



Standard Specifications for Roads & Bridges



**STANDARD SPECIFICATION
FOR
ROADS AND BRIDGES**

This Specification is intended to amplify the requirements of the Contract and nothing therein contained shall detract from anything contained in the Conditions of Contract, nor relieve the Contractor of any of his obligations under the said Conditions.

The Conditions of Contract and the Drawings shall be read in conjunction with this Specification and matters referred to, shown or described in either of the former are not necessarily repeated in the latter.

Notwithstanding the sub-division of this Specification under different headings, every part of it shall be deemed supplementary and complementary to every other part and shall be read together in so far as it may be practicable so to do.

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PART I

ROADS

NOTE

The dates quoted for British or American specifications whether BS, AASHTO or ASTM, are of the latest issues current at the time this Standard Specification was published. Any references to amendments, later issues or substitute specifications relevant to the Contract are given in the Special Specification of Particular Application.

ABBREVIATIONS

BS	British Standard, published by the British Standards Institution.
AASHTO	Standard Specification for Transportation Materials and Methods of Sampling and Testing adopted by the American Association of State Highway and Transportation Officials.
ASTM	Standard Specification adopted by the American Society for Testing and Materials.
HSFG	High Strength Friction Grip (Bolts).
CBR	California Bearing Ratio.
SWA	Steel Wire Armoured.
DIN	Deutsche Industrie Norm (German Standard).
RPM	Revolutions per Minute.

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GENERAL

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The Employer will make available the land required for the permanent Works as indicated on the Drawings. The Contractor must make his own arrangements for any land required for any other working areas outside the boundaries of the Works and the Employer will not accept any liability in connection with such land.

R1 02 NOTICE OF OPERATIONS

No important operation shall be carried out without the consent in writing of the Engineer or without full and complete notice, also in writing, being given to him sufficiently in advance of the time of the operation, so as to enable him to make such arrangements as he may deem necessary for its inspection.

R1 03 INFORMATION WHERE WORK IS INTENDED

The Contractor shall from time to time supply the Engineer's Representative with up-to-date copies of his main works programme and full information of the location of the sources of all materials. The Contractor shall also supply to the Engineer's Representative a daily programme of the work intended to be carried out the following day. This programme shall be in the hands of the Engineer's Representative by 17.00 hours, so as to enable him to make such arrangements as he may consider necessary for inspection.

R1 04 SETTING OUT

The Contractor shall verify the existence of all Permanent Ground Markers as are applicable to the Works and shall notify the Engineer's Representative of the absence of any of the markers within one week of taking possession of the Site. The Engineer's Representative will then provide the necessary information to enable the Contractor to replace any missing Permanent Ground Markers.

If subsequently during the Contract any of the Permanent Ground Markers become displaced the Contractor must then re-establish those that are still applicable, as directed by the Engineer's Representative, immediately at his own expense. The Contractor shall provide at his own expense stakes and such other material as required by the Engineer's Representative. Spacing of the final setting out stakes shall be as directed by the Engineer's Representative but normally not more than 20m apart, unless authorised by the Engineer's Representative because of a flat terrain or other special circumstances.

The Contractor shall thereafter, in accordance with the information included in the Contract, set out, mark and maintain on Site all references for the alignment, crosssections, bench marks and readily identifiable markers necessary for the setting out and checking of the Works. Subject to the checking of and any correction by the Engineer's Representative the Contractor shall keep permanent schedules and drawings of such information which he shall supply to the Engineer's Representative as the setting out proceeds.

Where setting-out markers are likely to be disturbed during the progress of the Works the Contractor shall temporarily transfer such markers to an adjacent point. The Engineer's Representative shall be immediately informed of such changes, including subsequent

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Re-establishment of these markers, and given full details of the relative position of the points.

Any changes in the stakes and marks caused by the development of construction shall not be made the basis of any claim for payment. Any relevant stakes or marks destroyed shall be replaced by the Contractor at his own expense.

The Contractor shall give the Engineer's Representative not less than 24 hours' notice of his intention to set out or give levels for any part of the Works, in order that control lines and grades may be furnished and checked and the necessary measurements made for record and payment with the least inconvenience to the Engineer's Representative and delay to the Contractor.

The Contractor shall, as a contingency of the Contract and without extra charge provide all necessary instruments (as specified for the Contract), appliances, labour and any other materials or staging which the Engineer's Representative may require for checking the setting out.

Upon the completion of the Contract the instruments will remain the property of the Contractor. Any survey marks made by the Engineer or the Engineer's Representative shall be carefully preserved. Working shall be suspended for such times as necessary for checking the lines on any part of the Works.

The horizontal alignment of highways or structures shall be set out from a base using the National Grid or from any other grid or base line used in the design, including any Survey Control Points which have been established on the ground and/or marked on the Drawings.

Structures shall be set out using the Structure Setting-out lines and where shown on the Drawings the clearances from existing topographical features.

The associated changes and/or co-ordinates and skew angles shall be checked by the Contractor. Where clearances from existing features are not shown on the Drawings the changes and/or co-ordinates and skew angles shall be used.

RI 05 APPROVAL OF SOURCES AND TYPES OF MATERIAL AND PLANT

As soon as possible after the Contract has been awarded, the Contractor shall submit to the Engineer a list of the suppliers from whom he proposes to purchase the materials, manufactured articles and machinery necessary for the execution of or incorporation in the Works. Each supplier must be willing to admit the Engineer or his representative to his premises during ordinary working hours for the purpose of obtaining samples of the materials in question. Alternatively, if required by the Engineer, the Contractor shall deliver the samples of the materials to the Engineer's Office. Samples shall be taken in accordance with the relevant British or American Standard where applicable. Materials subsequently supplied shall conform within any specified tolerances to the quality of samples which have been approved by the Engineer.

No material shall be used which is not obtained from a source approved by the Engineer. Approval of a source does not mean that all material in the source is approved.

The Contractor shall, before placing any order for materials, manufactured articles and machinery for the execution of or incorporation in the Works, submit for the approval of the Engineer as soon as possible after the Contract has been awarded a list of the names of the firms from whom he proposes to obtain such materials, etc. together with a list of the materials, manufactured articles and machinery which he proposes that the firms should supply.

No materials, manufactured articles or machinery shall be ordered or

obtained from any firm of which the Engineer shall not have previously approved in writing.

The information regarding the names of the suppliers may be submitted at different times, as may be convenient, but no sources of supply shall be changed without the Engineer's prior approval.

When any material or article is required to comply with a British Standard, such material or article or its container shall bear the stamp of the registered certification trade mark of the British Standards Institution. Alternatively, the Contractor shall submit to the Engineer test certificates furnished by the supplier or manufacturer of the material or article indicating compliance with the relevant British or American Standard.

R1 06 OFFICES FOR THE ENGINEER'S REPRESENTATIVE

The Contractor shall provide and maintain until three months after the issue of the Certificate of Completion and to the satisfaction of the Engineer for the use of the Engineer's Representative and his staff, approved central offices, portable offices, field laboratory buildings and residential provisions as specifically outlined in the Special Specification of Particular Application. Proper sanitary accommodation and washing facilities with an efficient water supply shall also be provided and the Contractor shall make all necessary arrangements, subject to the approval of the Engineer's Representative, for the use of any land required outside the areas indicated on the Drawings as being made available by the Employer for the execution of the Works.

During the currency of the Contract the Contractor shall supply all fuel, water, heating and cooling facilities, electric light, attendants, etc. required and make arrangements for the office being regularly and properly cleaned. Provision shall be made for an office telephone on an independent line where this is reasonably practicable. All equipment, furnishings, etc. shall be subject to the approval of the Engineer's Representative.

Unless otherwise specified in the Special Specification of Particular Application, upon the completion of the Contract all buildings and furnishings provided for the Engineer's Representative and his staff shall become the property of the Contractor, and shall be removed by the Contractor and the site made good and left clean and tidy.

Should the Contractor continue to work on the Site for maintenance purposes longer than three months from the issue of the Certificate of Completion, the Engineer may require any of the offices with any or all the equipment, supplies and furnishings to remain for occupation for as long as the Contractor is on the Site.

R1 07 TRANSPORT FOR AND ASSISTANCE TO THE ENGINEER'S REPRESENTATIVE

Within one month after the issue of the order to commence the Works, the Contractor shall provide the motor vehicles as specifically outlined in the Special Specification of Particular Application. Until these vehicles are accepted, the Contractor shall supply the same number of temporary vehicles to the Engineer's Representative and his staff, day and night as required. Fuel for the use of the vehicles on all necessary journeys in the vicinity of the Works shall be provided by the Contractor. The vehicles shall be taxed and insured by the Contractor for use by any authorised person holding a current driving licence and shall be free from any display or marking indicating the name of the Contractor. The Contractor shall also make available a driver at such times and for such durations as

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instructed by the Engineer's Representative. In the event of any vehicle being off the road for maintenance or on account of breakdown, the Contractor shall provide a substitute vehicle at no further charge.

Upon completion of the Contract all vehicles shall become the property of the Employer.

The Contractor shall, as and when required, provide experienced chainmen, information and assistance. He shall also supply and maintain approved pegs, markers, poles and other apparatus as required for checking the setting out of the Works, measuring up, ascertaining the quantities or qualities of the materials supplied and for the proper supervision, inspection and testing of the Works at every stage and for any purpose in connection with the Contract.

Particulars of assistance to the Engineer's Representative, including medical services and a list of the major instruments and other equipment, will be as specifically outlined in the Special Specification of Particular Application.

Upon completion of the Contract such instruments and equipment will remain the property of the Contractor.

R1 08 LIVING ACCOMMODATION, SHEDS AND STORES

The Contractor shall provide and maintain all such living accommodation, shelters, sheds and stores as are necessary for the execution of the Works, including the provision and maintenance of simple, unfurnished living accommodation, as specified in the Special Specification of Particular Application, to meet the needs of the Employer's daily-paid staff and shall make his own arrangements, subject to the approval of the Engineer's Representative, with the land owner of any land required.

R1 09 TEMPORARY TRAFFIC SIGNS

The Contractor shall erect and maintain on all works on highways and at prescribed points on the approaches to the Works all traffic signs and barriers necessary for the direction, protection and control of traffic and the size of all such signs and the lettering and wording thereon shall be approved by the Engineer's Representative before erection. The signs and barriers shall be illuminated by night either by flares or by other means.

R1 10 SITE FOR PLANT

The Contractor shall select and arrange for the use of sites for all central mixing plants for concrete, bituminous mixtures or the deposit of materials and/or the storage of plant. Before any land in the possession of the Government is used for a central mixing depot, the Engineer's Representative's consent shall be obtained in writing and upon the completion of the Contract, or before then if required by the Engineer's Representative, the plant shall be removed and all damage made good.

R1 11 RESPONSIBILITY OF CONTRACTOR

Where the approval of the Engineer or the Engineer's Representative is required under this Specification such approval shall not relieve the Contractor of his duties or responsibilities under the Contract.

R1 12 ACCESS TO CONTRACTOR'S RECORDS

The Engineer or the Engineer's Representative shall at all times have full access to the Contractor's time book and may check daily the time of any extra works with the Contractor's timekeeper or other person; but the fact of his agreeing upon any time shall in no way bind the Engineer to value the work other than by measurement.

R1 13 MAINTENANCE OF TRAFFIC

The Contractor shall provide, maintain and remove on completion of the Works, all temporary ramps, kerbing and traffic signs when it is necessary to divert traffic.

The Contractor shall be responsible for the maintenance of traffic flow on all public highways affected by the Works, providing an effective width wherever practicable of at least 6m. Single way traffic should be avoided as far as possible, but in the event of it becoming necessary on any particular length, the Contractor shall provide a width of at least 3m, arrange for traffic control by signals or flagmen and provide passing bays of agreed length at distances apart not exceeding 100m.

R1 14 REMOVAL OF OBSTRUCTIONS

The Contractor shall, if required by the Engineer or by Engineer's Representative, take away and remove all obstructions, obstacles, matters and things, whether concealed or not, which may be found or may be put on the Site, or on the adjacent land, or the approaches thereto, and which there may be occasion to remove for, or in connection with, the construction, excavation, completion or maintenance of the Works.

R1 15 TEMPORARY WORKS

The Contractor shall provide, maintain and remove on completion of the Works all temporary roadways, bridges, sleeper tracks and staging, etc. over roads, streams or unsuitable ground and he shall make them safe and suitable in every respect to carry all plant required for the Works, or for providing access or for maintaining diverted through traffic, or for any other purpose. The roadways, bridges, sleeper tracks, staging, etc. shall be constructed and maintained to the satisfaction of the Engineer, but the Contractor shall nevertheless be responsible for damage done to or caused by these temporary works.

Temporary bridge structures, where required on any site, shall be designed by the Contractor to carry the greater of the following alternative live loading and details shall be submitted to the Engineer for approval as Clause R1 16.

- (a) Live loading equivalent to the capacity of the existing bridge structure, if any, which is to be replaced.
- (b) Live loading equivalent to 50% of the standard loading for highway bridges, adopted by the Government of Iraq.

Carriageway widths on temporary bridges may be 3m single lane where approved arrangements are made for the proper direction and control of traffic at all times; otherwise the carriageway width shall be 6m double lane.

The Contractor shall make all necessary arrangements with and obtain permission from the authorities or land owners concerned before constructing temporary works and he shall obtain the approval of such works from the Engineer's Representative, but such approval will not relieve the Contractor of his responsibility.

General

Where no specific provision is made in the Bill of Quantities for any work of a temporary nature then it shall be considered as covered by the rates entered against other items in the Bill of Quantities.

R1 16 TEMPORARY STAGING FOR STRUCTURES

Temporary works, including staging or falsework, shall be provided by the Contractor to enable the construction of structures according to the approved erection programme. The staging, etc. shall be properly designed and constructed for the loads which it will be required to support.

The Contractor shall submit to the Engineer for his approval duplicate copies of complete drawings and calculations relating to strength and anticipated deflections of all temporary works and stagings he proposes to carry out or erect. Such details shall be submitted not less than eight weeks before the Contractor proposes to put such work in hand and he shall not commence the proposed work without the prior approval of the Engineer.

The approval of the Engineer shall not relieve the Contractor of his responsibility for the adequacy of such works or any of his liabilities or obligations under the Contract in respect of such temporary works or stagings.

R1 17 PROTECTION OF PROPERTY AND BUILDINGS

The Contractor shall take every precaution to preserve from damage any property, including buildings, fences, roads, paths, trees and shrubs, which is situated on or near the site of the Works and shall not demolish or remove any property except on the specific instruction of the Engineer or the Engineer's Representative. Where any building and property is in close proximity to the Works (including any trench, excavation, demolition or pumping operation) the Contractor shall support, shore or otherwise protect such buildings and property and shall be responsible for the making good of any damage which in the opinion of the Engineer is attributable to or in consequence of the carrying out of the Works. The Contractor's responsibilities under this Clause shall include the repair of any damage which in the opinion of the Engineer has been caused by subsidence or vibration.

R1 18 PROTECTION OF OR ALTERATION TO EXISTING WORKS OR SERVICES

The Contractor shall be entirely responsible for locating the position of all services, including telephone and telegraph lines, power lines, cables, sewers, oil and water pipelines, irrigation pipes and channels, and railway tracks, and their appurtenances, etc. All services which are encountered in the Works shall be adequately supported, slung up, strutted or otherwise protected from injury to the satisfaction of the person or the authority in whom they may be vested. Where existing land drains or irrigation culverts or ditches cross the site of the Works the Contractor shall take such steps as the Engineer considers necessary to maintain the flow of water as required along its existing course.

Except where shown on the Drawings included in the Contract or directed by the Engineer's Representative, the Contractor shall not alter or in anyway interfere with existing works or services. Where such works are required to be moved on account of unsuitable levels or situation, adequate notice is to be given to the Engineer's Represen-

tative who will arrange with the department or authority concerned for the work to be carried out. Where the Engineer requires the Contractor to move existing works or services or to execute work in connection therewith, the cost of such work, if not already provided for, will be paid on a daywork basis.

Wherever public utility services can be permanently diverted without temporary diversion at an interim stage of the Works, the Contractor shall programme his works accordingly. Should the Contractor prefer to order a temporary diversion to facilitate his programme, he shall bear all charges in respect of such temporary diversion. Where the permanent works cannot be completed without temporary service diversions, such temporary diversions will be ordered by the Engineer's Representative.

Any information supplied by the Engineer or the Engineer's Representative to the Contractor as to the presence or position of the apparatus of a department of authority or other services has been obtained from the respective authorities, etc. or from site inspection. No guarantee can be given as to the accuracy or completeness of this information, but this shall not relieve the Contractor of any of his obligations under the Contract. No excavation in the vicinity of services shall be commenced until the authority concerned has been notified and if practicable, their representative has been notified by the Engineer's Representative to be available for supervision of carefully-dug trial pits or trenches.

The Contractor will not be entitled to any additional payment as a result of delays occasioned by the alteration of existing works or services.

R1 19 PROTECTION OF WORKS FROM WEATHER

The Contractor shall, at his own expense, carefully protect from effect by weather all work and materials which may be damaged or affected thereby. Should any work be so damaged or affected, it shall be remedied or removed and new work substituted at the Contractor's expense, all to the Engineer's or Engineer's Representative's satisfaction.

R1 20 CLEANSING OF HIGHWAYS

The Contractor shall adopt an effective method of road cleansing control to avoid the deposit of mud or soil on highways adjacent to or on roads leading to the site of the Works or from vehicles or other plant used in connection with the Works. The Contractor shall remove and cart away at his own expense any mud or soil immediately it is deposited on highways and continue to maintain all such roads in a clean condition.

R1 21 PROGRESS PHOTOGRAPHS

When specified in the Special Specification of Particular Application progress photographs showing the progress of the Works each month and of the finished Works upon completion of the Contract shall be furnished in the kind and amounts so specified. The cost of this service shall be borne by the Contractor unless an item for such is placed in the Bill of Quantities.

General

R1 22 FILLING IN HOLES AND TRENCHES

The Contractor, immediately upon completion and examination of any work, shall at his own expense fill up all holes and trenches which may have been made or dug, level the mounds or heaps of earth that may have been raised or made and clear away all rubbish that may have become superfluous or have been accumulated or made in the execution of such work.

**R1 23 UNIT PRICES BID WHEN EXTENDED TO COVER CORRESPONDING
WORK PERFORMED AND TO COVER ALL COSTS OF THE CONTRACT
OF EVERY KIND AND NATURE**

The attention of the Contractor is drawn to the limited number of tender items in the Bill of Quantities and to the need of covering all costs of the works of every kind and nature in the said Tender items. No claims for extra payment will be considered except as specifically provided in the Contract Documents.

SECTION R2

Clearing And Grubbing-Up

R2 01SCOPE

The work covered by this Section of the Specification consists in the furnishing of all equipment and labor and in performing all operations in connection with demolition, clearing and grubbing-up including right-of-way areas and borrow areas, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the directions of the Engineer's Representative.

The Contractor shall demolish, break up and remove all buildings, structures and superficial obstructions on the Site in the way of or otherwise affected by the Works. He shall clear each part of the Site at times and to the extent required or approved by the Engineer's Representative.

Underground structures and chambers shall be demolished to the depths shown on the drawings. They shall be properly cleaned out and filled with suitable material, as defined in Clause R5 02-4 and compacted in compliance with Clause R5 11-4. Disused soil and surface water drains within 90cm of formation level shall be removed and trenches shall be backfilled in accordance with Clause R421.

Subject to the provisions of Clause 34 of the Conditions of Contract all materials arising from site clearance which are surplus to or unsuitable for use in the Works shall become the property of the Contractor and shall be disposed of by him either off the Site to his tip, or if agreed by the Engineer's Representative, on the Site in an approved manner.

R2 02 CLEARING

The roadway and borrow areas outside the standard right-of-way width shall be cleared of all trees, hedges, stumps, bush, existing structures, fences, mud-walls, debris from scarifying and removal of existing pavements, or other rubbish, except for such trees, or other vegetation designated on the Drawings, or directed by the Engineer's Representative, for preservation. The Contractor shall perform no clearing operations until he receives specific instructions in writing from the Engineer's Representative as to the performance of this work. Trees or shrubs outside roadway excavations or elsewhere to be left in place shall be protected from injury during construction operations.

