culvert sites at which survey has been carried out and specified documents provided and accepted by the Engineer and is deemed to include all site work and design office activities

5.13.6 PAYMENT

Payment for the survey carried out and accepted by the Engineer will be at the Contract unit price for each bridge and box culvert site specified in the Drawings and shall be full compensation for all labour, materials, equipment and incidentals necessary to complete the survey and design, including preparation of all survey drawings, reporting, interpretation of foundation results, designs, preparation of construction drawings all to the satisfaction of the Engineer.

Payment shall be made under the following heading:

Item Ref.	Description	Unit
5.13.(1)	Survey for Bridges and Box Culverts	Number

CONSTRUCTION SPECIFICATION

Section 6
Drainage and Protection Works

TABLE OF CONTENTS

6 DRAINAGE AND PROTECTION WORKS

6.1 REINFORCED CONCRETE CULVERT PIPES

6.1.1 DESCRIPTION

This work shall consist of furnishing and installation of reinforced concrete culvert pipe at such locations as are shown on the Drawings or by the Engineer in accordance with these Specifications and in accordance with the classes, lines, levels, grades and dimensions shown on the Drawings.

The work shall include the furnishing and construction of such joints and such connections to other pipes, catch basins, and walls and other items as may be required to complete the structure as shown on the Drawings.

The horizontal and vertical location of pipe culverts, their dimensions, skews and their inlets and outlets, as indicated on the Drawings, are subject to final decision and instruction to be given by the Engineer in writing. If changes occur in the above respects, they shall in no way affect or invalidate the unit rates concerned.

More culverts than shown on the Drawings may be required and, if so, the Engineer will indicate their location and size as the work proceeds.

6.1.2 MATERIALS REQUIREMENTS

6.1.2.1 Pipe

a) General - Reinforced concrete culvert pipes shall be preferably of the tongue and groove type rather than of the bell and spigot type. They shall be constructed in accordance with the details shown on the Drawings. Butt jointed pipes will not be permitted.

b) Concrete - Concrete used in the construction of reinforced concrete culvert pipes shall be in accordance with Section 5.1 of these Specifications, except where modified by the Drawings.

c) Reinforcement - Steel Reinforcement used in the construction of reinforced concrete culvert pipe shall be in accordance with Section 5.2 of these Specifications, except where modified by the Drawings.

d) Mortar - Mortar for joints shall contain one part portland cement and two parts sand by dry volume unless otherwise required by the Drawings or these Specifications. The sand shall conform to the requirements of AASHTO Standard Specification M 45.

The amount of water in the mix shall be such that the consistency of the mortar is suitable for the purpose intended and to the satisfaction of the Engineer.

All mortar shall be used within 30 minutes of adding the water.

6.1.2.2 Testing

Reinforced concrete pipes may be tested, at the discretion of the Engineer, in accordance with the requirements of AASHTO T 280.

6.1.2.3 Permissible Variations

a) Permissible variations in dimensions - The internal diameter of 300-600 mm pipe shall not vary more than ± 1.5% from the design diameter. The internal diameter of 700 mm -2.7 m pipe shall not vary more than ± 1.0% or 10 mm, whichever is greater, from the design diameter. The wall thickness shall not be less than that shown in the design by more than 5% or 5 mm, whichever is the greater.

   A wall thickness more than that required in the design shall not be a cause for rejection. Pipes having localised variations in wall thickness exceeding those specified above shall be accepted if three edge bearing strength and minimum steel cover requirements are met.

b) Permissible variations in the position of the reinforcement - The maximum variation in the nominal position of the reinforcement shall be ± 10% of the wall thickness or ± 10 mm whichever is greater. Pipes having variations in the position of the reinforcement exceeding those specified above shall be accepted if the three bearing strength requirements obtained on a representative specimen are met. In no case however shall the cover over the reinforcement be less than 10 mm.

c) Variations in laying lengths - Variations in laying lengths of two opposite sides of pipe shall not be more than 1% of the diameter with a maximum of 15 mm in any length of pipe except where bevelled end pipe for laying on curves is specified by the Engineer.

d) The underrun in length of a section of pipe shall not be more than 1% of the diameter with a maximum of 15 mm in any length of pipe.

6.1.2.4 Finish

Pipes shall be substantially free of fractures, large or deep cracks, and surface roughness. The ends of the pipe shall be normal to the walls and centre line of the pipe.

6.1.2.5 Marking

The following information shall be clearly marked on each section of the pipe.

(a) The pipe class

(b) The date of manufacture

(c) The name or trade mark of the manufacturer

6.1.2.6 Inspection and Rejection

The quality of materials, the process of manufacture and the finished pipe shall be subject to inspection and approval by an inspector employed by the Engineer.

Pipes shall be subject to rejection on account of failure to conform to any of the specification requirements. Individual sections of pipe may be rejected because of any of the following.

(a) Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint.

(b) Defects that indicate imperfect proportioning mixing and moulding.

(c) Surface defects indicating honeycombed or open texture

(d) Damaged ends where such damage would prevent making a satisfactory joint.

6.1.2.7 Repairs

Pipes may be repaired, if necessary, because of occasional imperfections in manufacture or accidental injury during handling and will be acceptable if, in the opinion of the Engineer, the repairs are sound and properly finished and cured and the repaired pipe conforms to the requirements of these Specifications.

6.1.3 CONSTRUCTION REQUIREMENTS

6.1.3.1 General

Installation of any pipe culvert shall not commence until the length of pipe called for at the location in question has been approved by the Engineer.

All existing pipe culverts designated on the Drawings "to remain" or "to be extended" shall be carefully examined on the inside of the pipe concurrently by authorised representatives of the Engineer and the Contractor. Pipe culverts considered by the Engineer to be defective shall be removed and replaced as provided for herein. All usable sections of existing pipe culvert shall be handled with extreme care, cleaned, removed from the site and stored at a location to be determined by the Engineer.

Pipes removed shall be replaced with new pieces of pipe and payment for this work shall be made as specified in Clauses 6.1.4 and 6.1.5 of these Specifications. The Contractor will be held responsible for the satisfactory removal of pipe sections in a usable condition.

All pieces of pipe used for new pipe culverts and extending existing pipe culverts shall be new pieces of pipe as specified in Clause 6.1.2 of these Specifications. Excavation and backfill of pipe culverts and extensions shall not be measured and payment for this work will be made as described in Clauses 6.1.4 and 6.1.5 of these Specifications.

6.1.3.2 Excavation

Unless otherwise directed by the Engineer, pipe culverts to be laid at or below existing ground level and/or under embankment shall have the fill constructed to a height of at least 600 mm above the top of the pipe and then a trench excavated to receive the pipe.

Where circumstances permit and only with the approval of the Engineer will the Contractor be permitted to construct pipe culverts on or in existing ground without first forming embankment.

Before laying the pipe culvert, the foundation shall be trimmed true to line and grade, as directed by the Engineer, over sufficient width to permit satisfactory construction of the

bedding. Special care shall be taken to remove any hard or deleterious material from the foundation area.

If a firm foundation is not encountered, owing to soft, spongy or unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with gravel or other suitable selected material properly compacted to provide adequate support for the pipe, unless other special construction methods are called for on the Drawings.

The prepared surface shall provide a firm foundation of uniform density throughout the length of the culvert.

Excavated materials shall not be deposited in the drainage channel and, so far as possible shall be utilised as back fill or embankment.

6.1.3.3 Bedding

Bedding details for pipe culverts shall be as shown on the Drawings. The Engineer shall decide, in the field, what type of bedding shall be used depending upon the foundation soils. Granular material to be used as bedding shall conform to the requirements as specified in Section 5.8 of these Specifications - Porous Backfill Material Type A, or similar material approved by the Engineer, and shall be compacted in layers not exceeding 100 mm thickness to a density not less than 90% of that determined by AASHTO T 180, or such other standard as shall be directed on the Drawings or by the Engineer.

6.1.3.4 Installation

All reinforced concrete culvert pipes shall be laid with cemented joints. The pipe shall be laid carefully, hubs up-grade, spigot ends fully entered into the adjacent hub, and true to lines and grades as shown on the Drawings or directed by the Engineer. Before succeeding sections of pipe are laid, the lower half of the hub of the preceding section shall be plastered on the inside with cement mortar (proportioned 2 of sand to 1 of cement) of sufficient thickness to bring the inner surface of the abutting pipes flush and even. At the same time the upper half of the spigot of the succeeding pipe shall be similarly plastered with mortar. After the pipe is laid, the remainder of the joint shall be filled with similar mortar, and sufficient additional mortar shall be used to form a bead around the joint. The inside of the joint shall be wiped and finished smooth. The mortar on the outside shall be protected for two days or until the Engineer allows backfilling to proceed.

When pipe culverts are to be installed at locations where no pipe previously existed, the embankment shall be placed in uniform layers to an elevation 600 mm over the top of the proposed pipe and a trench shall be excavated to at least the dimensions shown on the Drawings. When installation of pipe is completed, backfilling will proceed as described below to a level of at least 600 mm over the top of pipe, then embankment placing will continue as specified in Section 2.6 of these Specifications.

6.1.3.5 Backfilling

Backfilling shall be carried out with material approved by the Engineer placed in uniform layers not exceeding 100 mm in uncompacted depth and thoroughly compacted. Each layer of backfill material, if dry, shall be wetted uniformly to a moisture content approved by the Engineer to obtain a density of not less than 90% of that determined by AASHTO T180 or such other density as shall be directed on the Drawings or by the Engineer.

Special care shall be taken to compact thoroughly the material under the haunches of the pipe and to ensure that the backfill shall be brought up evenly on both sides of the pipe for the full required length. Heavy earth moving and compacting equipment shall not operate closer to the culvert than 1.5 metres until covered to a depth equal to at least one fourth of the diameter of the culvert, but in no case less than 600 mm, unless otherwise approved by the Engineer. Light weight equipment may be operated within the above limitation after embankment has been placed and compacted to give a minimum cover of 300 mm over the top of the culvert.

Material for backfill shall conform to the requirements of select fill material as specified in Clause 2.6.2 of these Specifications. Limits of excavation and backfill measured for payment are as shown on the Drawings.

6.1.3.6 Placing of Embankment

Only when all backfilling has been completed in accordance with sub-clause 6.1.3.5 Backfilling of these Specifications will the Contractor continue with forming embankment which shall be done in conformity with the requirements of Section 2.6 of these Specifications.

6.1.3.7 Imperfect Trench Method

If the imperfect trench method is required by the Drawings the pipe shall be bedded, the trench backfilled and the embankment placed as described above to a height above the top of the pipe equal to the vertical outside diameter of the pipe plus 300 mm. A trench equal in width to the outside diameter of the pipe shall then be excavated in the newly placed backfill or embankment directly over the pipe and down to an elevation 300 mm above the top of the pipe. The sides of the trench shall be kept as nearly vertical as possible. The trench shall then be backfilled with highly compactable soil material as directed by the Engineer. Straw, leaves, sawdust, all to the approval of the Engineer, may be used to fill the lower one fourth to one third of the trench. After the trench is backfilled the embankment shall be placed in accordance with the requirements of Section 2.6 of these Specifications.

6.1.3.8 Concrete for Culverts and Headwalls

Concrete box culverts and headwalls for box culverts shall be constructed as shown on the Drawings in accordance with the requirements of Section 5.1 of these Specifications.

6.1.3.9 Bar Reinforcement for Culverts and Headwalls

Steel reinforcement for culverts and headwalls shall be as shown on the Drawings and in accordance to the requirements as specified in Section 5.2 of these Specifications.

6.1.3.10 Unsuitable Foundation Material

Foundation soils deemed unsuitable for pipe culverts shall be removed and replaced with accepted material to the dimensions as specified in sub-clause 6.1.3.2 of these Specifications. This removal and replacement of material, as well as compaction requirements, shall be performed and paid for in accordance with Section 2.2 of these Specifications under Item No. 2.2(2), Roadway Excavation, Unsuitable.

6.1.3.11 Extension of Existing Culverts

Extension of existing pipe culverts shall be accomplished as specified on the Drawings.

Pipe extensions shall be made with new pipe only. Pipe culverts which are designated on the Drawing "to be extended" shall be examined as specified in sub-clause 6.1.3.2 of these Specifications. Pipe joints will also be carefully inspected by the Engineer and broken joints shall be resealed. Pipe culverts shall be extended by the method shown on the Drawings to connect the initial piece of extended pipe to the existing pipe. The culverts shall then be backfilled as specified in sub-clause 6.1.3.5 of these Specifications.

6.1.4 MEASUREMENT

Culvert Pipe shall be measured as the number of linear metres of pipe from end to end of each pipe structure (excluding the width of joints), complete and accepted in place. Excavation, bedding, backfill, and tamped fill will not be measured as such and will also be considered incidental to the laying of the pipe culvert structure.

Where additional excavation is required to remove unsuitable material, this quantity shall be measured in cubic metres bounded by vertical planes 500 mm outside the outer wall of the pipe and the plane of the lowered elevation. No separate or additional measurement will be made for the excavation of bell holes, when required, or for Portland cement used in constructing pipe joints. Where manholes, catchpits etc. occur, the length of pipe to be measured shall be from outside wall to outside wall of manhole.

Pipe culverts shall be measured from end to end along the centreline of the culvert and parallel to the foundation. Where two or three pipe culverts are placed on a mutual bedding, each culvert shall be separately measured.

Work such as resealing existing mortared joints on the inside of existing culverts, removal of existing headwalls and wingwalls and the reshaping and redirecting the stream bed to meet the new or extended culverts shall be considered incidental to the Contract as a whole and no separate measurement or payment will be made.

6.1.5 PAYMENT

Reinforced concrete culvert pipe, whether for a new culvert or extension shall be paid for at the Contract unit price per linear metre for the particular size specified on the Drawings or as directed by the Engineer. The price shall be full compensation for furnishing, hauling, and installing the pipe, excavation, bedding, jointing, granular material, backfill, compaction, pipe collars, resealing existing joints, removal of headwalls and defective sections of existing pipe, labour, tools, equipment and incidentals necessary to complete the work.

Removal of unsuitable materials, below the foundation elevation of the pipe culvert, shall be paid for under Item No. 2.2(2), Roadway Excavation Unsuitable of these Specifications.

Construction of concrete headwalls will be measured and paid for under Section 5.1 Concrete of these Specifications.

Payment shall be made under the following items :

Item Ref	Description	Unit of Measurement
6.1(1)	Reinforced Concrete Pipe, 800mm dia	metre
6.1(2)	Reinforced Concrete Pipe, 1000mm dia	metre
6.1(3)	Reinforced Concrete Pipe, 1200mm dia	metre
6.1(4)	Reinforced Concrete Pipe, 1500mm dia	metre
Etc.		

6.2 RIP RAP AND CONCRETE SLOPE PROTECTION

6.2.1 DESCRIPTION

This work shall consist of the provision and installation of riprap or concrete slope protection for stream banks, embankment slopes, cut slopes, bridge abutment slopes and other surfaces composed of erodible materials where protection is desired as shown on the drawings. Generally, the protection will form an impervious layer constructed in or on designated surfaces and shall have at its bottom and ends anti-scour devices such as cutoff walls, toe walls or sheeting. Slope protection may be constructed of concrete, stone riprap or sacked concrete as shown on the Drawings.

Slope protection shall also include impervious linings of concrete or stone riprap for ditches or gutters for the conveyance of surface runoff. The linings shall be placed in ditches, gutters, chutes, outlets or other locations as shown on the Drawings, directed by the Engineer or as specified in these Specifications. Anti-scour devices may also be included with these items.

A filter blanket will be provided where it is anticipated that there may be migration of fines through the riprap

If directed by the Engineer, the various types of slope protection shall be constructed in the locations so directed, whether or not shown at those locations on the drawings, in accordance with the Standard Drawings.

Other types of slope protection shown on the drawings such as grassing of slopes or gabions will be constructed in accordance with the relevant sections of these Specifications

6.2.2 MATERIALS REQUIREMENTS

6.2.2.1 Riprap Stone

Stone for riprap shall consist of field stone or rough, un-hewn quarry stone as nearly rectangular as practicable. The stone shall be sound, tough, durable, dense, resistant to the action of air and water and suitable in all other respects for the purpose intended. The stone shall have percentage of wear of not more than 50% as determined by AASHTO test method T 96 after testing stone which has been broken up in small pieces in conformance with T 96 requirements. Riprap stones shall, in general, be of the wide flat type with their larger faces roughly rectangular and parallel. The minimum thickness of stone shall be 150 mm (measured perpendicular to face of riprap). No face dimension shall be less that the thickness of the stone.

Stones for riprap shall be of one of the following classes as indicated on the drawings or as determined by the Engineer:

Class A Stones ranging in weight from a minimum of fifteen (15) Kg to a maximum of twenty five (25) Kg, with at least 50 percent by weight of the stones weighing more than twenty (20) Kg.

Class B Stones ranging in weight from a minimum of thirty (30) Kg to a maximum of seventy (70) Kg, with at least 50 percent by weight of the stones weighing more than fifty (50) Kg.

Class C Stones ranging in weight from a minimum of sixty (60) Kg to a maximum of one hundred (100) Kg, with at least 50 percent by weight of the stones weighing more than eighty (80) Kg.

Riprap stones for ditch lining, chute or outlet lining shall have a minimum thickness of 100 mm and minimum length and width dimensions of at least 250 mm. These stones shall not weigh less than 10 kilograms each and may range in weight between 10-25 kilograms. In other respects, the stones shall conform to the requirements described above.

6.2.2.2 Filter Material

The grading of filter material shall be as specified on the drawings or in the Special Provisions. If not otherwise specified it will be required that D15 of the filter is at least 4 times as large a D15 for the underlying embankment materials, and not more than 4 times the D85 for the embankment material.

[Where D15 and D85 are the particle diameters corresponding to fifteen percent and eighty-five percent respectively, passing (by weight) in a grain size analysis.]

Filter material required for bridge abutments and embankment slope protection shall be an accepted coarse aggregate material as specified in Section 5.8 of these Specifications, or as approved by the Engineer.

6.2.2.3 Concrete Slope Protection

Concrete slope protection for embankments or cut slopes shall be a Class D concrete slab constructed to the dimensions and details shown in the Drawings. The concrete slab may or may not contain steel reinforcement, as required by the Drawings. Steel reinforcement shall conform to the requirements of Section 5.2 of these Specifications.

Concrete for lining ditches, gutters, outlets and chutes shall also be Class D concrete, with or without steel reinforcement, as detailed in the Drawings. Class D concrete shall conform to the provisions of Section 5.1 of these Specifications.

6.2.2.4 Mortar

The mortar shall consist of one part of Portland cement and three parts of sand by dry loose volume with one fifth (1/5) part of hydrated lime and sufficient water to produce a mortar that is plastic and can be easily handled and trowelled. Retempering of mortar that has not been used for periods of 45 minutes or longer will not be permitted and such mortar shall be rejected. Cement for mortar shall conform to the requirement of Section 5.1 of these Specifications.

6.2.2.5 Sacked Concrete Slope Protection

Sacked concrete slope protection shall consist of a mixture of aggregates and cement placed in a jute or cotton sack having a minimum capacity of 30 litres or larger and an average thickness of 200 mm. Sacks shall be a type which will allow water to penetrate them easily. Sacked concrete slope protection shall conform to the requirements as detailed in the Drawings.

6.2.2.6 Incidentals

All incidentals required in slope protection shall conform to the requirements as specified in the Drawings, and these Specifications. These incidentals include, but are not limited to, such items as joint sealer, weep-holes and drain pipes.

6.2.3 CONSTRUCTION REQUIREMENTS

6.2.3.1 General

Unless otherwise specified riprap and concrete slope protection shall always be constructed as an impervious layer upon designated surfaces and shall have mortared joints.

Reinforced concrete drain chutes, unless otherwise specified, shall be constructed where curb and gutter is used with embankment heights greater than 6 metres to safely convey surface runoff down the embankment slope.

The drain chutes shall connect the drop openings integrated into the curb with the toe of the slope. The curb and gutter installation shall be placed along each shoulder edge when the roadway is in a normal cross section and only along the lower edge in a superelevated section. Spacing of drain chutes shall be as indicated on the Drawings or as directed by the Engineer. Grouted riprap protection shall also be placed at the toe of the drain chute as detailed in the Drawings.

Reinforced concrete drain outlets, unless otherwise specified, shall be constructed along the side slopes between the outlet of pipe culverts and the toe of embankment to guard against erosion wherever the vertical distance between the pipe outlet and toe of slope is declared critical by the Engineer. The drain outlet shall be a trapezoidal reinforced concrete gutter of a type as detailed in the Drawings. Grouted riprap protection shall be integrated into the discharging end of each drain outlet as detailed in the Drawings.

Concrete interceptor ditches, unless otherwise specified, shall be constructed at the toe of benches where depths of excavation exceed 5 metres and the subgrade material is subject to erosion. Interceptor ditch linings may be reinforced concrete or plain concrete and shall be as detailed in the Drawings or as directed by the Engineer.

Concrete, riprap or sacked concrete embankment slope protection shall be constructed at locations shown on the drawings or as directed by the Engineer. This type of slope protection shall generally be used where embankment intrude into streams or watercourses.

All riprap and concrete slope protection shall conform to the dimensions and requirements shown on the Drawings, these Specifications or as directed by the Engineer

6.2.3.2 Preparation

When newly constructed earthworks are to be provided with riprap or slope protection, the excavation or embankment shall be constructed to the planned profiles and dimensions, without making allowance for the space to be occupied by the protection works. Excavation for protection works will only be carried out immediately prior to its construction. The Contractor shall obtain the approval of the Engineer to his proposed method of construction prior to commencement of construction of the section of the works concerned

The areas to be covered shall, at the proper time, be laid out to intended positions, and all necessary cut and fill stakes, batter boards and construction lines set up. Every effort shall be made to have the surfaces in such condition as to require solely excavation immediately prior to the laying of the materials. Where, however, low areas are encountered they shall be backfilled and thoroughly tamped at the earliest practical time in advance of the laying of masonry, to avoid settlement after placing materials. It is not necessary that the entire area to be protected be excavated and fine graded in advance of the laying, work should be always laid upon a freshly excavated and stable surface.

Aggregates and cement for sacked concrete slope protection shall be mixed dry, by hand, or mechanically in the proportion of 1:10 (cement aggregate) measured by volume until the mixture is uniform in colour. Aggregates shall meet the gradation and quality requirements as specified in the Drawings. The mixture shall be placed into the sacks and filled approximately 75% full, and shall be securely and substantially sewed, the ends forming a straight edge.

The sacks when filled shall have an average thickness or depth of 200 mm.

6.2.3.3 Cut off Wall or Sheeting

Riprap and concrete slope protection will usually be accompanied by a bottom cutoff wall. Where the cutoff wall is composed of masonry, a trench shall be excavated to the dimensions required for the masonry, dewatered, and the masonry placed directly in the trench, visually without any form. Where the cutoff wall is composed of sheeting, care shall be taken not to disturb, by excavation or otherwise, any natural ground, stream beds or other formations intended to be in front of the sheeting.

After laying has been completed, backfilling shall be carried out around the edges and mechanically tamped. Special care shall be given to backfilling and compacting any spaces or volumes resulting from the removal of forms.

If the bottom of the riprap or concrete slope protection does not occur in rock or other natural strata accepted as non-erodible, riprap shall always be founded or sealed on the bottom with appropriate cutoff trenches or sheeting. For cutoff walls composed of masonry, the prepared trench shall be dewatered and completely filled with stones and mortar. The trench shall first be filled approximately 60 per cent with mortar and immediately thereafter stones shall be dropped and pushed into the unset mortar or concrete so as to make a solid, dense masonry wall.

Additional mortar or concrete may be added to the top so as to obtain a screeded, level top surface. Only such length of trench is to be worked upon at a time as to insure that all stones can be inserted in fresh concrete. Where the foundation under the riprap or concrete slope protection is unstable and the masonry cutoff may settle or fail, the cutoff masonry will be omitted and sheeting as required shall be driven. The cutoff masonry and/or sheeting shall be constructed before laying the riprap or concrete slope protection.

Where the cut-off wall is composed of sacked concrete and after laying and backfilling has been completed, the sacked concrete shall be thoroughly soaked by spraying with water to the satisfaction of the Engineer. The cut-off protection shall be constructed before laying the sacked concrete slope protection.

After cutoff masonry or sheeting has been placed and accepted the laying of slope protection shall be commenced in tight contact with the cutoff masonry or sheeting and laid from the bottom towards the top. Stone and precast concrete blocks shall be laid in close contact.

6.2.3.4 Placing Riprap

Stones placed below water line shall be distributed so that the minimum thickness of the riprap is not less than that specified.

Stones above the water line shall be placed by hand. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. The stones shall be laid perpendicular to the slope with ends in contact. The riprap shall be thoroughly compacted as construction progresses and he finished stones shall present an even, tight surface. Interstices between stones shall be chinked with spalls firmly rammed into place.

Unless otherwise provided, riprap shall have the following minimum thicknesses, measured perpendicular to the slope

Class A: 300 mm

Class B: 450 mm

Class C: 600 mm

The surface of riprap placed above the water line shall not vary from the theoretical surface by more than 80 mm at any point.

6.2.3.5 Loose Riprap

Loose riprap where specified on the drawings shall be placed by dumping and spreading in layers by a mechanical device or other methods approved by the Engineer, all to a secure, stable mass. Surface irregularities of the slope shall not vary more than 100mm along the intended slope. After completion and approval of the riprap placement, the surface voids of the riprap in the footing trench and on the lower portions of the slope shall be filled with excavated material and dressed to the satisfaction of the Engineer

6.2.3.6 Grouted Riprap

Riprap shall be arranged in such a way that the largest rocks are at the bottom of the slope. The surfaces of the rock shall be cleaned of adhering dirt and clay and shall be moistened. Rocks in the bottom courses and to a vertical height and thickness as shown on the drawings, or where directed by the Engineer shall be carefully arranged by hand to interlock and form a three-point bearing on the underlying rocks with their longitudinal axis normal to the embankment face.

As each of the larger stones is placed it shall be surrounded by fresh mortar and adjacent stones shall be pushed into contact. In the case of grouted riprap, the interstices may be partly filled with spalls or small stones, and finally all remaining joints or openings filled solidly with mortar. Where the pieces are composed of precast concrete, they shall be laid with broken joints. As each course is laid, the top of the joint shall be filled with mortar so that the succeeding course can be shoved into position in a full bed of mortar.

At the conclusion of a course to the specified levels all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints shall then be roughly pointed flush with the surface of the slope protection.

6.2.3.7 Reinforced Concrete Slope Protection

Reinforced Concrete Slope Protection may be either precast or cast-in-situ. Concrete construction shall be carried out in accordance with the requirements of section 5.1 and 5.2 of these Specifications.

a) Precast Concrete

Precast concrete slope protection shall be constructed on the site or other locations at the Contractor's option. Forms shall be composed of wood or steel and the pieces cast in horizontal positions. Lifting holes may be provided or rings, hooks, or other devices inserted to facilitate handing. Holes are to be filled with mortar if exposed in completed work. Curing shall be with burlap or cotton mats.

Slopes which are to receive the precast slope protection shall be graded and trimmed, and filled, tamped and screeded if necessary to final grade immediately prior to laying. A row of blocks shall be laid on ends (400 mm dimension normal to the slope) under all edges of slope protection, except where same is contiguous to pier or abutment walls. These end or edge blocks shall be set in trenches excavated as nearly neat to the block as possible. Any spaces between the block and sides of the trench shall be backfilled and tamped. Slope protection concrete blocks shall then be laid with broken joints, and all joints shall be mortared joints. As the edge is completed from bottom to top, backfill shall be placed against the completed edge and tamped. All blocks shall be full size, except where half blocks are required to complete courses. The completed exposed surface shall be accurate to a tolerance not exceeding ten mm in l.5 metres.

All blocks, slabs and stones shall conform to the dimensions and requirements stated on the Drawings.

b) In-situ Concrete

The slopes shall be prepared and trimmed to line and level using suitable material, compacted in accordance with the requirements of these Specifications to form a suitable sub-grade approved by the Engineer and formwork shall be installed in accordance with the relevant provisions of the Specifications

After fixing the reinforcement, the concrete shall be placed after water has been sprayed on the prepared area.

6.2.3.8 Sacked Concrete Slope Protection

In laying sacked concrete slope protection, the prepared sacks shall be bedded on the prepared surface upon which they are placed with the sewn ends all in the same direction. sacks shall be placed by hand, beginning at the bottom of the slope and laid with broken joints. The sacks shall be rammed and packed against each other and tamped on the surface so as to form a close and moulded contact and secure a uniform surface.

Sacks ripped or broken during placing shall be removed and replaced. Immediately after placing and tamping the sacks, they shall be soaked thoroughly by sprinkling with water. Water shall not be applied under high pressure.

6.2.4 MEASUREMENT

For structural work measured in accordance with Method A, as defined in sub-clause 5.1.6(a) of these Specifications, riprap shall be measured as the number of cubic metres of riprap of each class placed and approved

Concrete slope protection for embankment, cut slopes, and bridge abutment, ditch linings, drain outlets and mortared riprap at toes of chutes or outlets will be measured on a two dimensional basis in square metres. Linear dimensions shall be taken in not less than two directions and of sufficient number so that averages can be obtained and the product of the averages shall be the area for payment. Where slopes exist, measurement shall be along the surface of the slopes. Concrete interceptor ditch lining and reinforced concrete drain chute will be measured on a linear metre basis, along the slope of the ditch or chute.

Cutoff masonry, sheeting and anti-scour devices will not be measured but will be considered incidental to the slope protection item.

For structural work measured in accordance with Method B, as defined in sub-clause 5.1.6(b) of these Specifications, no separate measurement shall be made for riprap and concrete slope protection work.

6.2.5 PAYMENT

Riprap shall be paid for at the Contract unit price per cubic metre for each class of riprap.

Concrete slope protection work shall be paid for at the Contract unit price per square metre as listed below. The unit prices shall be full compensation for the work as described herein and shown on the Drawings, including all materials, excavation, forms, screeding, curing, hauling of materials, backfill, mortar, joints, equipment, tools, labour and incidentals necessary to the proper completion of the work.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
6.2(1)	Loose Riprap, Class A	Cubic metre
6.2(2)	Loose Riprap, Class B	Cubic metre
6.2(3)	Loose Riprap, Class C	Cubic metre
6.2(4)	Grouted Riprap, Class A	Cubic metre
6.2(5)	Grouted Riprap, Class B	Cubic metre
6.2(6)	Grouted Riprap, Class C	Cubic metre
6.2(7)	Reinforced Concrete Slope Protection	Square metre
6.2(8)	Sacked Concrete Slope Protection	Square metre
6.2(9)	Concrete Ditch Lining, Type I	Square metre
6.2(10)	Concrete Ditch Lining, Type II	Square metre
6.2(11)	Concrete Ditch Lining, Type III	Square metre
6.2(12)	Grouted Riprap Ditch Lining	Square metre
6.2(13)	Concrete Interceptor Ditch Lining	Metre
6.2(14)	Reinforced Concrete Drain Chute	Metre
6.2(15)	Reinforced Concrete Drain Outlet	Square metre
6.2(16)	Grouted Riprap at Toe of Chute or Outlet	Square metre

6.3 SUB-SURFACE DRAINS

6.3.1 DESCRIPTION

This work shall consist of providing drains for the removal of sub-surface water such as perforated pipe subdrains or layers of porous material placed below subgrade. The work shall be constructed to the lines, levels and dimensions as specified in the Drawings and these Specifications.

Subdrains may consist of perforated pipe placed in a trench and backfilled with sand and used to intercept and remove ground water encountered during excavation, usually in hilly or mountainous areas. The depth and location of subdrains shall be determined by the Engineer during construction when excavation reveals the location of ground water.

Subdrains may also be a type of rock and coarse sand fill placed at the toe of embankment on side slopes where the roadway section is constructed in both cut and fill, which allows subsurface water to drain along the interface of rock and new embankment and out through the filter. The location of this type of subdrain shall also be determined by the Engineer during construction where seepage is evident.

6.3.2 MATERIALS REQUIREMENTS

6.3.2.1 Pipe

Pipes for subdrains shall be perforated polyvinyl chloride (PVC) as detailed in the Drawings or as directed by the Engineer.

Pipes of other materials shall be permitted only if approved by the Engineer.

6.3.2.2 Pipe Backfill

Porous backfill material for bedding and backfilling pipe subdrains shall meet the gradation and quality requirements as specified in the Drawings or in Section 5.8 of these Specifications.

Impervious backfill material shall be a fine compactable material approved by the Engineer.

6.3.2.3 Rock Fill

Rock fill shall consist of broken rock of maximum 300 mm size and coarse sand as specified in the Drawings. Rock fill shall meet the requirements of rock embankment as specified in Section 2.6 of these Specifications.

6.3.3 CONSTRUCTION REQUIREMENTS

6.3.3.1 Trench and Bedding for Pipe Subdrains

Trenches shall be excavated to the width, line and grade as shown on the Drawings. Unless shown otherwise, the depth shall vary from one to 1.5 metres below the finished surface at the top of the trench where the construction is under a gutter, ditch or the roadbed, and to depths required for proper drainage at other locations. A 100 mm bed of

granular backfill material shall be spread in the bottom of the trench throughout its entire length and brought to a uniform grade.

6.3.3.2 Placing Pipe and Backfilling

Pipes of the kind and size required shall be embedded firmly in the bedding material.

Bell and spigot pipe shall be laid with the bell ends upgrade and the spigot ends fully entered in the adjacent bell and spot mortared to provide for centering of pipe, but not closed to the desired infiltration of water.

The joints of butt-jointed pipe shall be covered with two-ply tar paper strips not less than 150 mm in width and of sufficient length to permit the ends being turned outward and laid flat on the bedding material on either side of the pipe for a distance of 80 mm. In lieu of tar paper, the joints may be wrapped twice around with a strip of burlap or other approved material.

Perforated pipe shall be laid with the perforated side of the pipe down, and separate sections shall be firmly jointed with approved metal bands.

Polyvinyl chloride (PVC) pipe shall be perforated by drilling holes of one centimetre diameter at intervals of 100 mm extending along the length of the pipe. A crushed stone filter of maximum aggregate size l2.5 mm shall be placed at end joints around the pipe as detailed in the Drawings.

After the pipe has been laid and has been inspected and approved by the Engineer, porous backfill material shall be placed to the depth indicated on the Drawings. Care should be exercised not to displace the pipe or joint covering around and over the pipe. The upper portion of the trench shall then be filled with suitable material of either porous or impervious type as shown on the Drawings. All filling material shall be thoroughly compacted.

All work shall be constructed to the dimensions and other requirements stated on the Drawings or as directed by the Engineer.

6.3.3.3 Placing Rock Fill

Rock fill subdrains shall be placed in accordance with the requirements specified in sub-clause 2.6.3.2 of these Specifications and compacted as specified in Section 2.6 as "Rock Embankment".

The rock fill material shall extend from the benches cut into the natural side slope to the embankment slope as detailed in the Drawings to permit sub surface water to drain.

The porous sand material to be used shall meet the requirement for types B, C, D or E porous backfill material as specified in Section 5.8 of these Specifications.

6.3.4 MEASUREMENT

Subdrains with perforated PVC pipe shall be measured by the linear metre of pipe, the size of which shall be specified in the Tender and on the Drawings.

Subdrains with rock fill shall be measured by the cubic metre to the lines and dimensions shown on the Drawings or authorized by the Engineer.

6.3.5 PAYMENT

The quantities of subdrains, measured as provided above, shall be paid for at the contract unit price per unit of measurement. The payment shall be full compensation for trench excavation, furnishing and placing all materials, including outlets, backfilling, labour, equipment, tools and incidentals necessary to complete the work.

Payment shall be made under the following items:

Item Ref	Description	Unit of Measurement
6.3(1)	Subdrain, perforated PVC pipe _____mm	Metre
6.3(2)	Subdrain, rockfill	Cubic metre

6.4 MINOR DRAINAGE STRUCTURES

6.4.1 DESCRIPTION

This work shall consist of furnishing, constructing and/or installing miscellaneous types of drainage structures built according to the Specifications for concrete structures and in conformance with the Contract Drawings. Included are such items as inlet boxes, manholes, urban drains, irrigation slide gates, flap gates, retaining walls, spring boxes, pipe encasement, platforms, barriers and other incidental items not specified elsewhere.

6.4.2 MATERIALS REQUIREMENTS

Concrete shall conform to the requirements of Section 5.1 of these Specifications. Reinforcement, where required, shall conform to the requirements of Section. 5.2 of these Specifications. Iron castings for frames, covers and gratings for manholes and inlets shall conform to the requirements of AASHTO. Standard Specification M 105 Class 30.

The Class of concrete for miscellaneous structures, shall be as shown on the Drawings.

Manhole and inlet steps shall meet the requirements of the latest edition of the ASTM Designation A-207.

6.4.3 CONSTRUCTION REQUIREMENTS

Construction methods given under Sections 5.1 and 5.2 of these Specifications for Concrete shall apply for this item except as noted herein or in the Special Provisions.

Underground drainage structures, including earthwork and backfilling incidental thereto, shall be completed before the adjacent roadway surfacing is placed, but pipe endwalls shall not be constructed until adjacent works has been completed, as developments during construction may justify alterations in design or location of such endwalls. Also manholes, catch basins and inlets shall not be completed to final grade until after the relevant operations have been finished and all necessary arrangements have been made to ensure suitable connections at proper grade and alignment with pavements, gutter, curbs, etc.

Grates, and frames for grates, and covers for inlets and manholes shall be set in full beds of mortar or be otherwise properly secured as indicated in the Drawings, so as to be held rigidly in place to proper grade and alignment.

Inlet and outlet pipe at inlets and manholes shall be set or cut flush with the inside faces of the walls of such structures and shall extend a sufficient distance beyond the outside faces of the walls to provide ample room for making proper connections. The joint around the pipe in the structure wall shall be completely and neatly closed with mortar, or other material as may be specified, so as to make it watertight.

Pipe encasement shall be constructed in accordance with the Drawings.

6.4.4 MEASUREMENT

Catch Basins of the type indicated will be measured as units, complete in place in accordance with the Drawings or at the direction of the Engineer. Manholes, and Drop

inlets will be measured on a three-dimensional basis as the number of cubic metres of concrete placed in accordance with requirements approved by the Engineer.

Reinforced concrete pre-cast U drains, side drain access slabs, including foundations, and retaining walls, of the sizes specified, shall be measured on a linear metre basis. In the case of Retaining Walls, the height of the wall (H) shall be as measured from the top of the wall to the bottom of the footing.

6.4.5 PAYMENT

Miscellaneous structures, measured as provided above, shall be paid for at the Contract unit price per unit of measurement, respectively, for each of the items listed below that is shown in the Bill of Quantities. The prices and payment shall be full compensation for all necessary excavation, backfilling, formwork, concrete, reinforcement, all materials including cast iron and steel, transportation to site and fixing of precast units, welding, equipment, tools and labour necessary for proper completion of the work. The complete work includes all work associated with the structure and indicated on the drawings, if not specifically mentioned in another pay item.

Pay items, shall be as follows:

Item Ref	Description	Unit of Measurement
6.4(1)	Precast U drain and cover slab	Metre
6.4(2)	Side drain access slab including foundation	Metre
6.4(3)	Manhole, Type _____	Cubic metre
6.4(4)	Manhole, Type _____	Cubic metre
6.4(5)	Manhole, Type _____	Cubic metre
6.4(6)	Catch Basin, Type _____	Number
6.4(7)	Drop Inlet	Cubic metre
6.4(8)	RC Side Ditch, Type _____	Metre
6.4(9)	RC Side Ditch, Type _____	Metre
6.4(10)	RC Side Ditch, Type _____	Metre
6.4(11)	Retaining Wall, Type _____	Metre
6.4(12)	Retaining Wall, Type _____	Metre
6.4(13)	Retaining Wall, Type _____	Metre
6.4(14)	(more items as necessary)	

6.5 CONCRETE BARRIER, CURB AND GUTTER

6.5.1 DESCRIPTION

This work shall consist of providing concrete curb, mountable curb, concrete curb and gutter and concrete barrier as shown on the roadway drawings or as required at locations determined by the Engineer. The work shall be constructed as shown in the standard details and in conformance with the requirements of Section 6.5 of these Specifications.

This work shall also include barrier and curb markings of black and white paint where shown on the Drawings or designated by the Engineer.

6.5.2 MATERIALS REQUIREMENTS

Bedding material, where show on the Drawings, shall consist of Class E concrete as defined in Section 5.1 of these Specifications or approved granular material as defined in Section 5.8 of these Specifications, or as otherwise instructed by the Engineer.

Concrete for curbs and gutters shall be Class C1 as defined in Section 5.1 of these Specifications.

Paint shall be of approved industrial quality and shall conform to an international standard acceptable to the Engineer.

6.5.3 CONSTRUCTION REQUIREMENTS

Excavation shall be made to the required depth, and the base upon which the curb, gutter, or combination curb and gutter is to be set shall be compacted to a firm even surface. All soft and unsuitable material shall be removed and replaced with suitable material. If shown on the Drawings bed course material shall be placed and compacted to form a bed of the required thickness.

When a curb is placed next to a concrete pavement, expansion joints in the curb shall be located opposite expansion joints in the pavement. Expansion joints shall be formed at the intervals shown on the Drawings using preformed filler 10 mm in thickness in accordance with the requirements of Section 5.10 of these Specifications. Dummy joints with the concrete pavement shall not be measured and paid for separately but shall be considered incidental to the pay item for the curb.

Concreting shall be generally in accordance with the requirements of Section 5.1 of these Specifications. Forms shall be removed within 24 hours after concrete has been placed. Minor defects shall be repaired with mortar containing one part of Portland cement and two parts of fine aggregate. Repair will not be permitted on the faces and rejected portions shall be removed and replaced at the Contractor's expense. The exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or a wood block and rubbing the surfaces until they are smooth. The surfaces shall be wet thoroughly either by dipping the brick or block in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth, using water, it shall then be rubbed with a thin grout containing one part of Portland cement and one part of fine aggregate. Rubbing with grout shall continue until a uniform colour is produced.

When completed, the concrete shall be covered with suitable materials and kept moist for a period of 3 days. The concrete shall be suitably protected from the weather until thoroughly hardened.

After the concrete has set sufficiently, the spaces in front and back of the curb and gutter shall be refilled to the required elevation with the proper material, which shall be tamped in layers of not more than 150 mm, until properly compacted.

The finished work shall be true to line grade and level to within 3 mm and shall present a smooth appearance free from kinks and distortion visible to the eye.

6.5.4 MEASUREMENT

The quantity measured for payment shall be the number of linear metres of concrete of the several types and sizes of concrete gutter, curb, and the combination curb and gutter completed in place and accepted. Concrete curb, gutter and combination curb and gutter shall be measured in place along the centre of the gutter, or curb. No deduction shall be made for flattening of curbs for entrances or for curb drainage inlets.

Concrete Barrier will be measured by the linear metre along the longitudinal axis of the finished barrier, including the transitions at ends complete in place, as directed by the Engineer.

Curb Markings and Barrier Markings shall be measured on a two-dimensional basis by the square metre for the areas painted as directed by the Engineer.

6.5.5 PAYMENT

Concrete Curb, Mountable Curb, Concrete Curb and Gutter and Concrete Barrier as measured in Clause 6.5.4 of these Specifications shall be paid for at the respective Contract unit prices per linear metre, complete in place, which prices shall included all excavation backfilling, tamping, materials, formwork, equipment, tools, labour and all incidentals necessary to proper completion of the work.

Curb Markings will be paid for at the Contract unit price per square metre, complete and accepted by the Engineer, which price shall include all paints of required colours and quality, labour, tools and incidentals necessary to the satisfactory completion of the work.

Pay items will be as follows:

Item Ref	Description	Unit of Measurement
6.5(1)	Concrete Curb	Metre
6.5(2)	Mountable Curb	Metre
6.5(3)	Concrete Curb and Gutter	Metre
6.5(4)	Concrete Barrier, Type _____	Metre
6.5(5)	Concrete Barrier, Type _____	Metre
6.5(6)	Curb Marking	Square Metre
6.5(7)	Barrier Marking	Square Metre

6.6 GRASSING OF SLOPES

6.6.1 DESCRIPTION

This work shall consist of furnishing seed, sprigs or sods as required or permitted and planting then to give a healthy stable covering of grass which will maintain its growth in any weather and prevent erosion of the material in which it is planted.

This work includes the providing of block sodding or strip sodding on the topsoil covered slopes of embankment, subbase and shoulder and on other areas subject to erosion as shown on the Drawings and where required by the Engineer.

6.6.2 MATERIALS REQUIREMENTS

Grass shall be of species native to the country unless otherwise approved, harmless and inoffensive to people and animals and not of a kind recognised as a nuisance to agriculture. It shall be free of disease and noxious weeds, deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within two years of planting.

The term "grass" embraces sods, sprigs and seeds and, if the Engineer permits, may include plants of other types capable of giving effective protection.

Fertiliser shall be approved lime or mixtures of plant nutrients or both.

Sods and sprigs shall be planted with their root system substantially undamaged and packed around with moist earth in which they have grown.

6.6.3 CONSTRUCTION REQUIREMENTS

Seeds shall be planted by a method that ensures reasonably uniform coverage and that the seeds will germinate and strike roots without being washed out.

Sprigs shall be planted in a regular pattern such that surface water flowing over the area will have no clear channels to flow through but will be diverted into winding course by the presence of the sprigs. Sprigs shall be planted at a spacing of 300 mm or as required in the Contract Documents.

Sodding shall be done by planting sods to give continuous cover over the whole area.

Strip sodding shall be done by planting strips of sods not less than 80 mm wide, not more than 450 mm apart (centre to centre) or as required in the Contract Documents.

Strip sodding shall be planted with the strips lying along contours.

All sprigs and sods shall be planted with roots well buried in firm material.

Grass shall be planted at such a time and the work shall be done in such a way that at the time of the final construction inspection all areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels. In the case of strip sodding bare strips between the strips of sods will be permitted at the time of the construction inspection. In the case of sprigging bare patches between sprigs will be permitted provided clear paths for erosion channels do not exist.

Occasional small bare patches will not be cause for rejection. Any bare areas which, in the Engineer's opinion, may permit erosion shall be made good and replanted with sodding.

Surfaces to be planted, either by seeding, sprigging or sodding, shall be trimmed to the dimensions shown on the Drawings before any grassing is carried out.

Fertiliser shall be added at the time of planting if required in the Contract Documents or if it is necessary to ensure good ground cover within the required time.

Whenever a slope is completed, dressed and ready for grassing, the Contractor shall proceed with block sodding or strip sodding as designated on the Drawings or instructed by the Engineer.

The Contractor shall maintain the grass at his expense until the end of the Maintenance period. Maintenance shall consist of preserving, protecting and replacing grass, and such other work as may be necessary to keep it in a satisfactory condition to prevent erosion and to present a dense and uniform appearance. The Contractor shall be responsible for satisfactory growth and shall water, fertilise and mow the grass at such intervals as will ensure good ground cover of live grass all through the Maintenance Period.

6.6.4 MEASUREMENT

The quantity measured for payment shall be grassing (if the type is not specified) or seeding, strip sodding, sodding or sprigging measured as the number of square metres of planted surface (whether horizontal or sloping) measured on the slope, of required and accepted grassing well established in place.

Fertiliser will not be measured.

In the case of strip sodding planted surface shall mean the whole area including that initially uncovered between the strips.

6.6.5 PAYMENT

Block sodding, strip sodding or sprigging, as shown in the contract Drawings, will be paid for at the respective Contract unit prices per square metre, complete and accepted in place, which prices shall include all materials, handling, storage, site preparation, placing, maintenance, equipment, tools, labour, incidentals and satisfactory disposal of all unsuitable or surplus materials.

Payment will be made under the following items

Item Ref	Description	Unit of Measurement
6.6(1)	Block Sodding	Square metre
6.6(2)	Strip Sodding	Square metre
6.6(3)	Sprigging	Square metre
6.6(4)	Seeding	Square metre

6.7 TOPSOIL

6.7.1 DESCRIPTION

This work shall consist of furnishing, transporting and spreading topsoil removed from approved sources, in accordance with these Specifications.

6.7.2 MATERIALS REQUIREMENTS

Topsoil furnished by the Contractor shall consist of a natural friable surface soil without admixture of undesirable soil, refuse or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 50 mm in any dimension, noxious weeds, tall grass, brush, sucks, stubble or other litter, and shall have indicated by a healthy growth of crops, grasses, trees or other vegetation that it is free-draining and non-toxic.

6.7.3 CONSTRUCTION REQUIREMENTS

The Contractor shall notify the Engineer at least 5 days before he intends to start topsoil stripping operations. After inspection and approval by the Engineer, and prior to stripping any topsoil, the Contractor shall remove noxious weeds and tall grass, brush, stones larger than 50 mm in any dimension, and roots.

The topsoil shall be evenly spread on the designated areas to a depth that, after settlement and compaction, shall be that shown on the Drawings. Spreading shall not be done when the ground or topsoil is excessively wet or, otherwise in a condition detrimental to the work. The roadway surface shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones larger than 50 mm in any dimension, roots, stumps and other litter shall be raked up and removed.

Where shown on the Drawings and where instructed in writing by the Engineer, topsoil shall be placed on the slopes of embankment, subbase, shoulders and cuts and in ditches and other areas in a thickness of 100 mm measured perpendicularly to the slopes. To reduce erosion as much as possible, the placing of topsoil and the subsequent grassing may, at the instruction of the Engineer, be done simultaneously with or right after the placing and compacting of the individual layers of the embankment, subbase, shoulders or right after completing the cut.

Within the right-of-way no topsoil materials shall be obtained from areas outside the limits of earthworks as stated in Section 2.1 of these Specification but they may, if acceptable to the Engineer, be obtained from borrow pits, roadway excavation, channel excavation, excavation for structures and from areas under embankment. When obtained from areas outside the right-of-way, the Contractor must obtain permission or make contracts and pay any necessary fees.

Where layers of embankment fill are made from excavation of clayey silty materials conducive to the growth of grass, such layers may be extended in width to the outer surface of the prescribed layer of topsoil and no topsoil shall be placed thereon. The volume of fill corresponding to the prescribed layer of topsoil will not be measured as embankment, but will be measured and paid for as topsoil.

In the event sodding shall be placed and the root systems of the sods are as specified in Clause 6.6.3 of these Specifications topsoil may not be required. If, in the opinion of the Engineer, topsoil is not required under sods, it will not be measured for payment.

6.7.4 MEASUREMENT

Topsoil shall be measured by the square metre calculated as the net area, measured on the slope, instructed by the Engineer for each situation.

6.7.5 PAYMENT

Topsoil shall be paid for at the contract unit price per square metre as measured in Clause 6.7.4 of these Specifications. The rate for topsoiling shall include for the cost of providing the topsoil, all handling and hauling as necessary and complying with the requirements of Section 6.7 of this Specification.

Payment for topsoil will be made as follows:

Item Ref	Description	Unit of Measurement
6.7(1)	Topsoil for Medians	Square metre
6.7(2)	Topsoil for embankment slopes and side drains	Square metre

6.8 BRIDGE DRAINAGE

6.8.1 DESCRIPTION

This work consists of furnishing and installation of drain outlets on viaducts, approach structures and other structures, at interchanges, overpasses and underpasses including piping, gullies, gratings, inserts, fittings and other incidental parts necessary to provide for supports of drain pipes in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings.

6.8.2 MATERIALS REQUIREMENTS

6.8.2.1 Gully and Grating

The size and strength of gullies shall be as indicated on the Drawings. The Contractor is at liberty to propose alternative gullies of similar quality. Gratings shall be made of structural steel galvanised in accordance with AASHTO Standard Specification M111. All gullies shall be approved by the Engineer.

6.8.2.2 Cast Iron Piping

Cast iron piping and fittings shall comply with international standards to the satisfaction of the Engineer.

6.8.2.3 PVC Pipes

All PVC pipes and fittings shall comply international standards to the satisfaction of the Engineer.

6.8.2.4 Inserts

Inserts shall be carried out of steel conforming to AASHTO Standard Specification M183 (AASHTO A36) or as approved by the Engineer.

6.8.2.5 Fittings and other Incidentals

Material is to be as indicated on the Drawings or as approved by the Engineer.

6.8.3 CONSTRUCTION REQUIREMENTS

6.8.3.1 Storage and Handling of Materials

The steel and PVC parts shall be carefully handled and stored on blocking, racks or platforms so as not to be in contact with the ground and the steel parts shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter.

6.8.3.2 Gullies

Gullies are to be cast into the structure at the location as indicated on the Drawings. Special care must be taken to avoid displacement of gullies during concreting operations.

6.8.3.3 Cast Iron Piping

The pipe shall be provided with suitable joints that prevent lateral displacement. The pipes shall be embedded in the locations as indicated on the Drawings. During casting of concrete the piping shall be kept in the correct position by means approved by the Engineer.

6.8.3.4 PVC Pipe

The jointing shall be of a type recommended by the manufacturer of the pipes. Bends shall be of long sweep, free from kinks.

Embedded pipes shall be cast into the structure in the locations indicated on the Drawings. During casting of concrete the piping shall be kept in the correct position by means approved by the Engineer.

Exposed pipes shall be parallel or at right angles to walls, slabs and girders. All exposed pipes shall be attached to concrete, steel, masonry or timber by galvanised malleable iron or galvanised steel straps, clamps or hangers of an approved type, held at not less than two points by galvanised steel bolts or lag screws. The runs shall be supported at not greater than 1 metre centres on horizontal or near horizontal runs, unless otherwise specified and not less than 50 mm clear of the supporting members.

All ends of pipes installed during construction shall be closed against the intrusion of foreign material.

6.8.4 MEASUREMENT

For structural work measured in accordance with Method A, as defined in sub-clause 5.1.6(a) of these Specifications, this work shall be measured as the actual number of gully and grating of size indicated and shall include all cast iron piping, fittings, inserts, relevant erosion protection (if any) and other incidental parts necessary to provide for further support of drain pipes, satisfactorily completed and accepted.

No measurement or payment shall be made for the drain pipes and any other drain facilities shown on the Drawings. They shall be considered incidental to the gullies.

For structural work measured in accordance with Method B, as defined in sub-clause 5.1.6(b) of these Specifications, no separate measurement shall be made.

6.8.5 PAYMENT

The work measured as provided above shall be paid for at the Contract unit price per gully and grating.

The price and payment shall constitute full compensation for furnishing all materials as indicated on the Drawings including delivery, erection, surface treatment and finishing and for all labour, equipment, tools and incidentals necessary for the completion of the work.

Pay items shall be:

Item Ref	Description	Unit of Measurement
6.8(1)	Gully	Number
6.8(2)	Grating	Number
	(Size and Type shall be stated)	

6.9 GABIONS

6.9.1 DESCRIPTION

This work shall consists of the furnishing and installation of steel wire gabion boxes or mattresses at such locations as are shown on the drawings or designated by the Engineer in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings.

The work shall include the furnishing of the gabions and associated materials, the preparation of the sites and the supply and placement of rock fill for the gabions.

6.9.2 MATERIALS REQUIREMENTS

6.9.2.1 General

Wire gabion boxes and mattresses shall have appropriate mesh size to retain the rock filling.

Gabion box and mattress panels and diaphragms shall be selvedged. The selvedge wire shall be woven integrally with the mesh, or fastened to the mesh either by binding the edges of the mesh about the selvedge wire or by stainless steel clips, all in accordance with the manufacturer's recommendations.

6.9.2.2 Gabion boxes

Gabion boxes shall be proprietary products.

Gabion boxes shall be manufactured from heavily galvanised, hexagonally woven, steel-wire mesh having a wire diameter not less than that specified in Table 6.9.1 and a mesh opening of 80mm across the flats of the hexagon.

Binder wire and selvedge wire shall have minimum diameters as specified in Table 6.9.1

Table 6.9.1 Wire Mesh Requirements

	Diameter (mm)	Mesh Opening (mm)
Gabion Boxes:		
Mesh	2.7	80
Binder	2.2	
Selvedge	3.4	
Mattress:		
Mesh	2.0	60
Binder	2.0	
Selvedge	2.4	

6.9.2.3 Mattresses

Mattresses shall be either proprietary products or non-proprietary products constructed as described herein.

Proprietary mattresses shall be manufactured from heavily galvanised, hexagonally woven, steel-wire mesh having a wire diameter not less than specified in Table 6.9.1 and a mesh opening of 60mm across the flats of the hexagon.

Binder wire and selvedge wire shall have minimum diameters as specified in Table 6.9.1

Non-proprietary products shall be constructed from 1.8m minimum width rolls of chain wire mesh. Diaphragms are not required in this form of mattress and panels are not required to be selvedged.

6.9.2.4 Wire

All wire shall comply with the requirements specified in AS 2338 and AS 2423.

Galvanising shall be in accordance with the requirements specified in AS 1650.

Where specified the wire shall have a black PVC or other approved plastic coating of nominal thickness 0.55 mm (minimum thickness 0.4 mm).

Sufficient binding wire shall be available for binding/tying operations

6.9.2.5 Anchors

Anchor plates for wire mattresses shall be fabricated from grade 250 commercial quality steel and galvanised. All plate shall comply with the requirements specified in AS 3678 and AS 3679. All sharp edges and curves shall be ground smooth prior to galvanising.

All galvanising shall be in accordance with the requirements specified in AS 1650. Galvanising shall be carried out after cutting and drilling of the plates.

Anchor bolts securing anchor plates to concrete shall be supplied in accordance with the details specified. Anchor pickets shall be metal stakes or rods 1.8 metres long.

6.9.2.6 Rock

a) Gabion boxes - Rock used for filling gabion boxes shall be of a size not less than 120 mm and not greater than 200 mm. The rock shall be uniformly graded and not less than 80 percent by number shall be of size greater than 150mm. Rocks shall, wherever possible, be cubical, but in no case shall their least dimension be less than half their greatest dimension.

b) Mattresses - Rock used for filling mattresses shall be of a size not less than 75 mm and not greater than 150 mm. The rock shall be uniformly graded and not less than 80 percent by number shall be of size greater than 100 mm. Rocks shall, wherever possible, be cubical, but in no case shall their least dimension be less than half their greatest dimension.

6.9.3 CONSTRUCTION REQUIREMENTS

6.9.3.1 General

Where necessary, localised excavations shall be carried out to permit construction of gabion box or mattress protection work. The areas on which the boxes or mattresses are to be positioned shall be trimmed to the shapes specified on the drawings to within a tolerance of +/- 50 mm except where in the case of mattresses the provision of such tolerances will not permit the tops of mattresses to join neatly to the inverts of adjacent culverts.

Trimmed surfaces shall be free of roots, stumps, brush, rocks and other like protrusions. Gabion box and mattress protection works shall be constructed to the shapes and to other requirements specified herein

6.9.3.2 Anchor Plates and Pickets

Where specified, anchor plates and bolts shall be installed to secure mattresses to structures.

Where specified, anchor pickets shall be utilised to secure mattress protection work. Such pickets shall be installed prior to placing mattresses and shall be positioned along the line of the upstream edge of mattresses placed on stream beds and along the line of the top edge of mattresses placed on sloped areas. Nominal spacing of pickets shall be 1 metre.

Where geotextiles are employed under mattresses, neatly cut openings shall be made in the geotextile at the appropriate locations to permit insertion of pickets.

The tops of the installed pickets shall finish level with the tips of the mattresses. Pickets which cannot be driven full depth shall be cut off level with the tops of the mattresses.

6.9.3.3 Assembling, Positioning and Joining Boxes and Mattresses

Proprietary wire boxes and mattresses shall be assembled in accordance with he manufacturer's drawings and recommendations.

Assembled boxes and mattresses shall be positioned empty in the Works

a) Gabion boxes - The first row of boxes shall be securely positioned and filled before boxes in other rows are positioned. Other boxes may then be positioned, joined and filled as the work requires. Joining shall be effected by binding or clipping the boxes together in accordance with the manufacturer's recommendations.

b) Mattresses - The first row of mattresses shall be securely positioned and filled before mattresses in other rows are placed, joined and filled. The corners and all diaphragm points along the side of the first row of assembled mattresses shall be tied to the anchor plates and anchor pickets prior to placing rock filling. Mattresses in other rows may be positioned, joined and filled as the work requires. The joining of mattresses shall be in accordance with the manufacturer's recommendations.

c) Non-proprietary Wire Mattresses - Lengths of chain wire mesh shall be laid out flat on the ground surface and stretched sufficiently to remove any kinks and bends. Each length shall be sufficient to provide for the top, bottom and two ends.

The chain wire mesh shall be positioned length transverse to the direction of flow, leaving a top section of the mesh to be turned over to complete the mattress.

The bottom and ends of each length of chain wire mesh shall be bound to adjacent lengths through each individual mesh in turn. The outermost lengths of mesh shall be cut and shaped such that part of the bottom may be folded up to form end panels of height equal to the thickness of the mattress.

Wire ties, not less than 1.6 mm diameter and having sufficient length to secure the top of the mattress, shall be provided at 500 mm intervals in each direction along the bottom of the mattress.

6.9.3.4 Forming Shapes

Where necessary, the mesh panels of boxes and mattresses shall be neatly cut, folded and tied together to form mitre joints, angles, curves, slopes and other shapes not possible to obtain using rectangular units. Surplus mesh shall be completely cut out or be folded back on to and neatly tied to an adjacent box or mattress face. Cut/folded edges of boxes shall be selvedged. Adjacent cut/folded edges shall be bound or clipped together in accordance with the manufacturer's recommendations.

6.9.3.5 Tensioning of Mattresses

Unfilled, positioned mattresses shall be tensioned using a wire strainer, or by winching. The stretching apparatus shall be firmly attached to the free end of the assembled mattress. The tensioning process shall in no way distort the mattress shape. Adjacent mattresses shall be securely bound together along the top, bottom and sided whilst under tension.

6.9.3.6 Placing Rock Filling

a) Gabion Boxes - The method of placing shall produce a dense, evenly distributed filling with minimal voids and shall not significantly distort the box shape. Where necessary the outer and inner panels of the boxes shall be tied together during the placing operation to minimise distortion, especially when diaphragms are not employed. Care should be taken to avoid damaging the mesh and any geotextile placed under the box.

   Gabion boxes shall be hand-packed with broken rock as specified in sub-clause 6.9.2.6 of these Specifications. The sides shall be packed first in the form of a wall, using the largest pieces, with the majority placed as headers with broken joints to present a neat outside face. The interior of the gabion shall be hand-packed with smaller pieces and the top layers shall be finished of with larger pieces. The whole interior and top layers shall be packed tight and hammered into place.

b) Mattresses - Placing rock filling shall be carried out whilst the mattresses are under tension. Rock filling of mattresses shall be carried out entirely by mechanical methods. The method of placing shall produce a dense, evenly distributed filling with minimal voids and minimum distortion of the mattress shape. Care should be taken to avoid damaging the mesh and any geotextile placed under the mattress. Tension on the mattresses shall only be released when the mattresses have sufficient rock filling to prevent the mesh from slackening after release.