Bushes, undergrowth, small trees the trunks of which are less than 30cm in girth at 90cm above ground level, tree stumps less than 10cm diameter and hedges shall be uprooted and burnt or otherwise disposed of.

R2 03 Grubbing –Up

In roadway excavation areas all stumps and roots shall be completely removed and all structures, walls, or other objectionable matter other than soil shall be removed within a depth of at least 60cm below formation level and side slopes and within a depth of at least 30cm below bank slopes. Any parts of structures below these levels shall be cleared out, walls and floors punctured in order to prevent retention of water and the whole filled solidly with approved material and compacted to the satisfaction of the Engineer's Representative. All stump and root holes shall be backfilled with approved material and compacted to the same density as the surrounding material.

Borrow areas and excavation areas from which fill material will be taken shall be grubbed-up to remove all heavy grass, weeds or other vegetable growth, and all stumps, roots or other objectionable matter removed completely to exclude such matter from the materials to be used in construction.

Embankment areas shall be grubbed free from heavy grass, weeds or other vegetable matter to sufficient depth to enable a minimum depth of 90cm of filling from formation level, or to suit such depth of filling as otherwise directed by the Engineer's Representative to suit the material and site conditions.

All stumps and roots shall be completely removed and all structures and walls treated as outlined in Clause R203-1. All stump and root holes shall be backfilled with approved material and compacted to the same dry density as that of the surrounding material.

All stumps within the right-of-way, but outside the excavation or embankment area, shall be removed to a depth of at least 30cm below the original ground surface and the stump holes backfilled with approved material so that the ground surface will be uniform.

Where any material below the natural ground level under embankment or below formation level in cuttings is required to be excavated, it shall be removed to such depth and over such areas as are shown on the Drawings or as the Engineer's Representative shall direct.

The presence of short grass with up to only 10cm of topsoil in areas under embankment, except when removed under Clause R2 03-3 above, will not necessitate removal and replacement with compacted backfilling unless directed by the Engineer's Representative.

Any removal, without instructions from the Engineer's Representative of up to 10cm of such topsoil in embankment areas and backfilling to original ground level and compacting in accordance with Section R5 will be deemed to be included under this item and the quantity will be excluded from excavation or filling measurement.

Topsoil as defined in Clause R5 02-4 and its removal to any specified depth for retention for later use as a surface soil for seeding and the growth of grass will only occur when shown on the Drawings or directed by the Engineer's Representative. The site clearance shall include the removal of any sterile-salt layer.

R2 04 DISPOSAL

All materials arising from site clearance and grubbed-up matter shall directed by the Engineer's Representative.

R2 05 PAYMENT

Payment will be made for works in this Section in accordance with the measurement of the appropriate items in the Bill of Quantities and shall constitute full compensation for furnishing all equipment and labour and for performing all operations necessary to complete the work in accordance with this Section of the Specification.

SECTION R3

REINFORCED CONCRETE PIPE CULVERTS

R3 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour and in performing all operations in connection with constructing reinforced concrete pipe culverts, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and applicable drawings.

R3 02 MATERIALS

1. Precast Reinforced Concrete Pipes with dimensions, materials and manufacture shall comply as follows:—

2. **Cement:** Portland cement shall conform to the requirements of BS12 Part 2 (1971) Portland cement (ordinary and rapid-hardening) or to the requirements of BS4027 Part 2 (1972) Sulphate resisting Portland cement or AASHTO M85-74 Type V for High Sulphate Resistance Cement. Unless otherwise specified on the Drawings or in the Special Specification of Particular Application Type V, High Sulphate Resistant Portland Cement, as AASHTO M85-74 shall be used.

3. **Steel Reinforcement:** Reinforcement may consist of steel wire, fabric or bars conforming to the following standards:

BS4449 (1969). Hot Rolled Steel Bars for the Reinforcement of Concrete.

BS4483 (1969). Steel Fabric for the Reinforcement of Concrete.

AASHTO M32-74. Cold Drawn Steel Wire for Concrete Reinforcement.

AASHTO M55-73. Welded Steel Wire Fabric for Concrete Reinforcement.

AASHTO M31-74. Deformed and plain Billet Steel Bars for Concrete Reinforcement.

4. **Aggregate:** Aggregates shall conform to the requirements of the structural concrete section of this Specification, except that the requirement for grading need not apply.

5. **Mixtures:** The aggregates shall be so sized, so graded and proportioned, and thoroughly mixed in a batch with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test requirements. In no case, however, shall the proportion of Portland cement in the mixture be less than 7 standard bags (350kg) per cubic metre of concrete.

R3 03 MANUFACTURING REQUIREMENTS

1. Reinforced concrete culvert pipes shall conform to the requirements of AASHTO M 170-74 except as modified herein.

2. **Dimensions and Strength Test Requirements:** Shell thicknesses, the amount of circular reinforcement and the strength per linear metre for the various sizes of pipe shall conform to the minimum requirements listed in Table R 3/1.

TABLE R3/1
REINFORCED CONCRETE PIPES FOR CULVERTS
DIMENSION AND STRENGTH TEST REQUIREMENTS

Nominal Size (1) Internal Diameter		Minimum Shell Thickness	Minimum Circular Reinforcement (2)		Minimum Strength AASHTO M170	
Cms.	Inches	Cms.	Square Cms. Per Linear Metre	Square Inches Per Linear Foot	At 0.01 Inch Crack	Ultimate Load
					Pounds Per Linear Foot	Pounds Per Linear Foot
30	12	4.0	1.7	0.08	2250	3500
37.5	15	4.5	2.3	0.11	2625	4065
45	18	5.0	3.0	0.14	3000	4500
60	24	6.0	4.2	0.20	3000	5000
75	30	7.2	5.9	0.28	3375	5750
90	36	8.4	8.0	0.38	4050	6600

(1) Nominal size for any given single pipe installation may be either the metric or imperial size but not mixed.

(2) Single line reinforcement.

3. Reinforcement: Each line of reinforcement shall be assembled into a cage, which shall contain sufficient longitudinal bars or members extending through the barrel of the pipe to maintain the reinforcement rigidly in exact shape and correct position within the form. If the splices are not welded, the reinforcement shall be lapped not less than 30 diameters for bars and 40 diameters for cold-drawn wire. If welded, the member at either a welded splice or intersection shall develop a tensile strength of not less than 3,700 kgf/cm². The spacing centres of adjacent rings of the circumferential reinforcement shall not exceed 10cm. The circumferential reinforcement shall be located midway between the inner and outer surfaces of the pipe within a tolerance of ± 6 mm.

4. Joints: The ends of reinforced concrete culvert pipes shall be the ogee or spigot and socket types and of such design that when laid the joints shall form a continuous conduit with a smooth and uniform interior surface.

5. Internal Diameter: Variations of the internal diameter shall not exceed ± 1 per cent of the nominal size specified.

6. Absorption: The water absorption of the concrete pipe shall not exceed 6 per cent of the dry weight, when tested in accordance with AASHTO T33.

7. Curing: Pipes shall be subjected to any one of the methods of curing described in the following paragraphs (1) to (3) or to any other method or combination of methods, approved by the Engineer's Representative, that will give satisfactory results, provided that no pipe shall be used within a period of 14 days after curing. All pipes shall be marked with the date of casting.

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- (1) **Steam Curing:** Pipes shall be placed in a curing chamber, free from outside draughts, and cured in a moist atmosphere, maintained at a temperature between 38 and 54°C by the injection of steam for a period of not less than 24 hours or, when necessary, for such additional time as may be needed to enable the pipe to meet the strength requirements. When a curing chamber is not available, pipes may be placed in an enclosure of canvas or other closely woven material and subjected to saturated steam at the temperature and for the time specified above. The enclosure shall be so erected as to allow full circulation of steam around the entire pipe. The interior surfaces of the curing room or canvas jackets and the surfaces of the pipes shall be entirely moist at all times.
- (2) **Water Spray Curing:** Under the conditions of enclosure prescribed in (1) above, pipes may be cured by subjecting them to a continuous or frequently applied fine spray of water in an enclosure maintained at a temperature of not less than 21°C for a period of not less than 72 hours, or such additional time as may be necessary to meet the strength requirements.
- (3) **Saturated Cover Curing:** The sides and top of each pipe may be covered with heavy hessian or other suitable material, saturated with water before applying and kept saturated with water at a temperature of not less than 21°C for 72 hours, or such additional time as may be necessary to meet the strength requirements. The ends of the pipes shall be so enclosed as to prevent the free circulation of air through or around the pipe. If the temperature of the water is less than 21°C the curing period shall be increased as may be necessary to meet the strength requirements.

8. **Workmanship and Finish:** All pipes shall be substantially free from fractures, large or deep cracks, honeycombing, open texture, spalls and surface roughness. The planes of the ends of the pipe shall be perpendicular to the longitudinal axis.

9. **Inspection:** The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, test and approval at the place of manufacture. The Contractor shall make the necessary arrangements with the manufacturer to set aside in a separate area all pipes for which he desires approval.

- (1) **Test Specimens:** Pipes for the purpose of tests shall be furnished without charge by the Contractor and will be selected at random by the Engineer's Representative, they shall be pipes which would not otherwise be rejected under this Specification. The number of sections required for test will not be more than 2 per cent except that at least one of every size will be selected.
- (2) **Test Equipment:** If the manufacturer has equipment for conducting the crushing strength test, the Contractor shall make the necessary arrangements to have the required tests conducted in the presence of the Inspector designated by the Engineer's Representative. If the testing facilities are not available at the point of manufacture, the Contractor shall make the necessary arrangements to deliver, at no cost to the Employer, the pipe sections selected by the Inspector to a laboratory approved by the Engineer.
- (3) **Re-test:** Should any of the test specimens provided in accordance with the requirements listed in paragraph (1) above fail to meet the test requirements, the Contractor will be allowed a re-test on two additional specimens for each specimen that failed, and the pipe will be acceptable only when all of these retested specimens meet the strength requirements.

10. Rejection: Pipes shall be subject to rejection on account of failure to conform

To any of the above specification requirements or on account of any of the following:-

1. Fractures or cracks passing through the shell, except that a single end crack that does not exceed the depth of the joint shall not be cause for rejection. If a single end crack that does not exceed the depth of the joint exists in more than 10 percent of the pipes inspected, however, the defective pipes shall be rejected.
2. Defects that indicate imperfect mixing and molding.
3. Surface defects indicating honeycombing or open texture and exposure of reinforcement including rust marks caused by inadequate concrete cover.
4. Spalls deeper than one half the depth of the joint or extending more than 10cm around the circumference. If spalls not deeper than one half of the joint or extending not more than 10cm around the circumference exist in more than 10 per cent of the pipes, however, the defective pipes shall be rejected.
5. Misplaced reinforcement already exposed or verified by checking with an approved concrete reinforcement cover meter.

R3 04 INSTALLATION

1. Temporary Stream Flow: The Contractor shall provide, as may be necessary, for the temporary diversion of water in order to permit installation of culverts in the dry.
2. Multiple Pipe Culverts: Where multiple lines of pipe are used, they shall be spaced far enough apart to permit thorough tamping of the earth between the pipes. To this end, the adjacent sides of the pipes shall be at least half the nominal pipe diameter apart.
3. Laying: Reinforced concrete pipes shall be laid in a trench excavated to the lines and grades established by the Engineer's Representative. The trench shall be graded to afford a firm and uniform bearing throughout the entire length of the pipe. Holes for sockets shall be dug if necessary.
Where solid rock is encountered, it shall be removed below grade and the trench backfilled with sand or gravel in such a manner as to provide a compacted earth cushion with a thickness under the pipe: of not less than 4cm per meter of height of fill over the top of the pipe, with a minimum allowable thickness of 20cm. Where a firm foundation is not encountered, due to soft, spongy or other unsuitable material, all such unsuitable material under the pipe and for a width of not less than one diameter on each side of the pipe shall be removed and the space backfilled with sand or gravel, properly compacted to provide adequate support for the pipe.
4. Bedding: Immediately following excavation of the trench, pipes shall be laid and Jointed, except when shown otherwise on the Drawings, on pipe bedding material complying with the following specification.
Pipe bedding material shall be excavated material from the pipe trench or other material having a grading within the range given in Table R3/2 and which has a compaction fraction value of 0.2 or less when tested as specified below.

TABLE R3/2
PIPE BEDDING MATERIAL

U.S. Sieve Size		Per Cent Passing by Weight
mm	Imperial	
37.5	1½in	100
19.0	¾in	95-100

The following apparatus shall be used for testing:

- (i) Open ended cylinder 25cm long and 15cm diameter.
- (ii) Metal rammer with a striking face 4cm diameter and of total weight 1 kg.

Stand the cylinder on a firm flat surface. Using a sample of material having a moisture content equal to that of the material at the time of use, pour the sample of material into the cylinder without supplementary compaction and strike off the material level with the top of the cylinder. Lift the cylinder clear of its contents and place on a fresh area of flat surface. Replace about one quarter of the material in the cylinder and tamp vigorously until no further compaction is evident. Repeat this process quarter by quarter until the whole of the material measured loose in the cylinder is compacted.

The final measurement from the top of the cylinder to the compacted surface divided by the height of the cylinder is the compaction fraction value.

Brick or hard material shall not be placed under the pipes for temporary support except when used on concrete beds as specified in Clause R4 16.

Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel, bedding material being scraped away at each socket in the case of socketed pipes so that the socket does not bear on the bed.

Where a concrete bed, haunch or surround is specified it shall be constructed to the dimensions shown on the Drawings or as Clause R4 16 with Concrete Class 230 as specified in Table B8/5, Section B8.

The method of supporting pipes and placing concrete shall be as Clause R4 16. The upper surface of the concrete shall be struck off with a wooden screed or template and neatly finished off and in no instance shall concrete be thrown directly on pipes.

5. Jointing of Pipe Culverts: Proper facilities shall be provided for lowering sections of pipe into trenches. The pipe shall be laid carefully to the lines and grades given and the sections fully and closely jointed by means of stiff cement mortar to form a durable watertight joint.

Cement mortar shall consist of one part by volume of sulphate resistant Portland cement as specified for Materials in Clause R3 02 and two parts by volume of natural sand or crushed natural stone sand or a combination of both as specified in BS1200: (1976): Building Sands from Natural Sources. The constituent materials shall be accurately gauged and mixed in an approved manner. Cement mortar shall be made in suitable small quantities only as and when required, and any mortar which has begun to set or which has been

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mixed for a period of more than 30 minutes shall be rejected. All parts of the pipe to be in contact with mortar shall be washed clean and thoroughly wetted to ensure proper bond.

When the spigot and socket type of joint is used, the first pipe (down stream) shall be bedded to establish line and grade with the socket upstream. The interior surface of the socket shall be thoroughly cleaned with a wet brush and the lower portion filled with stiff mortar of sufficient thickness to make the inner surface of the abutting sections flush and even, when the pipes are laid. The spigot end of the second pipe shall be thoroughly cleaned with a wet brush and uniformly matched into the socket so that the sections are closely fitted. The annular space in the socket shall then be filled with mortar and the inner surface of the pipe at the joint brushed smooth.

In jointing ogee pipes, the ogee or rebated joint of each pipe shall be thoroughly wetted immediately before jointing together and buttered with a layer of freshly mixed cement mortar as above. The pipes shall be brought to proper line and level and the joints thrust securely together. All surplus mortar exuding from the interior and exterior faces of the joints shall be cleaned off and every precaution shall be taken to ensure that no further movement is applied to the pipe. All pipes shall be kept free from dirt by means of a wooden disc with a rod attached being worked inside the pipe during jointing. All joints shall be protected against direct sunlight and wind.

After the pipe joints have been made and inspected, the concrete mat shall be thoroughly washed and cleaned and the remainder of the bedding concrete (and of the haunching and surrounding concrete where required) shall be placed and consolidated under and around the pipeline in such a manner as not to cause any damage or disturbance to the pipes or joints. When specifically required in the Special Specification of Particular Application, external bands at the joints shall be placed as specified therein. The completed pipe joints shall be immediately protected from air and sun with an initial covering of moist earth, sand, canvas or hessian. If not backfilled at once, the initial covering shall be kept moist for at least 48 hours. In order to prevent the mortar from setting too rapidly, the ends of the pipe shall be covered in such a manner as to prevent air flowing during the time the mortar is in a plastic condition.

In the case of larger diameter culverts the Engineer's Representative may direct that the pipes shall be fitted together tightly by a winch.

Alternatively, ogee joints may be filled with an approved preformed joint filler, in which case the inside faces of the tongue and groove shall receive a coat of approved bituminous compound immediately before jointing. The inside of the joint must then be sealed with an approved cement bitumen mix or plastic filler to the satisfaction of the Engineer's Representative.

The interior of the pipe shall be kept free from all dirt, excess mortar and other foreign material as the pipe laying progresses and ~~left~~ clean at the completion of the culvert. Any pipe which is not in true alignment, or is damaged, shall be taken up and relaid at the Contractor's expense.

No pipe shall be laid which is cracked, has internal projections, is spalled or damaged, and all such sections of pipe shall be permanently removed from the Works.

6. Backfilling of Trenches: After the final inspection of the jointing of the pipes, backfilling shall proceed immediately as specified in Clause R4 21. The bedding material, or where none is specified, the approved backfill material as specified in Clause R4 21, shall be brought up equally on both sides of the pipe, first to the level of the centre of the pipeline

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and then to a height of 30cm above the top of the pipe barrel. The bedding or backfill material, up to the level of 30cm above the top of the pipe barrel, shall be placed in layers each not more than 15cm thickness and shall be carefully compacted for the full width of the trench with unpowered hand tools. The backfill material above the level of 30cm above the pipe barrel shall be as specified in Clause R4 21 and shall be placed and compacted as specified in Section R5.

7. Construction Plant: Movement of construction equipment over a culvert shall be at the Contractor's risk. Any pipe injured thereby shall be repaired or replaced at the opinion of the Engineer's Representative and at the Contractor's cost.

R3 05 HEADWALLS

Where indicated on the Drawings, the ends of the pipe culverts shall be protected by concrete or masonry headwalls constructed as shown on the Drawings. When headwalls are constructed, the ends of the pipes shall be neatly cut off flush with the outside face of the headwalls.

R3 05A REINSTATEMENT OF ROAD SURFACES

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3 06 MEASUREMENT

1. The unit of measurement for reinforced concrete pipe shall be the actual length placed in metres, measured along the slope to the nearest 0.1m, except that no payment will be allowed for pipes placed in excess of the length ordered by the Engineer.

2. The unit of measurement for concrete in headwalls shall be the cubic metre.

3. The excavation and backfill involved in installing the pipes, including the provision and placing of sand or gravel for pipe foundations, when necessary, to provide adequate support for the pipe where a firm foundation is not encountered, as specified above, shall be measured and paid for as provided in Section R5.

R3 07 PAYMENT

Payment will be made at the price tendered, per cubic metre for excavation, at the price tendered per linear metre for reinforced concrete pipes and at the price tendered per cubic metre for concrete.

SECTION R3A

UNREINFORCED CONCRETE PIPE CULVERTS R3A 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour, and in performing all operations in connection with constructing unreinforced concrete pipe culverts, complete, subject to the terms and Conditions of Contract and in strict accordance with this Section of the Specification and the applicable Drawings.

R3A 02 EARTHWORKS

The excavation required shall be performed in accordance with Section **R5** except that the trench width shall be the net width of the pipe plus concrete surrounding as shown on the Drawings.

R3A 03 PIPES

Concrete pipes and specials shall comply with the requirements of BS556 Part 2 (1972)

Concrete cylindrical pipes using sulphate resisting cement as AASHTO M85-74 Type (V), unless otherwise provided in the Special Specification of Particular Application.

R3A 04 LAYING, BEDDING AND JOINTING PIPES

Unreinforced concrete pipes shall be laid, bedded and jointed as specified for Reinforced Concrete Pipes in Clause R3 04, except that the jointing of spigot and socket concrete pipes shall be as specified in Clause R4 17.

R3A 05 REINSTATEMENT OF ROAD SURFACES,

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3A 06 MEASUREMENT

The unit of measurement for pipe culverts shall be as follows:

1. For drainage excavation the cubic meter in accordance with Clause **R5** 16-3.
2. For the pipes the linear meter.
3. For concrete the cubic meter.

R3A 07 PAYMENT

Payment will be made at the price tendered per cubic meter for drainage excavation, at the price tendered per linear meter for pipes and at the price tendered per cubic meter for concrete.

Corrugated Metal Pipes Culverts

R3B 06 REINSTATEMENT OF ROAD SURFACES

Where the surface of any road, footpath or verge has been disturbed it shall be fully reinstated by the Contractor to the satisfaction of the Engineer's Representative and any owner concerned.

R3B 07 CLEANING PIPE CULVERTS

On completion all metal pipe culverts shall be washed with water and left clean and free from obstructions.

R3B 08 MEASUREMENT

The unit of measurement for corrugated metal pipe culverts shall be the linear metre measured in place in accordance with the applicable drawings and/or directions of the Engineer's Representative.

Sandbed where ordered by the Engineer's Representative shall not be measured separately, but shall be deemed to be included.

R3B 09 PAYMENT

Payment shall be made in accordance with the unit prices of the various items stated in the Bill of Quantities and shall constitute full compensation for furnishing all equipment, plant, materials and labour, including any necessary earthwork excavation and backfill, provision of sandbed where ordered, and for performing all operations in connection with the construction of corrugated metal pipe culverts in accordance with this Section.

SECTION R3B

CORRUGATED METAL PIPE CULVERTS

R3B 01 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all plant, equipment, materials and labour and in performing all operations in connection with constructing corrugated metal pipe culverts, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R3B 02 EARTHWORKS

The earthworks required shall be carried out in accordance with the provisions of Section R5.

R3B 03 MATERIALS

Corrugated metal pipe culverts shall be made of corrugated steel pipe in accordance with AASHTO M36-74 from steel sheets conforming to AASHTO M218-74.

The 'pipe' shape shall be circular, pipe-arch, underpass or arch appropriate for the size required and of nestable or multi-plate construction as shown on the Drawings. Multi-plate pipes shall be joined by galvanized bolts and nuts specially shaped to suit the corrugations.

Where required by the Engineer, pipes shall be supplied with a factory applied bitumen coating.

Where appropriate, pipes shall be supplied with the appropriate bevel and skew or combination thereof to suit the embankment side slope and culvert skew.

R3B 04 INSTALLATION

All pipes shall be laid, bedded and jointed in accordance with the manufacturer's recommendations, including any strutting. Where required by the Engineer's Representative the pipes shall be given an additional coating of bitumen on site, particularly at joints.

Multiple installations shall be laid with centre lines parallel. The clear distance between adjacent 'pipes' shall not be less than that recommended by the manufacturer.

Where shown on the Drawings, headwalls and wing walls shall be constructed of concrete or riprap in accordance with Clause B8 07 or Section B19, respectively.

Backfilling shall be carried out in accordance with Clause R3 04-6.

Backfilling material shall be as Clause R4 21. There shall be a cover of at least 50cm over the crown of any pipe, before construction equipment is driven over it.

R3B 05 FOUNDATION BED

The pipes shall be placed on the excavated bed which shall have a uniform density so that the pipes are uniformly supported. Compaction shall conform to the requirements of Clause R5 11-4.

Where ordered by the Engineer's Representative the pipes shall be placed on a sand bed of approved material.

SECTION R4

PIPES AND GENERAL DRAINAGE

R4 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour, and in performing all operations in connection with constructing all sewage and surface water pipe drains and gullies complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the applicable Drawings.

R4 02 GENERAL DRAINAGE PIPES

All pipes and joints for use in surface water drainage and pipe drains shall comply with the requirements of Clauses R4 03 to R4 10 inclusive unless otherwise approved by the Engineer's Representative. Pipes for service ducts shall comply with the requirements of Clause R4 11.

R4 03 CONCRETE PIPES

Concrete pipes for general drainage use shall be of the spigot and socket or ogee jointed type and shall be of approved manufacture and design and comply with the requirements of BS556 Part 2 (1972) except that they may be supplied complete with flexible joints, as supplied by the manufacturer. Unless otherwise described in the Contract, they shall be Standard pipes.

Prestressed concrete pipes shall comply with the requirements of BS4625 (1970). The cement used in the manufacture of pipes shall be sulphate resistant Portland cement, to " according to AASHTO M85 Type (V)" unless otherwise provided in the Special Specification of Particular Application. Flexible joints shall be so constructed as to tolerate 2cm of longitudinal movement without breaking the seal. They shall also tolerate deviations in any direction from a straight line not less than those given in Table R4/1.

TABLE R4/1

CONCRETE PIPE FLEXIBLE JOINT MOVEMENT TOLERANCES

Pipe Dia meter		Angle
Cm	inches	
15 - 60	6 to 24	2°
60 - 120	27 to 48	1°
over 120	over 48	0-6°

Pipes for use in trench drains shall be porous pipes of approved manufacture and design with rebated or butt joints as specified in AASHTO M1 76-73.

The Contractor shall submit to the Engineer's Representative for his approval samples of the aggregate with which the pipes are manufactured and certificates as to compliance with Section R3. The date and manufacture shall be stamped on each pipe in respect of each consignment of pipes delivered on the Site. Each batch of pipes intended to be delivered to the Site shall be available for inspection by the Engineer's Representative at the place of manufacture and such tests as the Engineer's Representative may require shall be carried out. Pipes which are not approved by the Engineer's Representative shall be immediately removed from the Site.

R4 04 CLAY PIPES

Pipes to be used for sewage or surface water shall be of approved manufacture and design or "British Standard" pipes manufactured in accordance with the requirements of BS65 and 540 Part 1 (1971) with Type 1 sockets and supplied complete with the manufacturer's flexible joint or with Type 2 sockets for cement mortar.

Flexible joints shall provide for an angular deflection of not less than 5° for diameters up to 30cm and 2½° for diameters of 37-5cm or greater, the deflection being measured as deviation in any direction from a straight line. They shall provide for a draw of 2cm of longitudinal movement without breaking the seal.

Pipes for use in the construction of French drains shall be of approved manufacture and design. Agricultural tiles or pipes shall be best well-burnt earthenware, sound, true, circular in bore, with plain ends suitable for laying with open or butt joints.

R4 05 CAST OR SPUN IRON PIPES

Pipes shall be of approved manufacture and design with spigot and socket joints and shall comply with the requirements of BS437 Part I (1970) or BS1211 (1958).

R4 06 CORRUGATED METAL PIPES

Pipes for general drainage use shall comply with the Standard Specification for Zinc Coated (Galvanized) Corrugated Iron or Steel Culverts and Under drains AASHTOM36-74.

The pipes shall be manufactured from steel complying with AASHTO M218-74. Pipes for use in French drains shall comply with the Standard Specification for Zinc Coated (Galvanized) Corrugated Iron or Steel Culverts and Under drains, AASHTO M36-74 with the exceptions stated above for pipes for general drainage use. All corrugated metal pipes of 15cm nominal internal diameter shall be manufactured from sheet of 1 • 2mm minimum thickness (18 gauge). Pipes of nominal internal diameter greater than 15cm, but not greater than 60cm, shall be manufactured of sheet 1 -6mm minimum thickness (16gauge). If the Contractor wishes to use corrugated metal pipes of larger diameter than 60cm, he shall provide the diameter and gauge of pipe required by the Engineer to suit the flow characteristics and metal gauge requirements of the design.

R4 07 PITCH FIBRE PIPES

Pipes for general drainage use shall comply with the requirements of BS2760 (1973).

The pipes shall not be used for unsupported or exposed pipelines.

Pipes for use in French drains shall be perforated and shall comply with the requirements of BS2760 (1973).

R4 08 STEEL PIPES

Unless otherwise described in the Contract, steel pipes may be of any of the types and with any of the types of joint specified in BS 534 .

R4 09 PIPES OF SYNTHETIC MATERIALS

Pipes for general drainage use shall be approved pipes of polythene, polypropylene or polyvinyl chloride.

Pipes for French drains shall be perforated or slotted with slots not wider than 1mm and holes not greater than 8mm dia., but otherwise shall comply with BS3506 (1969).

R4 10 ASBESTOS CEMENT PIPES

Asbestos cement pipes shall comply with the requirements of AASHTO M217-73.

R4 11 SERVICE DUCTS

Service ducts shall have a smooth internal bore and joined so that no silt, grit, grout or concrete surround is able to enter the duct. Pipes with push-fit joints shall have a register to ensure that the joint is fully pushed home. They shall be constructed of:

1. Un plasticized polyvinylchloride pipes complying with Class B or C of BS 3506 (1969), bedded and surrounded in Class E concrete as specified in Clause B8 09 to the dimensions shown on the Drawings, when the pipe is laid in an excavated trench.

2. Steel pipes and joints complying with BS534 (1966).

3. Internally glazed vitrified clay ducts with plastic flexible sleeve joints.

When tested in accordance with Appendix B of BS65 and 540 Part 1 (1971) the ducts shall conform to the extra strength requirements of Table .5 of BS65 and 540 Part 1 (1971).

4. Glazed earthenware pipes with Type 1 sockets with flexible joints, manufactured in accordance with the requirements of BS65 and 540 Part 1 (1971), and shall conform to the extra strength requirements of Table 5 of BS65 & BS540 Part 1.

R4 12 GULLIES

Precast concrete gullies shall be round, un reinforced, made from sulphate resistant Portland cement, and shall comply with the requirements of BS556 Part 2 (1972) unless otherwise specified in the Special Specification of Particular Application. Each pot shall have an internal diameter of 45cm, an internal depth of 90cm and a 15cm diameter outlet;

a rodding eye, stopper and chain shall be fitted to each pot. Gullies leading into foul sewers or combined foul and surface water sewers shall be trapped.

Salt glazed ware gullies shall be of approved manufacture and design or comply with the requirements of BS 539 (1971) in respect of round street gullies.

Cast iron gullies shall be of approved manufacture and weights described in the Contract.

The gully pot shall be set on a foundation of 15cm of Class 150 sulphate resistant concrete and this shall be haunched up about the bottom of the pot to a height of 45cm above the bottom of the chamber and to a minimum thickness of 15 cm. A surround of sound brickwork 12cm thick shall be formed about the top of the gully pot to form a base to receive the frame, which shall be set in cement mortar at the correct level.

Junction pipes which are laid, but not immediately connected to gullies, shall be fitted with temporary earthenware stoppers or seals, and the position of all such junctions shall be clearly defined by means of stakes or training wires properly marked and labeled.

R4 13 GULLY COVERS AND FRAMES

Gully covers and frames shall be of approved manufacture and design.

R4 14 EXCAVATION

Excavation for culverts, pipelines and drains shall be carried out in trenches and be straight and true to the lines and levels shown on the Drawings. All trenches shall be excavated to such width as will give adequate room in the trench for the proper support of the pipe, and shall be excavated to a sufficient depth and width to enable the pipe and any specified or agreed joint, bedding, haunching and surround to be accommodated. Trenches shall be of width not exceeding the outside diameter of the pipe plus 30cm up to a level 30cm above the top of the pipe barrel, but the width of trenches for lines of flexible pipes shall not be less than the outside diameter of the pipe plus 30cm.

The sides of the trenches shall at all times be adequately supported by means of waling, struts and runners or sheet piling of sufficient number and dimension to prevent the falling in, movement or slipping of the ground, injury to workmen and damage to the Works or adjacent property.

Before any pipes are laid, or concrete bed placed in the trench, the base of the excavation shall be trimmed true in cross-section and gradient and hand-rammed solid. Any part of the formation which is disturbed or damaged shall be excavated to such additional depth as may be required by the Engineer's Representative and be made up to the proper level with normal Class E Concrete as Clause B8 09 at the Contractor's expense.

Where solid rock is encountered, it shall be removed below grade and the trench backfilled with compacted sand, gravel or bedding material as specified under Bedding in Clause R3 04-4 so as to provide a compacted soil cushion with a thickness under the pipe of not less than 3cm per metre of height of fill over the top of the pipe, with a minimum allowable thickness of 20cm. Where a firm foundation is not encountered, due to soft, spongy or other unsuitable material, all of such unsuitable material under the pipe and for a width of not less than one diameter on each side of the pipe shall be removed and the space backfilled with gravel or bedding material properly compacted to provide adequate support for the pipe.

Unless otherwise specified in the Special Specification of Particular Application, where pipes are installed in new embankments, the embankment shall be constructed to a minimum height equal to the outside diameter of the pipe plus 60cm and to a width of not less than five times the diameter of the pipe. The trench shall then be excavated with vertical sides as specified above for normal pipe trenches.

R4 15 EXCAVATION TO BE KEPT FREE FROM WATER

The Contractor shall keep the trenches and other excavations quite free from water, whether affected by floods, storms or otherwise, so that the works may be constructed in dry conditions. He shall construct, as may be required by the Engineer or Engineer's Representative, such grips or channels or sub-drains at levels lower than the bottom of the permanent works to convey the water to sumps which he shall construct in positions convenient for the disposal of the liquid drained thereto. The grips, channels, sub-drains and sumps shall be constructed clear of the permanent works and shall be filled solid with Class E concrete as Clause B8 09, as the permanent work proceeds to the satisfaction of and as may be ordered by the Engineer's Representative.

The sub-drains shall be formed with agricultural pipes of adequate diameter and laid in trenches not more than 30cm wide, and the trenches shall then be filled with approved filling material as Clause R4 22. Immediately before the construction of any permanent work is commenced these trenches shall be covered with approved waterproof paper which shall lap both sides of such trenches by at least 15cm.

The Contractor shall also provide, fix, maintain and work such engines, pumps, hoses, chutes and other appliances as are necessary to keep the sub-soil or accumulated water at a level lower than the bottom of the permanent works for such periods as the Engineer's Representative shall direct. After raising the water herein referred to, the Contractor shall immediately convey it away from the Works in such a manner as not to cause any nuisance or injury.

No water shall be discharged into any watercourse or sewer without the permission in writing of the Engineer, and such permission shall not be granted unless the Contractor shall have provided to the satisfaction of the Engineer an efficient settling basin or sand trap through which all such water shall pass before discharge into the said watercourse or sewer.

The Contractor shall take care to avoid undermining any part of the Works or other properties by pumping, but should undermining occur he shall immediately make good the same to the satisfaction of the Engineer's Representative.

The costs incurred by the Contractor in complying with the requirements of this clause shall be borne by the Contractor and included in the price rates for excavation or other appropriate items.

R4 16 LAYING AND BEDDING

Pipe sewers and drains shall be correctly laid in the position indicated on the Drawings, or to such other alignment as ordered by the Engineer's Representative.

All pipes shall be laid true to line and level, each pipe being separately boned between sight rails.

Reinforced Concrete Pipes shall be laid and bedded as Section R3 unless otherwise shown on the Drawings or directed by the Engineer's Representative.

Unless otherwise directed all concrete pipes shall be laid on a concrete bed of finished thickness of at least 15cm below the barrel of the pipe and a width of at least 7.5cm greater than the external "diameter of the pipe barrel. In such cases, a concrete mat at least 7.5cm thick shall first be laid on the bottom of the trench and shall be allowed to set before pipe-laying is commenced. Where the bottom of the pipe socket is liable to touch the concrete bed, the concrete should be cut out under the pipe socket before hardening.

The Contractor shall include in his prices for providing bricks or rectangular blocks composed of Class 230 concrete made in approved moulds at least 14 days before use and approved hardwood folding wedges. Two blocks shall be provided for each pipe, one behind the socket, and shall be set and boned in to the correct level on the formation bottom and the pipe shall be laid on them and properly centered and socketed. Two hardwood folding wedges of width equal to the width of the concrete block shall then be inserted between the body of the pipe and the block and shall be driven together until the pipe is brought to the exact level required. Blocks and wedges shall then be left undisturbed while the pipes are being jointed, the pipeline tested and the concrete surround is being placed in position.

The Contractor shall be responsible for ensuring that all blocks and wedges are of sufficient size and strength to prevent settlement of the pipes and any settlement shall be made good at his own expense.

The trenches shall only be bottomed up immediately in advance of pipe laying but no pipes shall be laid until a distance of at least 10m along the trench has been prepared and bottomed up to receive the pipes, unless specially permitted otherwise by the Engineer's Representative. The trenches and joint holes shall be kept free from water until the pipes are laid, jointed and surrounded with concrete.

At every point of loading or unloading pipes or castings must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed unless the written consent of the Engineer's Representative to the method proposed has been obtained.

R4 17 JOINTING PIPES

The general specification requirements for jointing concrete pipes shall be as Clause R304-5.

1. In the jointing of spigot and socket concrete pipes a ring or gasket of twisted tarred rope yarn, in one continuous piece, shall be wound tightly and uniformly round the spigot end of the pipe, to ensure the bores coinciding all round, then inserted in the socket of each pipe previously laid and lightly caulked with a wooden caulking tool and wooden mallet.

The yarn, composed of hemp, twisted jute or oakum, when in position shall not occupy more than one quarter of the total depth of the socket. The socket shall then be carefully and completely filled with mortar made with the consistency of putty and consisting of one part of sulphate resistant cement to three parts of sand and the joint leveled off and finished smooth at an angle of 45° outside the top end of the socket.

2. Individual lengths of clay pipe to BS 65 and 540 Part 1 (1971) and of concrete pipe to BS 556 Part 2 (1972) shall, unless specified to be laid with open joints, be coupled together by means of flexible joints of a type recommended by the manufacturer of the pipe and fitted in the manner recommended by the manufacturer of the joints.

Alternatively, spigot and socket joints may be caulked as for concrete pipes.

All pipe lines jointed in the last mentioned manner shall be tested by water pressure as Clause R4 19.

3. For cast (spun) iron pipes each pipe shall be driven well home so that the spigot enters the socket to its full extent. Yarn shall then be tightly caulked into the socket leaving a uniform space all round for lead, and the joint shall then be run with molten lead according to the manufacturer's instructions.

The lead shall be melted near where the joint is to be made and shall be at an adequate temperature when poured. The metal of the pipe shall be carefully cleaned and thoroughly dried, immediately before the joint is run, and an asbestos rope or jointed clasp ring used to retain the lead. The whole of the lead shall be packed into each joint in one running.

As soon as the lead is cool, the joints shall be properly caulked with a 2kg hammer and suitable caulking tools and brought flush with the face of the socket. The caulking of the lead is not to cease when the lead is flush with the face of the socket, unless the lead be solid and perfectly tight in the joint. The jointing of pipes before lowering into the trench will not be permitted.

The jointing of spun-cast-iron pipes with proprietary joints shall be carried out to the instructions issued by the manufacturer of the joints which shall be deemed to form part of this Specification.

4. Pitch fibre pipes shall be jointed with tapered collars of pitch fibre or approved flexible joints and synthetic pipes joined with approved synthetic sleeves.

5. Corrugated metal pipes shall be jointed with connecting bands of a type recommended by the manufacturer of the pipe. The connecting bands shall be of the same gauge of metal as the pipe being used.

6. Socketed pipes shall be laid with a space of about 10mm between the spigot and the inner end of the socket. Ogee jointed porous concrete pipes and perforated clay pipes with rebated joints shall be dry jointed.

7. Perforated pitch fibre pipes may be jointed with any of the joints specified in BS2760(1973).

8. The jointing of other types of perforated pipes shall be as specified in this clause.

R4 18 CONCRETING PIPES

The concrete used for bedding, hunching and surrounding the pipe shall be made with Type V Sulphate Resistant Cement and be Class E unless otherwise provided in the Special Specification of Particular Application or unless otherwise ordered by the Engineer or Engineer's Representative.