6.9.3.7 Closing Boxes and Mattresses

Gabion boxes and mattresses shall be closed as soon as practicable after filling. All lids of boxes shall be securely bound to edges and diaphragms, and the lids and top sections of mattresses shall be tied down in accordance with the manufacturer's recommendations

Tying of non-proprietary mattresses shall be carried out in a manner approved by the Engineer. The top section of each mattress shall be turned over the rock filling and securely bound to adjacent top sections through each mesh in turn. The free ends and sides of the outermost top sections shall be similarly bound to the top and side edges of the end panels.

6.9.4 MEASUREMENT

The work shall be measured as the number of cubic metres of gabion boxes or mattresses installed and approved in accordance with the Drawings or as directed by the Engineer.

No separate measurement shall be made for the rock filling as this will be considered as included in this work.

6.9.5 PAYMENT

The work measured as provided above shall be paid for at the Contract unit price per cubic metre of gabion box or mattress.

The price and payment shall constitute full compensation for the work described herein and as indicated on the Drawings including supply and delivery of all materials, excavation, installation of anchors plates, bolts and pickets, assembling, positioning and joining boxes and mattresses, forming shapes, placing rock fill and closing boxes and mattresses and for all labour, equipment, tools and incidentals necessary for the completion of the work.

Pay items shall be:

Item Ref	Description	Unit of Measurement
6.9(1)	Gabion boxes	Cubic metre
6.9(2)	Mattresses	Cubic metre
6.9(3)	Non-proprietary mattresses	Cubic metre

CONSTRUCTION SPECIFICATION

Section 7
Ancillary Works

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7 ANCILLARY WORKS

7.1 CONCRETE SIDEWALKS

7.1.1 DESCRIPTION

This work shall consist of concrete sidewalks constructed of in-situ concrete, concrete slabs or concrete blocks on prepared beds in accordance with these Specifications and in accordance with the lines, levels, grades, dimensions and types shown on the Drawings. If shown on the Drawings the work shall include the construction of bed courses.

This work shall also include concrete for median and island paving in accordance with the locations and details shown on the Drawings or as directed by the Engineer.

This work shall not include sidewalks on bridge decks, which shall be constructed in conjunction with the rest of the deck and shall conform to the relevant sections of these Specifications.

7.1.2 MATERIALS REQUIREMENTS

Bed course material, if any is shown on the Drawings shall consist of sand, gravel, crushed stone or other approved porous materials of 10 mm maximum size.

Concrete shall be of the class shown on the Drawings and shall conform to the requirements of Section 5.1 of these Specifications

7.1.3 CONSTRUCTION REQUIREMENTS

Excavation shall be made to required depth, and the foundation shall be shaped to conform to the section shown on the Drawings and compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material.

If indicated on the Drawings bed course material shall be placed and compacted to form a bed course of the required thickness.

Forms shall be made of metal or of straight and sound lumber at least fifty mm in thickness. They shall be free of warp and of sufficient strength to resist springing out of shape under pressure of the concrete. Forms shall be staked securely in position at the correct line and elevation.

Concreting shall be generally in accordance with the requirements of Section 5.1 of these Specifications. Preformed expansion joint filler of the dimensions shown on the Drawings shall be set in the positions shown on the Drawings before the placing of concrete is started.

The concrete sidewalk between expansion joints shall be divided into blocks by transverse cuts, extending to at least one-third the depth of the slab, where called for on the Drawings or directed by the Engineer.

The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool, so formed as to round the edges to a 10 mm radius.

All work shall be correct to line, grade and level to within 3 mm.

If shown on the Drawings, the Contractor shall construct the required sidewalk or island paving of individual precast concrete slabs or blocks of a size specified on said Drawings. If precast slabs are not specified, the Contractors electing to construct the required sidewalk, median or island paving in this manner must have the prior written approval of the Engineer.

7.1.4 MEASUREMENT

This work shall be measured on a square metre basis, complete and accepted in place.

7.1.5 PAYMENT

Concrete slab for island, median or sidewalk shall be paid for at the Contract unit price per square metre, complete in place, which price shall include all materials, sand bedding, equipment, tools, labour and all work incidental to satisfactory completion.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
7.1(1)	Concrete Slab for Island, Median or Sidewalk	Square metre
7.1(2)	Non-rectangular Concrete Blocks for Island, Median or Sidewalk	Square metre

7.2 GUARD RAIL

7.2.1 DESCRIPTION

This work shall consist of furnishing and installing the specified type or types of guard rail at locations indicated on the Drawings or as directed by the Engineer.

The work shall include all required posts, rails, cables, fixtures and fastenings, beams, anchorages and attachments as well as aligning and painting, if required, and all the processes necessary to complete the work.

7.2.2 MATERIALS

7.2.2.1 Posts

Steel posts shall be galvanised standard carbon steel pipe with round shape, outside diameter not less than 100 mm. and thickness not less than 4 mm. or as otherwise approved by the Engineer, and shall conform to the requirements given on the Drawings or by the Engineer.

7.2.2.2 Concrete and Reinforcement

Concrete shall conform to the requirements of Section 5.1 or 5.4 of these Specifications as appropriate. Reinforcement shall conform to the requirements of Section 5.2 of these Specifications.

7.2.2.3 Guard Rail

Beams for guardrails shall be Class A with a Type 1 finish in accordance with AASHTO M180 and shall be obtained from a manufacturer approved by the Engineer.

7.2.2.4 Bolts and Nuts

Bolts, nuts, rings and other hardware shall be galvanised in accordance with AASHTO standard M232 (ASTM A153) and all connections shall be able to withstand a side pull in any directions of 2,200 kilograms.

7.2.2.5 Paint

Paint shall be applied in the number of applications and of the type indicated in the Contract Documents. Paint shall conform to the appropriate specification as follows:

White and Tinted Ready-Mix Oil Base Paint	AASHTO M	70 Type 1 Class B
Aluminium Paint	AASHTO M	69

7.2.3 CONSTRUCTION REQUIREMENTS

7.2.3.1 Posts

Posts shall be set vertically in position to the lines and levels shown on the Drawings and in accordance with the manufacturer's published instructions. Posts shall be driven by a method approved by the Engineer. Any damage caused to the posts in driving will be cause for rejection.

7.2.3.2 Rail

Rails shall be erected in a manner that will result in a smooth continuous taut rail closely conforming to the line grade of the highway or as shown in the Drawings.

7.2.3.3 Steel Rails

Steel rails shall be supplied to the site fully fabricated requiring only bolting on site. Bolts shall be drawn tight except where otherwise required at expansion joints.

7.2.3.4 Concrete Rails

Concrete rails shall be erected in conformity with the requirements of Section 5.1 Concrete or 5.4 Prestressed Concrete of these Specifications as appropriate.

7.2.3.5 Painting

Wherever galvanised coating has been damaged by cutting, welding or driving, and when approved by the Engineer, the damaged areas shall be renovated either by the use of low melting point zinc alloy repair rods or powders made specifically for this purpose, or by the use of at least two coats of good quality zinc rich paint approved by the Engineer.

7.2.3.6 Relocation of Existing Steel Guard Rail

Where shown on the Drawings or directed by the Engineer, the Contractor shall carefully remove existing steel guard rail and posts, clean, paint and otherwise refurbish the various elements and reinstall in a location shown on the Drawings or indicated by the Engineer. All new bolts and nuts shall be used in the relocation of existing steel guard rail.

7.2.3.7 Tolerances

Guardrail shall be erected at the instructed offsets and levels from the pavement centreline and shall be correct within a tolerance of ± 20 mm in line and level. In addition adjacent plates shall not vary in line or grade by more than 5 mm measured from a line extended from one plate to the end of the adjacent plate. Where the guardrail is on a horizontal or vertical curve the calculated deflection shall be added to this tolerance.

7.2.3.8 Measurement

Steel guard rail shall be measured by the linear metre along the rail elements from centre to centre of posts for each continuous installation. Terminal sections will not be measured separately but will be considered incidental to the work. Steel beam guard rail barricade will be measured as a unit each, complete in place, as shown in the Contract Drawings.

7.2.4 PAYMENT

Steel Guard Rail, Relocated Steel Guard Rail and Steel Beam Guard Rail Barricade will be paid for at the respective Contract prices per unit of measurement, measured as specified above, which shall include furnishing and installing all steel rail elements, terminal sections, steel posts, brackets and splice plates, nuts, bolts, miscellaneous materials and backfill as well as all equipment, labour and incidentals necessary to the proper execution of the work.

Payment will be made under the following items:

Item Ref	Description	Unit of Measurement
7.2(1)	Steel Guard Rail, Type I	Metre
7.2(2)	Steel Guard Rail, Type II	Metre
7.2(3)	Relocated Steel Guard Rail	Metre
7.2(4)	Steel Beam Guard Rail Barricade	Metre

7.3 FENCING

7.3.1 DESCRIPTION

This work shall consist of furnishing and installing fences and gates of the type indicated, constructed in accordance with this Specification at the locations and in accordance with the lines, grades, levels, designs and dimensions shown on the Drawings.

7.3.2 MATERIALS REQUIREMENTS

Concrete shall conform to the requirements of Section 5.1 Concrete or Section 5.4 Prestressed Concrete of these Specifications as appropriate. Timber shall be sound timber free from shakes, splits, wavy edges and heart wood. The timber shall be well seasoned, treated in accordance with the requirements indicated on the Drawings and of the dimensions indicated. The species of timber shall be as stated in the Drawings or in these Specifications. Cable, chain link and barbed wire shall be of the gauge, weight, size and type indicated on the Drawings or in these Specifications and shall be galvanised. Hinges and fittings shall be of the size and type indicated in the Drawings or in these Specifications.

7.3.3 CONSTRUCTION REQUIREMENTS

Posts shall be set vertically to the depth shown on the Drawings and maintained in accurate alignment while fencing is erected and backfilling is done. Backfilling shall be done with suitable material, not necessarily the material excavated, and shall be well tamped into compacted layers not exceeding 100 mm thickness. On completion of erection the fence shall be firm with no loose or movable parts and true to lines grades and levels to within 100 mm. Gates shall be hung horizontally. Anchors shall be securely buried and backfilled as for posts and shall show no signs of movement when wires are strained tight.

Painting shall be in conformity with the requirements stated on the Drawings or in Section 5.12 of these Specifications.

7.3.4 MEASUREMENT

The quantity measured for payment shall be the number of linear metres of each type of fencing and the number of gates of each type, all as finally installed in the place required and accepted.

7.3.5 PAYMENT

This work measured as provided above shall be paid for at the Contract unit price for fencing and gates which rate and payment shall be full compensation for furnishing all materials and for all labour, equipment, tools and incidentals necessary to complete the work.

Payment shall be made under the following items:

Item Ref	Description	Unit of Measurement
7.3(1)	Fencing (description to be added)	Metre
7.3(2)	Gates (description to be added)	Number

If more than one type is used successive serial numbers may be used in brackets to define new items.

7.4 MARKERS AND GUIDE POSTS

7.4.1 DESCRIPTION

This work shall consist of guide posts, kilometre markers and right-of-way monuments furnished and installed in accordance with details shown on the Drawings and these Specifications.

This work shall also include the removal, rehabilitation and relocation of existing guide posts or kilometre markers on road rehabilitation or reconstruction projects as directed by the Engineer and in accordance with these Specifications.

7.4.2 CONSTRUCTION REQUIREMENTS

Details of construction materials, placing, painting, lettering, etc. are shown and fully described on the Drawings. Concrete and reinforcement steel shall conform to the requirements as specified in Section 5.1 and 5.2 of these Specifications. Any guide post or kilometre marker shown on the Drawings or designated by the Engineer to be removed and relocated shall be carefully excavated, removed, cleaned, repainted and refurbished to as-new condition and installed in the proper location as directed by the Engineer.

7.4.3 MEASUREMENT

This work shall be measured as the number of respective units each, properly constructed or relocated and accepted by the Engineer.

7.4.4 PAYMENT

Payment for Guide Posts, Relocated Guide Posts, Kilometre Stones, Relocated Kilometre Stones and Right-of-way Monuments shall be at the respective Contract unit prices each, complete in place, which prices shall include, furnishing and placing all materials, labour, equipment, tools and incidentals necessary to complete the work.

Pay items, shall be as follows:

Item Ref	Description	Unit of Measurement
7.4(1)	Guide Post	Number
7.4(2)	Relocated Guide Post	Number
7.4(3)	Kilometre Marker	Number
7.4(4)	Relocated Kilometre Marker	Number
7.4(5)	Right-of -way Monument	Number

7.5 ROAD SIGNS

7.5.1 DESCRIPTION

This work shall consist of furnishing, assembling and erecting posts, signs, sign frames and illuminated signs of a permanent nature in accordance with the details shown on the Drawings and as specified herein and in the Special Provisions at the locations shown on the Drawings and as directed by the Engineer.

The work shall include all necessary foundations, excavation, backfill, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations where required, application of paints and finishes, testing and all the processes necessary to complete the work. Design of signs and associated electrical installations is included in the work.

This work shall also include the removal, cleaning, restoration and reinstalling of existing road signs and posts which are in good condition but not presently in the proper location for the finished road construction. This work will be directed and approved by the Engineer on an as-needed basis.

7.5.2 GENERAL REQUIREMENTS

7.5.2.1 Sizes, Colours Types

Signs shall be the sizes, colours and types shown on the Drawings or as directed by the Engineer. They shall be reflectorised and constructed in accordance with the requirements of Section 7.5 of these Specifications.

7.5.2.2 Alternative Designs and Materials

The Contractor may submit or recommend alternative designs and construction materials to those specified in these Specifications or on the Drawings subject to the approval of the Engineer.

7.5.3 MATERIALS REQUIREMENTS

7.5.3.1 Mounting Posts

Mounting posts shall be manufactured from one of the following materials:

a) Reinforced Concrete Posts - Material shall conform to the requirements of Section 5.1 of these Specifications. Concrete shall be Class B1 unless otherwise specified on the Drawings or in these Specifications.

b) Prestressed Reinforced Concrete Posts - Materials shall conform to the requirements of Section 5.4 of these Specifications.

c) Steel Posts - Steel posts shall be in the form of round tubes or pipes of not less than 60 mm outside diameter or other approved sections of adequate torsional rigidity and strength complying with the appropriate specifications of the American Society for Testing Materials, the British Standards Institution, the American Association of State Highway Officials or a similar internationally recognised body.

d) Aluminium Alloy Posts - Posts shall be manufactured from one of the following alloys:

either

(i) Alloy 606l-T6, 6062-T6 or 6063-T6 complying with the following ASTM specifications where appropriate:

B 210 Drawn Seamless Tubes
B 221 Extruded Bars, Roads and Shapes
B 235 Extruded Tubes
B 241 Pipe
B 308 Structural Shapes, Rolled or Extruded.

or

(ii) Approved alloy sections to other internationally recognised specifications acceptable to the Engineer.

e) Post Caps - Caps for hollow posts or other hollow sections used in construction may be approved cast or sheet metal or a suitable weather resisting plastics material.

7.5.3.2 Base Housings

Base housings for metal posts carrying illuminated signs shall be of fabricated steel or aluminium alloy not less than 4.5 mm thick or of cut iron or cast aluminium alloy having an average thickness of not less than 8 mm and a minimum thickness of 6.5 mm. Steel shall comply with the requirements of sub-clause 7.5.3.1, item c) of these Specifications. Cast iron shall be A.S.T.M. Designation A48, Class 30. Fabricated aluminium alloy bases shall be of material complying with the requirements of sub-clause 7.5.3.1, item d) of these Specifications. Cast aluminium alloy bases shall be either A.S.T.M. Designation B26 or B108, Alloy SG 70A, Condition T6.

7.5.3.3 Sign Plates

Sign plates and panels shall be manufactured from one of the following materials:

a) Aluminium Alloy

(i) Flat sheets and plates shall be one of the following alloys:

either Alloy 5052-H34, 6061-T6 or 3003-H18 complying with A.S.T.M. Specification B209.

or

Approved alloy sheet or plate complying with such other internationally recognised specification as is acceptable to the Engineer.

(ii) Extruded panels shall be one of the following alloys:
either Alloy 6063-76 complying with A.S.T.M. Specification B 221

or

Approved alloy complying with such other internationally recognised specification as is acceptable to the Engineer.

b) Steel Plate, Sheet or Strip - The material shall comply with A.S.T.M. Specification A245, Grade B, or such other internationally recognised specification as is acceptable to the Engineer.

7.5.3.4 Frames and Stiffening

Except as otherwise provided in the Drawings or these Specifications sign plates requiring frames or stiffening as specified under sub-clause 7.5.4.5 of these Specifications shall have adequate ribs or flanges as an integral part of the sign plate or shall have a metal frame or stiffening bars constructed of structural sections in steel or aluminium alloy complying with the appropriate specifications of sub-clauses 7.5.3.1 and 7.5.3.3 of these Specifications.

7.5.3.5 Fixtures and Fittings

Brackets and clips shall be manufactured from approved cast metal, steel, stainless steel or aluminium alloy.

Screws bolts, nuts and washers shall be of steel, aluminium alloy or of a high tensile non-corroding metal. Washers in contact with surfaces which may be damaged by over tightening of nuts or bolts shall be of a suitable soft and weather resisting material.

Steel fixings and fittings which are in contact with aluminium shall be coated with zinc or cadmium. All steel fittings shall be rustproofed. Rivets shall be made from copper, brass aluminium alloy or pure aluminium. Brass, copper, lead or nickel shall not be used in contact with aluminium.

7.5.3.6 Electrical Components - General

Electrical equipment and parts shall comply with the provisions of sub-clauses 7.6.2.2, 7.6.2.3 and 7.6.2.4 of these Specifications.

7.5.3.7 Wiring

The provisions of sub-clause 7.6.3.2 of these Specifications shall apply except that for “lighting columns” and "columns" read "illuminated signs”.

7.5.3.8 Switching

The provisions of sub-clause 7.6.3.3 of these Specifications shall apply.

7.5.3.9 Preservatives, Paints and Finishes

All coatings, paints, varnishes and enamels used in the preparation and finish of the signs, posts and fittings shall be of the best quality, specially made for the purpose they shall serve, and of brands and types acceptable to the Engineer. To ensure compatibility, primers, undercoats and finishing costs shall, wherever possible, be of the same manufacture. All materials shall be stored, and used within such time limits, as specified or recommended by the manufacturers or in accordance with the directions of the Engineer.

Zinc coating (galvanising) on steel parts shall comply with ASTM specification A 123 or A 153 as appropriate.

All paint used for steel parts, other than finishes on a sign face, shall be high zinc oxide content coating material of approved formulation containing a minimum of seven kilograms

of zinc oxide (acicular type) per one hundred litres of coating material. The colour of the primer shall be different from succeeding coatings.

Priming paints for aluminium alloys, when required, shall be pigmented with chromates or chromes (excluding lead chromes) except on sign faces where the specified finish is unsuitable for use with such primers.

Reflective sheeting shall be "Scotchlite" Engineer Grade or other approved colourfast reflective material applied in accordance with the manufacturer's specifications or instructions.

Plastics sheeting, film, sheathings and sprayed plastic finishes shall be of approved types and thicknesses, of durable colour and weather resistant, and shall be fully compatible with any materials with which they will come into contact. Such finishes shall be applied in accordance with the manufacturer's specifications or instructions.

These coatings shall be in accordance with sub-clause 7.5.3.9 of these Specifications except that all aluminium sheeting and other members shall be anodised by a process approved by the Engineer.

Sign plates shall be covered with “Scotchlite" Engineer Grade or other approved colourfast reflective plastic sheeting over the whole front surface to the specified background colours.

All plastic sheeting shall be affixed to the sign plate with a heat activated adhesive properly applied in accordance with the sheeting manufacturer's specification and instructions. All joints in the sheeting shall be overlapped (from the top when practicable) and no butt joints will be permitted. Overlaps shall be not less than 6 mm. and sheeting shall extend over top and bottom edges and down side legs by at least 3 mm. Words, figures and other symbols shall be applied to this sheet material by the silk screen method using a translucent paint for coloured parts and an opaque paint for black parts all as approved by the manufacturer of the '“Scotchlite”' or other approved sheeting.

The whole of the face and edges of each finished sign plate shall have a full glossy coat of clear lacquer applied at the time of fabrication of the sign, and of a type specified or supplied by the manufacturer of the sheeting material.

Back of aluminium sign plates shall not be painted. Galvanised steel frames, brackets, bolts and nuts shall not be painted.

7.5.3.10 Reflective Beads

Beads for reflectorization of signs shall be of good quality, optically clear, lead-free glass with not less than 90% reasonable spherical and free from flaws. The beads shall contain not more than one per cent of sharp angular particles and not more than one half per cent of foreign matter and shall be free flowing under normal atmospheric conditions.

For reflectorizing white and yellow, the heads shall have a refractive index of not less than 1.90. For reflectorization of other colours the refractive index shall be not less than 1.60 and not greater than 1.70.

The beads shall contain not less than 80% by weight within one of the size ranges specified below.

Size Range (Microns)

250-177
210-149
177-125
149-105
125- 88
105- 74

The binder for the beads shall be formulated so as to provide maximum bead retention, high specular reflection and a firm bond with the surface to which it is applied.

7.5.4 DESIGN AND CONSTRUCTION REQUIREMENTS

7.5.4.1 General

The Contractor shall be responsible for the design of signs and all associated fittings and fixtures, including electrical equipment, in accordance with the Drawings and Section 7.5 of these Specifications. Full details of the Contractor's designs and proposed materials shall be submitted to the Engineer for approval before commencement of the work.

Signs shall be mounted on posts unless otherwise instructed by the Engineer in writing. Design and construction of signs shall be such that all sign plates, posts, fittings, lighting units, electrical equipment and conduit can be assembled and erected without site modification.

All signs considered by the Engineer to be in the way of reconstruction or rehabilitation works shall be carefully removed in accordance with Section 2.1 of these Specifications. Road signs so removed but in good condition and still necessary to the proper signing of the road shall be reinstalled in accordance with sub-clause 7.5.4.15 of these Specifications.

7.5.4.2 Mounting Posts

Posts shall be adequate in number and size to support the signs and any lighting fittings attached to the frames or posts. Where apertures are cut in posts for cable entry etc. due allowance shall be made to ensure that the post will be of adequate strength.

Post shall be such that, at a wind pressure of 150 kilograms per square metre, the maximum deflection at the centre of the sign is limited to one fortieth (1/40th) of the height measured from the ground for signs mounted on a single post and to one eightieth (1/80th) for signs mounted on more than one post.

The lengths of posts shall be adequate for the requirements allowing for embedment in the ground and/or extensions for lighting fittings. All posts shall be effectively prevented from rotation in the ground and if necessary in the case of metal posts, suitable metal base plates shall be provided for this purpose. Unless otherwise shown on the Drawings base plates shall be not less than 4.5 mm thick and shall have an area of not less than five tines the plan area of the post. Effective means for securing the base plate to the post shall be provided.

Where a post has to be sited close to a wall either the top of the post shall be angled away from the wall to provide adequate clearance for the sign or an adequate bracket or brackets shall be provided from the post for this purpose. In either case the post shall be of adequate strength and rigidity to withstand the additional bending moments and torsion resulting from the arrangement.

All open ended posts, or other hollow sections used in construction shall be effectively capped to prevent the entry of water.

Construction of reinforced concrete and prestressed reinforced concrete posts shall be in accordance with Sections 5.1 and 5.4 of these Specifications, respectively, and as approved by the Engineer. All surfaces above ground shall receive a rubbed finish complying with sub-clause 5.1.5.8, item d) of these Specifications.

Timber posts above ground shall be smooth planed.

7.5.4.3 Base Housings

Base housings for posts shall have ample accommodation for the electrical components to be fixed therein. Suitable means shall be provided for fastening the posts firmly to the base housings. Base plates shall have an area not less than two and a half times the plan area of the base housings and shall be not less than 4.5 mm thick in the case of steel and aluminium plate and not less than 6.5mm thick for cast housings.

A service door or panel of rigid construction shall be provided to give ready accessibility for maintenance purposes. The door or panel shall be weatherproof and shall be capable of being secured with key fastenings. Screws shall be of non-corrosive metal and captive. Screws of a self tapping type shall not be used.

Ventilation and drainage, sufficient to prevent undue condensation, shall be provided and the bottom of the housing shall be sealed to prevent the upward seepage of water. Arrangements shall be made for the service cable or conduit to enter the base housing at any depth between 150 and 300 mm below ground level and it shall be possible to lift away the post and housing without breaking the service joint. Cable entry holes shall be sealed, with a suitable gland, against the entry of dirt or water. Adequate earthing arrangements shall be provided.

7.5.4.4 Sign Plates

Aluminium alloy plates and panels shall have a minimum thickness of 2 mm. Steel plates and panels shall have a minimum thickness of 1.5 mm. Sign plates constructed of other materials shall be of adequate rigidity and strength and shall be suitable for the finishes which are to be applied to them. Where the Engineer so directs, tests shall be carried out to determine the suitability of a material and its finish for use as a sign plate.

Extruded plank type aluminium panels may be of either the interlocking or bolted type. Cold formed plank type steel sections bolted together through the flanges may also be used for panels. Where such panel sections are used the ends of the sections shall be covered to present a flanged appearance such that the edges of the sign present the same appearance all round.

Sign plates and panels shall be cut accurately to the shapes and sizes specified on the Drawings. All mounting holes shall be accurately located and, after drilling or punching, any burrs, rough spots and loose material shall be removed. All holes shall be drilled before painting.

7.5.4.5 Frames and Stiffening

Except where ribs or flanges are an integral part of the sign plate and provide the necessary stiffening, sheet metal sign plates exceeding one metre in any dimension shall

be stiffened by the attachment of a frame or stiffening member (s) to the back of the sign plate.

The post or posts supporting a sign may be taken into consideration for stiffening purposes. A bracket may form the stiffening frame or part of it.

The frame for a sign plate or plates shall be simple in design and shall have the minimum number of members to give it the required stiffness.

The stiffening or frame for a sheet metal sign plate may take the form of flanges round the edges of a sign, welded ribs or steel or aluminium sections with a minimum thickness of 2 mm. Where flanges are provided they shall be uniform on all edges of the sign.

Where metal frame members join they may be welded or joined with suitable brackets and nuts and bolts but in all cases the joints shall be strong enough to withstand the stresses induced in them.

7.5.4.6 Fixture and Fittings

Where necessary or desirable signs shall be mounted on existing suitable highway furniture, buildings or structures by means of a properly designed bracket or brackets.

The method of fixing sign plates, frames and brackets to posts shall be such as will facilitate removal for replacement or maintenance purposes and permit adjustment in the position of a sign without detaching it from its post or posts, but the sign and any framing shall be held firmly enough to withstand the load to which it will be subjected. Signs mounted on single posts shall have fixing to prevent the forced rotation of the signs on the posts. Clips and brackets shall be shaped to secure a firm hold on the post without placing any bending strain on the sign plate.

Where materials with different coefficients of expansion are fixed together, allowance for this shall be made so that the sign will not fail by shearing or buckling of fixing bolts, rivets or welds.

Where dissimilar metals are joined together, precautions shall be taken to prevent electrolytic action, particularly in the case of screws and rivets. This may be accomplished by using paint, lacquer or other suitable means to eliminate metal to metal contact.

Brackets used in the construction of signs may be manufactured from sheet or strip aluminium alloy, extruded sections, cast aluminium alloy or may be fabricated from steel sections. The minimum thickness of material shall be 3 millimetres. Welded joints shall be sound and their surfaces smooth. Holes shall be drilled before painting and shall be accurately located.

Steel or aluminium strip used for clips shall not be less than 2 mm thick.

Screws and bolts shall not be less than 8 millimetres in diameter and of adequate length, but without excessive projection of the screwed ends. In any situation where, if a screw were removed, the assembly would be insecure, that screw shall have not less than four full threads engaged when it is tight and shall be fitted with a locknut or a spring washer.

Where hollow rivets are used to connect sign plates to frames or fixings the holes shall be effectively blocked to prevent light shining through. Screw bolt or rivet heads on the face of a sign shall be as unobtrusive as possible and each shall match the colour of the part of the sign where it is located.

Caps for posts of hollow section shall be shaped to shed rainwater to the outside of the posts and adequate means of securing the caps to the posts shall be provided.

7.5.4.7 External Lighting Lanterns (Electric)

Full details of lanterns, including dimensions, shall be submitted by the Contractor to the Engineer before commencement of the work.

a) Materials and design - The body of the lantern and its fittings shall be of robust construction, of ample dimensions, and shall be made of cast or sheet metal, or of weather-resisting plastics material. Sheet metal shall have a thickness of not less than 1.5 mm.

Both the exterior and interior surfaces shall be reasonably smooth to prevent the accumulation of dirt and to facilitate cleaning. The upper surface shall be shaped to shed rainwater.

The lantern shall be of the enclosed type and access to the interior shall be by a hinged bowl or door, which shall seat closely when fastened. The fastenings shall be key operated.

If a gasket is used it shall be capable of withstanding the operation conditions without deformation or softening, and shall be attached in such a way that it will be retained in position when the bowl or door is repeatedly opened for maintenance purposes.

When closed the lantern shall be waterproof and means of ventilation shall be provided.

b) Electrical components - Two lampholders, wired in parallel, shall be provided, securely mounted and correctly located, for the lamps appropriate to the size of sign, as given below.

Lanterns shall be capable of accommodation tungsten filament pearl lamps of any of the ratings given below.

Size of sign	No. of lamps and rating
Up to 0.6 x 0.6 metre	2 x 25 watt
Up to 1.25 x 1.25 metre	2 x 40 watt
Up to 1.8 x 1.8 metre	2 x 60 watt

Alternatively, the lantern may be arranged for approved tubular fluorescent lamps. All lanterns shall be supplied complete with the necessary lamps.

The electrical wiring shall be totally enclosed in conduit. A readily accessible terminal block so insulated or shrouded as to prevent the accidental contact of a person with the live terminal, and an earthing terminal shall be provided. A 3-pin socket may be used instead of the terminal block and earthing terminal. Conduit tubing shall not be visible from the front of the sign.

c) Optical components - Separate reflectors shall be of anodised aluminium, vitreous enamelled steel or other suitable material. The surface of refractors not wholly within the lantern shall be protected by a hermetically sealed cover plate. Diffusers shall be of glass or plastics material and shall have smooth interior and exterior surfaces.

d) Finish - The surface of lanterns shall be finished with approved paint, enamel or vitreous enamel.

e) Photometric Performance - The light distribution of the lantern shall be such that when it is mounted with the appropriate sign the following conditions are satisfied in respect of the white portions of the sign:

(i) The average luminance of the sign shall be between 40 and 110 cd/sq-m.

(ii) The maximum luminance of the sign shall not exceed 325 cd/sq-m.

(iii) The distribution of illumination shall be reasonably uniform and the illuminated sign shall not present a patchy appearance. The ratio between the maximum and minimum luminance shall not exceed the following values.

Size of sign	Limiting ratio
0.6 x 0.6 metres	10 : 1
1.25 x 1.25 metres	30 : 1
1.3 x 1.8 metres	40 : 1

(iv) No light shall be emitted direct from the lantern towards oncoming traffic and tight spill shall be kept to a minimum.

f) Lantern Brackets - The length of the conduit bracket supporting the lantern shall be such that the outside edge of the lantern does not project more than the following distance from the front surface of the sign:

Depth of sign (metres)	0.75	1.20	1.80	2.70	3.60
Maximum outreach (metres)	0.45	0.60	0.90	1.10	1.35

The lantern shall be mounted so that:

a. the main illumination is downwards

b. the lantern does not obscure part of the sign

Conduit brackets shall be of adequate dimensions to minimise relative movement between the lantern and the sign due to vibration. Means shall be provided to prevent the lantern turning on the bracket.

7.5.4.8 Internally Illuminated Signs

a) General - Full details of the signs and their fittings, including dimensions, shall be submitted by the Contractor to the Engineer before commencement of the work.