The concrete shall be thoroughly worked into the joint holes and underside of the pipes, and shall be thoroughly compacted during the operation of placing. The Contractor shall include in his price tendered for this work the cost of any extra excavation required, for the disposal of the same and for all necessary shuttering.

Bedding concrete shall be rectangular in cross section. Concrete pipes shall be concreted as specified below, unless otherwise ordered by the Engineer or Engineer's Representative.

1. Any pipes laid in heading shall be completely surrounded with concrete to a minimum thickness of 15cm outside the barrel of the pipe.
2. All pipes and tubes laid in trench with 6m or more of cover shall be completely surrounded with concrete, as in (1) above.
3. All pipes having less than 1.1m of cover, shall be completely surrounded with concrete as in (1) above.
4. All pipes laid in trench with more than 4m of cover but less than 6m of cover shall be bedded on concrete at least 15cm thick, and shall be hunched with concrete at least 15cm thick to the horizontal diameter of the pipe, and the hunching shall be splayed above that level to meet the outside of the pipe tangentially.
5. All pipes and tubes of 45cm internal diameter and over shall, except where surrounded, be bedded on and haunched with 15cm of concrete as in (4) above.
6. Unless otherwise directed any pipe which is not surrounded or bedded and hunched shall be bedded on concrete as specified in Clause R4 16.
7. All pipes under carriageways shall be completely surrounded as in (1) above.

R4 19 TESTING AND CLEANING

1. Sealed jointed drains for foul water and cement mortar jointed pipes for surface water up to and including 45cm diameter shall be tested in sections (e.g. between manholes) immediately prior to backfilling of trenches, by filling with water under a head of not less than 1 -2m above the crown of the pipe at the high end and not more than 6m above the crown of the pipe at the low end. Steeply graded pipelines shall be tested in sections so that the above maximum head shall not be exceeded. Unless otherwise agreed by the Engineer's Representative the test shall commence one hour after filling the test section at which time the level of water at the vertical feed pipe shall be made up to produce the required 1 -2m minimum test head. The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to maintain the original water level and recording the amounts so added. The drain will have passed the test if the volume of water added does not exceed 1 litre per hour per 30m of drain per 2-5cm of nominal internal diameter. Drains failing to pass the test shall have the defects made good and be retested.
2. Drains for foul water and cement mortar jointed pipes for surface water exceeding 45cm in diameter shall be tested by means of a smoke test before they are covered up.

Both ends of the length of drain to be tested shall be sealed to the satisfaction of the Engineer's Representative and smoke shall then be pumped into the section from an approved smoke machine. Should any joint in the section show an escape of smoke the defects shall be made good and the drain retested.
3. The bore, linearity and jointing of all drains and service ducts less than 30cm diameter shall be checked by drawing through each completed length of pipe a mandrel 75cm long and 6mm less in diameter than the nominal bore of the pipe unless an alternative method of checking is agreed by the Engineer's Representative.
4. On completion of the Works, or earlier if the Engineer's Representative agrees, all pipes, manholes and drains other than french drains shall be flushed from end to end with water and left clean and free from obstructions.
5. French drains shall at all times be kept free of obstructions, both as regards the pipes and the filter material.

R4 20 CONNECTIONS TO EXISTING PIPELINES

1. Where shown on the Drawings or directed by the Engineer's Representative, existing sewers and drains shall be properly extended, connected and jointed to new sewers, culverts, drains or channels.

TABLE R4/2

RANGE OF GRADING

US Sieve Size mm Imperial		Percentage Passing by Weight	
		Type A	Type B
63-0	2 1/2m	-	100
37-5	1 1/2dn	100	85-100
19-0	3/4in	-	0-20
9-5	1/8m	45-100	0-20
3-35	No. 6	25-80	-
0-600	No. 30	8-45	-
0-150	No. 100	0-10	-
0-075	No. 200	0-5	-

When Type A material is used with perforated pipes, not more than 85 per cent shall be smaller than the diameter of the hole or 4/5ths of the width of slot in the pipe.

The fill material shall be deposited in layers each not exceeding 25cm loose depth and each layer shall be lightly compacted.

R4 23 RESTORATION OF SURFACES

After filling and compacting the excavations in the manner specified, the Contractor shall carry out the reinstatement of all damage and disturbed surfaces.

In cases where the top soil does not, in the opinion of the Engineer's Representative, differ from the sub-soil, the excavations shall be backfilled slightly proud of the adjacent undamaged surfaces, and so that the natural consolidation of the backfilled material will produce a surface flush with the adjoining undisturbed surface. Should the backfilling settle to a level lower than that of the adjoining surfaces the Contractor shall top-up the depressions as necessary or ordered by the Engineer's Representative. Should the Contractor have allowed too much surcharge or up stand in his backfilling so that after natural consolidation and settlement has occurred the backfilled material is still above of the adjoining undisturbed surfaces, the Contractor shall take such measures as the Engineer's Representative may direct to rectify the condition.

In all cases where the top soil differs from the sub-soil and in the cases of roads and other similar structures where the surface material differs from the sub-stratum, the Contractor shall immediately after the completion of his backfilling and compacting operation, form a temporary surface flush with or slightly above the adjoining undisturbed surfaces, as the Engineer's Representative may direct. The nature of the temporary surfaces shall be similar to the nature of the adjoining undisturbed surfaces and the use to which it will be put, and the Contractor shall abide by the instructions of the Engineer's Representative in this regard. After natural consolidation and settlement have occurred, the Contractor shall top-up and make good any resulting depression and he shall maintain all temporary surfaces for as long as the Engineer's Representative may direct. When the Contractor considers that the backfilled material has consolidated sufficiently to permit the placing of the permanent reinstatement on the surface, he may apply to the Engineer's Representative for permission, and should the Engineer's Representative agree to

the Contractor's proposals, the Contractor shall thereupon carry out the permanent reinstatement of the surfaces in such manner that the Engineer's Representative may direct.

All such connections shall be made during the construction of the main sewer, drain or other work and their positions recorded by the Contractor who shall daily hand to the Engineer's Representative a copy of the record of the connections made the previous day. Where pipe connections are made to a brick sewer, concrete culvert, stone built or lined channel, the pipes shall be well and tightly built into the concrete, brick or masonry work and be so placed as to discharge at an angle not greater than 60 degrees to the direction of the flow of the main sewer, drain or channel and with the end of the pipe carefully cut to the necessary angle. Where the connections are between pipe sewers or drains, special connecting pipes as shown on the Drawings shall be laid true and properly jointed.

- 2.. Where a pipe of 22 • 5cm diameter or larger is to be joined to an existing brick manhole the opening and the pipe shall be protected by the construction of a brick arch of two rings of bricks on edge.
3. Before entering or breaking into an existing sewer or drain, the Contractor shall give notice of his intention to the authority responsible for the pipe line to which the connection is to be made.

R4 21 BACKFILLING OF TRENCHES

Backfill material shall be approved by the Engineer's Representative and shall be free from stones or lumps exceeding 8cm in largest dimension, vegetable matter and other unsatisfactory material.

If the Contractor allows material which, on excavation, is suitable for re-use to become unsuitable and it is in this Condition when required for backfilling, he shall make good by running it to spoil and replacing with other suitable material, or when directed by the Engineer's Representative, the moisture content of the backfilling material shall be adjusted, before depositing in the trench, to facilitate compaction in accordance with Clause

R5 11-4 so that after compaction its dry density is not less than that of the soil in the trench sides.

Backfilling shall wherever practicable be undertaken immediately the specified operations preceding it have been completed, and the works have been inspected and approved by the Engineer's Representative so as to reduce the lengths of trenches open at any one time.

When concrete haunches or surround have been placed, compaction by mechanical means shall not be commenced until at least four days have elapsed from the placing of the concrete.

The material shall be deposited in layers each not exceeding 15cm thickness and each compacted as specified in Clauses R5 11-3 and 4 using, unless other compacting equipment is required or agreed, power rammers or vibrating plate compactors.

Where bedding material is specified just above the top of the pipes, then un powered hand tools shall be used.

Regardless of the method of compaction, no traffic or heavy loads shall be allowed over the backfilled surfaces until the four days for the setting of concrete have elapsed.

Movement of construction equipment over a culvert or pipe shall be at the Contractor's risk.

Any pipe injured thereby shall be repaired or replaced at the opinion of the Engineer's Representative and at the contractor's own expense.

R4 22 BACKFILL MATERIAL FOR FRENCH DRAINS

The filling around porous concrete, clay, pitches fiber or any other pipes used as a French drain shall be Type A or Type B material as Table R4/2 or other filling described in the Contract.

Type A or Type B material shall consist of hard, clean, crushed rock, or gravel and sand, having a grading within the limits of Table R4/2. The aggregate crushing value of the material shall not exceed 30 per cent. The material passing the 0-425mm sieve shall be non-plastic when tested in accordance with AASHTO T90-70 or BS1377 (1975) Test 3.

In all cases the standard of the final surface shall be not less good than that pertaining prior to the Contractor's entry upon the various sites.

Any permission given by the Engineer's Representative to the Contractor to carry out the permanent reinstatement of surfaces shall not absolve the Contractor from liability for reconstructing such permanent reinstatement as may be necessary should further settlement of the surface or damage thereto occur.

R4 24 MEASUREMENT

The unit of measurement for drainage pipe excavation shall be the cubic meter divided into stages, i.e. 0-2m deep, 2-4m deep, 4-6m deep, etc. The width of the trench shall be measured as 30cm greater than the external diameter of the pipe barrel and the Contractor shall allow in his rates for excavation for any width of trench in excess of these dimensions he may require. Depth of excavation for sewers is measured as the difference in level between the invert level of the pipe and the surface of the ground as it exists at the time

when the trench excavation is started, but not higher than the ground level immediately prior to the commencement of the Works.

The unit of measurement for pipe work shall be the linear meter. The length of pipelines shall be measured to the inside faces of the walls of the manholes.

All bedding, haunching and surrounding shall be measured separately per linear meter.

R4 25 PAYMENT

The prices for excavation shall include for working in such a manner as not to interfere with the stability of adjacent structures and properties; for the cost of all timbering or other support required; for the cost of all timber or other support left in place unless ordered or approved to be left in place by the Engineer's Representative; for making good slips and falls and excess excavations; for ground stabilization by means of dewatering, chemical processes or other approved method; for pumping and dealing with water whether

affected by floods, storms or otherwise; for the provision and sealing of temporary grips, channels, sub-drains and sumps; for temporarily storing excavated materials required for back fill or other purposes; for temporarily supporting, protecting, diverting and maintaining utility services; for maintaining flows in sewers and watercourses; for all work incidental, contingent or found necessary for the proper execution and safety of the works; and for all other contingencies whatsoever.

The price of pipe work shall include provision of the pipes, delivering to the site and all site handling, storage and transport; all cutting and waste; all laying and jointing including all labour and jointing materials and incidentals to complete the work in accordance with the Specification.

The price for bedding, haunching and surrounding will include all necessary work, labour, materials and shuttering necessary for completion of the Works in accordance with the specification.

SECTION R5 EARTH WORKS

R5 01 Scope

The work covered by this section of the Specification consists in furnishing all labour equipment, supplies and materials, and performing all operations in connection with soil or salt layer stripping, excavation, construction of embankments, excavation and backfilling around structures, and all incidental grading, all operations of "Embankment in Place" and in strict accordance with this section of the Specification and the applicable drawings.

In the provisions which follow, the term "Earthworks" will be used as a general term to designate all classes of grading, leveling, ditching and earth moving, and all other excavating and embankment construction work.

R5 02 General Notes, Definition, Classification

- 1 Accuracy of Work:** All earthworks shall be performed accurately and cross-sections as shown or indicated on the Drawings.

The cross-sections in embankments and cuttings showing the levels of the road formation shall be subject to such variation from the typical sections shown on the Drawings as may be necessary to provide satisfactory superelevation on curves and to take care of special conditions encountered at intersections and elsewhere.

- 2 Formation Level:** Formation level on embankments and in cuttings shall be the surface level of the underside of the sub-base, or where no sub base is specified, of the underside of the base. The levels and tolerance or irregularity of the surface shall be within the limits specified.

Any permitted deviation below the true levels shall be made up in sub-base or base material compacted as specified, which shall not be measured for payment.

- 3 Classification:** Pay excavations, as hereinafter defined and limited, shall be of five kinds which shall be designated as follows:

- (1) Drainage excavations.
- (2) Structural excavations.
- (3) Special borrow excavations.
- (4) Embankment in place.
- (5) General excavations.

All excavations shall be on a two-classification basis, (a) solid rock and (b) common excavations as hereinafter defined.

4. Definition:

- (1) Definitions of earthworks material.

- (i) **Topsoil** is a soil which on visual examination can be seen to be broken down by agricultural cultivation and / or is seen to be capable of supporting growth.

It shall include all old cut turf which is no longer suitable for turfing.

- (ii) **Suitable material** shall comprise all that which is acceptable in accordance with the Contract for use in the Works and which is capable of being compacted in the manner specified in this Specification to form a stable fill having side slopes as indicated on the Drawings.

- (iii) **Unsuitable material** shall mean other than suitable material and unless accepted by the engineer's Representative shall include:

- (a) Material from swamps, marshes or bogs and soils containing more than 12% organic matter when tested in accordance with Test 8 of BS1377 (1975).
- (b) Peat, logs, stumps and perishable material.
- (c) Material susceptible to spontaneous combustion.
- (d) Salty or gypsiferous soil containing more than 10% of soluble salts when used in the top 30cm of the embankment and 20% in the rest of the embankment.

The test should be run according to the earth manual of U.S. Bureau of reclamation appendix E8 with maximum dilution of 1:50.

- (e) Clay of liquid limit exceeding 70 and/or plasticity index exceeding 45 unless otherwise instructed in the Drawings and/or otherwise permitted by the Engineer.
- (iv) **'Rock' Excavation:** 'Rock' shall include only hard material or rock found in ledges or masses in its original position which in the opinion of the Engineer's Representative is impossible to remove by heavy mechanical excavating plant or by heavy duty hydraulic ripper, or by approved pneumatic tools, and which would normally be removed by blasting with explosives, or by drilling and broaching with wedges and sledge hammers if removed by hand. Also individual boulders or detached pieces of rock exceeding one quarter cubic meter in size in trenches one meter in width or less and exceeding one half cubic meter in general excavations and in trenches over one meter width, necessitating blasting as above. Removal of rock will only be classified as rock excavation when it is not possible to rip and excavate by a bulldozer with 350 HP and one ripper tooth all other excavation of rippable very weak rock and very hard soils will be classified as common excavation. Should any difference of opinion arise between the contractor and the Engineer's Representative whether any hard material is 'Rock' or is qualified for classification as 'Rock' according to the means required for its removal, then the matter shall be referred to the Engineer before any material is disposed of or covered up and his decision shall be final.
- (v) Common Excavation shall include all material not classified as rock and boulders or detached rock in pieces measuring less than the respective sizes specified in the foregoing clause, not requiring the same means of removal as 'Rock'.

5. Storage and Handling of Explosives and Blasting

- (i) The Contractor shall at all times observe and comply with all State Laws, Regulations and Rules which in any manner pertain to the handling, transportation and storage of explosives and the safety of persons and property.
- (ii) The Contractor shall only store explosives in a licensed or approved store or magazine provided with a separate compartment for detonators. The Contractor shall provide proper buildings for the store or magazine in locations to be approved by the Engineer as suitable for the storage of explosives in manner and quantities to be approved; he shall also be responsible for the prevention of any unauthorized issue or improper use of any explosives brought on the Works. Only responsible and experienced men shall be employed for handling explosives which shall be used in the quantities and manner recommended by the manufacturers and in conformity with the statutory regulations.

- (iii) When blasting is carried out, particularly in rock, the Contractor shall ensure, by adherence to proper safety distances and by the use of heavy blasting mats where directed by the Engineer, that no damage or injury is caused to persons, livestock or property on or off the Site. The shots shall be properly loaded and covered and only moderate charges shall be used unless authorised in writing by the Engineer's Representative. A register shall be kept by the Contractor of all explosives used so that a check can be made by the Engineer's Representative.
- (iv) Blasting shall be restricted to whatever hours the Engineer's Representative may prescribe. If in the opinion of the Engineer's Representative blasting would be dangerous to persons or adjacent structures or is being carried out in a reckless manner, he may prohibit it and order the rock to be excavated by other means. The use of powder or other explosives by the Contractor in large blasts as in seams, drifts shafts, pits or large holes is prohibited unless authorized in writing by the Engineer.

Where blasting is proposed adjacent to a structure, either existing or under construction, special care shall be taken when blasting in wet ground and irrespective of the weight of explosive, the written permission of the Engineer's Representative shall be obtained for each location or series of locations. The Contractor shall carry out preliminary site trials, and satisfy the Engineer that safe values of vibrational amplitude and particle velocity are obtained.

Unless otherwise agreed by the Engineer the amplitude shall not exceed 0 • 20mm and the particle velocity shall not exceed:
50mm/sec where blasting is confined to single events.
25mm/sec where blasting is continuous.

Vibrograph readings shall be recorded throughout the period of blastings for urban locations or in the vicinity of any buildings or structures, or as required by the Engineer.

- (v) The Contractor shall provide at the explosive store the necessary watchman day and night and shall make his own arrangements for safe transport of explosives.

R5 03 PAY EXCAVATION DESCRIPTION

1. General Excavation: Pay excavation shall comprise all excavation made within the net lines of the excavation cross-sections and above the excavation finished grades (formation levels) established by the Engineer. The excavation shall be carried out so as to avoid any under cutting and consequent instability of the finished sideslope.

2. Excavation for Sewers: In connection with excavation for sewers, pay excavation shall be limited to the pay widths and depths set forth on the Drawings.

3. Excavation for Culverts and Drains: In connection with the excavation for pipe culverts, pipes, siphons, pipe drains and tile drains, pay excavation shall be limited to excavation of specified or required depth and to a width equal to the outside diameter or width of the pipe, tile or culvert. In all cases involving sewers, pipes and drains, where the Drawings and Specification for trench width in Sections R3, R3A and R4 or Special Conditions of Contract indicate specific widths of excavation, it shall be understood that such define the widths of pay excavation, and over break will not be allowed.

Earthworks

4. Excavation for Structures: In connection with the box culverts, bridges, abutments, piers, retaining walls, headwalls, partition walls and like structures, pay excavation shall be limited to excavation within vertical planes parallel to and coincident with the net lines of the footings or bases of the structures.

5. Work not being a part of finished work: Removal of overburden from pits and quarries, excavation of rock, gravel and other material for use in surfacing or structures, excavation for haulage roads, excavation for detour roads and temporary roadways and other excavation (borrow excavation excepted) which is not directly a part of the finished work, shall not be considered pay excavation unless otherwise specifically so provided in the Special Specification of Particular Application.

6. Grading and Maintaining: Excavation involved in grading and maintaining road beds, roadways, sub grades, bases and foundations and excavation involved in backfilling and other re-handling and re-shaping of materials previously excavated shall not be considered pay excavation unless otherwise specifically so provided in the Special Specification of Particular Application.

7. Excavation outside the net line: Excavation outside of the net lines or road bed excavation cross-sections specified by the Engineer will be considered pay excavation only when such excavation is overbreak from the sides of excavation, which over break in the opinion of the Engineer's Representative could not have been avoided or foreseen by an experienced Contractor and caused the Contractor material expense for its removal.

R5 04 ROADWAY AREA PREPARATION

1. Removal of Unsuitable Material: In the event of unsuitable material as decided by the Engineer's Representative and defined in Clause R5 02-4 being found on the site of any embankment, cutting, bridge or drainage structure and borrow areas, the Contractor shall remove such material to the depth indicated on the Drawings or as directed by the Engineer's Representative in writing. No payment will be made for quantities of unsuitable material exceeding those stated in the Bill of Quantities unless the approval in writing of the Engineer's Representative is obtained prior to carrying out the work. Materials so removed shall be disposed of outside the Right of Way.

2. Diversions or Reshaping of Watercourses: Where directed by the Engineer's Representative streams or watercourses crossing or adjacent to the Works shall be diverted, enlarged or straightened.