The exterior of the sign shall have no sharp edges or protuberances and the exterior and interior surfaces shall be reasonably smooth to prevent the accumulation of dirt and to facilitate cleaning. The upper surface shall be shaped to shed rainwater.

b) Sign Housing - Sign housings shall be of cast or sheet metal or of weather-resisting plastics material, of adequate rigidity and strength, and so designed and constructed that light sources and any electrical gear are readily accessible for cleaning and maintenance purposes.

The housing shall be such that the assembled sign is waterproof and means of ventilation shall be provided.

Access doors or panels shall be of rigid construction, designed to seat closely when fastened and fastenings shall be key operated. Screws used for securing access doors and panels shall be non-corrosive and captive. Screws of a self tapping type shall not be used.

Gaskets shall be capable of withstanding the operating conditions without becoming permanently deformed, softened or hardened and any adhesive used for fixing then shall be chemically compatible with the gasket material and with the material to which the gasket is fastened.

Gaskets used to retain the face of a sign shall be so designed that the face is not easily removable by unauthorised persons and shall be positively held in position so as not to work loose during maintenance operations. Circular signs shall have means to prevent the sign face rotating.

Cable entry holes shall be sealed with a suitable gland against the entry of dirt or water.

The method of fixing the housing to the mounting post or posts shall allow easy removal for maintenance or replacement purposes and provision shall be made to prevent the forced rotation of a sign when it is mounted on a single post. Fixing holes and holes for reflectors shall be made before painting. The internal finish of metal housings shall be of approved white enamel.

c) Sign Face - The material used for the sign face shall be clear, opal or self coloured acrylic sheet with a minimum thickness of 3 mm or toughened glass with a minimum thickness of 4 mm. Other materials may be used provided their optical properties and mechanical strength in resistance to bending and impact are at least equivalent to those of acrylic sheet or toughened glass.

The legend symbol or border appearing on the sign face may be of plastics material in the form of foil or sheeting, paint, ink or screening paste, or an other material which is chemically compatible with the material used in the sign face and appropriate to the method of construction. Paints, inks or screening pastes used on acrylic sheet shall be acrylic based, material used in bonding acrylic sheet and forming fillets shall be approved bonding acrylic cement and any adhesive or solvent used on acrylic sheet shall be chemically compatible with it. In all cases, colours and diffusing surface shall have a uniform appearance.

Due allowance shall be made for differential expansion between the sign face and any retaining material and holes for fixing purposes shall have adequate clearance. Holes drilled in acrylic sheet shall be positioned so that their edges are not less than their own diameter from the edge of the sheet.

d) Electrical Components - Lampholders shall be provided, securely mounted and correctly located, for two standard tubular fluorescent lamps wired in parallel or one such lamp normally alight plus a second lamp (which may be a tungsten filament pearl type) arranged to come into service when the first one fails. For small signs the alternative of two tungsten filament pearl lamps may be acceptable. The lampholders, ancillary gear and wiring shall be to a three pin plug and shall be mounted on a frame so that the whole assembly can be removed from the sign without the use of tools.

A readily accessible terminal block and fuses shall be provided in the base of a supporting post for each illuminated sign. The terminal block shall be so insulated or shrouded as to prevent the accidental contact of a person with the live terminal and an earthing terminal shall be connected to the lampholders and to the base housing.

e) Optical Performance - The following conditions shall be satisfied in respect of white portions of the sign face when in new and clean condition.

(i) The average luminance of the illuminated portions shall be between 45 and 215 candelas per square metre.

(ii) The variation of luminance when viewed normally to the surface shall not exceed a ratio of 15 of 1.

(iii) The luminance at any point shall not exceed 540 candles per square metre.

7.5.4.9 Preparation and Painting

a) General - All painting and finishing shall be carried out in clean, dry surroundings using heat lamps for drying and ovens for baking as may be needed. All paints shall be applied with a pressure spray to form a smooth even film and all surfaces and edges shall be coated unless stated otherwise. Paint shall be applied only when the surface or previous coat is dry.

The following requirements shall, unless otherwise provided in the Special Provisions or on the Drawings, apply to preparation and painting of sign components other than the finish on sign faces but excluding plastics signs and components with finishes of reflective and plastics sheeting, film, sheathings and other proprietary finishes.

b) Aluminium Alloys - Aluminium alloys, other than sign faces, shall not be treated or painted unless they are in contact with earth. Surfaces in contact with earth shall be prepared as described in the next paragraph and two coats of approved asphaltic paint shall be applied.

Before painting, the surfaces of aluminium alloy sign plates shall be thoroughly degreased and pre-treated by anodising or by an equivalent process or by using an etching primer.

The prime coat shall then be applied. The back and edges of the plate shall receive a finish coat of light grey enamel.

c) Steel surface - All steel components shall be rustproofed by galvanising, cadmium plating or other approved treatment prior to painting. Where necessary the surface shall be cleaned and degreased before painting. All surface other than screws, bolts, nuts and washers, shall then receive one prime coat of high zinc oxide paint. All surfaces, other than sign faces shall receive a finish coat of high zinc oxide paint, tinted light grey.

d) Cast Iron - Cast iron surfaces shall be cleaned and painted with an organic zinc-rich primer.

7.5.4.10 Finish of Sign Faces

Recommendations by the manufacturers of paint, reflecting materials, plastics sheeting or other finishes, regarding the preparation of surfaces prior to the application of the finish and protection of the finish, shall be carefully followed.

The finish on the face of a sign shall present an even surface free from twists, cracks or faults or any other blemishes. When reflecting sheeting or film is used it shall, where possible, be in complete sheets. Joints shall be kept to a minimum, but where they are necessary they shall be constructed in accordance with the manufacturer's instructions. Care shall be taken to ensure a proper day and night colour match at joints.

Enamel surfaces shall consist of one undercoat and one top coat, applied and stoved, of uniform thickness, homogeneous and uniform in colour with an egg shell flat finish.

Legends shall be carefully coloured at their edges to ensure true proportions. On signs where light colours are applied over dark, at least two coats of light colour shall be applied.

Bead type reflectors shall be securely fixed to signs without appreciable reduction of the effective area of the beads. The beads shall be uniformly and closely spaced, giving a smooth and easily cleaned surface without interstices that can retain dirt or moisture. Beads shall not cover the black portions of signs.

7.5.4.11 Excavation and Reinstatement

The provisions of sub-clause 7.6.4.1 of these Specifications shall apply.

7.5.4.12 Concrete Embedment of Posts

Where so indicated on the Drawings the bases of posts shall be embedded in concrete. Concrete shall be class C2, as defined in Section 5.1 and shall contain the minimum quantity of water necessary to produce a mix that can be tamped and rammed round the base of the post such that the post will be firmly held in position immediately after completion of placing and compaction.

The minimum thickness of concrete embedment and its height shall be as shown on the Drawings.

The post shall be carefully positioned and plumbed and struts and stays applied as necessary to hold it in position during embedment. The concrete shall then be placed round the post in uniform lifts not exceeding 200 mm and each lift thoroughly rammed. Care shall be taken to avoid contamination of the concrete from the surrounding surface and soils. Any contaminating material failing into the concrete shall be immediately removed.

All the concrete embedment for a post shall be provided in one operation and where the surface of the concrete embedment is above the level of the surrounding surface the exposed portion shall be formed to present a neat and tidy appearance and sloped to shed water away from the post.

7.5.4.13 Conduits and Fittings

The provisions of sub-clause 7.6.4.3 of these Specifications shall apply.

7.5.4.14 Pull Boxes

The provisions of sub-clause 7.6.4.4 of these Specifications shall apply, except that inscriptions on covers shall be "Road Signs".

7.5.4.15 Relocation of Existing Road Signs

Existing road signs and posts which, in the opinion of the Engineer, are still in good and usable condition and necessary to the proper signing of the completed road, shall be removed, cleaned thoroughly repainted if necessary and reinstalled nearby in the location designated by the Engineer. Road signs not designated to be reused or relocated shall, upon removal, be cleaned and transported to a location as directed by the Engineer.

7.5.4.16 Inspection and Testing

Testing of electrical installations shall be in accordance with the provisions of sub-clause 7.6.4.5 of these Specifications.

Before fabrication of signs the Contractor shall supply an example of each type of sign with information concerning equipment and procedures and state the location of the workshops manufacturing the signs. The Engineer will inspect the facilities and, if satisfactory, issue approval to fabricate the remaining signs.

When so requested by the Engineer, samples of preservatives, paints and finishes shall be supplied by the Contractor and shall be tested by him as directed by the Engineer for the appropriate conditions (exposure, compatibility of materials, bonding, reflectance etc.) Testing shall be carried out for sufficient time to ascertain the quality and/or suitability of the materials.

7.5.5 MEASUREMENT

Measurement as described in this section shall only apply to permanent signs erected or reinstalled. Signs used temporarily for traffic diversion on temporary detour facilities will not be measured for payment.

The Contractor shall make his own templates dimensioned in accordance with the Drawings, or as instructed by the Engineer and shall supply all frames, bolts, nuts, washers, straps, temporary jigs and strutting, etc. necessary to erect the complete signs correctly positioned and aligned at locations shown on the Drawings or as directed by the Engineer.

7.5.6 PAYMENT

Payment for Sign Posts and Road Signs shall be full compensation for furnishing and erecting all materials including labour, tools, testing, frames, hardware and incidentals necessary to complete the work.

Payment for Relocate Road Sign and Post(s) shall include any necessary excavation, cleaning of post(s) and sign, painting of post and frame if necessary, all materials labour and equipment required to reinstall the sign and post(s) in a location satisfactory to the Engineer.

Pay items will be as follows:

Item Ref	Description	Unit of Measurement
7.5(1)	Sign Posts	Linear Metre
7.5(2)	Road Signs	Square metre
7.5(3)	Relocate Road Signs and Posts	Number
7.5(4)	Overhead Signs	Square metre
7.5(5)	Steel Truss for Overhead Sign	Linear Metre
7.5(6)	Foundation & Steel Post for Overhead Sign	Number
7.5(7)	Overhead Traffic Sign	Number

7.6 STREET LIGHTING

7.6.1 DESCRIPTION

This work shall consist of the supply of all lanterns complete, brackets, columns and other supporting devices, bases, cables, switchgear and all necessary ancillary equipment together with the transportation, storage, assembly, erection, connection and testing of the same in order to supply a complete street lighting system in accordance with the details shown on the plans and as specified herein and in the Special Provisions. Design of the system is included.

If shown in the Drawings or designated elsewhere in the Contract, this work shall consist of modifying and/or adding to an existing street lighting system or constructing a new street lighting system, as the case may be. To the greatest extent possible all materials, above ground and underground, used in existing lighting system and in good working condition shall be incorporated in the new system.

7.6.2 GENERAL REQUIREMENTS

7.6.2.1 Design

Designs, in accordance with the following articles of these Specifications, shall be prepared by the Contractor and submitted in three copies including design calculations, drawings, wiring diagrams and requirement and materials list to the Engineer within three (3) months after the Commencement date of the Contract.

7.6.2.2 Existing Conditions and Documents Required

All underground utilities are not necessarily shown on the Drawings and locations of underground utilities as shown on the Drawings are approximate only.

The Contractor shall take special precautions to protect any existing utility services such as power lines, telephone lines, gas and oil pipelines, sewers and water works affected by his operations at his own cost, and shall minimise and be responsible for any damage caused thereby. He shall at all times and at his own expense conduct his operations in accordance with the requirements of the Utility Authorities having jurisdiction.

The following data shall be furnished by the Contractor to the Engineer and shall be included in the design documents.

(a) Catalogues of electrical components; lanterns, ballast, etc.

(b) Plans and circuit diagrams, ground road connection diagram.

(c) Photometric data;

  i) Utilisation Curve
  ii) Isocandela Diagram
  iii) Horizontal Iso Foot Candle Diagram
  iv) Polar Light Distribution Curve

(d) Details of columns, brackets, base plates.

7.6.2.3 Responsibility for Design and Materials

Items of equipment and parts shall have maker's specifications agreeing with those of the USA Standards Institute, the American Society for Testing Materials, the American Association of State Highway Officials, or other similar internationally recognised body. All works shall be done and all goods shall be made in strict accordance with good international practice and to the satisfaction of the Engineer.

The Contractor shall be solely responsible for the adequate design and the co-ordinated functioning of all goods and construction furnished under this contract. All the component parts shall be designed so as to ensure their proper co-ordinated functioning and operation. All equipment shall be of the maker's standard models and shall include all recent improvements in design and materials. All materials used in manufacture and construction shall be of high quality and fully in accordance with the best modern practice.

The equipment offered and the work done shall be suitable for continued trouble-free operation under adverse climatic conditions of heavy rain, high humidity and intense sunlight. The equipment must be able to withstand over long periods ambient air temperatures varying from a normal of 40 ^{o}C to a maximum 50 ^{o}C.

7.6.2.4 Compliance with Manufacturer's Specifications

The Contractor shall ensure that the equipment and parts used will be entirely suitable for the work to be performed and that they will be manufactured to proper clearances and fit. He shall further ensure that the loading of equipment will under all normal circumstances not exceed the maximum laid down or agreed in writing by the manufacturer.

The Contractor shall be responsible for the inspection of all equipment and parts before their incorporation in the works to ensure that they comply with the contract and that they are not defective in any way as regards materials or workmanship. Should any such non-compliance or defects be found during the inspection, the Contractor shall correct or cause to be corrected such non-compliance and defects, all at the Contractor's expense and to the satisfaction of the Engineer.

7.6.2.5 Defects Liability Period

All repairs and replacements required during the Defects Liability Period shall be carried out promptly and an adequate supply of spares shall be available for this purpose.

7.6.2.6 Electricity Supply

The Contractor shall carry out negotiations with the electricity supply authority concerned for an electricity supply to the installation, and any costs associated with obtaining this supply shall be included in the Contract rates. The Contractor must ensure that the equipment supplied will function correctly at the supply voltage, and must allow for normal variations and surges.

7.6.2.7 Definitions

Unless specifically defined herein, definitions shall be as given in British Standard 892:1967 "Glossary of Highway Engineering Terms" and in British Standard Code of Practice CP 1004 "Street Lighting" both as amended at the time of Tender.

Lantern A housing for one or more lamps comprising the body and any refractor, reflector, diffuser or enclosure associated with the lamp or lamps.

Outreach The distance measured horizontally between the centre of a lantern mounted on a bracket and the centre of the column or wall face.

Overhang The distance measured horizontally between the centre of a lantern and the adjacent edge of the pavement.

Mounting Height The vertical distance between the centre of lantern and the surface of the pavement.

Spacing The distance measured parallel to the centre line of road, between successive lanterns. In a staggered arrangement, this distance is measured parallel to the centre line from the centre of a lantern on one side of the road to the centre of the next lantern on the opposite side.

Beam That portion of the light output of the lantern contained by the solid angle subtended at the effective light centre of the lantern containing the maximum intensity but no intensity less than 90% of the maximum intensity.

Luminous Flux The light given by a light source of lantern or received by a surface, irrespective of the direction in which it is distributed. The unit of luminous flux is the lumen.

Lower hemispherical Flux or Downward Flux The luminous flux emitted by a lantern in all directions below the horizontal.

Peak Intensity Ratio The ratio or the maximum intensity to the mean hemispherical intensity of the light emitted below the horizontal.

Mean Hemispherical Intensity The downward flux divided by 6.28. (This is the average intensity in the lower hemisphere).

Intensity Ratio The ratio of actual intensity in any direction of lantern to the mean hemispherical intensity.

Luminous Intensity The light giving power of a lantern in any particular direction. The unit of luminous intensity is the candela (cd).

Beam Centre A direction midway between the directions for which the intensity is 90 percent of the maximum in a vertical plane through the maximum and on a conical surface through the maximum.

Isocandela Curve A curve traced on an imaginary sphere with the source at its centre and joining all the points corresponding to those directions in which the luminous intensity is the same, or a plane projection of this curve.

Isocandle Diagram An array of isocandela curves.

Polar Curve Curve of light distribution using polar coordinates.

7.6.3 MATERIALS AND EQUIPMENT REQUIREMENTS

7.6.3.1 Lanterns

Lanterns shall be of the cut-off or the semi-cut-off type as shown on the Drawings or as specified in the Special Specification. Non-cut-off lanterns shall not be used.

Unless otherwise specified, the mounting height shall be not less than 7.6 metres nor more than 12.2 metres. At junctions, or where high mast lighting is specified, this maximum height may be exceeded, but in such case, a means must be provided to lower the lanterns for repair and cleaning.

Where there is no speed limit on the road or where there is a speed limit of more than 60 kilometres per hour the minimum clearance between columns and the edge of the pavement shall normally be 1.5 metres but where this is not reasonably attainable, the minimum clearance may with the previous permission of the Engineer be reduced to 1.0 metre.

Where there is a speed limit of less than 60 kilometres per hour the minimum clearance between columns and the edge of the pavement should be 1.5 metres but this may be reduced to:

- 0.50 metre for crossfalls of not more than 1 in 40 towards the curb
- 0.60 metre for crossfalls of between 1 in 40 and 1 in 24 towards the curb
- 0.75 metre for crossfalls of more than 1 in 24 towards the curb

with the previous permission of the Engineer.

Each lantern should normally direct two beams along the length of the road. The polar curves of the lanterns in both horizontal and vertical planes be smooth and free from any abrupt variations so that the luminous intensity diminishes smoothly and progressively from its maximum. For centrally mounted lanterns the beams should be approximately axial; for lanterns mounted at the sides of the roadway, the maximum toe-in of the beam will be $15^{0.}$ Adequate but not excessive light should be directed towards the curbs and outer edge of the road. Where area illumination is required using high mast lighting, these provisions shall not necessarily apply.

For cut-off lanterns, the beam should be in a direction about 65^0 from the downward vertical. The peak intensity ratio shall be between 2.0 and 4.0; the intensity in the zone 0^0 to 30^0 below a horizontal plane through the lantern shall be between 0.3 and 2.0. An intensity ratio of 1.2 shall lie between elevations of 72^0 and 78^0 from the downward vertical in the vertical plane parallel to the axis of the roadway and the horizontal intensity ratio in the same plane shall be not greater than 0.15.

In the case of semi-out-off lanterns, the beam should lie in a direction about 75^0 from the downward vertical. The peak intensity ratio shall be between 1.8 and 4.0. The intensity ratio in the 0^0 to 30^0 zone below a horizontal plane through the lantern shall be between 0.3 and 1.7. An intensity ratio of 1.2 shall lie between elevations of 78^0 and 84^0 from the downward vertical in the vertical plan parallel to the axis of the roadway and the horizontal intensity ratio in the same plane shall be not greater than 0.6 except that in the case of sodium lamps, the intensity ratio of 1.2 shall lie similarly between 80^0 and 86^0 and the horizontal intensity ratio in the same plane shall not exceed 0.7.

The siting of lanterns shall be in accordance with the following table that gives minimum required illumination. Particular care shall be taken with the siting of lanterns on bends and summit vertical curves. At junctions and roundabouts, lantern spacing shall be designed so as to give at least the minimum illumination required by the following tables and also lanterns shall be spaced and sited, where possible, so as to delineate the course of the roadway plainly to road users approaching from any normal direction without any possible misleading impressions. The level of illumination provided at road junctions and roundabouts shall be at least as high as that on any of the approach roads and in the case of roundabouts, a minimum level of illumination at any curb line of 10 lumens per square metre shall be provided.

Required Minimum Average Horizontal Illumination
Lumens per Square Metre

	Central Urban Areas	Sub-Urban Areas	Rural Areas
High Grade Dual Carriageways	21.5	15.0	10.75
At Junctions	21.5	21.5	15.0
Main Route	21.5	13.0	9.7
Secondary Routes	13.0	9.7	6.5
Local Roads	9.7	6.5	2.1 (Residential areas only

The Contractor shall certify that the design of the installation has been done in accordance with "American Standard Practice for Roadway Lighting" (D 12.1-1963) published by the Illuminating Engineering Society, 345, East 47th Street, New York, or in accordance with British Standard Code of practice CP 1004 of 1963 "Street Lighting" published by the British Standards Institution, 2, Park Lane, London, W.l, except in so far as these have been varied by the provisions of these Specifications or the Special Provisions.

All lanterns shall be new, totally enclosed, side entry, dustproof, insect proof and water tight and tested for these requirements. All lanterns shall be supplied complete with all the necessary control gear fully wired and fixed and ready for erection. The gear shall be integral with the lanterns. The lantern wiring shall be of a size and insulated with materials that will effectively withstand the current, voltage and temperatures expected within the lantern during both the starting and operating modes in the ambient temperatures of the site. The lamp compartment of the lantern shall be accessible via a hinged bowl that shall, in the closed position, bed firmly upon a soft resilient gasket that shall be firmly secured to the lantern by means of stainless steel clips and large pins. In the lowered position the bowl shall be restrained from becoming detached or blown against the other parts of the lantern or column arm or bracket. Reflectors, if used, shall be mirror type and made of anodised aluminium sheet. The bowl (refractor), if made of transparent acrylic, shall not display any drop in output due to colour changes within the first five (5) years of service.

A sample lantern of the type proposed for use in this Contract is to be supplied to the Engineer for his approval, together with a certificate of approval by the electricity authority concerned before any installation is made. Transverse and longitudinal cross-section drawings of the lantern at 1:10 scale shall also be furnished to the Engineer.

7.6.3.2 Wiring

The wiring shall be of a type approved by and agreed with the electricity supply authority.

All wire and cables shall be new with annealed copper core and shall be PVC insulated and free of all joints except at terminal blocks, junction boxes and specially designated joints. Wires conveying power supply to lighting columns shall terminate in suitable sockets or terminal blocks which shall be PVC insulated and sheathed underground cable 600 V. Multiconductor connections shall maintain a consistent colour coding of cores throughout the installation.

All metallic parts not carrying current shall form an electrically continuous system which shall be grounded, or they shall be separately grounded, using bare copper conductors with a minimum cross-sectional area of 4 square mm. All items below ground level shall be so designed and installed that they will continue to operate without fault if immersed in ground water.

No joint shall be made in a cable without the specific approval of the Engineer in writing.

Where tee or through joints are approved in power cables they shall be made in compound filled joint boxes and accessories specially manufactured for PVC cables. The compound shall be a two-part resin-hardener system that will form a void free quick-setting compound.

The conductor connections within the joint shall be made using compression crimps or other means of positive mechanical clamping.

7.6.3.3 Switching

The switching supplied for control of lanterns shall be of a type approved by and agreed with the electricity supply authority. If approved by the supply authority photoelectric relay switching will be permitted, each device controlling a group of lanterns.

7.6.3.4 Columns and Brackets

Columns shall be of steel construction and shall consist of tapered round hollow shafts with anchor bases. Each column shall be provided with a suitable cable slot and a weatherproof service door fitted with a tamperproof lock. All locks shall be of the same pattern, and six keys shall be provided for them.

A non-hygroscopic mounting board composed of electrically insulating material shall be fitted in an easily accessible position inside the column, and shall be of suitable size to take all necessary electrical equipment. Adjacent to this mounting board, there shall be provided on the inside of the column two stainless steel studs, not less than 40 mm long nor less than 8 mm diameter complete with stainless steel lock nuts and washers, for use as earthing connections.

Brackets to provide the required outreach shall be of sufficiently strong construction to support the lantern under all normal conditions without significant movement, and shall be provided with suitable fittings to take the lanterns. When in position, brackets shall be inclined upwards at an angle of approximately 15^0 to the horizontal, and shall be fixed to their supports by suitable welding, fastenings or wall plates.

Columns and brackets shall be structural steel having the following mechanical properties:

- Thickness of sheet steel (min) 4 mm
- Ultimate Tensile Strength (min) 4,000 kg/cm^2
- Yield point (min) 2,500 kg/cm^2
- Elongation (min) 21%

Straightness. That part of the column above the ground shall not deviate from straightness by more than an amount calculated at a rate of 2 mm per metre of column length.

7.6.3.5 High Mast Lighting

Columns carrying high mast lighting shall be designed to permit the whole of the lantern carriage to be easily, safely and quickly lowered to ground level for maintenance works. The columns shall be designed in accordance with British Standard 449 or other internationally accepted standard for design of structural steelwork in buildings, except that the temporary horizontal deflection of the top of the column may be up to 7.5% of the

height above ground. In calculating the bending moment at ground level due to wind load, it shall be assumed that the wind speed at a point ten metres above ground level is 60 kilometres per hour, and the design of the column shall be such that wind excited oscillations are damped as much as possible. Adequate allowance shall be made for the stresses produced by such oscillations. Details shall be given of the vertical and horizontal load and the bending moment at the foundations.

The base plate shall be free from laminations and all dimensions of the base plate shall be provided, including details of the holding down bolts. A cable entry hole of not less than 300 mm diameter shall be provided centrally in each base plate, and the bottom of the mast shall pass through the base plate and be welded on both sides. An alternative construction of equal strength may be accepted by the Engineer, but a butt weld on to the base plate will not be accepted.

Each holding down bolt shall be tensioned to the design value, and within the maintenance period, the bolts shall be checked and retightened as necessary. after which the nuts shall be repainted.

The columns shall be delivered to the site in the minimum practicable number of lengths. Any joints necessary shall be positioned as near the top of the columns as possible.

The lantern carriage shall support the designed number of lanterns without significant sway or movement, and shall be capable of supporting these lanterns and a cradle with two men for maintenance work. The lantern carriage shall be protected to prevent damage to the painted surface of the columns, rotation of the carriage during raising and lowering shall be prevented and correct location when raised shall be ensured by some positive means. It shall be possible to remove the lantern carriage without lowering the column.

The lantern carriage shall be raised and lowered by a self-sustaining winch capable of being operated either by hand or by a portable electrically operated tool. It shall be possible to lock the winch in any position by a simple, robust and easily operated mechanism. The worm gear shall have a ratio of at least 20:1

The winch shall have removable handles, and it shall be mounted within the base compartment at a convenient working height. The opening in the column shall be of sufficient size to allow proper operation and maintenance of the winch mechanism. A weatherproof label shall be fixed in an obvious position within the column base, giving a full list of all lubricating points on the winch and other mechanism, and details of recommended lubricants. Winches fixed inside the column shall be provided with a substantial cover to fully protect them from falling dirt and dust.

A sufficient number of turns of the hoisting cable shall be left on the winch drum when the carriage is fully lowered to ensure that the cable anchorage on the drum does not take the full load of the carriage at any time.

The last 300 mm of travel to the fully raised position of the carriage shall be by hand operation, and for this purpose either a limit switch shall be provided to cut off the power supply to the portable electric tool at the appropriate time, or else some form of indication shall be provided to indicate when the carriage is 300 mm from the fully raised position.

The winch cable shall be of stranded stainless steel wires and shall have sufficient capacity to carry safely the lantern carriage complete with lanterns and a cradle with two men attached thereto. Great care shall be taken during installation to ensure that the hoisting cables do not twist or kink, and any set twist or kink shall be sufficient reason for the rejection of that cable.

All parts of the raising and lowering mechanism which are inaccessible after erection of the columns shall be adequately protected against moisture, dirt and corrosion. Where necessary, pulleys shall be fitted with shields to prevent the winch cable becoming displaced. Pulleys for electrical cables shall be of sufficient diameter that the cable will not be bent to a smaller radius than that permitted by local regulations or those of the British Institution of Electrical Engineers, 14th Edition. Where necessary for continued trouble free operation, metal parts shall be of stainless steel or other approved non-corrodible material.

When power tool operation is used, a suitable power outlet shall be provided and the operator shall be adequately safeguarded against any electrical shocks. The power tool shall preferable be designed to work on a reduced voltage and in this case, a suitable approved type of transformer shall be provided. The power tool shall be designed so that continuous operation will cause no harmful effects on either the winch or the tool, and in the event of power failure the winch shall be self locking. Conversion from power to hand operation and vice versa shall be quick and easy and shall not require special tools. Full information on the type of power tool proposed shall be give with the tender.

7.6.3.6 Protection Against Corrosion

Unless otherwise specified, columns, bracket arms, and brackets shall be protected against corrosion either by painting or galvanising as follows:

a) Painting:

i) Columns and masts shall be treated internally with hot asphalt under high pressure so as to give a complete and unbroken asphaltic covering or other approved anticorrosion treatment shall be applied to give at least equally good protection. Bases shall be similarly treated up to a level of 250 mm above ground level.

ii) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down and all external surfaces cleaned by shot blasting or other approved method to a white metal finish free of all signs of rust. Immediately following this treatment the items shall be painted with a coat of inorganic zinc silicate with a minimum dry film thickness of 75 microns followed by two coats of MIO epoxy, each with a dry film thickness of 125 microns, or they shall be treated in a similar and not less effective manner acceptable to the Engineer to prevent subsequent corrosion. After erection, all imperfections and damages shall be made good to the Engineer's satisfaction and the items shall be given a final coat of aluminium paint.

b) Galvanising

i) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down. Poles and other ferrous materials shall be galvanised both inside and outside by the hot dip process in accordance with ASTM A525. Weight of zinc coating shall not be less than 550 grams per square metre.

ii) Bases of columns, both inside and outside, shall be coated with bituminous paint up to a level of 250 mm above the base plate.

7.6.4 CONSTRUCTION REQUIREMENTS

7.6.4.1 Excavation and Reinstatement

Excavation for cable or conduit laying or for foundations and reinstatement shall be carried out in accordance with the provisions of Section 2.5 of these Specifications. Reinstatements shall be such that the surface is restored to at least its original standard.

7.6.4.2 Concrete Work

All necessary foundations and footings or other concrete work shall be carried out in accordance with Sections 5.1 and 5.2 of these Specifications. Unless otherwise specified on the Drawings or in these Specifications, concrete shall be Class C2, as defined in Section 5.1 of these Specifications. Foundations shall be placed in one operation except that the top 50 mm may be placed after the superimposed structure is in position. The exposed portions of foundations shall be formed to present a neat and tidy appearance and sloped to shed water away from the structure supported. Where existing obstructions prevent the construction of foundations as shown on the plans, then an effective alternative may be provided subject to the prior approval of the Engineer.

7.6.4.3 Conduits, Fittings and Boxes

Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 5.11 of these Specifications, except that chemically stable tough plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.

The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of the same size.

No reducing couplings will be permitted.

When metal conduits are used, cuts shall be made square and true and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous metal conduit has been damaged in handing, such damaged places shall be painted with rust preventing paint before installation.

All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

Conduits shall be laid to a depth of not less than 500 mm below paved sidewalks and medians and not less than 750 mm below the roadway surface. The location of all conduits at curb lines shall be marked by means of a "Y", at least 100 mm high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 mm vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box to facilitate pulling. Conduit entering the bottom of the box shall enter in the direction of the run.

7.6.4.4 Pull Boxes

Pull boxes shall be installed as shown on the plans and in any case at not more than 60 metres intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 100 mm thick and may be of approved pre-cast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on sidewalks, the covers being inscribed “Street Lighting” on the outside. Under the roadway, covers shall be of steel or cast iron, inscribed as specified above, and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with the surrounding paved areas, whether footwalk or roadway, but in unpaved areas the tops of pull boxes shall be buried 300 mm below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

7.6.4.5 Testing

A functional test shall be made on completion of the work in order to demonstrate that every part of the equipment and installation functions as intended and specified. This test shall consist of not less than five nights continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected and the test continued until the required five nights of satisfactory operation have been performed.

Prior to the functional test, the Contractor shall carry out the following tests to the entire satisfaction of the Engineer.

i) Each circuit shall be tested for continuity

ii) Each circuit shall be tested for earthing

iii) A '“megger”' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes.

The distribution horizontal illumination value of specified spacing in each code item, in rate of lux measured between two luminaries every two metres along longitudinal and transverse roadway lines, are essentially measured to show maximum, mean and minimum illumination and also uniformity ratios.

$$\text{Uniformity ratio} = \frac{\text{minimum illumination}}{\text{average illumination}} = \text{not less than } 4.0$$

$$\text{and} = \frac{\text{maximum illumination}}{\text{minimum illumination}} = \text{not more than } 6.0$$

iv) Rainproof Test

The lantern under test shall be mounted in its normal orientation on an adjustable support as shown is BS 1788, so that the fitting is near the centre of the area described by the oscillating tube.

After being switched on for one hour, the lantern shall be subjected to a spray of water at a temperature not exceeding 20 0C and at a pressure of approximately 0.4 kg/cm2, the tube being oscillated so as to describe an angle of 60 degrees from the vertical and in both directions from it. This treatment shall be continued for 20 minutes, the fitting being switched off after 10 minutes.

At the end of this test, there shall be no damage to the lamp or enclosure and no visible evidence of water having accumulated in the fitting.

On the completion of testing, the Contractor shall supply to the Engineer three copies of 'as built' plans and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design.

7.6.5 MEASUREMENT

Prior to the preparation of the design drawing referred to in sub-clause 7.6.2.1 of these Specifications, the Contractor together with the Engineer shall inspect the entire existing electrical lighting system (if any) to determine the condition of any present installations and the ability of its components to be reused. Tapered steel lighting poles and column high mast mountings, with height and single or double bracket requirements specified on the drawings and/or in the Tender and fitted with high pressure sodium lamps, will be measured as sets complete including all connecting cable and ancillary items required for the operation of the street lighting system.

7.6.6 PAYMENT

The work measured as provided in Clause 7.6.5 shall be paid at the Contract unit price for each item, such price and payment constituting full compensation for all inspections, design, materials, labour, equipment, tools and incidentals needed to complete the work. All materials and work necessary for satisfactory completion of the installation which are not specifically mentioned in the Bill of Quantities shall be deemed to be included in the items shown.

Tapered steel poles, single or double brackets, and column high mast mounting, with high pressure sodium lamps, will be paid for at the Contract unit prices per set, complete and accepted in place, which prices shall be all inclusive of junction boxes, poles, bracket arms, luminaries, painting, retro-reflective sheets, ballast, pole foundations, transformers (where necessary or as specified), transformer bases, cable, conduit, trenching, pull wires, cable and conduit markers, labour, equipment and incidentals necessary to the complete operation of the lighting system.

Payment will be made under the following items:

Item Ref	Description	Unit of Measurement
7.6(1)	Tapered Steel Pole Single Bracket, with one High Pressure Sodium Lamp _____watts cut-off	Set
7.6(2)	Tapered Steel Pole, Double Bracket, with two High Pressure Sodium Lamp _____watts cut-off	Set
7.6(3)	High Mast Complete with Lanterns, Spare Parts, Foundation, Drawpits, Trenches, Cables, Ground & Accessories	Set
7.6(4)	Soffit Complete with Lanterns, Spare Parts, Drawpits, Trenches. Cable, Ground & Accessories	Set
7.6(5)	Supply Pillars Complete with Foundation Fence, Drawpits, Trenches, Cables, Ground & Accessories	Set
7.6(6)	Relocated Tapered Steel Pole, Single Bracket	Set
7.6(7)	Relocated Tapered Steel Pole, Double Bracket	Set

7.7 ROAD TRAFFIC SIGNALS

7.7.1 DESCRIPTION

This item shall consist of the supply of all signal heads, supports, controllers, detectors, cables, switchgear with all necessary ancillary equipment together with the transportation, storage, erection, connection and testing of the same in order to supply a complete traffic signal installation in accordance with the Drawings and as specified herein and in the Special Provisions.

7.7.2 GENERAL REQUIREMENTS

7.7.2.1 Design

Designs shall be prepared by the Contractor in accordance with the principles set out in Clause 7.7.4 of these Specifications. Signals shall be designed to operate by the combination of time switch and vehicle actuated controller fitted with speed measuring equipment to included primary and secondary detectors. Designs shall take into account the mix of traffic, in particular the high proportion of two-wheeled vehicles, and the existence of cycle lanes. Complete details of the design of the signals for each junction, in three copies, including design calculations, drawings, wiring diagrams and requirement and materials list and specification, shall be submitted to the Engineer for approval within three months after the commencement of the Contract.

7.7.2.2 Responsibility for Design and Materials

The provisions of sub-clause 7.6.2.3 of these Specifications shall apply.

7.7.2.3 Compliance with Manufacturer's Specifications

The provisions of sub-clause 7.6.2.4 of these Specifications shall apply.

7.7.2.4 Defects Liability Period

The provisions of sub-clause 7.6.2.5 of these Specifications shall apply.

7.7.2.5 Electricity Supply

The provisions of sub-clause 7.6.2.6 of these Specifications shall apply.

7.7.2.6 Definitions

The provisions of sub-clause 7.6.2.7 of these Specifications shall apply.

7.7.3 MATERIALS REQUIREMENTS

7.7.3.1 Signal Face

Each signal face shall consist of three electrically operated and controlled optical units arranged vertically. The top unit shall show red, the centre amber and the lowest green. Additional optical units may be added if required for special facilities. Suitable visors will be fitted to all optical units. Louvres and sighting screens shall be supplied if required to give the most efficient operations under all conditions. Each signal face shall conform to a sample supplied to and approved by the Engineer.

7.7.3.2 Optical Units

Optical Units shall consist of a lens, a reflector, a lampholder and a clear traffic signal lamp visible to the traffic to be controlled. They shall be housed in a non-ferrous corrosion resistant casing that shall be weather tight and capable of being securely fixed in direction and elevation. Access shall be provided by hinged doors which when shut shall be forced against a neoprene gasket on the body and fastened by a simple, corrosion resistant, non-detachable fastening device which does not required special tools for operation.

7.7.3.3 Lenses

Lenses shall be made from best quality glass, free from imperfections, and shall conform to the latest requirements of the relevant ASA or British Standards for colour and transmittance. All lenses will be unlettered and shall be mounted so as to display a circular area 200 mm in diameter towards the traffic to be controlled. The lens shall be so designed and finished that when it is installed in an optical unit as herein described, that unit shall, when the lamp is illuminated, display a uniformly bright area to traffic without any shadows or dark areas. The polar curve shall be reasonably smooth and free from sudden changes or secondary maxima. The mounting of the lens shall ensure that there will be no escape of light from the lamp, apart from that passing through the lens itself.

7.7.3.4 Reflectors

Reflectors may be of silvered glass or metal. Silvered glass reflectors shall conform to Clause 8.02 of the Institute of Traffic Engineers Technical Report No. 1 “Adjustable Face Vehicle Traffic Control Signal Head Standard” as approved by the American Standards Institute. Metal reflectors shall be of non-ferrous metal not less than 0.55 mm thick plated with nickel and then chromium plated, or other suitable construction that is not less effective. Metal reflectors shall be stiffened and supported to prevent distortion.

7.7.3.5 Lampholder

Each lampholder shall be suitable for an Edison screw lamp or other type approved by the Engineer and the dielectric shall be of a tough incombustible insulating material which will not be affected by prolonged heating to 200^0C nor by prolonged immersion in water. The lampholder shall be permanently positioned in such a way that the lamp filament shall be at focal centre of the reflector. A means shall be provided to rotate either the lampholder or the reflector so that the lamp lead-in wires will be at the top, and there shall be a suitable clamp to ensure that the lamp will not unscrew due to vibration. The lampholder shall be provided with two insulated wires of sufficient length to reach the specified terminal block at all times. The metal parts of the lampholder shall be electrochemically compatible with other contiguous metals.

7.7.3.6 Lamps

The lamps shall be Edison screw type, or such other type as approved by the Engineer, having an output of 665 lumens minimum.

7.7.3.7 Wiring

All lampholders shall be wired to a suitable terminal block mounted in the housing, and shall be ventilated to avoid condensation. Wires shall be P.V.C. insulated and free of all joints except in terminal blocks and shall be permanently colour coded to facilitate maintenance and repair. At each signal location unless shown otherwise on the Drawings there shall be a terminal compartment provided on the mounting which shall be provided with a terminal block containing 12 poles each with two screw type terminals of suitable size. A weathertight cover shall be provided to the terminal compartment which will give ready access to the terminal block, and the terminal compartment and cover shall be of sufficient strength to remain intact if the mounting pole is knocked down. Ventilation or other suitable means shall be provided in the terminal compartment to avoid excessive condensation. Connections from the signal face to the terminal compartment, where external, shall be protected by approved metallic tubing. Buried cables from the controller to signals and detectors shall be suitably armoured or laid in approved conduit and free of all joints except at terminal blocks of junction boxes. Wiring to signal will not be run to a terminal block on a signal pedestal unless it is to be connected to a signal that is mounted thereon. Sufficient conductors shall be provided to perform the functional operation of the signal system throughout and in addition between the controller and the signals three spare conductors shall be provided of size equal to the largest conductor in the run except neutral. Wires subject to bending due to opening and closing of doors shall be stranded. All metallic parts not carrying current shall form an electrically continuous system which shall be earthed, or they shall be separately earthed, using bare copper conductors with a minimum cross-sectional area of 4 square mm. All items below ground level shall be so designed and installed that they will continue to operate without fault if immersed in ground water.

7.7.3.8 Pedestals

Pedestals shall consist of solid drawn or longitudinally butt welded mild steel tube, 115 mm outside diameter and not less than 4.5 mm wall thickness. The length of the pedestal shall be sufficient so that the centre of the lowest signal aspect will be at least 2.15 metres above ground when the foot of the pedestal is buried at least 600 mm below ground. A suitable base plate and finial shall be provided for each pedestal. Where necessary or desirable, signal heads may be mounted on existing suitable street furniture or buildings by means of a properly designed bracket or brackets, and where mounting has to be done close to a wall the signal head may be attached to the pedestal via a bracket, but in this case the pedestal shall be at least 127 mm outside diameter and at least 165 mm outside diameter for one metre above ground level and of sufficient length so that the base of the signal head will be at least 2.4 metres above ground. Brackets shall be so designed that they will allow full adjustment of the signal heads and will support the signal heads rigidly under all normal conditions. Pedestals shall be provided with cable slots near the base and with the required cable bush holes in correct position. All cable slots and holes shall be free of burrs and rough edges. Suitable means shall be provided to fasten base plates, brackets and signal heads firmly to pedestals and to allow adjustment where required.

All nuts, bolts, fastenings, hinges and adjusting brackets on pedestals, finial, terminal compartment and signal heads shall be cadmium plated or of stainless steel or made corrosion resistant in a not less effective manner.

7.7.3.9 Painting

Paint and painting shall be in accordance with Section 5.12 of these Specifications with the following additions and modifications. Pedestals and brackets shall be provided with a prime coat and two coats of undercoat before delivery and sufficient finishing coat shall be provided for final painting after erection. The signal heads, terminal compartments, visors, louvres, and sighting screens shall be delivered primed-and with two undercoats and a finishing coat. Controller and other cases shall be finished with two coats of an approved aluminium paint on the outside and shall have priming, two undercoats and one finishing coat of paint on the interior. A coating of sprayed molten zinc will be accepted as an alternative to painting of cabinets.

7.7.3.10 Detectors

Detectors where vehicle actuated signals are required, shall be either pneumatic one way or two way or inductive loops.

a) Inductive Loops - Inductive loops shall consist of a loop or loops of insulated conductor, a sensor unit relay and a power source. The loop detector shall operate on the principle that a vehicle standing or crossing over the loop will cause a change in inductance which will be detected by the sensor unit, so-operating the detector relay in the signal controller. The loop shall be installed in slots cut in the highway surface or laid under the wearing course and the depth, orientation and dimensions of the loop shall be as recommended by the manufacturer. The sensor unit shall be a solid state electronic device capable of sensing changes in the inductance of one or more loops and mounted in a waterproof container that will be located and suitably housed under the roadway or sidewalk close to the loop or loops.

   The detector shall be so designed constructed and adjusted that

   i) It shall respond only to a vehicle passing over or standing over any portion of the loop.

   ii) It shall detect vehicles passing over it at speeds up to 100 kph.

   iii) The detector relay shall be de-energised immediately after a vehicle passes over it.

   iv) It shall re-balance to ignore parked vehicles and shall thereafter detect subsequent vehicles passing over it.

   v) It shall operated normally under any range of weather, temperature and humidity conditions and it shall not be affected by normal variations of line voltages.

   vi) Where operating as a speed detector which will influence the operation of the controller, the detector shall be fully capable of detecting differences of speed which are consistent with the capabilities of the controller.

   Inductive loop detectors shall detect over the entire width of the approach road leaving no gaps of more than 400 mm. Where required for separate detection, individual detectors will be provided for each traffic lane, and these shall be so designed and installed that there will be no mutual interference between them.

b) Pneumatic Detectors - Pneumatic detectors shall be designed to be bolted securely into a metal frame set flush in the roadway so that the detector may be replaced without disturbing the roadway surface. The detector frame shall be designed to take the full live loading to be expected on the road. The detector shall extend the full width of the approach with no gaps of more than 400 mm, and where required separate detectors shall be with no gaps of more than 400 mm, and where required separate

detectors shall be provided for each traffic lane. Operation shall be by pressure operating a pressure sensitive electrical switch that relays a demand to the controller. The pressure sensitive switch shall be waterproof and located in a waterproof container located under the roadway or the sidewalk in such a way that the switch will be readily available for inspection and checking after installation. Means shall be provided to ensure that arcing in operation is reduced to a minimum so that the switch will not require frequent cleaning or adjustment.

The detector tread rubber shall extend over approximately the whole length of the detector and shall have the following properties.

When new:

Shore Durometer Type 'A' Hardness - 62 to 70

Tensile Strength at break - 175 kilograms per sq-cm minimum

Elongation at break - 500% minimum

After ageing in a Geer Oven for 120 hours- 140 kilograms per sq-cm minimum at 70°C

Tensile strength at break - 120 kilograms per sq-cm

Elongation at break - 400% minimum

After ageing in oxygen bomb for 120 hours at 70°C and 21.2 kilograms per square centimetre pressure

Tensile strength at break - 105 kilograms per sq-cm

Elongation at break - 350% minimum

The Contractor shall provide certified test sheets from an approved laboratory for each batch for tread rubber, or other satisfactory evidence that the tread rubber is of approved type. The number of joints between the rubber tread and the pressure sensitive switch shall not exceed two. The tube connecting the tread and the pressure switch shall be readily replaceable and laid within a protective conduit which shall be kept free of water. A separate pressure switch shall be provided for each tread.

Pressure sensitive detectors shall be capable of being operated by wheels having a wheel load of 25 kilograms or more. Detectors shall actuate at speeds up to 100 kilometres per hour under normal conditions. When provided with suitable relay equipment, directional detectors shall operate to make a demand on the controller when a vehicle crosses in one direction but not when it crosses in the opposite direction. When a detector is required to operate as a speed detector, the treads shall be spaced sufficiently far apart that differences of speed will be detected which are consistent with the capabilities of the controller.

For each detector, whether inductive or pressure sensitive, a button shall be provided at the controller which can simulate a demand on that detector. An ON/OFF switch shall also be provided at the controller for each detector to allow that detector to be switched out of circuit independently of any other detector. Both buttons and switches shall be clearly and permanently labelled to indicate which detector is controlled and switches shall have the ON and OFF positions labelled, the detector being in the circuit when the switch is in the ON position.

7.7.3.11 Controller

a) General - The controller shall be a complete electrical mechanism for controlling the operations of the traffic control signals, including the timing mechanism and all necessary auxiliary equipment, securely mounted in a cabinet. Preference will be give to solid state circuitry and to designs having replaceable units for ease of maintenance. Interval timing shall be by electronic and not by mechanical means. The colour sequence of signal indications shall be as given in sub-clause 7.7.4.1 of these Specifications and there shall be control to ensure that green will not be shown at the same time on opposing phases under any circumstances. Operation shall be either by fixed time sequences, (variable by time switch) or shall be by vehicle actuation or by combination of both, as specified in the Special Provisions or as directed by the Engineer, and as herein described.

The operating voltage shall be as given in the Special Provisions, or as directed by the Engineer, and the controller shall be designed to operate satisfactorily with voltage variations up to +17.5% or -20.0% from that specified. The timing of the controller shall be within ±7.5% of correct at the rated voltage and shall not be affected by more than ±10% for a ±10% change in voltage or a ±4% change in frequency of the supply.

The controller shall be so designed that temperature variations between 10^0 C and 70^0 C shall not change the timing by more than 5% or otherwise the cabinet shall be artificially ventilated to keep the internal temperature within satisfactory limits. In the event of power failure, the controller shall shut down and re-commence operations without the necessity for manual re-setting.

The controller shall be provided with suitable mechanism for closing and opening signal circuits, which shall be positive and without any dark intervals, flickering or conflicting signal indications. All contact points which carry make or break current shall be of fine silver, silver alloy or an alternative better material and shall be capable of carrying, making or breaking a current of 150% of maximum demand load through one million operations without electrical or mechanical trouble.

Every current interrupting device shall be equipped with a suitable radio interference suppressor installed at the input power point. Interference suppressors shall be of a design which will minimise interference on both broadcast and aircraft frequencies.

The controller shall provide for the proper phase intervals and sequences as herein specified or as may be required by traffic conditions. The setting of time intervals shall be by means of a positive method against a scale calibrated in seconds. This timing scale shall be easily accessible and identifiable within the controller and it shall not be necessary to remove or change wires or contacts to adjust the time intervals.

b) Manual Operation - Manual operation shall be possible by means of an approved key or by external buttons on the controller housing. If push buttons are used, they shall be inoperative until the controller has been switched to manual operation by means of a switch mounted under a lockable cover. The automatic operation of the controller shall not be upset by manual operation, and automatic control shall resume without the need for any manual adjustment at the end of manual operation.

Provision shall be made for the following manual operations:

i) substitution of flashing signals in place of the normal cycle (where flashing signals have been specified)

ii) allocating right of way to approaches independently of the pre-set timing of the controller

iii) switching signals to "OFF"

Provision shall be made that under no circumstances will an approach lose its right of way without having at least the appropriate minimum green time plus amber time.

c) Time switch - Where a time switch is required this shall be capable of two 'ON-OFF' periods per day of a minimum length of sixty minutes each and with a minimum period of sixty minutes between successive 'ON-OFF' positions. The setting dial shall clearly distinguish between day and night, and the switching mechanism shall be fitted with a selective device enabling all switching to be eliminated on any one day in the week or early or late switching on two selected days. The week dial shall be clearly marked with the days. The time mechanism shall be fitted with a first quality mechanical movement that shall be electrically wound and shall have a minimum spring reserve of twelve hours.

d) Flashing signals - Where flashing operation is called for, this shall permit either amber or red flashing on any or all approaches. The flashing unit shall generate signal indications at the rate of not more than 60 nor less than 50 per minute, and the rapidity of flashes shall remain constant. The illuminated period of each flash shall be approximately equal to the non-illuminated period. A switch or fuse shall be provided which will allow the controller to be isolated and shut down when the flashing signals are in operation.

e) Switches and Fuses - The controller shall be provided with a main switch and fuse which will isolate the complete installation. There shall also be provided one general purpose outlet and fuse. All fuses and switches shall be adequately and permanently labelled.

f) Controller Housing - The Controller shall be housed in a weatherproof cabinet of aluminium, sheet metal, glass fibre or other approved material having sufficient strength and rigidity to protect the contents from the effects of water, dust and accidental blows. Sheet metal shall be at least 2 millimetres in thickness at all points and reinforced where necessary. Ferrous metal shall not be buried and it shall be rust-proofed by galvanising or some other equally effective means. If aluminium or aluminium alloy is used, it shall be suitably protected against electrolytic or chemical corrosion and in the base of the housing it shall contain at least 8% of silicon.

The housing shall be securely fixed to a concrete base through which connections shall be made to detectors and signals. All doors shall be hinged with concealed hinges, and provided with locks, the door hinges and pins being of non-corrodible metal which shall require lubrication not more often than once per year. Doors shall open and shut freely without binding on the frame or the base. Otherwise, doors may consist of a stiff removable panel having self-positioning interlock joints provided with suitable gaskets. Such panels shall be provided with at least two locks. All locks shall be captive, flush-fitting and non-corrodible and shall operate by a standard key which will fit all housings.

The controller shall be sited in such a way that it will not cause an obstruction or hazard to traffic or pedestrians, and where it will not be subject to accidental damage from traffic.

The cables running to signals and detectors shall be terminated in a convenient and readily accessible position on blocks having the required number of terminals and provided with non-hygroscopic non-inflammable insulating bases. Sufficient space shall be left between terminals and between blocks to enable external cables to enter and be formed in a neat manner without obstructing individual terminal points. Electrical connection between controller and the terminals shall be by approved plug and socket connections.

Each terminal point and connection shall be clearly marked by colour coding or by a numbering system. Ends of all spare conductors shall be shielded, covered or insulated so that no live parts will be exposed.

g) Identification - All equipment and replaceable assemblies shall be marked with a part number and any other identification which is required for re-ordering.

h) Records - The following records shall be provided and kept within the housing, either fixed to the inside of the main door or placed within a metal pocket provided thereon.

i) A wiring diagram of the system showing the colour coding or number of the conductors,

ii) a layout plan of the intersection showing the detectors, the signals controlled by each phase and the cycle details. and

iii) a suitable ruled card shall be fixed within the controller upon which space is provided to record maintenance undertaken, the date of visit and the name of the person doing the maintenance.

The signal serial number shall be stencilled in two conspicuous locations on the outside of the housing in letters not less than 25 mm high.

i) Fixed Time signal controller - In addition to the foregoing requirements, where fixed time signals are required, the controller shall be capable of carrying out the following operations, although it shall not necessarily be limited to these:

i) allocation of right of way by suitable timed green aspects to the various approaches in accordance with the timings previously set on the controller.

ii) changing from one phase to another by means of the correct sequence of aspects as given in sub-clause 7.7.4.1 of these Specifications and maintaining the correct pre-set amber periods throughout. It shall be possible to vary the length of inter-green period without use of special tools.

iii) allowing a late start or early cut off on one or more phases as may be specified.

iv) Displaying left or right filter arrows as may be specified.

By means of a time switching device it shall be possible to alter the phase and cycle lengths to allow for varying traffic conditions. It shall be possible to operate at least three such programmes during a period of 24 hours.

It shall be possible to integrate the controller into a linked system working under a master controller if required, and to add a facility for vehicle counting. The sequence of phase shall be capable of alteration without any modification to the controller. When specified, it shall be possible automatically to dim the traffic signal lights during the hours of darkness.

j) Vehicle - actuated Signal Controller – In addition to the foregoing requirements where vehicle actuation is called for the controller shall be capable of, but not necessarily limited to the following operations.

i) In the absence of detector actuation, the right of way shall remain on the phase on which the last demand was made. However, a recall switch shall be incorporated into each phase which, when closed, will result in the right of way automatically returning to that phase without further demand. (Automatic Reversion).

ii) When the right of way is transferred to a phase in response to a demand, this right of way shall continue for at least a pre-set and adjustable minimum period. (Minimum Green Time)

iii) Continued demands beyond a predetermined number on a phase having the right of way shall cause the initial minimum right of way period to be extended, the extension being proportional to the additional demands. (Vehicle Extension Periods)

iv) In the absence of demands from other phases continued demands on the phase having the right of way shall hold that right of way. When a demand is made from another phase, the phase holding the right of way shall lose it, even in the event of continuing demands, after a pre-set adjustable maximum period (Maximum Green Period). The timing of the maximum green period shall commence from the first receipt of a demand from another phase.

v) Should there be outstanding demands on the phase losing the right of way or should further demands be made on a phase during the clearance period, then right of way shall revert automatically to the phase losing it once demands of other phases have been satisfied.

vi) The transfer of right of way shall take place only after an adjustable clearance period, which may differ between different phases (Inter-green Period).

vii) Provision shall be made for green filter arrows and late-start or early cut-off facilities on any phase. If these are not required at the outset, there shall be provision for their inclusion at a later stage if required.

viii) It shall be possible to incorporate the controller into a linked system under a master controller if required, and there shall be facilities for resumed independent operation either on a time basis or as a result of altered traffic conditions.

ix) Traffic counting and queue detection, if not specified, may be required at a later stage and facilities for these should be incorporated or it should be possible to add them easily when required.

k) Vehicle actuated controller with speed measuring equipment - When the controller is to be used with speed measuring detector, the following additional facilities will be required on the controller, as well as items (i) to (ix) above:

i) The minimum green time referred to in sub-clause 7.7.3.11 item j (ii) above of these Specifications shall be reduced according to the number of demands that have been made below the predetermined number from sub-clause 7.7.3.11 item j (iii) of these Specifications so that if there are less than the pre-determined number of vehicles waiting for the right of way only sufficient time will be given for that number to clear the Junction before right of way is given to another phase that has made a demand. (Variable Minimum Green Time)

ii) The vehicle extension period given in sub-clause 7.7.3.11 item j (iii) above of these Specifications shall be variable in length and not fixed, the length of each vehicle extension period being inversely proportional to the speed of the vehicle making the demand at the detector pad (Variable Vehicle Extension Period)

iii) If a demand is made on a phase not having the right of way and all demands have been met on the phase having the right of way, then the right of way shall be given to the phase making the demand after a minimum inter-green period. However, if at the expiration of the maximum green period on the phase having the right of way there are still vehicle extension periods outstanding, the inter-green period shall be lengthened by the introduction of an all-red period if required to ensure that the right of way is not given to an opposing phase before fast traffic has cleared the junction on the phase losing the right of way. (Variable Inter-green Period)

7.7.4 DESIGN REQUIREMENTS

This clause is intended to give general guidance in the principles to the followed in design where the Contractor is required to undertake this function.

7.7.4.1 Sequence

The sequence of aspects on any one signal face shall be:

Red
Red and Amber
Green
Amber

During any aspect, there shall be no visual flicker of the signal illumination.

7.7.4.2 Siting of Signals

Siting of signals will be carried out in detail at the junction and shall be agreed by the Engineer. Each approach road shall be served by a minimum of two signal faces as follows:

(a) the Primary Signal which will be located not less than 1.0 metre beyond the Stop Line on the nearside of the road. Where there is a central median, a second primary signal shall be provided similarly on the offside of the approach, and

(b) the Secondary Signal which will be on the diagonally opposite side of the junction facing the approach, that is, on the back of the primary signal serving the opposite approach in the case of a four arm junction. The secondary signal may be opposite the offside of the approach where there is a central median, but in any case should not be outside an angle of 30^0 extended from the centre line of the approach at the Stop Line to the offside. Where the distance from the Stop Line to the secondary signal is more than 50 metres, additional secondary signals should be provided.

No part of any signal or pedestal shall be within 500 mm of the kerb line, and the height of the centre of the green aspect shall be not less than 2.l5 metres nor more than 3.0 metres from the ground.

The axes of the beams from the optical systems shall be directed at a point 45 metres away from the primary signal face at a point approximately 1.5 metres above the centre line of the approach, unless sharp gradient changes make this undesirable.

7.7.4.3 Stop Lines

Stop Lines shall be located as shown on the site layout plan.

7.7.4.4 Detectors

Detectors, where vehicle actuation is specified, shall be not more than 45 metres nor less than 30 metres from the stop line on each approach, although on difficult approaches carrying only slow traffic, this minimum may be reduced to 20 metre. On high speed roads, where secondary detectors are called for, these shall be placed at not more than 165 metres from the stop line.

7.7.4.5 Phases

The number of phases at the intersection shall be kept to the minimum required to avoid dangerous conflict of traffic. Where additional phases are called for by unusual traffic conditions at certain times, these additional phases shall be suppressed when not required. In designing the number of phases and the details of the cycle, the principle shall be to arrive at the arrangement which will at all times give minimum average delays to traffic with adequate capacity and maximum safety to both vehicles and to pedestrians.

7.7.4.6 Filter Signals

Filter Signals mounted at the side of the main signal may be used to allow a movement in one direction. A green filter arrow indication shall always be followed by an amber and red aspect, and if this cannot be done on the main signal, separate amber and red aspects must be provided for the filter signal. Particular care shall be taken to ensure that filtering traffic does not form an undue hazard to pedestrians crossing and guard rails, slip roads, islands or some resiting of the stop line may be required to avoid this. Filtering traffic will not be permitted when it will have to merge with through traffic. Where an early cut-off is used for offside turning traffic, an offside filter arrow will be provided to indicate to turning traffic that it is safe to proceed.

7.7.4.7 Clearance Period

Clearance periods shall have a minimum length of four seconds. Where required for safety or to allow turning traffic to clear a longer clearance period may be introduced but this should be kept to the shortest period that is consistent with the demands of traffic and safety at any time.

7.7.4.8 Linked Systems

When a linked system is called for, or where linking with nearby signals appears desirable, this system shall be designed to give progression of green periods in both directions along the routes involved and at speeds that will give high capacity. The speeds through the system shall be as uniform as possible and the demands of cross traffic shall be fully met. With fixed time signals, there shall be the facility to change automatically the programme of linking, if necessary, so as to give preference to the heavier flows at different times of the day. With vehicle actuated signals, local controllers shall be free to revert to independent operation when there ceases to be a continuous demand providing that this will not interfere with the overall progression through the system. All calculations done for linked systems will be submitted for checking.

7.7.4.9 Signal Timing

Signal Timing will be done on the basis of traffic demands as estimated from the traffic flows. Verification and adjustment will be required on site after the system is in operation, but the contractor must show by calculations that the system proposed is capable of handling the estimated maximum and normal flows in an efficient manner and with minimal delays. With fixed time signals, he will submit details of phases and cycles for each approach throughout the day. In the case of vehicle actuated signals, he will give similar details of maximum cycle time, maximum and minimum green times, vehicle extension periods and inter-green periods.

7.7.5 CONSTRUCTION REQUIREMENTS

7.7.5.1 Excavation and Reinstatement

The provisions of sub-clause 7.6.4.1 of these Specifications shall apply.

7.7.5.2 Concrete Work

The provisions of sub-clause 7.6.4.2 of these Specifications shall apply.

7.7.5.3 Conduits, Fittings and Boxes

Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 5.11 of these Specifications, except that chemically stable, tough plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.

The Contractor may use a larger size of conduit than that specified, at no extra charge, if be wishes, but in this case the entire run shall be of the same size. No reducing couplings will be permitted.

When metal conduits are used, cuts shall be made square and true and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous metal conduit has been damaged in handling, such damaged places shall be painted with rust preventing paint before installation.

All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

Conduit shall be laid to a depth of not less than 500 mm below paved sidewalks and medians and not less than 750 mm below the roadway surface. The location of all conduits at curb lines shall be marked by means of a 'Y' at least 100 mm high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 mm vertically above the foundations and shall be sloped towards the handhold opening. Conduit entering pull boxes shall terminate at least 50 mm inside the box wall and at least 50 mm vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box to facilitate pulling. Conduit entering the bottom of the box shall enter near the sides or end to leave the centre clear. All conduit shall enter in the direction of the run.

7.7.5.4 Pull Boxes

Pull boxes shall be installed as shown on the plans and in any case at not more than 60 metre intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 100 mm thick and may be of approved precast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on sidewalks, the covers being inscribed 'Traffic Signals' on the outside. Under the roadway, covers shall be of steel or cast iron, inscribed as specified above and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with the surrounding paved areas, whether sidewalk or roadway, but in unpaved areas, the tops

of pull boxes shall be buried 300 mm below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

7.7.5.5 Testing

A functional test shall be made on completion of the work in order to demonstrate that every part of the equipment and installation functions as intended and specified. This test shall consist of not less than five days continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected and the test continued until the required five days of satisfactory operation have been performed.

Prior to the functional test, the Contractor shall carry out the following tests to the entire satisfaction of the Engineer,

i) Each circuit shall be tested for continuity

ii) Each circuit shall be tested for earthing

iii) A 'megger' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes.