Where in diversions or reshaping of streams or watercourses the original channels lie within the earthworks, such channels shall be cleaned of all vegetable growth and soft deposits and filled with approved material compacted in accordance with the Clause R5 11-4 hereof.

3. Intercepting Ditches to Protect Cuttings and Embankment: Open ditches to protect cuttings and embankments shall be constructed in accordance with the Drawings or as directed by the Engineer. Where possible intercepting ditches shall be constructed in advance of general earthworks in cuttings and embankments. Unless otherwise directed they shall be 30cm wide at the invert (bottom), of an average depth of 50cm and with the sides trimmed back to a slope of 1½ to 1.

The inverts shall be accurately graded so as to carry off the water to the outlet determined upon. For ditches blasted out in rock the sides shall be roughly trimmed to leave firm slopes. The material excavated from ditches shall, if considered suitable by the Engineer's Representative, be deposited in the embankments or otherwise disposed of as directed.

4. Under draining of Embankments: If ordered by the Engineer's Representative the foundation of embankments and the formation in cuttings shall be provided with under drains or sub-drains. Trenches shall be excavated to the dimensions indicated, their inverts graded to outfall and lined with precast slabs, stone pitching or with compacted crushed stone where shown on the Drawings or directed by the Engineer's Representative, if necessary compacted by ramming.

Where springs or seepages are encountered, or at other land drain locations, approved clay tile pipes shall be laid open jointed in the trenches which shall then be carefully backfilled with granular filter material to form french drains as specified in Section R4.

R5 05 DRAINAGE EXCAVATION

1. Description: Drainage excavation shall comprise and include the furnishing of equipment and labour and performing all operations in connection with the pay excavation lying outside road formation excavation cross-section as follows:

- (i) the installation of pipe culverts, pipe siphons, pipe drains and sewers.
- (ii) the excavation lying below the established invert grade, flow line grade or floor for pipe culverts, pipe siphons, pipe drains, tile drains and sewers.
- (iii) the moving or salvaging of pipe culverts, pipe siphons, tile drains and sewers.
- (iv) the shaping of slopes and ditches to form inlet basins to culverts and in the construction of miscellaneous structures, where such shaping and construction is specifically called for on the Drawings.
- (v) the excavation required in construction of inlet ditches, outlet ditches, diversion ditches, drain ditches, canals, channel changes and other ditches (excepting cut ditches, borrow ditches and other ditches in road bed section) having a bottom width of 2m or less.

2. Excavation for Pipelines: The width of trenches for pipes and special requirements for excavation shall be as specified under 'Pipe Laying' in Sections R3, R3A and R4. Should the Contractor desire to use mechanical appliances for excavating trenches or for laying pipes he shall submit his proposals for the Engineer's Representative's approval, which will not relieve the Contractor from responsibility for damages to pipes, mains, etc.

3. Timbering: The sides of pits, trenches and other excavations shall where required be adequately timbered and supported to the satisfaction of the Engineer's Representative and all such excavations shall be of sizes sufficient to enable the pipes and concrete to be laid accurately, and proper refilling and ramming to be carried out.

4. Pumping: Trenches and headings shall be kept free from water until, in the opinion of the Engineer's Representative, any concrete or other works therein are sufficiently set and the Contractor shall, at his own expense, construct any sumps of temporary drains that the Engineer's Representative may deem necessary.

Earthworks

The Contractor shall make good at his own expense any damage caused by prolonged and excessive pumping and shall take all precautions necessary for the safety of adjoining structures and buildings by shoring or otherwise during the time the trenches are open.

5. Backfilling: All backfilling to pipe trenches shall be as specified in Sections R3, R3A and R4. Filling shall be placed equally on both sides of the pipe and stepped so as to avoid unequal pressures. Shoring and other supports shall be removed as the filling proceeds and no timber supporting members shall be covered with filling material.

R5 06 STRUCTURAL EXCAVATION

1. Description: The work covered by this Section consists in furnishing all equipment, labour, material and in performing all operations in connection with the structural excavations. Structural excavation shall comprise and include all pay excavation lying outside the road bed excavation cross-section required in connection with the construction of bridges, box and arch culverts, abutments, piers, retaining walls and partition walls. The work shall be performed in strict accordance with this Section of the Specification and the applicable Drawings.

2. Inspection: The Contractor shall notify the Engineer's Representative before starting any excavation. From time to time during the progress of excavation the Engineer's Representative will examine the character of material being taken out. He shall have authority to stop the excavation at any time to make bearing tests and the Contractor shall give any assistance which the Engineer's Representative may desire in making such tests for which there will not be an extra payment.

3. Depth and Dimensions of Footings: Pits and trenches for foundations of structures shall be excavated to the levels and dimensions shown on the Drawings or to such other dimensions as the Engineer's Representative may direct.

The Engineer may require the Contractor to excavate below the foundation levels shown on the Drawings or he may order him to stop when suitable foundation material is encountered.

4. Bottom of the Excavation: The bottom of all excavations shall be carefully graded and if required by the Engineer's Representative stepped or benched horizontally. All excavations shall be taken out as nearly as possible to the exact dimensions of the foundations to minimize backfilling. In excavations for foundations of structures a bottom layer of soil shall be left in place temporarily and subsequently removed only when the concrete is about to be placed, in order that softening or deterioration of the surface of the excavations by exposure may be avoided so far as possible. The thickness of the layer will depend on the type of soil and will be determined by the Engineer's Representative. Any pockets of soft material or loose rock in the bottoms of pits and trenches shall be removed as directed and the cavities so formed filled with concrete Class E as specified in Clause B8 09. After the completion of placing of any blinding concrete required by the Contract, no trimming of the side faces shall be carried out for 24 hours. When any excavation has been taken out and trimmed to the levels and dimensions shown on the Drawings or directed by the Engineer's Representative, the Engineer's Representative shall be informed accordingly so that he may inspect the completed pit or trench and no excavation shall be filled in or covered with concrete until it has been so inspected and the Contractor has been authorised to proceed with the work.

5. Surplus Material: All surplus excavated materials from excavations not required for refilling shall, if considered suitable by the Engineer's Representative, be deposited in embankments or otherwise disposed of as directed.

6. Excavation Greater than Necessary: Excavation to a depth greater than directed shall be made good by the Contractor at his own expense with concrete Class E.

Excavation to a width greater than necessary in rock shall be made good by the Contractor at his own expense by completely filling the excess volume of excavation with concrete of the same class as the foundation of the structure.

Excavation, to a width greater than necessary in material other than rock shall be made good by the Contractor at his own expense and to the satisfaction of the Engineer's Representative by completely filling the excess volume of excavation against the completed foundation either with concrete Class E or if decided by the Engineer's Representative with approved material compacted to a dry density not less than that obtaining in the adjacent soil.

7. Shoring to Excavations: The sides of all excavations shall be adequately shored at all times to the satisfaction of the Engineer's Representative who may require the Contractor to submit details of his proposals for such work, but the submission of such details shall not relieve the Contractor of any responsibility for the safety of the work.

Timber or other shoring materials are to be removed as the work proceeds unless otherwise directed or permitted by the Engineer's Representative.

The Engineer's Representative may direct timbering to be left in trenches or other excavations. Timbering so left in will be measured and paid for as provided in Bill of Quantities, except where in the Engineer's opinion the necessity for leaving in the timber or any other material has arisen from carelessness or neglect on the part of the Contractor.

8. Cribbs and Cofferdams: The Engineer may require that drawings showing the proposed methods of construction of cofferdams and cribs should be submitted for approval, but such approval shall not in any case relieve the Contractor of his responsibility.

Cribs and cofferdams for foundation construction shall be carried out to adequate depths and heights, shall be safely designed and constructed and be made as water tight as is necessary for the proper performance of the work and the internal dimensions shall be such as to give adequate working space for the handling of formwork, the inspection of external faces and to allow pumping from sumps outside the forms.

The length of the material used for the cofferdams and cribs shall be of sufficient length to allow possible lowering of the footings if directed by the Engineer's Representative.

No timber and bracing shall be placed inside cofferdams or cribs that cannot be subsequently removed without damage to the concrete.

The cofferdams and cribs shall be a sufficient protection of fresh concrete against damage from a sudden rising of the stream and an efficient prevention against damage of foundation by erosion.

The cofferdam and crib material used shall be of sufficient length to allow possible lowering of footings as may be directed by the Engineer's Representative.

Earthworks

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away.

No pumping will be permitted during the placing of concrete or for a period of at least 24 hours thereafter, unless it be done from a suitable sump or well point separated from the concrete work.

Unless otherwise provided the Contractor shall remove all cofferdams, cribs, sheeting and bracing down to the elevation or original ground line or to the new stream bed level in case of channel change or to the top of footings in dry holes. The removal shall be done in such manner as not to damage the finished concrete or any part of the new structure.

9. Foundation Seal: When required on the Drawings or ordered, a concrete foundation seal shall be constructed. The foundation enclosure shall then be pumped out and the balance of the concrete placed in the dry. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure or until five days have elapsed after the last seal concrete has been placed. When weighted cribs are employed and the weight utilised partially to overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal.

10. Water in Excavation: During the time that excavation is being carried out and until the constructional works can suffer no damage from flooding, all excavations shall be kept free from water, as specified in Clause R4 15.

Where excavations have to be made and foundations formed below the known ground water level, the Contractor shall submit a full and clear description, supported by such drawings as may be necessary of the methods he proposes to use in respect of each foundation to enable the whole work to be executed in the dry and such measures shall be adopted as the Engineer's Representative approves.

Precaution shall be taken to prevent upward piping of the bottom of excavations either by cutting off sheeting, by lowering the water table or by other means and all such precautions shall be subject to the approval of the Engineer prior to adoption.

11. Refilling of Foundation Pits: Refilling of foundation pits and trenches shall be carried out as soon as possible after the foundations have acquired adequate strength as determined by the Engineer's Representative.

Refilling may only be commenced after structural works within the excavations have been inspected and approved by the Engineer's Representative.

Timber sheeting and other excavation supports shall be carefully removed as the filling proceeds except as otherwise specified or ordered, but the removal of such supports will not relieve the Contractor of his responsibility for the stability of the works.

12. Permeable Backing to Earth Retaining Structures: Where shown on the Drawings or required by the Engineer, back drainage to structures shall be provided. This shall comprise:—

- (i) A minimum thickness of 30cm free draining layer of approved granular material well graded from 8cm to 0.2 mm, or precast porous concrete blocks laid in stretcher bond with dry joints in 22.5cm thick walling.
- (ii) a cut-off of approved clay puddle well worked with water to produce an impervious plastic sealing material or of concrete Class E.
- (iii) weep holes through the structure.

The clay puddle or concrete where required shall be worked well into the material immediately below the lowest set of weepholes so as to provide an effective barrier to the seepage of moisture. The drainage layer shall be lightly compacted, shall be brought up level with the backfilling and shall be maintained as a distinct material there from.

13. Granular Fill to Structures: When selected granular filling is specified in the Special Specification for Particular Application for compaction against earth retaining structures, it shall consist of well-graded crushed or uncrushed gravel, stone, rock fill, crushed concrete or natural sand or a combination of any of these. It shall not contain unsuitable material as defined in Clause R5 02-4 (iii) nor have a soluble sulphate content exceeding 2-5g per liter when tested in accordance with Test 10 of BS1377 (1975).

All material shall pass a 150mm sieve and not less than 95 per cent shall pass a 100mm sieve, and at least 90 per cent shall pass a 75mm sieve but not more than 10 per cent shall pass a 0-075mm (No. 200) sieve.

14. Preservation of Channel: When foundations or substructures are to be constructed in or adjacent to running streams no excavation shall be done outside cribs, cofferdams, caissons or sheet piling nor shall the natural stream bed adjacent to the structure be disturbed, without the written permission of the Engineer's Representative. If any open pit excavation or dredging is permitted at the site of the structure before the placement of cribs or cofferdams, the Contractor shall, after the foundations are in place, backfill such excavation to the original surface of the stream bed with material satisfactory to the engineer's Representative.

The backfilling material shall be of such quality and shall be placed in such manner that it will offer the same resistance to scour as the material removed.

Material deposited within the stream area from foundation excavations shall be removed and the stream bed freed from obstruction thereby. On navigable streams the Contractor shall at all times maintain the depth of water and horizontal clearances required for the passage of water traffic. He shall also furnish and maintain all necessary channel signals and lights during the construction period.

R5 07 SPECIAL BORROW EXCAVATION AND BORROW MATERIAL

1. Description: Special borrow excavation shall comprise and include pay excavation in borrow pits lying outside and beyond the roadway limits and specifically designated in the special provisions. Special borrow excavation shall not include excavation in borrow areas or ditches which are a part of, continuous to, or adjacent to the road bed cross-section.

Earthworks

The work consists of furnishing all necessary job equipment and labour, carrying out the pay excavation in borrow pits, material haulage and usage for embankment or back filling.

The Contractor shall bear all expenses connected with the opening and operating of borrow pits.

2. Borrow Areas: Borrow material for fill shall be obtained from the borrow areas designated on the Drawings or from the areas selected by the Contractor, subject to the approval of the Engineer's Representative.

No borrow pit shall be opened until the material has been sampled in depth and approved as suitable and written approval given by the Engineer's Representative for the commencement of the excavation. Rock and unsuitable material for filling shall not be excavated, or if excavated by the Contractor, shall be re-deposited in the pit as instructed and shall not be measured.

3. Right to Procure Material: The employer will compensate the owners for all materials taken from borrow areas designated on the Drawings. Should the Contractor select to use any borrow area not designated on the Drawings, he shall obtain from the owners the right to procure materials from such source and shall pay all royalty and/or other charges and expenses involved.

4. Haulage Roads: Roads for hauling the soil out of the borrow area should be provided by the Contractor. These works will not be paid as an extra payment.

R5 08 EMBANKMENT IN PLACE

1. Description: Material for Embankment in Place shall be obtained from borrow areas within the Right of Way as indicated on the Drawings or from areas selected by the Contractor, subject to the approval of the Engineer's Representative.

When borrow areas are permitted within the Right of Way they should be confined to the outer 10 meters of the Right of Way and be of regular shape, continuous over the complete length where borrow is permitted and neatly finished. The depth will be limited to 1.5 meters or to groundwater level whichever is the less. All borrow pits whether within the Right of Way or not must be self draining to prevent the accumulation of stagnant water.

All work on borrow areas is to be to the approval of the Engineer's Representative

2. Material: All material for the embankment shall be subject to the approval of the Engineer's Representative. Any unsuitable material deposited in the Works shall be removed and replaced by acceptable material by the Contractor at his own expense.

Material unsuitable for the embankment encountered in the designated borrow area may be used as required to widen uniformly embankments, flatten slopes, to fill low places in the right of way or for other purposes as the Engineer may direct or may be completely rejected. Such unsuitable material shall be measured in its final location and shall be paid for at the price tendered for Embankment in Place.

Overhaul will not be allowed and no direct payment will be made for any losses of material which may result from shrinkage, compaction, foundation settlement, erosion ,leakage or any other cause.

R5 09 General Excavation

1. **Description:** General excavation shall comprise and include all excavation other than drainage excavation, excavation for structures, special borrow excavation and the excavation for Embankment in Place. General excavation shall also be understood to include cut ditches, borrow ditches and other ditches in the road bed section or shown on the typical road bed cross-section.
2. **Performing the Excavation:**
 - i. Prior to beginning the excavation work it is necessary to carry out all clearing and grubbing in accordance with section R2.
 - ii. Excavation of every description within the grading limits of the project shall be completed to the lines and grades shown on the Drawings or as directed by Engineer's Representatives, including benching for embankments ,as specified in clauses R5 11-1 (V) and R5 11-1 (VI).
 - iii. Excavation shall proceed in such sequence and manner and shall be so correlated with other phases of construction that suitable conditions for the maximum drainage discharge will be provided at all times. Ditches shall be maintained so as to ensure proper drainage at all times.
3. **Excavation to Formation Level:**
 - i. The excavation shall be carried out so as to avoid any undercutting and consequently instability of the finished side slope.
 - ii. Should the slopes of any cutting be excavated beyond that required, the Contractor shall make good each affected area in a manner satisfactory to the Engineer without additional charge.
 - iii. Where excavation reveals a combination of suitable and unsuitable materials the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable materials. The unsuitable materials shall be disposed of in accordance with Clause R5 04-1 .
 - iv. If with the agreement of the Engineer's Representative any suitable material excavated from within the site is taken by the Contractor for his own use, for instance for producing aggregates for concrete, crushed stone base or sub-base, for surfacing or for haul roads or for any other purpose in or connected with the Works, sufficient suitable filling material to occupy, after compaction, a volume corresponding to that which the excavated material would have occupied in embankment, shall be provided by the Contractor from his own resources free of charge.
 - v. No suitable excavated material shall be dumped or run to spoil, except with the written permission of the Engineers Representative, if the Contractor can show to his satisfaction that this procedure would be economically advantageous.
 - vi. Material used for haul roads shall not be re-used in embankment or elsewhere without the permission of the Engineer
 - vii. Excavation shall be discontinued when climatic conditions prevent the placing of the excavated material in embankment in accordance with the Specification.
4. **Dressing Formation Level in Rock Cuttings:**

Where rock or hard material is encountered at formation level in cuttings , the contractor shall dress the rock surface in a manner to suit the construction to be superimposed.

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The rock shall be trimmed approximately to formation level so that the resultant surface is sufficiently smooth for the satisfactory operation of spreading equipment.

Any over break or excess excavation shall be made good at the contractors' expense in the material to be superimposed and additional compaction effect shall be applied to the satisfaction of the Engineers' Representative without extra payment. If the over break is irregular or exceeds 8cm, the Engineers' Representative may require the excess excavation to be made good with concrete Class E the Contractors' expense .

5. Improvement of Subgrade in Cuttings:

- i. Where in cuttings the material encountered in the subgrade at or near formation level is in the opinion of the Engineer's Representative unsuitable, this material shall be excavated and disposed of as the Engineer may direct and replaced with approved filling material compacted as specified in Clause
- ii. Where the material is suitable, but insufficiently compacted, such material shall be removed, replaced in layers as necessary and compacted as specified for embankments and the Contractor shall provide additional approved filling material that may be needed up to formation level due to shrinkage of material compacted.
- iii. Such work as is directed to authorize outlines will be paid for where itemized in the Bill of Quantities. Any excess excavation beyond that ordered will not be paid for, but the void shall be filled in and compacted as specified at Contractor's expense.

R5 10 Control and Disposal of Excavation Material

The methods used in making road bed excavations shall be such as will not shatter or loosen excavation slopes, but will leave the slopes accurately and smoothly trimmed. As far as practicable, the materials to be excavated shall be loosened by means of rooters and scarifiers or shall be excavated without previous loosening. Such as must be done shall be controlled in a manner which will avoid possible shattering or loosening of materials behind the slope lines to which the excavations are to be made, as directed by the Engineer. Excavated materials suitable for use in embankment construction and backfilling shall be used in the construction of embankments and in filling and backfilling work as indicated on the Drawings or directed by the Engineer.

Should the quantities of excavated materials be greater than required to construct all the embankments or other required filling and backfilling, the excess material shall be used to widen embankments uniformly or shall be otherwise disposed of as the Engineer may direct. When excess materials are used to widen embankments uniformly, the limits between which the embankments are to be widened with any given quantity of excess materials shall be as the Engineer's Representative directs. Excess materials not used in embankment widening shall be deposited at such locations and to such lines, grades and cross-sections as the Engineer's Representative may direct. The excavation and disposition of filling material for each, or part of each, embankment shall be spread and compacted, in separate and clearly defined areas, for each particular kind of material as directed by the Engineer.

Excavation shall not be carried out when conditions prevent the placing of the excavated materials at the specific locations at which their use is desired by the Engineer.

Any material unsuitable for use in embankment construction and backfilling shall be disposed of in such manner as the Engineer may direct. Excavated materials deposited contrary to the requirements above stated and without the consent of the Engineer, shall be picked up and redeposit as the Engineer directs and at the Contractor's expense.

R5 11 Embankment construction**1. Embankment Area Preparation**

- i. Prior to placing the filling, the grubbing up and clearing shall be performed within the given area according to Section R2, the unsuitable material shall be removed and any other work shall be completed in accordance with the Clause R5 04.
- ii. Unit Dry Weight of natural ground shall comply with minimum 88% of that determined by AASHTO TI 80-74 (Modified AASHTO Compaction Test) up to the depth 25cm, otherwise the natural ground shall be compacted and drained whenever needed to achieve this percentage at no extra cost to the employer.
- iii. Where the surface contains holes, ditches, gullies, etc., such depressions shall backfilled with approved material compacted to the same density as that of surrounding material.
Where the ground has been ploughed, ripped or otherwise loosened, it shall shaped and compacted as specified below in Clause R5-11-4.

- iv. Where the area of deposited filling is on an existing pavement, concrete, rock or other hard material, including natural densely compacted soils without vegetation, the area shall be scarified to a depth of at least 15cm and finely broken up in order that the fill material may be well bonded with the old surface .

Where the height of the new embankment above the existing ground is less than 50 cm the scarified material shall be shaped and compacted as specified to the same minimum density as specified for the new embankment.

- v. Where an embankment is on sloping ground of at least 1 in 4 slope, or at such other locations as the Engineer's Representative may direct, the surface of existing ground shall be benched (in nearly horizontal steps or trenched) as shown on the drawings including if necessary any under-draining of the affected part of the Site.

The benching or trenches shall be kept free of water.

- vi. Where the new embankment will envelop an old embankment on one or both sides, the side slopes of the old embankment shall be benched as directed by the Engineer , and the new fill brought up in successive layers to the level of the old embankment before the height is increased.

In such areas the fill material and the excavation from the benching shall be deposited and compacted as specified below in Clause 1-5-4.

- vii. Where an embankment is to be placed over an existing pavement, concrete, rock etc. the old pavement, etc. shall be scarified as clause R5 11-1 (iv) and completely broken up so that all cleavage planes are destroyed and fill material will bond properly.

Where the old pavement is of the rigid type and the depth of new embankment is less than one meter, the old pavement shall be completely removed and disposed of as directed by the Engineer.

2 -Field Compaction Trials:

- i. The Contractor shall put forward in writing to the Engineer for his approval a list of the plant he proposes to use for compaction of filling in embankment and elsewhere where required.

Earthworks

- ii. The precise manner in which the earthworks are to be compacted shall be the subject of field compaction trials to establish the type, sequence and numbers of passes of the compaction plant necessary to obtain the degree of compaction specified hereafter, the optimum moisture content associated with such plant and the thickness of layer that may be effectively compacted.
- iii. An area within the site selected by the Engineer and approximately 20 m by 20m in plan shall be stripped of any surface growth and then excavated as required by the Engineer to a depth not exceeding 0.5m. The Contractor shall then bring in the material under trial and carry out the trial with the approved plant to establish the criteria set out above. On completion of the trial the Contractor shall reinstate the area and leave it generally tidy.
- iv. The field compaction trial shall proceed until such time as both the Engineer's Representative and the Contractor are agreed as to the procedure necessary to obtain the required degree of compaction in the embankments as specified. The agreed procedure embracing the type, sequence and number of passes of the plant required to compact a layer of the agreed thickness before compaction and the limits within which the moisture content of the soil shall lie at the time of compaction shall be recorded and shall thereafter form the basis of the field control of the compaction plant on that material.
- v. A field compaction trial shall be carried out on each major soil type as determined by the Engineer's Representative.

3. Construction of Embankments:

- i. Embankments shall be constructed to the lines and grades as shown on the Drawing or to the outlines specified by the Engineer.
- ii. The Contractor shall make allowance for construction, if any, of embankment foundation and for compaction and shrinkage of fill material, so that on completion of the earthworks the profile of the embankment is as required.
- iii. Embankments shall be formed of suitable material, other than that described as unsuitable in Clause R5 02-4 and shall be constructed and compacted as specified below in Clause R5 11-4.
- iv. Embankments shall be constructed of material spread in successive layers for compaction, each layer extending over the full width of the embankment at the height of the layer and the Contractor shall ensure that the required compaction is obtained throughout each layer, not omitting the material which after trimming will form the side slopes. Rolling shall begin at the edge of the fill and progress toward the centerline overlapping on successive trips by at least one half the width of the roller unit.
On superelevated curves rolling shall begin at the low side and progress towards the high side.
- v. Where materials of appreciably different characteristics are to be deposited in embankments such materials shall be spread in separate layers, each layer composed of only one type of material. Layers shall be reasonably leveled, or if directed, at such cross falls as will shed storm water and prevent ponding. Fill material shall not be stockpiled on embankments and if in the opinion of the Engineer's Representative the plant used for depositing the material does not spread the material uniformly in a satisfactory manner, the Contractor shall employ plan to spread and grade layers for compaction.
- vi. Earthmoving plant shall be positively controlled by the Contractor and routed over the full width of the embankment so as to ensure a degree of uniform compaction from such plant.

The depth of beach layer of filling shall suit the compaction plant and the compaction procedure evaluated in the Field Compaction Trials, unless otherwise directed by the Engineer's Representative.

- vii. Any hard material that is not broken down by the passage of the compacting plan shall either not be accepted by the Contractor for filling material or be broken down by discing, harrowing or other means into individual pieces not exceeding in any dimension half the depth of the compacted layer.
- viii. Exceptionally, where in the opinion of the Engineer's Representative the material available for forming the embankment is predominantly of rock fragments of such size that the material could not be placed in layers for compaction as specified above, nor could reasonably be broken down, the embankment or part thereof as directed may be formed as R5 11-4. Rock used in rock fill embankments shall be of such size that it can be deposited in layers so as to suit the conditions evaluated in the field compaction trials, unless otherwise directed by the Engineer's Representative. The material shall be spread and leveled by a heavy crawler tractor weighing not less than 15 tons. Each layer shall consist of reasonably well graded rock and all voids shall be filled with broken fragments or with other selected material for the compaction of the layer. Large lumps of material shall not be concentrated in "nests", but shall be distributed and well packed round with finer material. This is particularly important if non-durable rock is used.
- ix. Rock fill shall not be permitted within 40cm of formation level. Where materials of different characteristics are readily available, those of relatively high bearing capacity shall be placed in the topmost 40cm below formation.
- x. No rock fragments more than 12cm in any dimension shall be placed within 40cm of formation level. No logs, stumps, scrub or other perishable material shall be deposited anywhere within the embankment.
- xi. The maximum size of rock fragments incorporated in the embankment must not exceed $\frac{2}{3}$ (two thirds) of the agreed layer thickness used for compaction and in no way exceeds 0.05 cu.m in total.

4 . Compaction of Earthworks:

- i. Work on compaction of materials in embankments shall only be carried out when the material has a moisture content within the limits agreed in the field compaction trials. The Contractor shall, if required, adjust the moisture content of material spread without extra charge. Should the material be too dry, the required amount of water shall be applied uniformly and thoroughly mixed in the soil by blading, disking or harrowing until a uniform and satisfactory moisture content is obtained throughout the depth of the layer. Should the material be too wet, it shall be aerated by blading, disking or harrowing until the moisture content is satisfactory. The Contractor shall conserve the moisture content of material excavated when this is close to the optimum moisture content and such material shall not be stockpiled or double handled, but shall be spread and compacted without delay. Allowance shall be made for evaporation, for instance in excessively hot weather, by the addition of extra moisture so that compaction may be carried out satisfactorily. The Engineer may order cessation of the work or further field compaction trials if the required degree of compaction is not obtained.
- ii. The degree of compaction shall be measured in each layer at least twice every 2000m² for comparison, or more frequently as required by the Engineer's Representative.

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The determination of the dry density achieved shall be performed in accordance with AASHTO T191-61 or T205-64 (cone method or balloon method), or other suitable method subject to the approval of the Engineer's Representative, and compared with the maximum dry density as determined by AASHTO T180 74 (Modified AASHTO Compaction Test). The results so measured shall be reported in writing to the Engineer's Representative daily or when required.

No compacted layer shall be covered until approved by the Engineer who may require a compacted layer to be scarified to a shallow depth to ensure bonding with the layer to be superimposed.

- iii. Rolling of earth embankments shall be made at the percentages indicated in the table of the maximum density for the modified compaction. The Contractor is advised to make trial sections to determine the earth layers, method of rolling and machinery required for achieving such percentages.

The degree of compaction required shall comply with the following minimum percentage of Unit Dry Weight as determined by AASHTO T180-74 (Modified AASHTO Compaction Test) unless otherwise directed by the Engineer's Representative.

- a. All structural and/or drainage excavation which is to be backfilled and/or all backfill behind and around the structures, etc., 95%.
- b. Sub grade soil compaction (the active soil layer) 30cm below the formation in all parts of the embankment and cut areas throughout the whole length and width of section shall be not less than 95%. Drainage whenever needed and compaction to achieve this percentage shall be carried out by contractor at no extra cost to the employer.

The minimum CRB shall be 4% at 95% of the maximum density established according to AASHTO T180, liquid limit and plasticity index should be less than 55% & 30% respectively otherwise the soil shall not be regarded as suitable to be used for subgrade.

Soils with a maximum dry unit weight in modified compaction of less than 1.70g/cm³ are considered unsuitable for use in the top 300mm. Soil layer immediately below the surface of the sub grade and has the fore mentioned density shall be replaced with suitable soil or granular material.

- c. Requirements for embankment soil compaction.
All portions of the soil embankment throughout the total width and depth on the cross-section shall be compacted as given below.
Subgrade and Shoulders shall be compacted to a minimum of 95% modified AASHTO dry density.
Embankment with height less than 2 m (excluding subgrade) shall be compacted to a minimum of 94% modified AASHTO dry density. For embankments with higher heights, the layers in the upper 2m (excluding subgrade) shall be compacted to a minimum of 94% modified AASHTO and the lower layers shall be compacted to a minimum of 93% modified AASHTO.
As side slopes are subject to weather, special care should be given to the compaction of the layer edges forming them.

- iv. The depth of compacted layer is the height by which an embankment is raised by each successive compacted layer.

- v. Each layer of rock used as rock fill in embankments shall be spread and leveled in accordance with Clause R5 11-3 and systematically compacted by at least 12 passes of a towed vibratory roller with a static load per cm width of roll of at least 18kg or a grid roller with a load per cm width of roll of at least 80kg or other approved plant. Where, however, the rock contains sufficient soft material for satisfactory compaction to the requirements for well-graded granular soil the fill shall be compacted to such latter requirements. When materials of widely divergent characteristics are used in embankments and fill areas they shall be spread and compacted in separate clearly defined areas in such a manner as to comply with the requirements of Clause R5 I 1-3. If more than one class of material is being used in such a way that it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material which requires the greatest compactive effort is being compacted.
The number of passes is the number of times that each point on the surface of the layer being compacted has been traversed by the item of compaction plant.
- vi. The thickness of the layers and the necessary number of passes or blows of compacting means shall suit the results of the Field Compaction Trial.
The degree of compaction shall be controlled by the number of passes or blows as indicated by the Field Compaction Trial or otherwise as directed by the Engineer. Compaction shall continue until negligible movement occurs under heavy wheel load.
- vii. For rock fill, the number of passes with the equipment and layer thickness chosen shall be sufficient when the settlement of the fill during the nth pass of the compaction roller amounts to maximum 5% (five percent) of the settlement up to the nth pass. Rock fill shall always be compacted by at least 12 passes of compaction roller as specified in clause R5 11-4 (V) no matter the results of the trial compaction tests. The specified maximum settlement shall only be used to determine the necessary number of passes if 12 passes are not sufficient

5- Equipment:

- i. The Contractor shall provide sufficient equipment in numbers and capacity of all types available to ensure the completion of the work according to the Specification and within the Contract time.
All equipment used in the performance of the work shall comply with the definitions and requirements in (ii) below and shall be subject to the approval of the Engineer or the Engineer's Representative. It shall be maintained in satisfactory working condition at all times and sufficient reserve equipment shall be readily available to maintain the proper continuity of all earthwork operations under practicable working conditions.
- ii. The following definitions and equipment requirements shall be used as a guide for assessing and quoting the comparative performance of various compacting equipment during Field Compaction Trials.
In defining the number of passes of pneumatic-tyred rollers to meet the compaction requirements, the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of spacing between the wheel tracks, provided each spacing does not exceed 23cm. Where the spacing exceeds 23cm the assessed effective width shall be the sum of the widths of the individual wheel tracks.

Earthworks

The load per cm width is the total weight on the roll divided by the total roll width.

Where a smooth-wheeled roller has more than one axle the machine will be assessed on the basis of the axle giving the highest value of load per cm width. For pneumatic-tired rollers, the wheel load is the total weight of the roller divided by the number of wheels.

Vibratory rollers are self-propelled or towed rollers having means of applying mechanical vibration to one or more rolls.

- a. The requirements for vibratory rollers are based on the use of the lowest gear on a self propelled machine and a towing speed of 1.6 to 2.4km/h for a towed machine. If higher gears or speeds are used an increased number of passes shall be provided in proportion to the increase in speed of travel.
- b. Vibratory rollers operating without their vibration mechanism in use will be classified as smooth-wheeled rollers.
- c. Vibratory rollers shall be operated with their vibration mechanism operating only at the frequency of vibration recommended by the manufacturers. All such rollers shall be equipped with a device automatically indicating the frequency at which the mechanism is operating.
Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically-weighted shafts.
- d. The static pressure under the plate of a vibrating-plate compactor is calculated by dividing the total weight in kg of the machine in working order by the area in square millimeters in contact with compacted soil.
- e. Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at traveling speeds of less than 50m per minute, but if higher speeds are necessary the number of passes shall be increased in proportion to the increase in speed of travel.
Vibro-tampers are machines in which an engine-driven reciprocating mechanism acts on a spring system, through which oscillations are set up in a base-plate.
Power rammers are machines which are actuated by explosions in an internal combustion cylinder, each explosion being controlled manually by the operator.
- f. In the case of power rammers one pass will be considered as made when the compacting shoe has made one strike on the area in question.
Where combinations of different types of categories of plant are used, the Compaction requirements shall be:
- g. The depth of layer shall be that for the type of plant requiring the least depth of layer; and
- h. The number of passes shall be that for the type of plant requiring the greatest number of passes.

However, where the Contractor uses a lighter type of plant to provide some preliminary compaction only to assist the use of heavier plant, this shall be disregarded in assessing the above requirements.

Particular care is necessary in the use of compacting equipment in uniformly graded materials. In the case of vibratory rollers having a static load per cm width of vibratory rollers of less than 12kg, self propelled rollers are unsuitable

and such rollers should be towed by track laying tractors. The use of smooth-wheeled rollers, grid rollers and pneumatic tired rollers for compacting uniformly-graded materials is also limited to low loads per cm width or wheel loads not exceeding 1.5 tones.

6 Sampling and Testing:

The soils shall be systematically sampled and tested in accordance with the following AASHTO Standards or BSI377 (1975).

i. Classification Tests	AASHTO	BSI377
Preparation of test sampler Dry	T87-72	Cause 1,5
Preparation of test sampler Wet	T146-49	
Mechanical Analysis	T88 -77	Test 7
Specific Gravity	T100 -74	Test 6
Atterberg Limits		
Liquid Limit	T89-68	Test 2
Plastic Limit	T90-70	Test 3
Shrinkage Factors	T92-68	Test 5
Moisture Content	-	Test 1
ii. Compaction Tests		
Dry Density (2.5kg rammer)	T99-74	Test 12
Modified AASHTO compaction	T180 -74	Test 13
Dry Density (vibrating hammer)	—	Test 14
Density in Place		
Drive Cylinder	T204-64 (1974)	Test 15 D
Sand Replacement	TI 91-61 (1974)	Test 15
Balloon Method	T205	
California Bearing Ratio	T193 -72	Test 16

Tests shall be made as often as deemed necessary by the Engineer's Representative to ensure compliance with the requirements of this Section of the Specification.

Testing will be performed by the Employer without cost to the Contractor.

Tests for compaction shall be on a random basis and cover the entire width of the section.

Testing of any layer of construction will be deemed acceptable providing 8 out of 10 consecutive tests are equal to or in excess of the minimum and the remaining 2 tests do not fall below the minimum by more than 2%.

7- Embankments at Approaches to Bridges: To avoid interference with the construction of bridge abutments and wing walls the contractor shall, at points to be determined by the engineers` representative, suspend work on embankments and/ or cuttings forming the approaches to such structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works.

The contractor shall allow in his rates for earthworks entered in the bill of quantities, for any extra cost which may arise from such suspension.

8- Reinstatement of Damage by Rain

Through the currency of the contract all damage to completed earthworks attributable to rain and rainfall runoff or to any other cause shall be made good by the Contractor within 24 hours of such damage occurring without additional cost to the employer.

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- 9- Slips, Subsidence and Over breaks:** In the event of any slip, slide or subsidence taking place in the earthworks extending beyond the required profile of embankment, the Contractor shall dispose of the material in the slip and make good as required by the Engineer's Representative. The classification of material from slips or slides will be in accordance with its condition at the time of removal, irrespective of its prior condition, without additional cost to the employer.

R5 12 Grade And Alignment Control

1. The entire work shall be constructed to the exact position and elevation in conformity to the lines and grades shown on the Drawings or as directed by the Engineer.

The Contractor will be given control line and grade at various intervals throughout the work; he must provide his own men and instruments for determining alignment, elevation and position of all construction between such points, subject to the check and Correction by the Engineer. The Contractor shall keep the Engineer informed a reasonable time in advance of the time and place he intends to do work, in order that control lines and grade may be furnished and the necessary measurements made for record and payment with the least inconvenience to the Engineer and delay to the Contractor. Any changes in the stakes and marks caused by the development of construction shall not be made the basis of a claim for payment. Any stakes or marks destroyed by the Contractor shall be replaced by him at his own expense.

2. **Tolerances in Surface Levels:** The finished earthworks surface unevenness when tested by a 3m straight edge, by taking the measurement at the deepest point between two contact points of the straight edge, shall comply with the following surface level tolerances.

Formation: - 3cm.

Side slopes:- 10cm. The side slopes of rock cuttings need only be trimmed to give an average side slope as specified; the finished appearance of the rock face will vary to suit the character of the rock.

Verges or Shoulders: -3cm.

The Contractor shall inform the Engineer's Representative in a reasonable time in advance, of the time and place of work, so as to ensure that the taking of measurements, is of the minimum inconvenience to the Engineer and minimum delay for the Contractor.

R5 13 Overhaul

Overhaul will consist of performing all operations necessary for the authorized transportation of fill material more than a distance of five hundred meters from the centre of mass of the material in its original position to the centre of mass of the resulting embankment.

R5 14 PITCHING

Where shown on the Drawings or directed by the Engineer's Representative hand-set pitching laid dry or in 1:3 cement mortar shall be placed to stabilize slopes or as a protection against water or other erosion to form a flat or curved surface as required by the Engineer. The stones shall comprise good hard durable broken boulders or pieces of rock of a type approved by the Engineer's Representative, roughly squared and shaped, set on their edges with their longest dimension at right angles to the flow of water. They shall be securely bedded, breaking bond, closely packed with any interstices locked and filled by selected stone spalls hammered in. Pitching shall be laid on a bed of approved granular material of 80mm thickness.

- The depth of the stones and their weight shall generally not be less than
- (a) 22cm and 25kg for heavy pitching to culvert ends and approaches, and protection of structures, revetment to slopes and where directed,
 - (b) 17cm and 10kg for lighter pitching where directed to ditches, beams, etc.

The ends of pitched areas shall be protected from undermining by the use of edge stones at least twice the general size and weight set on end. In large or sloped areas of pitching, key stones shall be provided at the rate of one per square meter, at least one and a half times the general size and weight, set on end.

The pitching to the batters of the earthworks and diversions of waterways shall be carried down in trench to such a depth as will ensure a sound footing for the lowest course; subsequent to pitching, the trench shall be backfilled to normal ground level with approved, well compacted material.