On the completion of testing, the Contractor shall supply to the Engineer three copies of “as built" plans and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design.

7.7.6 MEASUREMENT

This item will not be measured, payment being made on a lump sum basis.

The details of the work to be included in the lump sum measurement shall be as shown on the Contract Drawings and as specified in these Specifications.

7.7.7 PAYMENT

The lump sum payment for the traffic signal system shall be full compensation for furnishing all labour, materials, tools equipment, supervision and incidentals and for doing all the work involved in furnishing and installing the system shown on the Drawings and as specified herein and in the Special Provisions, and as directed by the Engineer, including any necessary backfill, concrete foundations, restoration of footwalk, roadway, curbing and appurtenances damaged or destroyed during construction and in making all tests. It shall also cover the costs of design.

The lump sum payment shall be deemed to include full compensation for all additional materials and work not shown on the Drawings or specified which are necessary to complete the installation.

Payment will be made under the following item:

Item Ref	Description	Unit of Measurement
7.7(1)	Traffic Signals at PK _____	Lump Sum

The location of traffic signals are to be stated in the Bill of Quantities.

7.8 ROAD MARKINGS

7.8.1 DESCRIPTION

This work shall consist of the application of continuous or intermittent lines, letters or figures and the supply and installation of reflecting road studs, including any necessary excavation, grouting and finishing of the pavement, to the dimensions and at the locations shown in the Contract Documents or as directed by the Engineer, including the supplying of all labour, tools and equipment, materials, warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work, and shall consist of hot applied thermoplastic or cold applied road marking paint, reflectorised with glass beads, as directed.

This work shall also include the construction of raised bar divisors in accordance with the details and locations shown in the Drawings or directed by the Engineer.

7.8.2 MATERIALS REQUIREMENTS

7.8.2.1 Hot Applied Thermoplastic Materials

The laid material shall be one of three types (a), (b) or (c) detailed below as required by the Contract Documents or as directed by the Engineer, and in accordance with AASHTO, ASTM, BS or other similar internationally recognised Standards.

a) Non-reflectorised Thermoplastic - The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess adequate thermoplastic properties over the range of climatic conditions of the location viz. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give a marking which is effective for at least eighteen months under normal traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the setting time, the softening point (^{o}C) and the open flash point (^{o}C) shall be stated.

   The material shall be supplied in containers which do not contaminate the contents and which protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

b) Reflectorised Thermoplastic - The material shall be in accordance with (a) above except that glass beads shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of glass beads included shall be between 13% and 22% by weight of the total mix. The whole of the glass beads shall pass a 1.70 mm sieve and not more than 10% shall pass a 0.425 mm sieve. The glass beads shall be free of sharp angular particles and not less than 80% shall be of transparent glass, reasonably spherical and free from flaws.

c) Reflectorised Thermoplastic with Glass Bead Surface - The material shall be in accordance with (b) above except that a layer of glass beads shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed glass beads shall be of the same quality as that incorporated in the reflectorised thermoplastic but may be smaller in size; not more than 20% shall pass a 0.210 mm sieve. Glass beads shall be applied at rate of 250-450 grams per square metre such that the combined total of glass beads incorporated in and superimposed on the thermoplastic shall be between 20% and 26% by weight of the material.

7.8.2.2 Reflectorised Road Marking Paint

a) Description - The paint shall be a cold-applied ready mixed paint suitable for application to cement concrete or bituminous pavements. The paint shall be durable and made reflectorised by superimposing glass beads on the surface of the paint. The paint shall also be suitable for applying by brush or mechanical means. The following particulars of the paint shall be supplied:

i) composition (analysis by weight)

ii) application

iii) type and maximum amount of reducer (thinner)

iv) drying time (to touch)

v) setting time (to recoat)

vi) recommended coverage (litres per square metre)

vii) heat resistance (max. road temperature)

viii) details of any primer, undercoat of tack coat required.

The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.

b) Colour - The paint colour shall be the type as detailed on the Drawings or as directed by the Engineer.

i) White - the white paint shall have a directional reflectance of not less than 80 percent when compared with a magnesium oxide sample when tested in accordance with the Federal Test Method Standard No. 141, Method 6121.

ii) Yellow - The yellow paint shall have a directional reflectance of not less than 40 percent when compared with a magnesium oxide sample when tested in accordance with the Federal Test Method Standard No. 141, Method 6121.

The C.I.E. chromaticity colour coordinates shall be within the limits as specified in Table 7.8.1.

TABLE 7.8.1 - Limits of Chromaticity Colour Coordinates

X	Y	Test Method No.
0.490	0.455	
0.511	0.433	
0.514	0.480	4525 Federal Standard 141
0.535	0.458	

c) Properties - The paint shall conform to international standards to the satisfaction of the Engineer.

TABLE 7.8.2 - Quantitative Requirements

Characteristics	Requirements		Test Method No.
	Min	Max	
Non-volatile Vehicle (% by weight)	38.0	44.0	4051 Federal Std 141
Total Dry Solids (% by weight)	67.0	77.5	4041 Federal Std 141
Consistency, Krebs Unit (KU)	65.0	85.0	1281 Federal Std 141
Unit Weight (kg/litre)			
White	1.35	-	4184 Federal Std 141
Yellow	1.38	-	4184 Federal Std 141

TABLE 7.8.3 - Drying Time Test

Drying Time	Requirements		Test Method No.
	Min	Max	
No Pick-up (minutes)	-	40.0	ASTM D-771

d) Sampling - Random samples of paint shall be taken as noted below for testing.

Number of Containers of Material (20 litre capacity)	Samples Required
less than 120	1
121 - 200	2
201 - 300	3
301 - 400	4
401 - 500	5
more than 500	One sample for every 200 containers

Samples of paint supplied in containers larger than 20 litres shall have the same ratio of number to volume as shown above. Each sample shall contain a minimum of 10 litres of paint taken as described below.

i) Open the container and pour off the surface oil into another dry and clean container.

ii) Stir the remaining paint immediately and gradually add the oil to the original container while stirring until the paint and oil are thoroughly mixed.

iii) Pour the paint into the empty container and back again into the original container as many times as required until the paint and oil are thoroughly mixed.

iv) Pour out a 10 litre sample of paint while stirring into a clean, dry container and cover with a tight-fitting lid. The sample container shall then be made air-tight by sealing with paraffin wax or with a tight rubber sheet. In the event the paint is supplied in 20 litre containers, one sealed container may be taken as a sample.

e) Testing - Testing of all paint samples shall conform to the requirements as detailed in as listed below.

i) Federal specification TT-P-85D dated June 26,1969

ii) Federal Test Method Standard No. 141 Paint, Vanish, Lacquer and Related Materials, Method of Inspection, Sampling and Testing.

iii) ASTM Specification D-77I.

7.8.2.3 Road Studs

All road studs, reflecting and non-reflecting, shall comply with the requirements of BS 873. Only road studs which have been approved by the Engineer shall be incorporated in the Works. The Contractor shall submit details of the road studs he proposes to use in the Works to the Engineer for his approval.

7.8.2.4 Glass Beads

a) Description - Glass beads in this Specification means the glass beads used for superimposing on the surface of road marking paint as specified in sub-clause 7.8.2.2 of these Specifications.

Glass beads shall have a spherical shape and be free of flaws and sharp angular particles. These characteristics, when tested in accordance with Test Method T 1207, Department of Main Roads, N.S.W., Australia, Material Testing Manual, shall not be less than 70 percent by weight.

b) Properties - Glass beads shall be resistant to chemicals and shall retain their brightness after soaking in the following solutions.

- Buffered acid solution
- 1 N calcium chloride
- Distilled water which is free from carbon dioxide gas. This water when titrated with 0.1N hydrochloric acid at the amount of not more than 2.5 millilitres will reach a neutral point.
- The glass heads when soaked in sodium sulphide shall not turn black.

All testing regarding the brightness of glass beads shall be in accordance to the requirements of Federal Specification TT-P-85 b.

i) Index of Refraction - The index of refraction of the glass beads shall be not more than 1.50 when tested by the immersion method in accordance with Test Method T 1203, Department of Main Roads, N.S.W., Material Testing Manual.

ii) Sizes - Glass beads shall meet the gradation requirements as specified below, except as otherwise directed, in accordance with Department standard Test Method 204/2516.

TABLE 7.8.4 - Grading Requirements for Glass Beads

Sieve Designation	Percentage by Weight Passing
0.850 mm	100
0.600 mm	95 - 100
0.425 mm	30 - 80
0.250 mm	10 - 30
0.150 mm	0 - 5
0.075 mm	0 - 1

c) Sampling - Random samples of glass beads shall be taken from each sack for testing. The number of samples shall be one percent of the total sacks of the glass beads supplied. Each sample shall contain a minimum of two kilograms of beads which shall be collected by use of a sample splitter or by quartering.

d) Testing - All testing required for glass beads shall be as specified herein in paragraphs (a) and (b) in sub-clause 7.8.2.4.

7.8.2.5 Raised Bar Divisor

Materials for raised bar divisor shall be asphalt concrete, cement concrete or other material approved by the Engineer.

7.8.3 CONSTRUCTION REQUIREMENTS

7.8.3.1 Thermoplastic Materials

a) Preparation of Road Surface - The material shall be applied only on a surface which is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty. In the case of smooth polished surfaces e.g. smooth concrete, old asphalt surfacing with smooth polished surface stones, and/or where the method of application requires or the Engineer directs, a tack coat shall be applied to the surface prior to the application of the material. The tack coat and the rate of application shall be as the manufacturer of thermoplastic material shall recommend, with the approval of the Engineer.

b) Preparation of Thermoplastic Material - The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics which have natural resin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

c) Laying - Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand-screed, hand-propelled machine or by self-propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the

material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

In the case of screeded application the material shall be laid to a thickness of not less than 3 mm. or more than 6 mm unless specifically authorised by the Engineer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5 mm. unless specifically authorised by the Engineer. In all cases the surface produced shall be uniform and appreciably free from bubbles and streaks. Where the Contract Documents require or the Engineer directs that glass beads shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic immediately after laying such that the quantity of glass beads firmly embedded and retained in the surface after completion complies with the requirements of sub-clause 7.8.2.1, item (c) of these Specifications.

Road marking of a repetitive nature, other than centre lines, lane lines, etc. shall, unless otherwise directed by the Engineer be set out with stencils which comply with the size and spacing requirements shown on the Drawings.

d) Re-use of Thermoplastic Material - At the end of the day's work as much as possible of the material remaining in the heater and/or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature has not been exceeded and that the total time during it is in a molten condition does not exceed the requirements of sub-clause 7.8.3.1, item (b) of these Specifications.

7.8.3.2 Road Markings Paint

a) Preparation of Road Surface - The paint shall be applied on a surface that is clean and dry. It shall not be laid over loose detritus, mud or similar extraneous matter or over a thermoplastic marking or over an old paint marking that is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Engineer.

b) Preparation of Paint - All cold-applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot-applied paints shall be heated in a properly designed heater, preferably thermostatically controlled, to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be permitted unless otherwise agreed by the Engineer.

c) Laying - Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self propelled machine according to the marking configuration and the type of paint approved for use or as directed by the Engineer. The rate of application of the paint for each coat shall be that recommended by the manufacturer unless otherwise directed by the Engineer.

When more than one coat is used the succeeding coat shall not be applied until the previous coat has fully set.

Road markings of a repetitive nature, other than centre lines, lane lines etc. shall, unless otherwise directed by the Engineer, be set out with stencils that comply with the size and spacing requirements given in the Drawings.

Glass beads shall be superimposed on the surface of the freshly applied paint immediately after laying to give immediate reflectivity. Glass beads shall be applied at a rate of 250-450 grams per square metre, unless otherwise directed by the Engineer.

d) Protection of Marking - All markings shall be protected from traffic until they have dried sufficiently to show no pick-up of tyre marks. The Engineer in the field shall determine a time period in which traffic will not be allowed to pass over the particular road markings being used.

7.8.3.3 Road Studs

Road studs shall be installed in the locations shown on the Drawings. They shall be installed exactly as prescribed by the manufacturer. Road studs not installed in compliance with these instructions shall be rejected and removed from the Site.

7.8.3.4 Defective Materials or Workmanship

Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located, all at the Contractor's expense and to the satisfaction of the Engineer.

7.8.3.5 Protection of Traffic

The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage or disfigurement by construction equipment, tools and materials or by spatter, splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

7.8.3.6 Raised Bar Divisor

Raised bar divisors shall be constructed in accordance with the details and in the locations shown on the Drawings or directed by the Engineer.

7.8.4 MEASUREMENT

7.8.4.1 Thermoplastic or Road Markings Paint

Marking shall be measured by the area in square metres completed, accepted and measured in place. Where the width or length of laid marking proves to be greater than that specified and is accepted by the Engineer the specified width or length shall be used when calculating areas for payment. Where the width or length of laid marking proves to be less than that specified and is accepted by the Engineer the actual width or length of laid marking shall be used when calculating areas for payment.

7.8.4.2 Reflecting Road Studs

The quantity to be paid for shall be the actual number of studs instructed, supplied, installed and accepted.

7.8.4.3 Raised Bar Divisor

Raised bar divisors shall be measured by the linear metre along the longitudinal axis of the raised bar itself.

7.8.5 PAYMENT

Reflectorised thermoplastic markings and reflectorised road paint markings of the colours specified will be paid for at the respective Contract unit prices per square metre, complete and accepted in place, which prices shall include all materials preparation of surfaces, equipment, labour, tools, and incidentals necessary to the proper completion of the work.

Reflecting road stud will be paid for at the Contract unit price each complete, installed and accepted in place. Raised bar divisor will be paid for at the Contract unit price per linear metre, complete and accepted in place, which price shall include all material, labour, equipment, tools and incidentals necessary to the proper completion of the work.

No partial payment for road markings will be allowed.

Pay items shall be:

Item Ref	Description	Unit of Measurement
7.8(1)	Reflectorised Thermoplastic Markings, Yellow	Square metre
7.8(2)	Reflectorised Thermoplastic Markings, White	Square metre
7.8(3)	Reflectorised Road Marking Paint, Yellow	Square metre
7.8(4)	Reflectorised Road Marking Paint, White	Square metre
7.8(5)	Reflectorised Paint Markings at Bridge Ends and Others	Square metre
7.8(6)	Reflectorised Road Studs	Number
7.8(7)	Raised Bar Divisor	Metres
7.8(8)	Reflecting Target Type 1 for Curb	Number
7.8(9)	Reflecting Target Type 2 for Guard Rail	Number
7.8(10)	Reflecting Target Type 3 for Barrier	Number

7.9 BUS STOP SHELTER

7.9.1 DESCRIPTION

This work shall consist of the furnishing and erecting of shelters at bus stop locations shown on the Drawings or as directed by the Engineer. This work shall also include the careful dismantling, refurbishing and reconstruction of existing bus stop shelters which in the opinion of the Engineer, are in suitably good condition.

7.9.2 MATERIALS REQUIREMENTS

Timber shall be hardwood to the satisfaction of the Engineer.

Concrete used in the reinforced concrete slab shall be as shown on the Drawings.

7.9.3 CONSTRUCTION REQUIREMENTS

Construction of shelters shall be in accordance with the Drawings.

All timber surfaces shall be preserved against decay and insect damage by preservative paints approved by the Engineer and in accordance with AASHTO Designation M-133-73. The roof of the shelter shall be factory painted

Any changes or substitutions of materials as detailed on the Drawings are subject to approval by the Engineer.

7.9.4 MEASUREMENT

The quantities measured for payment shall be the actual number of bus stop shelters constructed or relocated and accepted by the Engineer.

7.9.5 PAYMENT

Payment shall be full compensation for furnishing and placing all materials, labour, equipment, tools and incidentals necessary to complete the work, including maintenance of the shelter during the contract period.

Pay items shall be:

Item Ref	Description	Unit of Measurement
7.9(1)	Bus Stop Shelter	Number

CONSTRUCTION SPECIFICATION

Section 8
Unexploded Ordnance

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8 UNEXPLODED ORDNANCE

8.1 LAND MINE CLEARANCE

8.1.1 DESCRIPTION

This work shall consist of the detection and disposal of land mines that exist within the confines of the site and the certification that the entire site is free from contamination and is safe for all construction operations.

The work shall include the following activities:

(a) Detailed Contamination Survey

(b) Detection and Disposal of Mines

The Contractor shall carry out all necessary mine detection and disposal and shall carry out such checks as shall be necessary to enable him to take full responsibility for safety from the risk of mines over the whole area of the Site and for all construction operations.

8.1.2 GENERAL REQUIREMENTS

8.1.2.1 Standards

The sub-clauses of this specification relating to the detection, marking, clearance and disposal of landmines are derived from the minimum international standards required for mine clearance issued by the Mine Clearance Policy Unit, Department of Humanitarian Affairs, United Nations, New York.

8.1.2.2 Limits of Work

De-mining to remove both anti-personnel and anti-tank mines is required to provide a safe working environment for road construction.

Clearance is required along the route alignment that is to be cleared of mines and UXO to an overall width as defined in the Drawings or in the Special Provisions. This comprises a civil works area where the road will be constructed, plus a safe working zone added to the outer peripheries of the civil works area to provide reasonable safe turning and working room for plant and construction vehicles.

Additional de-mining followed by magnetometer search for UXO may be required outside of the right-of-way to allow access to resource areas, camp sites, construction lay downs, bridge abutments and approaches, etc.

The limits of clearance required along the route will be determined from the results of the detailed contamination survey carried out in accordance with the provisions of sub-clause 8.1.4.2 of these Specifications and as approved by the Engineer.

8.1.2.3 Clearance Performance Requirements

Searches in all areas are to comprise a 100% area sweep by mine/metal detectors to detect all mines/fused mine portions, regardless of geologic conditions. In mined areas also contaminated with UXO a deep magnetometer search is to be performed after the mine clearance. Searches are to achieve the removal of all mines and UXO within the specified size/depth capacity of the search equipment. Areas completed are to be certified free of mines and UXO.

8.1.2.4 Contractor's Nominated Ordnance Expert

The Contractor shall nominate and provide an Ordnance Expert, who shall have appropriate internationally recognised qualifications or appropriate verifiable experience in its own or other countries, acceptable to the Engineer. It will be the sole responsibility of the Contractor's Ordnance Expert to declare each area of the site safe for construction operations and no construction activities shall be carried out in any area until this has been done.

8.1.2.5 Staffing

Personnel involved in mine clearance, demolition and other EOD work must satisfy the following criteria:

(a) EOD staff supervising de-mining must have qualifications and experience commensurate with the United Nations Standards; and

(b) staff supervising magnetometer survey or conducting Quality Control operations must have received formal recognised training on and have field experience in magnetometer use; and

(c) national EOD staff must have passed the recognised standard CMAC de-miner training course or equivalent training.

8.1.2.6 Mine/UXO Disposal

The Contractor will be responsible for the disposal of all mines and UXO recovered. Where collateral property damage is likely to occur as a result of disposal activity, the Contractor must first advise the Engineer before proceeding.

8.1.2.7 Explosives

The Contractor will be responsible for the supply, storage and security of all explosives required for mine disposal and their use will conform with the requirements of Section 9.9 of these Specifications.

8.1.2.8 Compensation

In the course of clearance operations it may be necessary to damage crops, remove fences etc. The Contractor will be required to notify the Engineer in writing with a copy to the Employer prior to taking any action that may cause damage resulting in demands for compensation being presented.

8.1.2.9 Insurance

The following minimum levels of insurance cover, placed with reputable internationally recognised underwriters and effective within Cambodia are required:

(a)	Public Liability	USD 5,000,000
(b)	Professional Indemnity	USD 2,000,000
(c)	Expatriate death, sickness, injury and repatriation	USD 200,000 min
(d)	National staff workers compensation as required by Cambodian labour law	
(e)	Vehicle third party as required by Cambodia law	

Prior to the commencement of any site activities the Contractor will be required to supply evidence that insurance covers are in place. Once in place, covers are to remain effective for the duration of the contract period.

8.1.2.10 Medical and Emergency Evacuation

The Contractor is required to provide the following as a minimum:

(a) HF and VHF radio link to the MPWT operational base and to medical elements in Phnom Penh. Reliable telecommunications equipment may also be utilised where such coverage exists;

(b) Selected personnel are to be equipped with hand held communication capability on site locations;

(c) CASEVAC and MEDEVAC procedures must follow established evacuation guidelines as laid down in the UN De-mining Standard;

(d) formal evacuation arrangements for expatriate staff with an internationally recognised supplier of such services;

(e) trained first aid/medical attendants equipped with medical kits to trauma level; and

(f) dedicated safety vehicles equipped with radio communications with each work element.

8.1.2.11 Government Registration and Liaison

The Contractor will be required to demonstrate that it possesses formal registration by the Cambodian Mines Action Centre (CMAC) prior to commencing any site works.

In addition the Contractor will be required to secure the necessary approvals and clearances from the appropriate Cambodian Government Department enabling it to carry out UXO works in Cambodia.

The Contractor shall maintain close liaison at all times with the appropriate authorities in the country, particularly those engaged in the ordnance clearance operations, and shall cooperate with them, particularly in the disposal of unexploded ordnance.

8.1.3 EQUIPMENT REQUIREMENTS

8.1.3.1 Mine Detection

The Contractor is required to nominate the search instruments to be used for the mine clearance task. Mine detectors used must be from the four models recommended by the United Nations Mine Action Centre Bosnia and Herzegovina, in their report "Hand Held Metal (Mine) Detector Trials" dated 10 March 1997. Acceptable detectors are:

(a) Forester Minex 4

(b) Guartel MD8

(c) Minelab F1A4

(d) Vallon ML1620B

These detectors are all capable of operating in adverse geology and rainy/moist conditions and are capable of detecting all landmines used in Cambodia in lateritic conditions.

For detecting on the existing road formation, the Contractor may either use the above specified mine detectors, or other metal detectors of its choice that meet the performance capabilities as defined in the requirement for UXO area clearance in sub-clause 8.2.3.1 of these Specifications.

Performance capabilities of magnetometers are as defined in the requirements for UXO area clearance in sub-clause 8.2.3.1 of these Specifications.

8.1.3.2 Protective Equipment

All personnel conducting de-mining must wear adequate protective equipment when appropriate.

Eye and face protection is to be provided by the use of a fragmentation visor or equivalent goggles. The visor must meet the minimum standard of personal protection that is to be capable of withstanding a v50 rating (dry) of 450 m/s for a 1.102 fragment in accordance with US NIJ 01012.03 standards.

Protective jackets should be worn but are optional when de-mining in the prone position. The jacket should be designed to protect as well as deflect blast and fragmentation away from the operator. Sleeves are not mandatory but the jacket must have groin protection. The jacket must be capable of withstanding a v50 rating (dry) of 450 m/s for a 1.102 g fragment in accordance with US NIJ 0101.03 standards.

8.1.3.3 Provision of Equipment to the Engineer

The provision of equipment, manpower and assistance to the Engineer for Audit checking of the Contractor's work, prior to endorsement of any certificate shall be the responsibility of the Contractor, and the quantities of equipment, manpower and assistance shall be such as to be compatible with planned rates of construction progress.

8.1.4 OPERATION REQUIREMENTS

8.1.4.1 Method Statement and Programme

Within 28 days from the issue of the Notice to Proceed the Contractor shall submit to the Engineer a detailed method statement for the de-mining and UXO clearance works. The method statement incorporating a detailed, resourced programme to ensure that all areas within the project site are safe, to internationally accepted standards, for construction operations shall include:

(a) intended procedures for the clearance;

(b) work plans showing estimated time schedules;

(c) clearance team structure;

(d) type of equipment proposed.

(e) quality control programme

The Programme shall be revised and submitted to the Engineer at monthly intervals throughout the contract period and shall be adhered to whenever possible.

8.1.4.2 Detailed Contamination Survey

Prior to any mine and UXO clearance operations being conducted the Contractor will be required to carry out a detailed contamination survey of the Site to determine the extent of the mine and UXO clearance operations required.

a) Mine Fields - Survey and delineation of mined areas is to be conducted in accordance with the United Nations International Standard for Level 2 Surveys.

At those minefields identified in previous Level 1 surveys, Level 2 surveys are to be conducted by surveying 1 metre wide cross sections of 10 metres in length measured outwards from the edge of the existing trafficked formation. Strips are to be placed every 20 metres apart.

All bridges and culverts in open rural areas, other than those identified in previous surveys as being mined, are to be surveyed to determine if they are mined. Where justified from inquiries of local inhabitants or military, 1 metre wide cross sections commencing at each end of the culvert or bridge and placed at 15 metre intervals are to be employed until mine fade-out is established.

The minefield survey is also to note and incorporate any new minefields laid or cleared since the previous surveys.

b) UXO Contamination - Survey and delineation of UXO contaminated zones will be carried out in accordance with the provisions of Clauses 8.1 and 8.2 of these Specifications and shall consist of 100% metal detector searches on 2 metre wide cross sections over the full width as defined in the Special Provisions at 100 metre intervals along the centreline of the alignment. Magnetometer searches are not required.

8.1.4.3 Mine Clearance Safety Distances

Minimum safety distances must be applied for personnel undertaking mine clearance activities. Distances should be modified based on the known danger areas of individual mines and munitions, the terrain or where the presence of trip wires or booby traps is

suspected. The minimum safety distances for an Anti-Personnel blast mine as stated by the United Nations International Standards are to be applied for all de-mining activities and site layouts.

8.1.4.4 Positioning and Marking

To enable accurate positioning and recording of search areas within the limits defined in the Special Provisions, the Contractor will be required to geodetically survey and mark the road centre line. Long term marking is required for areas that are not scheduled for clearance work for an extended period of time.

Outer boundaries of all areas cleared must be accurately recorded and marked to facilitate subsequent identification during construction. Semi-permanent markers identifying the periphery of de-mined sections are to be set in concrete and are to be marked steel, preferably stamped for easy identification and placed at 20 metre intervals, with standard temporary markers between. Regular maintenance and replacement of any damaged or missing markers until the ground is handed over for construction will be required.

All safe lanes, safe routes and control areas must be marked to define clear and uncleared areas. Uncleared areas are to be marked in accordance with United Nations International Standards for mine clearance.

8.1.4.5 Contractor's Quality Control and Certification

The Contractor is required to include in its Method Statement as required under sub-clause 8.1.4.1 of these Specifications a formal Quality Control Programme. Quality Control checks constituting a minimum 5% of the de-mined area are required. For any existing road formation, 10% is to be subjected to Quality Control checks.

The control areas are to be searched initially by mine/metal detector as appropriate and then by magnetometer.

Control areas and results are to be recorded and reported by formal log. Log sheets are to be personally signed off by the Contractor's Ordnance Expert and are to be available for examination by the Engineer.

At least seven days before the Contractor intends to enter any area of the site to commence construction works, the Ordnance Expert shall submit, to the Engineer, his certificate declaring the area concerned to be safe for all intended construction operations. The certificate shall clearly define the area concerned and shall be supported by the log sheets which will give details of the types of survey carried out and the classes and methods of disposal of the various mines encountered.

8.1.4.6 Audit of Cleared Areas

The Engineer may perform a formal 5% re-check of de-mined areas and a 10% check of UXO cleared areas. These percentages may be increased at his discretion.

If mines or UXO are located during these checks, then a re-search at the Contractor's cost will be required. Finds triggering re-searching are:

(a) a mine of any description whole or partial with the firing train intact per 5% of grid will require a repeat de-mining of that grid; and

(b) one BLU 26/36 or metallic item of equivalent detectability per 10% of grid will require re-searching for UXO in that grid.

When satisfied, the Engineer shall endorse the Contractor's Ordnance Expert's certificate. The Contractor shall not enter the area of the site concerned until such endorsement has been obtained. Such endorsement shall not relieve the Contractor of any of his responsibilities under the Contract.

Before providing such endorsement, the Engineer shall be entitled to consult the nationally-recognised authority for UXO clearance in respect of the thoroughness of the ordnance search, and shall be entitled to withhold endorsement if so advised.

8.1.4.7 In-construction Support

The Contractor will be required to provide sufficient mine and UXO detection and disposal resources to clear incidental areas outside the site for the permanent works that may arise during the construction of the Works, including, but not limited to resource sites and their access, diversion roads, camps and laydowns, etc. These resources will also be required to check bridge and culvert sites for the possibility of mines laid in the interval between clearance and construction works commencing.

8.1.5 MEASUREMENT

Detailed Contamination Survey for minefields shall be measured by square metre of area surveyed and recorded in accordance with the provisions of sub-clause 8.1.4.2 a of these Specifications.

Detailed Contamination Survey for UXO shall be measured by kilometre of alignment surveyed and recorded in accordance with the provisions of sub-clause 8.1.4.2 b of these Specifications

Mine Detection and Disposal shall be measured by square metre of site approved for clearance as determined by the results of the Detailed Contamination Survey and certified and endorsed as cleared in accordance with the provisions of sub-clause 8.1.4.6 of these Specifications.

No separate measurement will be made for detection and disposal of areas outside of the right-of-way such as camp sites, borrow pits, etc

8.1.6 PAYMENT

Payment for the Detailed Contamination Survey for mines shall be made at the Contract price per square metre measured in accordance with the provisions of Clause 8.1.5 of these Specifications.

Payment for the Detailed Contamination Survey for UXO shall be made at the Contract price per kilometre measured in accordance with the provisions of Clause 8.1.5 of these Specifications

Payment for mine detection and disposal shall be made at the Contract prices per square metre measured in accordance with the provisions of Clause 8.1.5 of these Specifications.

Payment shall be deemed to be full compensation for all personnel, mobilisation costs, equipment, materials, transportation etc and all associated costs, including disposal of ordnance as well as all ordnance detection incidental to site investigation, all in accordance with this Specification and to the satisfaction of the Engineer.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
8.1(1)	Detailed Contamination Survey – Mines	Square metre
8.1(2)	Detailed Contamination Survey – UXO	Kilometre
8.1(3)	Mine Detection & Disposal	Square metre

No additional payment will be made for the provision of In-construction support as required in accordance with sub-clause 8.1.4.7 of these specifications as all associated costs will be deemed to be included in the rates for detection and disposal.

8.2 UNEXPLODED ORDNANCE CLEARANCE

8.2.1 DESCRIPTION

This work shall consist of the detection and disposal of unexploded ordnance (UXO) that exist within the confines of the site and the certification that the entire site is free from contamination and is safe for all construction operations.

The Contractor shall carry out all necessary UXO detection and disposal and shall carry out such checks as shall be necessary to enable him to take full responsibility for safety from the risk of UXO over the whole area of the Site and for all construction operations.

8.2.2 GENERAL REQUIREMENTS

8.2.2.1 Standards

The Sub-Clauses of this specification relating to the detection and disposal of UXO are derived from standard peace time range area clearance procedures typically in use by NATO military forces with modifications drawn from experience in the Indochina region. The procedures and methodology recommended by the United States Army Corps of Engineers for remediation of formerly used military sites were also taken into account and the resultant procedures closely follow best international practice for commercial activity in this field.

8.2.2.2 Limits of Work

Searching to remove UXO is required to provide a safe working environment for road construction. Clearance is required along the Project route alignment that is to be cleared of UXO to an overall width as defined in the Special Provisions. This comprises a civil works area where the road will be constructed, plus a safe working zone added to the outer peripheries of the civil works area to provide reasonable safe turning and working room for plant and construction vehicles.

The complete width as defined in the Special Provisions including any existing trafficked road formation, with the exception of intact pavement sections, is to be searched by metal detector using UXO area clearance techniques.

The complete width as defined in the Special Provisions including any existing trafficked road formation together with all paved sections, is to be swept by magnetometer.

Additional searching for UXO may be required outside of the right-of-way to allow access to resource areas, camp sites, construction lay downs, bridge abutments and approaches, etc.

The limits of clearance required along the route will be determined from the results of the detailed contamination survey carried out in accordance with the provisions of sub-clause 8.1.4.2 of these Specifications and as approved by the Engineer.

8.2.2.3 Areas of Non-Original Soil

Areas of non-original soil may exist containing UXO of indeterminate size at indeterminate depth. The maximum cut depth will be limited by the capability of the search equipment in

geologically reactive soil. Where earthworks are to occur below 30 cm in such areas, (detection performance depth for BLU 26/36 or equivalent) then complete UXO removal can only be achieved by successive search-then-cut techniques. During initial searches the Contractor will be required to record and report on such areas to ensure that the required search-then-cut process is applied later in conjunction with construction.

8.2.2.4 Clearance Performance Requirements

Searches are to comprise a 100% area sweep by metal detector to remove shallow items, followed by a magnetometer search. Magnetometer searching is to be conducted at no greater than 1 metre lane separation.

Searches are to achieve the removal of all UXO within the specified size/depth capacity of the search equipment. All areas completed are to be certified free of UXO to within these limitations.

8.2.2.5 Contractor's Nominated Ordnance Expert

The Contractor shall nominate and provide an Ordnance Expert, who shall have appropriate internationally recognised qualifications or appropriate verifiable experience in its own or other countries, acceptable to the Engineer. It will be the sole responsibility of the Contractor's Ordnance Expert to declare each area of the site safe for construction operations and no construction activities shall be carried out in any area until this has been done.

8.2.2.6 Staffing

Personnel involved in UXO clearance, demolitions and other EOD work must satisfy the following criteria:

(a) EOD staff supervising UXO searching must have qualifications and experience commensurate with the United Nations Standards; and

(b) staff supervising magnetometer survey or conducting Quality Control must have received formal recognised training on and have field experience in magnetometer use; and

(c) national EOD staff must have received a formal course providing them as a minimum, with instruction on UXO recognition, metal detector use, UXO excavation and first aid.

8.2.2.7 UXO Disposal

The Contractor will be responsible for the safe disposal of all UXO recovered. Where collateral property damage is likely to occur as a result of disposal activity, the Contractor will be required to first advise the Engineer before proceeding.

8.2.2.8 Explosives

The Contractor will be responsible for the supply, storage and security of all explosives required for UXO disposal and their use will conform the requirements of Clause 9.9 of these Specifications.

8.2.2.9 Compensation

In the course of clearance operations it may be necessary to damage crops, remove fences etc. The Contractor will be required to notify the Engineer in writing with a copy to the Employer prior to taking any action that may cause damage resulting in demands for compensation being presented.

8.2.2.10 Insurance

The Contractor is required to provide the insurances as defined in sub-clause 8.1.2.9 of these Specifications.

8.2.2.11 Medical and Emergency Evacuation

The Contractor is required to provide the facilities and arrangements as defined in sub-clause 8.1.2.10 of these Specifications.

8.2.2.12 Government Registration and Liaison

The Contractor will be required to demonstrate that it possesses formal registration by the Cambodian Mines Action Centre (CMAC) prior to commencing any site works.

In addition the Contractor will be required to secure the necessary approvals and clearances from the appropriate Cambodian Government Department enabling it to carry out UXO works in Cambodia.

The Contractor shall maintain close liaison at all times with the appropriate authorities in the country, particularly those engaged in the ordnance clearance operations, and shall cooperate with them, particularly in the disposal of unexploded ordnance.

8.2.3 EQUIPMENT REQUIREMENTS

8.2.3.1 UXO Detection

The Contractor is required to nominate the search instruments to be used for the UXO clearance task. Search instruments must be capable of operating in adverse reactive geology (lateritic soils) and rainy / moist conditions.

The proposed metal detectors must be capable of confidently detecting the following when operating in areas of laterite and in hot/moist conditions:

(a) projectiles 20 mm HE or items of equivalent detectability to a depth of 25 cm; and

(b) BLU 26/36 or items of equivalent detectability to a depth of 30 cm.

The proposed magnetometers must be capable of confidently detecting 81mm HE Mortar Bombs or items of equivalent detectability, to a depth of 1.25 metres in low magnetic noise conditions and to 0.75 metres in areas of high magnetic background noise, such as laterite.

The Contractor is required to provide evidence constituting an independent and objective verification of proposed instrument capability. Instrument capability will be tested and

approved by the Engineer prior to its use on site. Further performance audits will be conducted during contract execution.

8.2.3.2 Provision of Equipment to the Engineer

The provision of equipment, manpower and assistance to the Engineer for Audit checking of the Contractor's work, prior to endorsement of any certificate shall be the responsibility of the Contractor, and the quantities of equipment, manpower and assistance shall be such as to be compatible with planned rates of construction progress.

8.2.4 OPERATION REQUIREMENTS

8.2.4.1 Method Statement and Programme

The Contractor is required to provide a Method Statement and Programme as defined in sub-clause 8.1.4.1 of these Specifications.

8.2.4.2 Positioning

To enable accurate positioning and recording of search areas within the limits defined in the Special Provisions, the Contractor will be required to geodetically survey and mark the new road centre line. The outer boundary limits of clearance work, measured from the surveyed centre line, may then be located and marked.

The limits of the construction support areas requiring clearance will be defined by the Contractor. The boundaries of all areas cleared of UXO must be recorded and marked by semi-permanent means to facilitate subsequent identification during construction.

8.2.4.3 Contractor's Quality Control and Certification

The Contractor is required to include in its Method Statement as required under sub-clause 8.2.4.1 of these Specifications a formal Quality Control Programme. Quality Control surveys constituting a minimum 10% of the searched area are required.

The control areas are to be searched initially by metal detector followed by a magnetometer search.

Control areas and results are to be recorded and reported by formal log. Log sheets are to be personally signed off by the Contractor's Ordnance Expert and are to be available for examination by the Engineer.

At least seven days before the Contractor intends to enter any area of the site to commence construction works, the Ordnance Expert shall submit, to the Engineer, his certificate declaring the area concerned to be safe for all intended construction operations. The certificate shall clearly define the area concerned and shall be supported by the log sheets that will give details of the types of survey carried out and the classes and methods of disposal of the various UXO encountered.

8.2.4.4 Audit of Cleared Areas

The Engineer may perform a formal 10% check of UXO cleared areas. These percentages may be increased at his discretion.

If UXO are located during these checks, then a re-search at the Contractor's cost will be required. Finds triggering re-searching are either:

(a) one BLU 26/36 or metallic item of equivalent detectability per 10% of grid will require re-searching for UXO in that grid; or

(b) three 20mm rounds or metallic items of equivalent detectability per 10% of grid will require a re-search of that grid.

When satisfied, the Engineer shall endorse the Contractor's Ordnance Expert's certificate. The Contractor shall not enter the area of the site concerned until such endorsement has been obtained. Such endorsement shall not relieve the Contractor of any of his responsibilities under the Contract.

Before providing such endorsement, the Engineer shall be entitled to consult the nationally recognised authority for UXO clearance in respect of the thoroughness of the ordnance search, and shall be entitled to withhold endorsement if so advised.

8.2.5 MEASUREMENT

UXO Detection and Disposal shall be measured by Hectare of site approved for clearance as determined by the results of the Detailed Contamination Survey and certified and endorsed as cleared in accordance with the provisions of sub-clause 8.2.4.4 of these Specifications.

Sites identified for clearance shall be classified as normal or difficult. Normal clearance is defined as the UXO clearance that will be conducted in open rural areas. Intense clearance is defined as the UXO clearance that will be conducted at bridge and culvert sites and in built-up areas as designated by the Engineer.

No separate measurement will be made for detection and neutralisation of areas outside of the right-of-way such as camp sites, borrow pits, etc

8.2.6 PAYMENT

Payment for UXO detection and disposal shall be made at the Contract prices per hectare measured in accordance with the provisions of Clause 8.2.5 of these Specifications.

Payment shall be deemed to be full compensation for all personnel, mobilisation costs, equipment, materials, transportation etc. and all associated costs, including disposal of ordnance as well as all ordnance detection incidental to site investigation, all in accordance with this Specification and to the satisfaction of the Engineer.

Payment will be made under the following items:

Item Ref	Description	Unit of Measurement
8.2(1)	UXO Detection and Disposal – Normal	Ha
8.2(2)	UXO Detection and Disposal - Intense	Ha

No additional payment will be made for the provision of In-construction support as required in accordance with sub-clause 8.1.4.7 of these specifications as all associated costs will be deemed to be included in the rates for detection and disposal

CONSTRUCTION SPECIFICATION

Section 9
Miscellaneous

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9 MISCELLANEOUS

9.1 FACILITIES FOR THE ENGINEER

9.1.1 DESCRIPTION

This work shall consist of the provision and maintenance for the duration of the work, of facilities for the Engineer, its staff and the Employer's representative. The site shall be shown on the Drawings or as directed by the Engineer.

Preferably the location of the facilities shall be at a central location of the work's site near to the Contractor's office and shall remain for the exclusive use of the Engineer and his staff.

This work shall include all furnishings and fittings that shall conform to the relevant sections of these Specifications.

All permanent site accommodation, office and laboratory provided for the Engineer will become the property of the Employer, except that rented temporarily.

9.1.2 MATERIALS REQUIREMENTS

9.1.2.1 Buildings

The Contractor shall provide the following buildings, for the exclusive use of Engineer, at a site adjacent to the works, the preferred layouts of which are shown on the Drawings.

(a) Fixed office accommodation of approximately 125 m^2 internal floor area;

(b) Materials testing laboratory and storerooms, of approximately 125 m^2 internal floor area;

(c) Living accommodation comprising houses, of approximately 100 m^2 internal floor area each;

Buildings may be of prefabricated or indigenous construction provided they are to the approval of the Engineer and provided they can be demonstrated to satisfy broadly the following specified requirements. Any proposed changes to the internal layout of the buildings shall be subject to the prior approval of the Engineer.

Rented existing buildings may only be substituted with the express approval of the Employer, and then only if, in the opinion of the Engineer, the buildings are conveniently located for his purposes and are equivalent in every respect to the buildings specified herein.

Buildings shall be located such that they are well above previously recorded flood levels. If necessary, and subject to the approval of the Engineer to the concept and the detailed design, buildings may be raised off the ground on reinforced concrete piles.

(i) Thermal Insulation Values

'U' Values:	Roof	0.69W/m^2 K(0.59 kcal/ m^2 h C)
	Walls	0.56W/m^2 K(0.48 kcal/ m^2 h C)
	Floor	0.59W/ m^2 K(0.51 kcal/ m^2 h C)

(ii) Fire Rating

External roof surface	FAA Rating BS 476 : Part 3 : 1958
Internal walls and ceiling	Class 3 Surface Spread of Flame BS 476 : Part 7 : 1971
External walls	Class 'O' classification as defined in The Building Regulations 1985 : Schedule 1 : Part b: Appendix A8 (b) issued by Dept. of Environment . Tested in accordance with BS 476: Part 7: 1971 and BS 476: Part 6: 1968.

(iii) Design Loads (BS 6399: Part 1: 1984)

Roof	75 kgf/ m^2
Floor	290 kgf/ m^2

(iv) Wind Loading (CP 3 Chap V: Part 2: 1972)

Buildings shall be adequately anchored to respective ground slabs to withstand wind speeds up to 60 m/s (135 mph) and shall be so constructed as to comply with the requirements of CP3 for a wind speed loading of 60 m/s.

(v) Air Conditioning

Adequate air conditioning shall be provided to maintain interior temperatures at less than 25 Degrees C. The laboratory shall be air conditioned to such a degree as to ensure that the interior temperature is maintained at about 21 Degrees C throughout the year.

(vi) General

All windows shall be mosquito proofed. All windows shall have pelmet boxes: these shall be 150mm high 100 mm deep with 100 mm overlap at both ends. They shall be provided with curtain rails and fittings. Where windows exceed 1.25m wide the curtain rails shall overlap at the centre.

All windows shall be louvered, at least 1.2m high, the sill being approximately 0.9m above finished floor level, except in the case of the laboratory where the sill height shall be adjusted to suit laboratory benching.

All offices and living rooms shall be fitted with one ceiling fan each and the kitchens and the bathrooms with one extractor fan.

All doors shall be provided with locks. A damp/termite proof layer shall be provided and shall extend under all floors and outside walls.

The floors to all buildings shall be concrete, 0.1 m thick. Floors for domestic accommodation shall be surfaced with a wooden block flooring except in the kitchen and bathroom where thermo-plastic flooring shall be used. Floor coverings for the Site offices shall be wood/vinyl with rugs or fitted carpets or carpet tiles, all to the approval of the Engineer.

All interior and exterior wall finishes shall be to the approval of the Engineer.

Internal and external walls shall be painted with one prime coat and two top coats of waterproof paint. Internal and external woodwork shall be treated with one prime coat, one coat of gloss undercoat and a gloss finishing coat. Knots shall be sealed before priming.

Roofed and paved verandas shall be provided on the front elevations of all buildings as indicated on the drawings. External single and double doors shall be located on the front and rear elevations respectively, where applicable.

9.1.2.2 Utilities

a) Electricity - The Contractor shall provide electricity supply of 220-240 volts, AC 50 cycles per second for 24 hours per day to all buildings. Power generators shall be provided adequate to provide continuity of supply in the event of failure of the main supply. Power points shall be supplied in numbers and at locations to the satisfaction of the Engineer. The power supply shall be fully earthed and shall be subject to power peak protection and voltage regulation.

b) Water - Piped water of suitable quality for domestic use shall be supplied to all buildings, together with sufficient tank storage to provide continuous running water appropriate to the type of building during periods of discontinuity in the supply. The Contractor shall also provide any additional treatment or equipment (such as purifiers and filters) necessary for the provision of drinking water in all buildings. Water heaters shall be connected to the kitchen sink hot water taps and to the bathroom hot water taps and shower.

c) Gas - The Contractor shall supply bottled gas, kerosene or any other fuel as appropriate for the equipment he provides for the use of the Engineer.

d) Telephone - The Contractor shall provide to the Engineer's site office and at each of the Engineer's houses, one telephone connection connecting into the national telephone system and offering communications, within the country and internationally, and allowing both voice and facsimile operation. The connections shall be independent of any telephone system installed by the Contractor for his own use.

   The Contractor shall provide two telephone hand-sets and one facsimile transmitter and receiver, to the Engineer's office and one hand-set each to the Engineer's laboratory and the Engineer's houses. The equipment installed under this clause shall provide at least 90% availability of communications in any one month and shall be replaced by the Contractor, at no additional cost to the Employer, if it consistently fails to meet this standard. All equipment shall be subject to the approval of the Engineer. The Contractor shall provide to each of the Engineer's houses connection to a range of terrestrial and satellite television channels, to the approval of the Engineer, together with all necessary decoding equipment.

e) Waste Disposal - The Contractor shall be responsible for providing suitable hygienic methods for the treatment and disposal of waterborne sewage, waste water and refuse from all buildings. Methods of refuse disposal shall specifically exclude surface dumping.

f) Communications Tower - The Contractor shall be responsible for supplying and installing a 30 m high communications tower at the Engineer's Site Office. Communications equipment is to supplied and installed by others.

9.1.2.3 Furnishings and Fittings

The office, laboratory and houses shall be fully furnished and equipped by the Contractor in accordance with the schedules included in the Drawings. The details and sizes of furniture and equipment given in the schedules are approximate only and the Contractor shall supply full details of the furniture and equipment that he intends to purchase, for the approval of the Engineer. Crockery, cutlery, kitchenware, kitchen utensils, glassware, tableware, bed and household linen, pillows, cushions, carpets, curtains and other small items shall be provided to the satisfaction of the Engineer.

The Contractor shall supply and maintain computer equipment and software for the exclusive use of the Engineer in accordance with the schedules included in the Drawings.

Requirements for the provision of testing equipment and the operation of the Materials Testing Laboratory are given in Section 9.3 of these Specifications.

9.1.2.4 Equipment, Consumables and Maintenance

The Contractor shall supply all consumable stores, required for the use of the Engineer and his staff including survey field books, computer supplies, photocopier supplies, plan printer supplies, purpose-printed forms and other stationery, toilet supplies, batteries for calculators and durable polythene materials sampling bags for the office and the laboratory, as well as supplies for the preparation of tea and coffee for consumption in the office and laboratory, all as required by the Engineer.

In addition, the Contractor shall supply safety equipment for the use of the staff of the Engineer and the Employer when working on the Site, appropriate to the tasks they are undertaking. Such safety equipment shall include safety helmets.

The maintenance of the office, the laboratory and the accommodation and their surrounds, and all furniture, fittings and equipment provided for the use of the Engineer shall be the responsibility of the Contractor. He shall ensure that an adequate supply of replacement items and spare parts covering all the facilities is always available on site. In the case of work station computing facilities, the Contractor shall ensure that adequate back-up is available in the event of a malfunction. He shall ensure that the Engineer's office and laboratory are cleaned each day.

9.1.3 CONSTRUCTION REQUIREMENTS

At the Engineer's camp(s) all-weather access roads shall be provided between the Engineer's housing, his office the laboratory and the site. Covered hard standings for vehicles shall be provided outside the offices and laboratories, together with a water supply, hose and wash down area for cleaning vehicles. The Contractor shall obtain approval of the Engineer for the layout of the accommodation, laboratory and office prior to construction.

All necessary site works required for the provision of the facilities for the use of the Engineer shall be carried out to the approval of the Engineer. Such works shall include earthworks, drainage, roads, parking, footpaths, fencing, landscaping, topsoiling, planting, lighting, and any other incidental work.

The Contractor shall be responsible for ensuring that the facilities provided for the Engineer are secure and shall erect security fencing, employ day and night watchmen and take any other measures agreed with the Engineer.

Notwithstanding the foregoing the Contractor shall provide such details as the Engineer may request pertaining to any facilities for the Engineer. Unless the Engineer agrees otherwise all facilities provided for his use shall be new. The Contractor shall not complete any arrangements for additional land, nor place orders for the purchase of any items, nor start work on the installation of the Engineer's facilities until he has received the approval of the Engineer. Full details of the facilities which the Contractor proposes to provide for the Engineer shall be submitted within 15 days of the Letter of Acceptance.

The Contractor shall complete the provision of facilities for the Engineer within 90 days of the date of the receipt of the instruction for Commencement of Works.

Until completion of facilities, which shall include use of the specified computing facilities for the Engineer, the Contractor shall provide such temporary facilities as may be required by the Engineer, in the execution of his duties under the Contract. Alternatively, the Engineer may make his own arrangements for temporary facilities in which case the Contractor shall reimburse the Engineer for the costs so incurred.

9.1.4 STAFF REQUIREMENTS

The following staff shall be provided by the Contractor for the exclusive assistance of the Engineer in his office:

- secretaries/word processor operators;
- computer operators;
- draftpersons;
- office messengers

Such staff shall be subject to the approval of the Engineer and shall be responsible solely to him, although they will be in the employment of the Contractor.

Staff for the laboratory, survey staff and drivers for the Engineer shall be provided as described in the appropriate sections of these Specifications.

The Contractor shall provide safety equipment for the use of the Engineer's staff and for official visitors to the site. This equipment shall include protective headgear.

The Contractor shall provide a rent allowance to both professional and other members of the domestic staff of the Engineer as instructed by the Engineer. The rent allowances shall be paid on a monthly basis and shall be subject to reimbursement through the monthly certificate.

9.1.5 MEASUREMENT

Provision of the office, materials testing laboratory and housing for the use of the Engineer shall be measured by numbers of the respective building types completed and fully furnished, fitted and equipped in accordance with these Specifications and ready for occupation, all to the satisfaction of the Engineer.

Maintenance of the office, materials testing laboratory and housing for the use of the Engineer shall be measured on a monthly basis, for each building, commencing when the building, or short-term temporary substitute, acceptable to the Engineer, is occupied by the Engineer and ceasing when the building is no longer required by the Engineer.

Provision of full-time staff to work exclusively for the Engineer and provided by the Contractor shall be measured by the month for each individual category of staff required by the Engineer. This shall include the provision of full time survey staff as defined in Section 9.4 of these Specifications, but shall specifically exclude laboratory staff and drivers who are deemed to be covered by other rates and prices included in the Bills of Quantities.

9.1.6 PAYMENT

Payment for the provision of the office, laboratory and housing for the use of the Engineer shall be paid at the Contract unit price per type of accommodation as detailed below and as measured under Clause 9.1.5 of these Specifications. Such prices shall be deemed to cover all costs of material, plant, labour, tools, equipment, associated transportation, furniture, fittings, safety equipment, services connections, all necessary Site works and all incidentals necessary to complete to the works. Payment for the Engineer's office shall be specifically deemed to include for the cost of providing the required computer equipment, as listed in the Drawings and for the cost of provision of the survey equipment for the use of the Engineer as specified in Section 9.4 of these Specifications and as listed in the Drawings.

Payment for the laboratory shall be specifically deemed to include for all the costs of providing laboratory equipment as defined in Section 9.3 of these Specifications.

Payment for maintenance of the office, laboratory and housing for the use of the Engineer shall be paid at the Contract unit price per month as detailed below and as measured under Clause 9.1.5 above. Payment shall be deemed to include all costs involved in maintaining in good repair, and cleaning, the buildings and surrounds, furniture, fittings and equipment, the supply of all services, all communications costs, including rentals, television connections, the provision of all consumable stores for the offices and laboratories, including the provision of safety equipment, the replacement of all equipment that may have become worn or otherwise unserviceable, the provision of security, the supply of all laboratory staff required by the Engineer and the supply of standard documents (as defined in Section 9.3 of these Specifications). Payment under maintenance items may be withheld if, in the opinion of the Engineer, the Contractor fails to meet his full obligations to maintain the facilities as defined here in.

Payment for full time staff for the Engineer provided by the Contractor shall be made at the Contract unit price per month for each category of staff and shall be deemed to cover all costs including wages, social charges, mobilisation and demobilisation costs, accommodation and all other allowances, overtime etc.

Pay items shall be as follows:

Item Ref	Description	Unit of Measurement
9.1(1)	Provide office accommodation for the Engineer	Number
9.1(2)	Provide materials testing laboratory for the Engineer	Number
9.1(3)	Provide housing accommodation for the Engineer	Number
9.1(4)	Maintain Engineer's office accommodation	Month
9.1(5)	Maintain Engineer's materials testing laboratory	Month
9.1(6)	Maintain Engineer's housing accommodation	Month
9.1(7)	Rent allowance for the Engineer's Senior Domestic Staff (fixed rate)	Person-month
9.1(8)	Rent allowance for the Engineer's Junior Domestic Staff (fixed rate)	Person-month
9.1(9)	Provide full time staff to work for the Engineer	
(a)	Secretary/word processor operator	Person-month
(b)	Computer operator	Person-month
(c)	Draftsman	Person-month
(d)	Office messenger	Person-month
(e)	Surveyor	Person-month
(f)	Chainman	Person-month
(g)	Laboratory Technician	Person-month
(h)	Laboratory Assistant	Person-month

9.2 TRANSPORT FOR THE ENGINEER

9.2.1 DESCRIPTION

This work shall consist of the provision and maintenance for the duration of the work, of vehicles for the Engineer and its staff.

All vehicles, except those hired temporarily, provided for the use of the Engineer and its staff, shall become the property of the Employer.

9.2.2 GENERAL REQUIREMENTS

Unless otherwise agreed by the Engineer, all vehicles provided for the Engineer's use shall be new.

Vehicles to be provided by the Contractor for the exclusive use of the Engineer both on and off the site shall comprise the following types:

Type A - 4- wheel drive, 7-9 seat all-terrain vehicle, minimum engine capacity 2500 cc.

Type B - 4- wheel drive, long wheel base pick up with double cab and canvas cover, minimum engine capacity 2500 cc.

Type C - Motorcycle of robust construction, minimum engine capacity 150 cc.

All vehicles shall be diesel-engined, except the motorcycles which shall be capable of operation on locally-available grades of petrol. The vehicles shall be taxed and insured, by the Contractor, for any driver, and the Contractor shall provide all fuel and carry out all maintenance and repairs.

The Contractor shall be responsible for keeping stocks of such spare parts for the Engineer's vehicles as are necessary for the minimisation of times taken to maintain and repair the Engineer's vehicles.

The Contractor shall provide drivers for each of the Engineer's vehicles types A and B.

Alternative, suitable vehicles shall be provided if any of the Engineer's vehicles is unserviceable.

The Contractor shall provide such details of the vehicles he proposes to provide for the Engineer as the Engineer may request and no arrangements shall be made for the provision of these vehicles without the Engineer's prior approval. Full details of the vehicles shall be submitted to the Engineer within 15 days of the Letter of Acceptance. The Contractor shall complete the provision of vehicles for the Engineer within 90 days of receipt of the notice to commence the works.

Until the Engineer's vehicles are provided, the Contractor shall provide such temporary vehicles as may be required by the Engineer, at no cost to the Employer.

9.2.3 MEASUREMENT

Provision of vehicles for the use of the Engineer, including vehicles specified for the use of the materials testing laboratory in Section 9.3 of these Specifications, shall be measured

by numbers of the respective types of vehicles specified and supplied, complete, delivered to the site, and to the satisfaction of the Engineer.

Maintenance of the Engineer's vehicles shall be measured on a monthly basis, per type of vehicle, commencing when each vehicle is available to the Engineer for his use, subject to the satisfaction of the Engineer, and ceasing when the vehicle is no longer required by the Engineer. No measurement or payment shall be made for the provision or maintenance of temporary vehicles.

9.2.4 PAYMENT

Payment for the provision of vehicles for the use of the Engineer shall be made at the Contract unit price per type of vehicle. Payment shall be deemed to cover all costs involved in procuring and delivering the vehicles to the site in good order including importation and delivery charges, manufacturer's checks etc.

Payment for maintenance of the Engineer's vehicles shall be made at the Contract price per month for the type of vehicle. Payment shall be deemed to include full compensation for all fuels lubricants and other consumables provided, for all costs involved in providing drivers, taxing and insuring of vehicles, maintenance, spare parts, repairs and the cost of any alternative vehicles provided while any of the Engineer's vehicles is unserviceable.

Pay items shall be as follows:

Item Ref.	Description	Unit
9.2(1)	Provide Type A vehicle for the use of the Engineer	number
9.2(2)	Provide Type B vehicle for the use of the Engineer	number
9.2(3)	Provide Type C vehicle for the use of the Engineer	number
9.2(4)	Maintain vehicle Type A	month
9.2(5)	Maintain vehicle Type B	month
9.2(6)	Maintain vehicle Type C	month

9.3 MATERIALS TESTING & QUALITY CONTROL

9.3.1 DESCRIPTION

This work shall consist of the provision of equipment, operation and maintenance for the duration of the work, of the materials laboratory and quality control testing for the works in accordance with the requirement and to the satisfaction of the Engineer and its staff.

All equipment, except those items hired temporarily, provided for the use of the Engineer and its staff for the materials testing and quality control of the works, shall become the property of the Employer.

9.3.2 GENERAL REQUIREMENTS

9.3.2.1 Materials Laboratory

The laboratory provided by the Contractor as specified in Section 9.1 of these Specifications shall be used exclusively for design and control testing of materials to be incorporated in the works.

The laboratory shall be fully equipped to carry out all of the tests indicated in Clause 9.3.3 of these Specifications and the equipment provided shall conform in every respect to the standards listed in Clause 9.3.3 of these Specifications. The Contractor shall provide sufficient quantities of testing equipment to meet the specified testing requirements, commensurate with his planned rates of production, including an adequate stock of breakable and consumable items.

The Contractor shall submit the proposed layout and a full list of the equipment and furniture he intends to order, with his Works Programme to be submitted in accordance with the requirements of Clause 14 of the General Conditions, for the comment and approval of the Engineer.

All furniture fittings and equipment provided for the laboratory shall be new, unless otherwise agreed by the Engineer.

Such approval by the Engineer shall not relieve the Contractor of his responsibility to ensure that the laboratory is adequately equipped and the Contractor shall have no claim for delays resulting from the inadequacy of the testing facilities.

9.3.2.2 Temporary Laboratory

The Engineer may require the Contractor to provide additional temporary laboratory accommodation for the use of laboratory staff, for testing purposes, at key locations on Site. Such key locations may include crushing plant, asphalt plant and major bridges sites.

The temporary laboratory accommodation may comprise not more than three, lockable, 6 m long shipping containers or other similar moveable, weather proof, secure shelters acceptable to the Engineer. The Contractor shall relocate such temporary facilities about the Site when requested to do so by the Engineer.

9.3.2.3 Staffing

The Contractor shall be responsible for staffing the laboratory, He shall provide a suitably qualified and experienced Senior laboratory technician and sufficient technicians and assistants to meet the testing requirements. It is anticipated that this will require not less than 4 technicians and 15 skilled assistants.

Details of the proposed staffing shall be submitted to the Engineer for approval and he shall be entitled to ask the Contractor to remove or replace any member of the laboratory staff, whether previously approved or not, if in doubt about their competence. The Contractor shall have no claim for delays resulting from the inadequacy of numbers or inexperience of laboratory staff.

9.3.2.4 Transport

The Contractor shall provide all transport necessary to the proper functioning of the laboratory and its day-to day field investigation, sampling and testing requirements. For this purpose the Contractor shall provide 3 type B vehicles together with drivers, maintenance and all running costs, as defined in Section 9.2 of these Specifications which shall be for the exclusive use of the laboratory. In cases when this provision of laboratory transport is inadequate to meet laboratory requirements the Contractor will supplement the laboratory transport on a temporary basis. The Contractor shall have no claim for delays resulting from insufficient laboratory transport.

9.3.2.5 Provision of Facilities

The Contractor shall complete the provision of all the required laboratory facilities within 90 days of the issue of the Notice to Commence.

9.3.3 EQUIPMENT REQUIREMENTS

The materials testing laboratory shall be fully equipped with all the necessary equipment and a full range of consumable stores to carry out the following tests:

Test Description	AASHTO Test Reference	Other Reference
Particle size analysis of soils	T88	
Determination of the liquid limit of soils	T89	
Determination of the plastic limit and plasticity index of soils	T90	
Specific gravity of soils	T100	
Density of soil in place by the sand cone method		
Moisture density relation of soils using a 4.54 Kg ram and a 450 mm drop	T180	
California bearing ratio	T193	
Sand equivalent	T176	
“Speedy” moisture content determination	T217	
Sampling stone, slag, gravel, and stone block for use as	T2	

Test Description	AASHTO Test Reference	Other Reference
highway materials		
Amount of material finer than 0.075 mm Sieve in aggregate	T11	
Unit weight of aggregate	T19	
Sieve analysis of fine and coarse aggregates	T27	
Specific gravity and absorption of fine aggregate	T84	
Specific gravity and absorption of coarse aggregate	T85	
Soundness of aggregates by use of sodium sulphate or magnesium sulphate	T104	
Friable particles in aggregates	T112	
Lightweight particles in aggregates	T113	
Flakiness Index		BS 812
Elongation Index		BS 812
Organic impurities	T21	
Aggregates crushing test		BS 812
10 per cent fines test		BS 812
Bitumen Coating and stripping	T182	
Immersion tray test		TRL Overseas Road Note 3
Quality of water	T26	
Slump test	T119	
Compressive strength of concrete cylinders	T22	
Preparing concrete field test specimens	T23	
Flexural strength of concrete	T97	
Preparing concrete lab test specimens	T126	
Sampling freshly mixed concrete	T141	
Compressive strength of mortar cubes		BS 4550

The laboratory shall be supplied with a continuous recording rain gauge and a maximum/ minimum thermometer to the approval of the Engineer.

Where tests other than those listed above are called for, in these Specifications or elsewhere in the Contract, the Contractor may choose to provide the capability to carry out the tests in the Contract materials testing laboratory or to have the tests carried out, at the Contractor's expense, at another laboratory acceptable to the Engineer.