Pitching laid in cement mortar shall be laid in panels with weepholes, the joints between the panels being approximately 2cm in thickness and extending the full depth of the pitching; the joints shall be filled with a sand-bitumen mixture consisting of approximately one part by weight of bitumen heated as necessary to two parts by weight of a clean sharp sand. The dimensions of the panels shall be approximately two meters square, but the precise dimension in any instance and the spacing of the weep holes shall be as required by the Engineer. In laying the pitching the lines of the panel joints shall be picked out with a straight fillet laid on the face of the earthworks and the stones set up carefully to the edge of the fillet. Subsequent to laying the pitching, the fillet shall be removed and the joint caulked with the sand-bitumen mixture as above.

R5 15 MAINTENANCE

After completion the roadway (all construction items within the right of way) shall be continuously maintained by the Contractor to the satisfaction of the Engineer and to the required grades and cross-sections, until the project is accepted.

R5 16 MEASUREMENT

1. Salt Stripping: The unit of measurement for salt stripping shall be the cubic metre.

The number of cubic metres for payment shall be computed by the average end area method from cross-sections taken by the Engineer's Representative, before and after stripping.

Measurement will not include stripping of any description from excavation or borrow areas, which will be paid for as Excavation.

2. Removal of Old Pavement: The unit of measurement for the removal of old pavement shall be the square metre. The number of square metres for payment shall be the area actually removed; it shall not include the area of pavement scarified, but left in place.

3. Excavation; The unit of measurement for excavation shall be the cubic metre.

The number of cubic metres of excavation shall be computed by the average end area method from cross-sections taken by the Engineer's Representative before commencing and after completing the required excavation.

The number of cubic metres for payment shall be the cubic metres of material removed from all excavation and borrow areas, including:

Material which is acceptable, utilised in backfill or embankment construction as herein specified, material from drainage excavation and structural excavation, material used in shoulder construction as required in other sections of the Specification, salt stripping from excavation or borrow areas and authorised waste material.

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Measurement will not include, the cubic meters of material excavated beyond the net cross-section line shown on the Drawings unless authorized by the Engineer, the cubic meters of excavated material which is used for any purpose other than that indicated on the Drawings unless directed by the Engineer, the cubic meters of salt stripping from the embankment area, or the cubic meters of material removed prior to the original cross-section measurement.

4. Overhaul: The unit of measurement for payment will be the "meter-station".

The number of overhaul units to be paid for will be the product of the overhaul distance expressed in stations multiplied by the quantity of excavation in cubic metres and shall be expressed in "meter-stations".

A "station" will be one hundred meters.

Haul distances of five hundred meters, or less, shall be designated as "free haul" for which no overhaul payment will be made.

The limit of free haul will be determined by fixing on the profile two points five hundred meters apart, one on each side of the neutral grade point, selected in such a way that the included quantities of excavation will balance the included quantities of embankment. All material hauled beyond the free haul limit of five hundred meters will be overhaul and shall be estimated and paid for on the basis of the following method of computations:

- (i) All material, whether roadway or borrow excavation within the limits of five hundred meters will be eliminated from further consideration.
- (ii) The overhaul distance will be the distance between the centre of gravity of the remaining mass of excavation and the centre of gravity of the resulting embankment, less five hundred meters, free haul.
- (iii) The amount of overhaul to be paid for shall be obtained by multiplying the overhaul distance in stations, measured along the centre line of the improvement, by the quantity of the remaining mass of excavation, computed by the average end area method from cross-sections taken by the Engineer's Representative immediately after salt stripping has been performed and after completing the necessary excavation.

If the material is to be obtained from borrow pits, or is to be wasted in spoil areas, it shall be hauled over the shortest practical route, which shall be designated by the Engineer's Representative before hauling begins from any source of supply. The overhaul distance for all material hauled over five hundred meters shall be the distance from the centre of gravity of the borrow pit to the centre of gravity in place on the road, or from the excavation in the roadway to spoil bank, at the point designated by the Engineer's Representative, less five hundred meters. The overhauled material distance shall be the total distance as provided above but less the free-haul distance of five hundred meters, regardless of the route used by the Contractor in material hauling from pits to spoil areas or from stripping points to the place where material is to be used in the road.

- 6. Embankment in Place:** The quantity of embankment in place to be paid for under Clause R5 08 will be the number of cubic meters of material measured in its final compacted position, placed and disposed of as required by the Drawings and Specification within the limits shown on the Drawings unless otherwise ordered in writing by the Engineer.

R5 17 PAYMENT

1. Salt Stripping: The cubic meters of salt stripping, computed as specified in Clause R5 16-1, hereof, will be paid for at the price tendered per cubic meter of salt stripping, which payment shall constitute all compensation for furnishing all equipment, labour and incidentals necessary to complete the stripping and removal of salts material from the embankment area.

2. Removal of Old Pavement: The square meters of old pavement removed, measured as specified in Clause R5 16-2, will be paid for at the price tendered for removal of old pavement, which payment shall constitute full compensation for furnishing all equipment, labour and incidentals necessary to complete the removal of old pavement in accordance with this section of the Specification and the applicable Drawings.

3. Excavation for Structures: The quantity of excavation for structures for which payment will be made, will be the quantity actually removed, but it shall not exceed the volume in place within vertical planes coincident with the outside of the net lines of the footings, from the surface of the ground as it exists at the time when the foundation excavation is started, but not higher than the ground level immediately prior to the commencement of the work to the elevation shown on the Drawings or to such elevation as the Engineer may direct. The Contractor shall not be entitled to payment in respect of excavation to any greater extent, whether horizontally or vertically, than is necessary to receive the structure for which the excavation is intended.

Any work connected with keeping the excavation dry, with any bailing or pumping, timbering, shoring, sheet piling, cofferdams, caisson or with other special appliance for supporting of sides and with filling, ramming and disposal of surplus materials shall be included in the rates for excavation and will not be paid for under separate rates in any other part of the Bill of Quantities.

4. Excavation: The volume of excavation of the various classes as given in Clause R5 02-3, measured as specified in Clause R5 16-3, hereof, will be paid for at the price tendered per cubic meter of excavation, which payment shall constitute full compensation for: maintaining grade and alignment control stakes, required excavation of all types, including Drainage Excavation, Special Borrow Excavation, General Excavation, Salt Stripping, opening and operating borrow pits, preparation of the embankment area and construction of the embankment, including backfilling around structures, bailing or pumping water, close timbering, sheet piling, cofferdams, caissons or other special appliance for supporting sides of trenches or pits in Drainage Excavation and Excavation for Structures, maintenance of the completed work until final acceptance and furnishing of all other materials, including the necessary water for compaction, labour and incidentals necessary to complete the work required in accordance with this section of the Specification and the applicable Drawings.

Earthworks

5. Overhaul: The number of meter-stations, computed as specified in Clause R5 16-4, will be paid for at the price tendered in the Bill of Quantities per meter-station, which payment will constitute full compensation for all equipment, labour and incidentals required for transporting fill in excess of 500m.

If the Drawings or Bill of Quantities show no overhaul quantities or a note that overhaul will not be paid for as a separate item, then the costs of all overhaul will be considered as included in and completely compensated for by the prices tendered for other items of work included in the Bill of Quantities.

6. Embankment in Place: The price tendered for this item shall include the cost of furnishing all labour, material and equipment, including water required for compaction and all other things necessary to complete the work of constructing the Embankment in Place including ramp and shoulder construction.

7. Shrinking and Swelling: In measuring all excavations the quantities shall be regarded as the net cubic content of the void formed by the removal of the material excavated in accordance with the Specifications and Drawings, no allowance being made for shrinking, bulking, swelling or settlement.

Note: The volume of borrow material is obtained by deducting the total volume of suitable fill available from excavations within the works from the total volume of fill required to complete the embankments. In all cases the net cubic content is used without allowance for shrinking, swelling, bulking or settlement.

SECTION R6

Selected Granular Material-Subbase Course

R6 01 Scope

The work covered by this section of the specification consists in furnishing all plant, equipment, material and labored, and in performing all operations in connection with the construction of a selected granular material sub-base course on a prepared subgrade, complete, subject to the terms and conditions of the contract, and in strict accordance with this section of the specification and the applicable drawings and the directions of the engineering's representative.

R6 02 Materials

The materials shall consist of sand, gravel or sand-gravel mixture obtaining from source selected by the contractor and approved by the engineer, approval of the source shall not mean that all material in the source is approved. The sub base material as finally graded and compacted to the correct profile on the sub grade shall comply with the following requirements:-

Coarse Aggregate (that retained in 2mm (No.10) sieve)). Coarse aggregate shall consist of hard, durable particles or fragments of gravel free from dirt and other objectionable matter. It shall have a percentage of wear not exceeding 45 when tested in accordance with AASHTO standard method T96-74.

Fine aggregate (passing the 2mm sieve). The Fine aggregate shall consist of sharp natural sand or a well graded mixture of sharp natural sand, silt, clay and stone dust or other similar binding or filler materials from approved sources.

It shall not contain more than 2% of organic matter when tested in accordance with test No. 8 of BS 1377. Soluble salts shall not be more than 10 % when tested according to the Earth manual of U.S. Bureau of reclamation Appendix E8 with maximum dilution of 1:50. The sulphate content in terms of SO₃ shall not be more than 5 % by weight when tested in accordance with BS 1377 test No. 9 (i.e. gypsum content equals to 10.75 %). The content of clay lumps (AASHTO T 112) shall not be more than 0.25 %. The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 3/5 of the fraction passing the 0.425 mm (No.40)sieve. The material passing the 0.425 mm (No.40) sieve when prepared in accordance with AASHTO T 146 and tested by the appropriate methods shall conform with the following requirements :

Property	Standard Method	Maximum
Liquid Limit	AASHTO T 89	25 %
Plasticity Index	AASHTO T 90	6 %

When used for shoulders of roads without an impervious surfacing, and for a subbase layer which is kept uncovered as the surface course for several years, the liquid limits should not exceed 35 % and the plasticity index should fall in the range 4% to 9%.

The granular sub-base shall be in accordance with table R6/1 Type, C or D. The last one (type D) can be used for the stabilization of shoulders and for the replacement of unsuitable soil.

Selected Granular material – Subbase Course

The grading type and total thickness shall be as shown on the drawings or described in the Bill of Quantities.

The grading as used in the work shall not vary from the low limit on one sieve to the high limit on the adjacent , but shall be uniformly graded.

Table R6/1
Selected Granular Material – Grade Requirements

US Sieve Size	Type A	Type B	Type C	Type D
Mm Alternative				
75 3 in	100			
50 .0 2 in	95-100	100		
25,0 1 in		75-95	100	100
9.5 3/8 in	30-65	40-75	50-85	60-100
4.75 No.4	25-55	30-60	35-65	50-85
2.36 No.8	16-42	21-47	26-52	42-72
0.30 No.50	7-18	14-28	14-28	23-42
0.075 No.200	2-8	5-15	5-15	5-20

The California Bearing Ratio for the type B ,C,& D when tested in accordance with(ASTM D 1883)using modified compaction shall not be less than 35 % for type B, at 30 % FOR TYPE c& 20 % for type D AT 95 % of the maximum density established according to AASHTO T 180 Or ASTM D 1557.

The material shall be laid and compacted to the requirements of Clause R6 12 and with the minimum of drying out or segregation.

Where the contractor proposes to use the subbase for construction traffic he shall at his own expense increase the thickness and strength of the sub-base to accommodate the method of construction and the type of plant and vehicles which he propose to use. Such thickening shall be across the whole width of the carriageway, unless otherwise agreed by the Engineer.

The increased thickness of the sub-base course shall be achieved by lowering the formation level by an amount equal to the increase in thickness of the sub-base course.

R6 03 Sampling and Testing

The Sources of material shall be selected in advance of the time when the material will be required in the work and adequate representative samples submitted to the Engineer for testing and preliminary approval not less than 20 days before such material is required for use in the work.

The Employer will sample and test the materials on the site as frequently as deemed necessary. Any material found not to conform with the requirements, then or later, will be cause for rejection. All rejected material shall be removed and replaced by the contractor with material meeting the requirements at no cost to the Employer.

R6 04 Equipment

All equipment, tools and machines used in the performance of the work shall be either new or in the top grade second hand condition or be subject to the approval of the Engineer, and shall be maintained in satisfactory working condition at all times.

Blade Graders. Blade Graders shall have an adjustable blade for slopes and shall be self-propelled. Other approved suitable spreading equipment may be used.

Sprinkling equipment. Sprinkling equipment shall be suitable for applying water uniformly and at controlled quantities to variable widths of surface.

Transporting and mixing equipment . the mixing equipment shall be of an approved type that that will collect and thoroughly mix the material that has been spread on the subgrade or the material transported to the spreader –mixer. The addition of water shall be metered and the mixing controlled so that the resulting mixture is entirely uniform and the specified moisture content of maximum density.

Compaction Equipment. Compaction Equipment shall be of the most suitable type for compacting the sub-base material to the density specified and can comprise smooth-wheeled power rollers, pneumatic–tyred rollers, rubber-tyred compactors, vibratory rollers, vibrating - plate compactors or vibro tampers, all operated to the specified number of passes to achieve the maximum specified density obtained in trials on the materials.

R6 05 OPERATION OF QUARRIES, PITS AND STOCKPILING

All strata and pockets of unsuitable material overlying or occurring in the deposit shall be hauled to spoil. The method processing and blending the material and of operating the pit shall be changed or modified to obtain material conforming to the specified requirements as directed by the Engineers` Representative.

Approved sand may be stockpiled in the manner and at the location approved by the engineers` representative. Prior to stock piling , storage sites shall be cleared and leveled by the contractor

In sand and gravel pits, or works stockpiling areas which are close to water table, precautions shall be taken against contamination by crystal mush or surface crusts on a pit floor or other stockpile area , by the provision of an approved impervious membrane before stockpiling.

R6 06 Weather Limitation

Sub-base shall be constructed only when weather conditions do not detrimentally affect the quality of the finished formation . It shall not be placed when the temperature is below 3° C. Any areas of the sub-base that are damaged by the effects of freezing temperatures or other weather conditions during any phase of construction shall be completely scarified, re-shaped and re-compacted in conformance with the requirements of this specification without additional cost to the Employer.

R6 07- Preparation of Subgrade

Prior to construction of the sub-base course, the previously prepared formation shall be cleaned of all foreign substances, freed from mud and slurry and properly shaped and compacted by rolling to an even and uniform surface as shown on the Drawings. Any ruts or soft yielding spots which occur in the subgrade, any area having inadequate compaction, or any deviation of surface from the requirements specified shall be corrected by the scarifying, removing and /or adding approved material, re-shaping and re-compacting the unsatisfactory areas to the required density and to the established line and grade. Appreciable irregularities in the surface of the subgrade shall be corrected by balding and rolling, adding water where necessary.

R6 08-Grade and Alignment Control

Grade and alignment Control stakes shall be furnished, set and maintained by the contractor, subject to checking by the Engineer, in order that the work shall conform to the lines, grades and cross-sections shown on the drawings. The Stakes shall be set in rows on and parallel with

Selected Granular material – Subbase Course

the centerline of the pavement and spaced so that string lines may be stretched between them, but in no case more than 15m apart.

R6 09- Placing and Spreading

Where the sub-base course thickness exceeds 20 cm, it may be constructed in two or more layers of equal thickness depending on the compaction equipment available. No superimposed layer shall be placed before the previous layer has been approved by the Engineer. All material shall be placed and spread evenly. Spreading shall be undertaken either concurrently with placing or without delay. Sub-base material shall be spread using a mechanical spreader or spreader box operated with a mechanism which levels off the material to an even depth.

A template cut to the camber or cross fall of the finished course shall be used for checking.

R6 10 -Mixing

Mixing shall be accomplished in one or more passes of the mixer through the material, but in any event shall be continued until the resulting mixture is entirely uniform and of proper moisture content. If at any time the material is excessively moistened during construction, it shall be aerated by re-mixing until the moisture content is acceptable. Areas of segregated material shall be corrected by removing and replacing with satisfactory material or by re-mixing. When necessary to meet the requirements specified, additional approval material shall be spread in such amounts as are found to necessary and the added material shall be uniformly mixed into the sub-base material, adding water as required to obtain the specified density.

Any other satisfactory method of mechanical mixing of the sub-base materials may be employed subject to the approval of the Engineer.

R6 11 Compaction

Each layer shall be compacted until the entire depth of the course is at least 95 percent of density at optimum moisture as determined by AASHTO T 180-74 or 95 percent of the maximum dry density achieved in the BS compaction Test 4-5 kg rammer (Test 12) in BS1377(1975).

Compaction shall be completed as soon as possible after the material has been spread.

The surface of any layer of material shall on completion of compaction be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

R6 12-Thickness and Finish

The surface of each sub-base course shall be properly shaped to a smooth uniform surface parallel to the finished surface of the carriageway and shall not vary more than 2 cm when tested with 4m straight edge.

The entire work must be constructed to the exact position and level in conformity to the lines and grades shown on the drawings. The tolerance for level is +1 cm to – 2 cm.

The completed sub-base course will be tested for the required thickness and surface before acceptance.

The tolerance for thickness is + 10 % to – 15 %. Any areas of the completed sub-base having a compacted thickness less than the thickness shown in the respective items of the bill of Quantities and/or on the drawings or where any tolerance is exceeded shall be rectified by scarifying the top 75 mm, reshaping with added material and re-compacting all to the specification. This area treated shall be not less than 30 m long and 2m wide or such length to be determined by the Engineer as necessary to obtain compliance with the specification.

Skin patching of an area without scarifying the surface to permit proper bonding of the added material will not be permitted.

R6 013- Maintenance

The completed sub-base course shall be maintained in an acceptable condition at all times as directed by the Engineer prior to the construction of the road base. Traffic will not be permitted on the sub-base during the rainy season.

R6 14 – MEASUREMENT

The unit of measurement for the sub-base course shall be the square meter. The number of square meters shall be the accepted sub-base course as measured in place. Measurement shall not include any areas in excess of those shown on the Drawings , except for any areas authorized by the engineer in writing.

R6 15 PAYMENTS

The area of sub-base course , determined as specified in clause R6 14 will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub-base course, including preparation of sub grade, the furnishing of all materials, supplies, plant, equipment, tools and labored; the handling, mixing manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance; and for furnishing of all other labour, and incidentals necessary for the completion of the work required by this section of the specification.

SECTION R6E

SOIL CEMENT STABILISED SUBGRADE, SUB-BASE OR BASE

R6E 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with constructing soil cement stabilized sub grade, sub-base layer or base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R6E 02 MATERIALS

1-: **General** :The mix-in place method of construction will only apply to sites with naturally occurring sand, gravel, or sand and gravel mixture, unless otherwise provided in the special specification of particular application. For the stationary plant method of construction, the materials shall comply with the specification or materials from any other sources selected by the contractor shall be subject to the approval of the Engineer's Representative.

2-: **Soils**: Soils are divided into two groups according to their type:

(i) Salty and clayey soils (for subgrade). When this type of soil is used for cement stabilization it shall fulfill the following requirements:

(a) Maximum liquid limit 45%

(b) Maximum plasticity index 20%

(c) Ph value of soil-cement tested in accordance with BS192(1975) not less than 12.1

(d) Maximum content of soluble salts

Sulphates 4%

Chlorides 8%

(e) Finer than 0.002 mm (clay) below 35%

If the soil at the site does not meet the conditions mentioned under (c), the soil shall be improved on the basis of laboratory testing by adding calcium chloride up to 2% of the weight of the dry soil. The addition of calcium chloride might help in achieving the strength requirement.

Sandy and gravelly soils. Sandy and gravelly soils shall fulfill the following requirements:

(ii) Sandy and gravelly soils. Sandy and gravelly soils used for cement stabilization shall fulfill the following requirements:

(a) Passing maximum size 50mm sieve 100%

(b) Passing 5mm (No. 4) sieve above 50%

(c) Passing 0.4mm (No. 36) sieve above 15%

(d) Passing 0.075mm (No. 200) sieve below 5%

(e) Finer than 0.002mm (Clay) below 3%

Soils which do not meet these requirements shall be subject to the approval of the Engineer's Representative, whose decision will be made following laboratory testing.