9.3.4 OPERATION REQUIREMENTS

9.3.4.1 Supervision

All testing and the running of the laboratory shall be carried out under the direct control of the Engineer except that the Contractor shall be permitted to carry out tests to confirm potential materials sources and mix design prior to their adoption for the Works and other such tests as the Contractor may require in direct connection with the Works.

The Contractor shall supply all samples of materials for testing. He shall provide assistance, labour, technician staff, attendance, transport and anything else necessary, as may from time to time be required by the Engineer, in taking and packing samples in approved containers, dispatching them for test, preparing them for test, examining and testing them and presenting the test results. In the event that any sampling and testing is carried out at the manufacturer's plant or at any laboratory other than the site laboratory, the cost of such sampling and testing or the furnishing of test certificates shall be borne by the Contractor.

9.3.4.2 Codes and Standards

Reference is made throughout these Specifications to American Association of State Highway and Transportation Officials (AASHTO) codes, American Society for Testing Materials (ASTM) codes, Australian Standards (AS) codes, British Standard (BS) codes, British Standard Codes of Practice (CP) and to publications of the (British) Transport Research Laboratory (TRL). The references shall be taken to refer to the latest published version of each of these publications as at a date 28 days before the latest date for submission of tenders for this Contract. The Contractor shall supply for the exclusive use of the Engineer's laboratory, one copy of each of the publications referred to in these Specifications.

Whenever, in these Specifications, a specific standard for materials is not nominated, the materials shall conform to the standards required by one of the above nominated bodies or to another equivalent internationally recognised standard acceptable to the Engineer.

9.3.4.3 Material Standards

All materials provided by the Contractor for inclusion in the Works shall conform to the standards set out in these Specifications, on the Drawings or as otherwise directed by the Engineer.

Unless otherwise stated, all goods, materials, transportation, equipment and services for the Works shall be provided by the Contractor. The Contractor shall be entirely responsible for the identification of sources of materials and their provision in accordance with the requirements of the Specifications.

Before placing any order for materials and manufactured articles for incorporation in the Works, the Contractor shall submit to the Engineer the names of the firms from whom he proposes to obtain such materials and manufactured articles. The submission shall include, for the for each firm, a description of the materials and manufactured articles to be supplied, their origin, the manufacturer's specification, and other relevant details as required by the Engineer. The Contractor shall pass to the Engineer samples of such materials and manufactured articles and, where appropriate, the manufacturer's certificates of recent tests carried out on similar materials and manufactured articles.

9.3.4.4 Making Good

The Contractor shall be responsible for making good any holes, damage or other blemishes to the permanent Works resulting from the testing or sampling of the materials. These shall be made good to the standards required for the element of the Works concerned. The Contractor may, at his own cost and only with the agreement of the Engineer, use a superior materials to effect such making good if he deems this a more effective way of achieving the standards required

9.3.4.5 Compaction Trials

Full scale laying and compaction site trials shall be carried out by the Contractor on all earthwork and pavement materials proposed for the Works using the constructional plant and methods proposed by the Contractor for constructing of the Works. The trials shall be carried out with the agreement, and in the presence of the Engineer, and on a surface comparable in performance and smoothness to the surface on which the actual layer will be constructed.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of the mixing and compaction equipment to provide and compact the material to the specified density and to confirm that the other specified requirements of the completed earthwork or pavement layer can be achieved.

Emphasis is placed on the need to ensure uniformity of moisture content throughout the layer to be compacted, without which no uniformity of compaction will be achieved.

Each trial area shall be at least 50 metres long and to the full construction width and shall be laid to the specified depth for the material. It may form part of the Works provided it complies with the requirements of these Specifications.

Any area which does not comply with the requirements of these Specifications shall be removed.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. Trials on each pavement layer shall be undertaken at least 28 days ahead of the Contractor proposing to commence full scale work on that layer.

The Contractor shall compact each section of trial over the range of compactive effort the Contractor is proposing and, in so-doing, will trim the layer to level and will achieve a surface finish comparable to that required for the layer in practice. If appropriate, the following data shall be recorded for each level of compactive effort at each site trial:

i) The composition and grading of the material before the site trial.

ii) The moisture content at the time of compaction and the optimum moisture content for the specified compaction.

iii) The type, size, tyre pressures, frequency of vibration and the number of passes of compaction equipment.

iv) The maximum dry density or target density as appropriate measured on a sample before and at intervals through the site trials.

v) The densities achieved.

vi) The compacted thickness of the layer.

vii) Any other relevant information as directed by the Engineer.

At least eight sets of tests shall be made by the Contractor and the Engineer on each 50 metres of trial for each level of compactive effort and provided all eight sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

If, during the execution of the Works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall stop until the cause is investigated by the Contractor. Such investigation may include further laboratory and site trials on the material to determine a revised set of data as above which all subsequent material will be provided and processed to achieve the specified requirements.

Agreement by the Engineer to a set of data recorded in site trial shall not relieve the Contractor of any responsibility to comply with the requirements of these Specifications.

9.3.5 MEASUREMENT

Measurement for the provision and maintenance of the laboratory building, furnishings, fittings and equipment is provided for under Section 9.1 of these Specifications.

The provision of full time laboratory staff to work exclusively for the Engineer shall be measured under the provisions of Section 9.1 of these Specifications.

Measurement for the provision and maintenance of vehicles for the use of the laboratory is provided for under Section 9.2 of these Specifications.

The performance of compaction trials shall not be the subject of separate measurement.

No other measurement shall be due in connection with the conformance by the Contractor with the provisions of this section of the Specification.

9.3.6 PAYMENT

Payment for the provision and maintenance of the laboratory building, furnishings, fittings and equipment is provided for under Section 9.1 of these Specifications.

Provision of full time laboratory staff to work exclusively for the Engineer shall be paid for under the provisions of Section 9.1 of these Specifications.

Payment for the provision and maintenance of vehicles for the use of the laboratory is provided for under Section 9.2 of these Specifications.

The costs involved in conducting compaction trials shall be deemed to have been included by the Contractor in rate included in the Bills of Quantities for other items of works.

No payment shall be due in connection with the conformance by the Contractor with the provisions of this section of the Specification. Specifically, the costs involved in making good shall be deemed to be included in the rates and prices included in the Bills of Quantities for the relevant items of works.

9.4 SURVEY AND SETTING OUT

9.4.1 DESCRIPTION

This work shall consist of the provision of equipment and staff for the duration of the work for the conducting the necessary survey and setting out operations in connection with checking or establishing line, level, control and quantification of the various items of the works in accordance with the requirements of the Engineer and its staff.

All equipment, except those items hired temporarily, provided for the use of the Engineer and its staff for the survey of the works, shall become the property of the Employer.

9.4.2 GENERAL REQUIREMENTS

9.4.2.1 Survey Control.

Immediately after receiving notice to commence the Works the Contractor shall carry out the following.

(a) The Contractor shall establish construction control points for both distance and level along the length of the road alignment. These control points shall be located outside the area to be occupied by the Permanent Works, and successive points shall be mutually inter visible, not more than 1 km apart and shall be at spacing and locations such that all future setting out can be carried out from them. The Contractor shall clearly mark and protect the construction control points, which shall comprise steel pins set in concrete, until completion of the Contract."

(b) The Contractor shall provide to the Engineer a tabulated list of all such control points, suitably reference for ease of identification and use by the Engineer for checking of the Works

9.4.2.2 Survey Assistance to the Engineer.

The Contractor shall provide the Engineer with all necessary assistance for checking the setting out, agreement of levels and any other survey or measurement which the Engineer requires to carry out in connection with the Contract. Such assistance shall include:

(a) provision and maintenance of the survey equipment scheduled in the Drawings, for the exclusive use of the Engineer;

(b) provision of all suitably qualified and experienced surveyors to work under the direction of the Engineer as detailed in sub-clause 9.4.2.2 of these Specifications.

(c) provision of all necessary survey equipment and support for these surveyors including assistants, chairmen, labourers, hand tools, pegs and materials.

9.4.2.3 Staffing.

The Contractor shall provide the following full-time survey staff to work exclusively under the direction of the Engineer. The staff provided shall be competent and experienced and, if at any time the Engineer shall object to any of the staff provided, the Contractor shall immediately replace the person concerned.

- Senior Surveyors.
- Surveyors.
- Chainmen.

In addition, the Contractor shall provide any temporary survey staff required by the Engineer together with any additional survey equipment required.

9.4.3 OPERATION REQUIREMENTS

9.4.3.1 Existing Ground Levels

Prior to commencing construction of the permanent works the Contractor shall carry out a centreline level survey with cross sections every 100 metres of the existing road formation. From this survey the Contractor shall provide for the Engineer drawings of the existing vertical profile with cross sections which will be used as the basis for determining the quantities of earthworks placed during the widening of the embankment.

In addition, the Contractor shall survey such areas of the existing ground as the Engineer shall direct, prior to their disturbance due to construction operations and agree them with the Engineer.

The elevations established from the survey will also be used by the Engineer to specify any changes that may be made to the embankment heights and for any additional fill required at culvert and bridge approaches.

9.4.3.2 Survey Controls in the Construction of Roadworks

The Contractor shall provide adequate survey beacons, batter-boards, profiles and road pins for the accurate control of line and level of roadwork.

Completion of sub-grade construction and line and level for sub-base and base construction shall be controlled by the use of road profiles which shall be erected at sufficient intervals on both sides of the road and shall be accurately set out to allow accurate control of the shape of the surface of each layer, including the construction of cambers and crossfalls, to within the tolerances specified.

9.4.3.3 Survey Controls in the Construction of Bridges and Culverts

The Contractor shall provide adequate survey beacons, bench marks and recovery marks for the accurate control of location and level of bridge and culvert construction.

Bench marks and recovery marks shall be suitably located in sites protected from all construction traffic, preferably in undisturbed ground and shall consist of steel pins set in concrete blocks, clearly marked with an identification number for ease of reference.

Sufficient marks shall be established for each abutment at sites where access across the river or obstacle being crossed may not be possible at al times.

9.4.4 MEASUREMENT

Measurement for the provision of survey equipment for the use of the Engineer is deemed to be included in the measurement of the provision of the office for the Engineer under Section 9.1 of these Specifications.

The provision of full time survey staff to work exclusively for the Engineer shall be measured under the provisions of Section 9.1 of these Specifications.

No other provision of this section shall be subject to measurement.

9.4.5 PAYMENT

Payment for the provision of survey equipment for the use of the Engineer is deemed to be included in the payment of the provision of the office for the Engineer under Section 9.1 of these Specifications.

Provision of full time survey staff to work exclusively for the Engineer shall be paid for under the provisions of Section 9.1 of these Specifications.

No other provision of this section shall be subject to payment and compensation for compliance by the Contractor with the provisions of this section is deemed to be included in rates and prices for items of works included in the Bill of Quantities.

9.5 TRAFFIC AND TRAFFIC CONTROL

9.5.1 DESCRIPTION

This work shall consist of the provision of all measures as are necessary for the safe passage of public traffic along and through the works at all times and in accordance with the requirements of the Engineer and its staff.

The work shall include the staging of construction activities, the provision of traffic signs and warning devices, the use flagmen or other personnel to direct traffic and any other measures appropriate for the safe and effective passage of public traffic.

This work shall include of maintenance by the Contractor of the existing road and bridges in a condition at least as good as that in which it was handed over to him from the time he is given Possession of the Site until the road is reconstructed or until it is no longer required for the passage of public traffic.

The Contractor shall also take necessary care at all times to ensure the convenience and safety of residents along and adjacent to the works.

Any failure of the Contractor in the performance of these works will entitle the Engineer to carry out such works as he deems to be necessary and to charge the Contractor with the full cost thereof, which sum will be deducted from any monies due of which may become due to the Contractor under the Contract.

9.5.2 GENERAL REQUIREMENTS

9.5.2.1 Passage of Traffic Through the Works

The Contractor shall so order his works that public traffic may continue to pass safely along the route of the road at all times. The Contractor shall so order his work in half -widths or in short lengths so that public traffic may continue to pass either over sections of the existing road or over sections of the new works. The Contractor shall be responsible for safety of the public on the Site.

Any reductions in the width of road available for public trafficking shall be such that the widths of road available for traffic at any time shall be compatible with the volumes of public traffic normally using the road.

9.5.2.2 Diversion Roads

The Contractor may, for his own convenience of working, construct diversion roads and divert public traffic on to them. The standards of construction and geometry of these roads shall be such that, in the opinion of the Engineer, they are compatible with the volumes of traffic expected to pass along them. This may include the provision of a bituminous road surfacing.

The Contractor shall be solely responsible for all aspects of the arrangement of access to the land required for such diversion roads and for the construction of the roads.

When the diversion roads are no longer required the land over which they passed shall be fully restored to its previous condition.

Such diversion roads shall not be the subject of separate payment, and all costs concerned shall be borne by the Contractor.

9.5.2.3 Use of Traffic Control Devices

Notwithstanding the contents of sub-clauses 9.5.2.1 and 9.5.2.2 of these Specifications, the Contractor shall not divert public traffic or change patterns of trafficking in any way without providing such barriers and signing that the Engineer considers adequate to ensure continued safety of public traffic.

All traffic control measures shall be in operation 24 hours per day and shall be supplemented by lights at night when the Engineer considers this necessary.

At least two weeks before he intends to alter trafficking patterns in any way the Contractor shall present plans to the Engineer for traffic signing and control. If the Engineer does not approve these plans the Contractor shall make such amendments to them as are necessary in order to make them, in the Engineer's opinion, satisfactory. Prior to implementation of the new trafficking arrangements, the Engineer shall inspect the Contractor's signs, barriers and signals and only when the Engineer agrees shall they be put into operation.

9.5.2.4 One-Way Traffic

When traffic volumes are, in the opinion of the Engineer, sufficiently low to make one-way trafficking practicable, he may agree to this being implemented. One-way trafficking will only be permitted by the operation of temporary traffic lights. Unless specifically approved by the Engineer the use of flags or "Stop/Go" boards will not be permitted to control traffic.

The arrangements for one-way trafficking shall be subject to the provisions of sub-clause 9.5.2.3 of these Specifications.

9.5.2.5 Temporary Road Closure

Notwithstanding the provisions of sub-clause 9.5.2.1 of these Specifications, the Contractor may be permitted to delay the passage of public traffic for short periods, not exceeding fifteen minutes, subject to the prior approval of the Engineer.

If longer delays are considered necessary they will only be permitted with the prior approval of the appropriate roads authority and subject to any prior public notice which may be required.

9.5.3 MATERIALS REQUIREMENTS

Materials and devices used for the control of traffic such as road posts, hazard markers, warning tapes, traffic signs, flashing amber lights, traffic signals, barricades, diversion cones, bollards, detours, etc shall conform to the current AS, ASTM or BS standards or as are approved by the Engineer.

9.5.4 CONSTRUCTION REQUIREMENTS

9.5.4.1 Maintenance of Existing Road and Bridges

When public traffic is to be passed though the Works in an incomplete state the Contractor shall take all steps necessary to provide a smooth free-draining running surface and to maintain it in that condition.

He shall ensure that the surface is neither excessively dusty nor dangerously slippery and shall, if directed by the Engineer, water the surface to lay dust or provide a thin gravel topping to the trafficked surface.

The Contractor shall ensure that safe access is maintained at all times across bridges and culverts within the limits of the site. This may include the repair or replacement of bridge deck materials or the construction of a by-pass where more appropriate, but at all times the Contractor should not delay the passage of vehicles for excessive periods.

The Contractor shall render such assistance to the public as shall be necessary to allow safe and convenient passage of traffic at all times.

9.5.4.2 Trafficking the Works by the Contractor's Equipment

Contractor's equipment, which shall specifically include all tracked equipment and compaction equipment, other than that properly equipped with road-going pneumatic tyres, shall not be permitted to traverse any finished pavement layers or surfacing works or unprotected structural works, except by use of purpose-constructed transporters, or by use of some form of protection acceptable to the Engineer.

No Contractor's equipment which by virtue of its load, or for any other reason, is likely, in the Engineer's opinion, to damage the Works, may pass over the Works, unless adequate precautions are taken which, in the opinion of the Engineer, will prevent such damage.

9.5.4.3 Traffic Control Devices

Traffic signs, signals, barricades, warning tapes, road posts, hazard markers, traffic cones, bollards, etc shall be so placed as to be easily and opportunely visible to oncoming traffic to ensure drivers will know immediately what instructions they are to follow.

The siting of these devices shall conform to the current AS, ASTM or BS standards or as approved by the Engineer.

9.5.5 MEASUREMENT

Measurement in respect of the passage of public traffic through the Works and the maintenance of safe traffic operations, including the regular maintenance of the existing road shall be computed by the product of the length of any section of the road of which the Contractor is given possession, measured in kilometres and the time measured in months, from the time the Contractor is given possession of the section of road and ceasing at the time a Taking-Over Certificate is issued in respect of the section of road concerned.

9.5.6 PAYMENT

Payment for the maintenance of safe traffic operations shall be made at the rate quoted in the Bill of Quantities per kilometre-month, computed as described in Clause 9.5.5 of these Specifications.

Payment shall be deemed to include all labour, equipment and materials, including the provision of all signs, signals and other traffic safety devices, traffic control, the provision of diversion roads, when applicable, the maintenance of the existing road and bridges, and all other things necessary for the maintenance of safe traffic operations.

Notwithstanding the above, the Engineer may withhold Certification of payment under the item for maintenance of safe traffic operations if, in its opinion, the Contractor has failed to properly implement any of the provisions of this section of the Specifications

Pay items shall be as follows:

Item Ref.	Description	Unit
9.5(1)	Maintain Safe Traffic Operations	Kilometre-month

9.6 PROGRESS PHOTOGRAPHS

9.6.1 DESCRIPTION

This work shall consist of the provision of progress photographs of the works for the duration of the works as determined by the Engineer.

9.6.2 GENERAL REQUIREMENTS

The Contractor shall provide at the commencement of the contract and at monthly intervals thereafter a record of the Works with photographs taken at locations and times determined by the Engineer.

The camera(s) used shall be of the type which records on the negative the date on which a photograph was taken.

The Contractor shall provide for the Engineer on average 30 photographs each month which indicate significant and obvious progress for the month and also highlight any major events or incidents which have occurred.

One set of colour prints with all negatives, suitably referenced shall be submitted to the Engineer each month, of a size and in a format to be agreed with the Engineer.

9.6.3 MEASUREMENT

Measurement of progress photographs shall be by the month, and shall be dependent on the fulfilment by the Contractor, to the satisfaction of the Engineer, of the provisions of this section of the Specifications.

9.6.4 PAYMENT

Payment for progress photographs shall be made at the unit price per month for this item and shall be deemed to include for the cost of all transportation, equipment, materials and labour required.

Payment will be made under the following items

Item Ref	Description	Unit of Measurement
9.6(1)	Progress Photographs	Month

9.7 PROJECT INFORMATION BOARDS

9.7.1 DESCRIPTION

This work shall consist of furnishing and installing information boards at suitable sites on the works as directed by the Engineer.

9.7.2 MATERIALS REQUIREMENTS

The boards and supporting posts and frames shall be manufactured from good quality materials in accordance with the requirements of Section 7.5 of these Specifications

The information boards shall provide details of the Contract and conform to such size and format as shown on the Drawings or as the Engineer shall direct

9.7.3 CONSTRUCTION REQUIREMENTS

The information boards shall be erected at the beginning and the end of the works, at the site offices and at other suitable locations as approved by the Engineer.

Neither the Contractor nor any of its subcontractors shall display any other information or notice boards on the Site without the express permission of the Engineer.

9.7.4 MEASUREMENT

Measurement of project information boards shall be by number of boards instructed for installation and installed to the satisfaction of the Engineer.

9.7.5 PAYMENT

Payment for project information boards shall be made at the unit price per board approved by the Engineer and shall be deemed to include for the cost of all transportation, equipment, materials and labour required.

Payment will be made under the following items

Item Ref	Description	Unit of Measurement
9.7(1)	Project Information Board	Number

9.8 SITE CLEAN-UP

9.8.1 DESCRIPTION

This work consists cleaning up and reinstatement of the site to the satisfaction of the Engineer on completion of the works prior to issue of the Taking-Over Certificate.

9.8.2 GENERAL REQUIREMENTS

Upon completion of the Work and before acceptance and final payment will be made the, Contractor shall clean the roadway and adjacent property defaced or occupied by him in connection with the Work of all rubbish, weeds, brush, excess materials, falsework, temporary structures and equipment.

All parts of all types of the Work shall be left in a neat and presentable condition and as approved by the Engineer.

The above requirement shall apply to all campsites, quarries and workshops, whether temporary or permanent and all temporary buildings and the foundations of the same shall be removed and the ground reinstated to an acceptable condition.

Borrow pits shall be reinstated in accordance with the requirements of sub-clause 2.3.3.3 of these Specifications

9.8.3 MEASUREMENT

This item will not be measured payment being on a lump sum basis.

9.8.4 PAYMENT

The lump sum payment for site clean up shall be full compensation for all labour, materials, tools, equipment, supervision and incidentals and for doing all the work involved in cleaning up the site to the satisfaction of the Engineer in accordance with the requirements of Section 9.8 of these Specifications

Payment will be made under the following item

Item Ref	Description	Unit of Measurement
9.8(1)	Site Clean Up	Lump Sum

9.9 SOCIALLY TRANSMITTED DISEASES INFORMATION AND EDUCATION PROGRAMME

9.9.1 DESCRIPTION

This work shall consist of the implementation of an information and education programme in relation to socially transmitted diseases, including AIDS/HIV, for the contractor's workforce and the local population within the project road corridor in accordance with the requirements of sub-clause 34.7 of the Conditions of Particular Application.

9.9.2 GENERAL REQUIREMENTS

The programme shall operate throughout the contract period and be undertaken in cooperation with local health authorities and non-government organisations involved in campaigns directed at such diseases.

The Contractor shall employ the services of an internationally recognised organisation with particular experience in this field to supervise the programme. The Duties shall include, but are not limited to the following:

(a) Formulate and implement an information and education programme in collaboration with local health authorities, non-government organisations and in accordance with the policy and practice of the National Aids Programme (NAP)

(b) Meetings with the contractor's workforce and local population to disseminate current information on the subject

(c) Individual or group counselling, distribution of literature and posting of notices

(d) Review the programme every 6 months with recommendations for any improvements.

The Contractor shall submit, within 56 days from receipt of the Letter of Acceptance, details of the programme for the approval of the Engineer.

Temporary accommodation, transport, education facilities, visual aids, computers, printing and photocopying facilities, literature, pamphlets, leaflets, posters and other requirements for the implementation of the programme shall be provided by the Contractor.

The Contractor shall also provide its workforce with suitable means of protection against socially transmitted diseases.

9.9.3 MEASUREMENT

Measurement of this programme shall be by the month and shall be dependent on the fulfilment by the Contractor, to the satisfaction of the Engineer, of the provisions of this section of the Specifications.

Measurement shall commence on the approval of the programme by the Engineer and shall cease on the expiry of the time for completion of the whole of the Works as defined by Clause 43 and 44 of the Conditions of Contract.

If in the opinion of the Engineer, the service provided by the Contractor at any stage becomes inadequate, measurement for payment will cease, to be recommenced when the Engineer is satisfied that satisfactory service has been reinstated.

9.9.4 PAYMENT

Payment for this programme shall be made at the unit price per month for this item and shall be deemed to be full compensation for personnel, mobilisation costs, transport, accommodation, education facilities, equipment, material and incidentals required.

An extra over item is provided, as a percentage (to be inserted at bidding up to a maximum of 20%) of the fixed rate, for all the Contractor's administrative costs, including overheads and profit.

Payment will be made under the following items:

Item Ref	Description	Unit of Measurement
9.9(1)	Socially transmitted diseases information and education programme	Month
9.9(2)	Extra over item 9.9(1)	Month

CONSTRUCTION SPECIFICATION

Section 10
Daywork

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10 DAYWORK

10.1 DAYWORK

10.1.1 DESCRIPTION

This work consists of furnishing of labour, materials and equipment to carry out specific activities as instructed by the Engineer, in accordance with the provisions of Sub-Clause 52.4 of the General Conditions on a daywork basis.

10.1.2 GENERAL REQUIREMENTS

In accordance with the provisions of Sub-Clause 52.4 of the General Conditions the Engineer may instruct that varied work be undertaken on a daywork basis.

Work shall not be executed on a daywork basis except by written order of the Engineer.

The rates entered against the various items of the Daywork Bill shall apply to any quantity of work ordered by the Engineer. Quantities of work indicated against items of the Daywork Bill are nominal, and the extended total of the Daywork Bill, carried forward to the summary, is Provisional and may be expended as a whole, in part, or not at all, at the decision of the Engineer. Payments for daywork shall be subject to the price adjustment in accordance with the provisions of Clause 70 of the General Conditions.

10.1.3 MEASUREMENT

10.1.3.1 Labour

In calculating payment due to the Contractor for execution of daywork, the hours for labour will be reckoned from the time of the arrival of the labour at the job site to execute the particular item of daywork, to the time of departure from the job site, but excluding meal breaks and non-working periods.

Only the time spent working by those classes of labour directly engaged in the daywork ordered by the Engineer, and who are considered competent, by the Engineer, to perform such work, will be measured. The time of local gangers actually doing the work with the gangs will also be measured, but not the time spent by foremen or other supervision personnel.

The Contractor shall be entitled to payment in respect of the total time that labour is employed on daywork, calculated at the basic rates entered in the Daywork Bill.

The rates for labour shall be deemed to cover all costs to the Contractor including (but not limited to) the amount of wages paid to such labour, transportation time, overtime, subsistence allowances, and any sums paid to or on behalf of such labour for social benefits in accordance with local law, as well as Contractor's profit, overheads, superintendence, liabilities and insurance and allowance to labour, timekeeping and clerical and office work, the use of consumable stores, water, lighting and power; the use and repair of staging, scaffolding, workshops and stores, portable power tools, manual equipment and tools; supervision by the Contractor's staff, foremen and other supervisory personnel; and charges incidental to the foregoing.

The rates are stated in United States Dollar, but payment will be made in the same portions of United State Dollar and other currencies as are defined in Sub-Clause 72.2 of the General Conditions.

10.1.3.2 Materials

The Contractor shall be entitled to payment in respect of materials used for daywork (except for materials for which the cost is included in the percentage addition to labour costs as detailed heretofore), at the rates entered in the Daywork Bill in respect of materials and shall be deemed to include overhead charges and profit as follows;

(a) the rates entered in the Daywork Bill for materials shall be deemed to include provision freight, insurance, handling expenses, damage, losses, etc., and shall provide for delivery to store for stockpiling at the Site. The rates are stated in United State Dollars but payment will be made in the same portions of United State Dollars but payment will be made in the same portion of United State Dollars and other currencies as are defined in Sub-Clause 72.2 of the General Conditions.

(b) the cost of hauling materials for use on work ordered to be carried out as daywork from the store or stockpile on the Site to the place where it is to be used will be paid in accordance with the terms for labour and constructional equipment.

10.1.3.3 Constructional Equipment

The Contractor shall be entitled to payments in respect of constructional equipment already on Site and employed on daywork at the basic rental rates entered in the Daywork Bill in respect of constructional equipment.

The said rates shall be deemed to include due and complete allowance for depreciation, interest, indemnity and insurance, repairs, maintenance, supplies, fuel, lubricants, and other consumables, and all overhead profit and administrative costs related to the use of such equipment. The cost of drivers, operators and assistants will be deemed to be included in the rates entered for constructional equipment.

In calculating the payment due to the Contractor for constructional equipment employed on daywork, only the actual number of working hours will be eligible for payment, except that, where applicable and agreed with the Engineer, the travelling time from the part of the Site where the construction equipment was located when ordered by the Engineer to be employed on daywork and the time for return journey thereto shall be included for payment.

The basic rental rates for constructional equipment employed on daywork are stated in United State Dollars but payments to the Contractor will be made in same portions of United State Dollars and other currencies defined in Sub-Clause 72.2 of the General Conditions.

10.1.4 PAYMENT

Pay items shall be as follows:

a) Labour

Item Ref.	Description	Unit
10.1(1)	Ganger	Hours
10.1(2)	Skilled labourer (tradesman)	Hours
10.1(3)	Unskilled labourer	
10.1(4)	Mason	Hours
10.1(5)	Carpenter	Hours
10.1(6)	Steel Fixer	Hours
10.1(7)	Driver - vehicle up to 10t	Hours
10.1(8)	Driver - vehicle over 10t	Hours
10.1(9)	Equipment operator, crane	Hours
10.1(10)	Equipment operator, tractor, loader, excavator, grader, etc	Hours

b) Materials

Item Ref.	Description	Unit
10.1(100)	Cement, ordinary Portland or equivalent in bags	Tonne
10.1(101)	Steel reinforcement grade 300 plain round	Tonne
10.1(102)	Steel reinforcement grade 400 deformed	Tonne
10.1(103)	Coarse concrete aggregate (nominal 19 mm)	Cubic Metre
10.1(104)	Fine concrete aggregate	Cubic Metre
10.1(105)	Sand	Cubic Metre
10.1(106)	Crushed Rock Basecourse	Cubic Metre
10.1(107)	Laterite	Cubic Metre
10.1(108)	Lime	Tonne
10.1(109)	Bitumen, Pen grade 60/70	Tonne
10.1(110)	Bitumen, Pen grade 80/100	Tonne
10.1(111)	Bitumen Emulsion	Tonne
10.1(112)	Sealing Aggregate, 19 mm	Cubic Metre
10.1(113)	Sealing Aggregate, 12 mm	Cubic Metre
10.1(114)	Crusher dust	Cubic Metre
10.1(115)	Rock Riprap Class A	Cubic Metre
10.1(116)	Rock Riprap Class B	Cubic Metre
10.1(117)	Rock Riprap Class C	Cubic Metre
10.1(118)	RC Pipes, 800 mm dia	No.
10.1(119)	RC Pipes, 1000 mm dia	No.
10.1(120)	RC Pipes, 1200 mm dia	No.
10.1(121)	RC Pipes, 1500 mm dia	No.

c) Constructional equipment

Item Ref.	Description	Unit
10.1(200)	Dozer with blade and ripper, min 55 kW	Hour
10.1(201)	Dozer with blade and ripper, min 100 kW	Hour
10.1(202)	Motor Grader, min 100 kW	Hour
10.1(203)	Wheeled Loader, min 2 cu-m capacity bucket	Hour
10.1(204)	Excavator, up to 1 cu-m capacity bucket	Hour
10.1(205)	Roller, vibratory, smooth drum, min 10 tonnes	Hour
10.1(206)	Roller, vibratory, pad-foot, min 10 tonnes	Hour
10.1(207)	Roller, vibratory, smooth drum, min 1.5 tonnes	Hour
10.1(208)	Roller, pneumatic tyred, min 15 tonnes	Hour
10.1(209)	Backhoe/Loader, min 0.5 cu-m capacity loader bucket	Hour
10.1(210)	Dump truck, min 6 cu-m capacity	Hour
10.1(211)	Flat-bed truck, min 10 tonnes capacity	Hour
10.1(212)	Low Loader truck and trailer, min 40 tonnes capacity	Hour
10.1(213)	Water Tanker with spraybar, min 6,000 l capacity	Hour
10.1(214)	Bitumen Distributor, with spraybar, min 6,000 l capacity	Hour
10.1(215)	Mechanical Road Broom	Hour
10.1(216)	Chip spreader (self mobile or lorry-mounted), minimum spread width 3 m	Hour
10.1(217)	Water Pump, min 100 mm dia	Hour
10.1(218)	Mobile Crane, min 25 tonnes capacity	Hour
10.1(219)	Concrete mixer, min 1 cu-m capacity	Hour