(iii) Cement: The cement to be used for stabilization shall be Portland cement, or sulphate resistant cement as directed by the Engineer's Representative according to the Soil Cement Stabilized Subgrade, Sub-Base or Base results of laboratory tests. The Portland cement shall conform to the requirements of BS 12 Part 2 (1971) Portland cement (ordinary and rapid hardening), BS4027 Part 2 (1972), or to AASHTO M85-74 Type V for High Sulphate Resistant Portland Cement.

For storage of cement at least two silos shall be used. Before recharging a silo it shall be emptied completely and cleaned. During the time of charging a silo shall not be used for batching. The silos and all batching devices shall be maintained regularly.

At the time of use all cement shall be free-flowing and free of lumps. Under normal circumstances cement shall not be stored for a longer period than four months. Any cement that has remained in store for a period in excess of four months, or of which there is any doubt as to its quality, shall be re-tested by standard mortar tests to determine whether it still meets the requirements of BS4027 Part 2 (1972). No such cement shall be used in the Works without the approval of the Engineer's Representative.

- (iv) Water: The water to be used for cement stabilization shall be clean and free from injurious substances. Water from doubtful sources shall not be used until tested as specified in AASHTO T26-72 and approved by the Engineer's Representative.

R6E 03 MIX DESIGN~

Before starting the work of stabilization, the proposed mix design shall be submitted by the Contractor for the approval of the Engineer's Representative. The mix design shall indicate the exact percentage of cement and water to be used so as to obtain a mixture with the following properties. The mix design shall be in accordance with AASHTO T134.

1. The compressive strength of one set of 3 test specimens shall be 25-50 kg/ cm² after storage in a box with minimum humidity 95% for a period of 7 days. The molding shall be in accordance with AASHTO T134 and the testing shall be in accordance with AASHTO T22.
2. The maximum permissive swelling of volume shall be 2% and the maximum loss in weight 8%. (Testing shall be performed in accordance with AASHTO T135-70).
3. Tolerances allowed on the site.
Cement content 1 to + 2% of that given in the mix design
Water content 0 to + 2% of that given in the mix design

R6E 04 COMPOSITION OF MIXTURE

The granular material shall be mixed with sufficient cement to provide a crushing strength to the requirements stated in this Clause.

The cement content shall be determined at the laboratory so that the minimum compressive strength is {25kg/cm² and an average compressive strength of the test specimens is 35g/ cm² minimum at 7 days}.

The moisture content of the mixed cement stabilized material shall be not less than the optimum as determined by the Vibrating Hammer Method Test of BS1924, (1975) nor more ,than 2 per cent above the optimum as determined by this test or such higher value as may be agreed by the Engineer's Representative on the basis of the preliminary trial. (This testis identical to Test 14 of B51377 (1975) for soil susceptible to crushing during compaction.

Alternatively tests shall be carried out in accordance with AASHTO T134-70 at the optimum moisture content. The samples shall be kept moist for 7 days in a storage box located in the shade at the site of the Works. Before crushing, the samples should be kept for 2 hours in the water. A swelling test shall be performed according to AASHTO T 135.

The permissible swelling shall be 2% in volume and the maximum loss of weight shall be 8%.

The tests shall be made for each type of material subject to cement stabilization.

R6E 05 EQUIPMENT AND METHOD OF STABILISATION

Equipment, tools and machines used in the performance of the work covered by this section of the specification shall be subject to the approval of the engineers` representative and shall be maintained in satisfactory working condition at all times.

The thickness of layer to be stabilized shall be not less than 8cm when compacted. If the compacted thickness does not exceed 20cm and provided the plant meet the requirements specified in this clause, the material may be constructed in one layer using either stationary plant or mix-in-place for the mixing process. If the course to be stabilized exceeds 20cm in thickness when compacted it shall be constructed in two or more layers each within the range 8 to 20cm in compacted thickness. When two or more layers are employed the mix-in-place process will be permitted only for the construction of the bottom layer.

Cement stabilized subgrade, sub-base or base shall be constructed only when the atmospheric temperature is above 4°C and when the weather is not rainy.

R6E 06 STATIONARY PLANT METHOD OF CONSTRUCTION

If stationary plant is used it 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 cement 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 specified in this Clause. Special care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip so that it is fed evenly along the mixing trough and that with both paddle and pan mixers the cement is proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized.

Mixing shall be continued until the mixture has the uniformity required by this Clause and for not less than 1 minute unless a shorter minimum period is permitted by the Engineer's Representative after satisfactory preliminary trials.

If continuous mixing is used the paddles, baffles and rate of feed of materials shall be adjusted to give a uniformly mixed material. If a spray is used for distributing water into the mixer uniformity in moisture content throughout the mix.

R6E 07 MIX-IN-PLACE METHOD OF CONSTRUCTION

The plant used for pulverizing and mixing the stabilized material will be approved by the Engineer on the basis of preliminary trials to establish that the plant is capable of producing the degree of mixing and uniformity of stabilized material specified in this Clause to the full thickness of the layer being processed. For granular materials both single and multi-pass equipment may be used.

The mixers shall be equipped with a device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of Stabilized Subgrade, Sub-Base or Base mixing is obtained at all times. The cement shall be spread ahead of the mixer by means of a cement spreader, fitted with a device to ensure a uniform and controllable rate of spread of cement both transversely and longitudinally.

If multipass processing is employed, the naturally occurring granular material shall first be pulverized to the required depth with successive passes and the moisture content adjusted if it is more than 3 per cent below the value required for compaction. The cement shall then be spread and mixing continue with successive passes until the required depth uniformity of processing has been obtained.

If it is necessary to adjust the moisture content of the material to the optimum for compaction, water shall be added during the mixing operation using a water sprayer of such design that the water is added in a uniform and controllable manner both transversely and longitudinally.

The mixing machine shall also be set so that it cuts slightly into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

The Engineer may approve the use of scarifier or prepariser ahead of the mixer.

The output of the mixing plant shall be such that a minimum rate of 22 linear meters per hour measured longitudinally of completed stabilized layer can be maintained in order to permit satisfactory compaction of the material.

R6E 08 COMPACTION

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with approved rollers. Compaction shall continue until the entire depth and width of the subgrade or sub-base is uniformly compacted to the minimum density of 95% modified AASHTO according to AASHTO TI 34-70. The compaction shall be completed as soon as possible after mixing normally within two hours. This period depends mainly on the setting time of cement and the weather conditions.

The minimum state of compaction to be attained will be determined by the Preliminary Trial to meet the requirements of Clause R6-11.

Compaction shall not take place after cement hydration and any soils cement material which has been mixed or deposited after cement hydration shall be removed and replaced with fresh material mixed and treated in accordance with the requirements of this Section.

R6E 09 PRELIMINARY TRIAL

At least 10 days before the main work of stabilization is started, the Contractor shall construct an area of stabilized material of 400-800m² as a preliminary trial at a location to be approved by the Engineer's Representative. For this trial, the Contractor shall use the materials, mix proportions, mixing layer compaction plant and construction procedure that he proposes to use for the main work.

The preliminary trial is to test the efficiency of mixing, spreading and compaction plant and the suitability of the methods and organization proposed by the Contractor. The results of the dry density measurements made in the stabilized trial area will be used to confirm the moisture content and minimum state of compaction to be attained in the main stabilization work.

R6E 10 THICKNESS AND FINISH

The surface of the subgrade and each sub-base course or base shall comply with the requirements of Clause R6 12. Any modification to meet the Specification shall be completed, together with the compaction, within two hours after mixing and any removal of, or making good to deficient areas will be at no cost to the Employer. The thickness shall be as shown on the Drawings or as directed by the Engineer's Representative and shall comply with the following requirements:

The tolerance for level shall conform to Clause R5 12 (2) for Earthworks and Table 9/6 as amended for other layers of construction. In-situ dry density of compacted layers minimum 95% modified AASHTO according to AASHTO T134 70.

The smoothness of the finish surface shall not vary by more than 2cm when tested with a 4m straight edge. The maximum tolerance of the cross fall shall be $\pm 0.5\%$.

R6E 11 CURING AND MAINTENANCE

After compaction the stabilized subgrade, the sub-base layer or base shall be protected against drying out by keeping it continuously damp or wet for a period of at least 3 days or by coating with an approved curing material as directed by the Engineer's Representative. The rate of application of the curing material shall be as directed by the Engineer's Representative.

The completed cement stabilized subgrade, sub-base or base shall be maintained in an acceptable condition at all times, as directed by the Engineer's Representative, prior to the construction of the base course.

No vehicular traffic shall run on the stabilized subgrade, sub-base layer or base until the curing period as directed by the Engineer's Representative has elapsed, with a minimum no-traffic period of 7 days.

One day shall be added to the period which would otherwise be required before running traffic of any sort on it for each night on which the temperature of the surface of the layer in question falls to 0°C or below.

R6E 12 SAMPLING AND TESTING

Tests shall be made as often as deemed necessary to ensure compliance with the requirements of this Specification and in accordance with Clause R603.

The minimum number of tests shall be generally as follows:

For every 5,000m² of completed stabilized layer immediately after completion of compaction

In-situ density AASHTO T191-61 (1974) or

AASHTO T205-64

AASHTO T238-73

AASHTO T27 -74

Grading Test AASHTO T27 -74

Cement Content Test AASHTO T211-65 (1974)

For every 10,000m² of completed stabilized layer or for one day are run

:

One set of 3 test specimens for testing the compressive strength, grading and curing of specimen according to Clause R6 E03.

The material shall be taken from the construction site before compaction.

For every 50,000m² of completed stabilized layer:

One moisture density relation test AASHTO T134-70 with material taken fresh from the construction site.

The thickness of the stabilized layer shall be checked while determining the in-situ Density.

R6E 13 MEASUREMENTS

The unit of measurement for payment shall be the square meters of completed and accepted sub grade, sub-base or base as measured in place. Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorized by the Engineer in writing.

R6E 14 PAYMENTS

The square meters of subgrade, sub-base or base, determined as specified in Clause R6E 13, will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub-base course, including Preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labor; the handling, mixing, manipulating, placing, shaping, compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance including the protection of stabilized layers; and the furnishing of all other labor and incidentals necessary for the completion of the work required by this Section of the Specification.

SECTION R6F

LIME STABILISED SUBGRADE OR SUB-BASE

R6F 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor and in performing all operations in connection with the construction of lime stabilized **sub grade** or sub-base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and the applicable Drawings and the directions of the Engineer's Representative.

R6F 02 MATERIALS

1. General: The mix-in-place method of construction will only apply to sites with naturally occurring heavy clay soils, clayey gravels or soils containing a sufficient proportion of clay to enable satisfactory stabilization with lime, unless otherwise provided in the Special Specification of Particular Application. For the stationary plant method of construction the materials shall comply with the Specification or materials from any other sources selected by the Contractor shall be subject to the approval of the Engineer's Representative. Lime stabilization has been successfully used in clayey soils which have a plasticity index greater than 8. This type of stabilization can only be used for soils which contain a high percentage of clay or **silty** clays.

2. Lime: The lime to be used for stabilization shall be calcium hydroxide (slaked or **hydrated** lime) or calcium oxide (quicklime) conforming to the requirements for building lime as Table R6F/1, or lower quality lime produced from **temporary** burning pits or kilns when approved by the Engineer's Representative.

TABLE R6F/1

SPECIFICATION REQUIREMENTS FOR LIME

Property	lime	
	Quicklime	Hydrated Lime (Ca (OH) ₂)
Calcium and magnesium oxides	Not less than 92 per cent	Not less than 95 per cent
Carbon dioxides – at kiln-elsewhere	{ Not more than 3 per cent }	Not more than 5 per cent Not more than 7 per cent

The properties of lime shall be in accordance with AASHTO M 216 and shall be tested in accordance with AASHTO T219.

3. Water: The water to be used for lime stabilization shall be clean and free from injurious substances, potable water is preferred and organic water not permitted. Water from doubtful sources shall not be used until tested as specified in AASHTO T26-72 and approved by the Engineer's Representative.

Lime Stabilised Subgrade or Sub-Base

R6F 03 COMPOSITION OF MIXTURE

1. **General:** The soils containing clay shall be mixed with sufficient lime to provide a crushing strength to the requirements of this Clause; this should normally be between 3% and 8% lime content and as a guide trials should commence at 1% of lime for each (by weight of dry soil) 10% of clay in the soil.

The lime content shall be determined by laboratory mixing and tests so that the average compressive strength of any ten consecutive field determinations is not less than 1.0 N/mm² with not more than two results below this figure and no result less than 0.7 N/mm² at 7 days as specified in the Special Specification for Particular Application.

The moisture content of the mixed lime stabilised material shall be in accordance with the tests in Clause R6E 03.

2. **Testing:** The following tests shall be carried out on the soils to decide on their suitability for use in the mixture.

- | | |
|----------------------------|-------------------------|
| (i) Particle size analysis | AASHTO T88 |
| (ii) Atterberg limits | AASHTO T89 & AASHTO T90 |
| (iii) Acidity | BS 1377, Test No. 11 |
| (iv) Compaction test | AASHTO T99 |
| (v) Natural water content | AASHTO T93. |

3. **Mix Design:** The mix design shall be worked out in the laboratory and it shall state the following. The mix design shall be in accordance with AASHTO T220.

- (i) The percentage of lime and water (optimum content and tolerances).
- (ii) The density of lime stabilisation mixture minimum 95% modified AASHTO T220.
- (iii) The required results of the compressive strength at 7 days, which shall not be less than 1.0 N/mm².
- (iv) The minimum number of tests to be carried out.

R6F 04 EQUIPMENT AND METHOD OF STABILISATION

The requirements of this Section shall be in accordance with Section R6E.

When using calcium oxide (quicklime), its caustic nature will require special consideration in handling, since it will attack equipment corrosively and precautions shall also be taken against the risk of severe skin burns to personnel.

Suitable handling methods shall be used, such as fully mechanised or bottom dump handling equipment, or protective clothing worn by the operators. Working operations should take into account the wind direction to minimise the dust problem and consequent eye or skin irritation to any personnel involved or in the vicinity.

Even when calcium hydroxide (slaked or hydrated lime) is used, care must be taken against the effects of prolonged exposure to the skin.

R6F 05 STATIONARY PLANT METHOD OF CONSTRUCTION

The requirements of this Section shall be in accordance with Section R6E.

R6F 06 MIX-IN-PLACE METHOD OF CONSTRUCTION

The requirements of this Section shall be in accordance with Section R6E.

R6F 07 COMPACTION

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with approved rollers. Compaction shall continue until the entire depth and width of the subgrade, sub-base or base is uniformly compacted to the minimum density of 95% mod. AASHTO according to AASHTO T220.

If quick lime is used, it shall not be permitted to compact the layers immediately after spreading the lime, because the hydration of the lime will cause damage to the compacted layers. The time within which the compaction shall be completed will be estimated in the laboratory. The dry density of the compacted layers shall not be less than 95% of the maximum dry density determined in the laboratory.

Compaction shall not take place after lime hydration and any lime stabilised material that has been mixed or deposited after lime hydration, shall be removed and replaced with fresh material, mixed and treated in accordance with the requirements of this section.

R6F 08 PRELIMINARY TRIAL

The requirements of this Section shall be in accordance with Section R6E.

R6F 09 THICKNESS AND FINISH

The surface of the subgrade and each sub-base course or base shall comply with the requirements of Clause R6 12. Any modification to meet the Specification shall be completed, together with the compaction, within 1½ hours after mixing and any removal of, or making good to deficient areas will be at no cost to the Employer. The thickness shall be as shown on the Drawings or directed by the Engineer's Representative and shall comply with the following requirements:

1. The tolerance for level shall conform to Clause R5 12(2) for earthworks and Table R9/6 as amended for sub-base.
2. The smoothness of the finished surface shall not vary by more than 3cm when tested with a 4m straight edge.
3. The maximum tolerance of the crossfall shall be $\pm 0.5\%$.

R6F 10 SAMPLING AND TESTING

The requirements of this Section shall be in accordance with Clause R6E 12 for soil cement stabilisation, except that the test for cement content shall be omitted and AASHTO T232 Determination of Lime Content shall be substituted.

Lime Stabilised Subgrade or Sub-Base

R6F 11 MEASUREMENT

The unit of measurement for payment shall be the square metre. The area shall be the square metres of completed and accepted subgrade or sub-base course as measured in place. Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorised by the Engineer in writing.

R6F 12 PAYMENT

The area of subgrade or sub-base course at the depth specified in the Special Specification of Particular Application, determined as specified in Clause R6F 11, will be paid for at the price tendered per square metre, which payment shall constitute full compensation for the construction and completion of the sub-base course, including preparation of subgrade, the furnishing of all materials, supplies, plant, equipment, tools and labour; the handling, mixing, manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance; and for furnishing of all other labour and incidentals necessary to complete the work required by this Section of the Specification.

SECTION R6G

BITUMEN STABILISED SUBGRADE OR SUB-BASE

R6G 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labor and in performing all operations in connection with construction of bitumen stabilized sub grade, sub-base or base and all incidentals subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification and the applicable drawings and the directions of the Engineers Representative.

R6G 02 MATERIALS

The mix-in-place method of construction will only apply to sites with naturally occurring sand, or sand and gravel mixture, unless otherwise provided in the Special Specification of Particular Application. For stationary plant method of construction the material shall comply with the Specification or other sources selected by the Contractor and approved by the Engineer's Representative.

The material shall be such as:—

Passing 0-075mm (No. 200 sieve) shall not exceed 30%.

Liquid Limit shall not exceed 30%.

Plasticity Index shall not exceed 15%.

Bitumen: When the moisture content of the sand necessitates drying or heating and the stationary plant method of construction is therefore used, the bituminous material shall comply with the requirements of Clause R902-5 for hot mix asphaltic concrete, or can be a viscous cut-back that requires heating.

In dry areas where the natural moisture content of the sand is low the bituminous binder shall be a proprietary fluid cut-back bitumen in accordance with Clause R8 02-2. The use of bitumen emulsion or foamed penetration grade bitumen will be subject to the approval of the Engineer's Representative after trials for bitumen stabilization referred to in the Special Specification for Particular Application.

In wet areas the drying may be accomplished, when directed and approved by the Engineer's Representative, by the use of up to 2 per cent of hydrated lime in conjunction with a cut-back bitumen containing special acids to re-act with the lime.

The stabilizing agent to be used shall be cut back bitumen RC 70 or RC 250 or RC 800 complying with AASHTO M81 or MC 70 or MC 250 or MC 800 complying with AASHTO M82. Cationic emulsified bitumen SS Type complying with AASHTO M208 may also be used.

The choice of stabilizing agent shall be made on the basis of Laboratory trials taking into account the type of soil, climatic conditions of the site and the available equipment.

R6G 03 COMPOSITION OF MIXTURE

Bitumen-soil mixtures shall be ascertained by laboratory trial mixes using the procedure for determining the compressive strength of bituminous mixes in compliance with AASHTO T167. This test is to be carried out in such a way as to ensure that the optimum composition of the mix is established.

The laboratory trial mixes shall have as a minimum the compressive strength and Marshall Stability shown in Table R6G/1 after being air cured for a period of 7 days.

Testing shall be in accordance with AASHTO T167.

TABLE R6G/1

	Sub-grade	Sub-base
Compressive Strength at 25° C	1 N/mm ²	2 N/mm ²
Marshall Stability at 60° C	1 KN	2 KN

The Index of Retained Strength when tested in accordance with AASHTO T165 shall not be less than 70%.

On the basis of the results of the laboratory trial mixes site trials shall be carried out to establish the exact percentage and temperature of binder to be used and to determine the suitability of the equipment that it is proposed to use. The cost of these trials is to be included in the rates for Bitumen Stabilized mixtures.

R6G 04 EQUIPMENT AND METHOD OF STABILISATION

Equipment, tools and machines used in the performance of the work covered by this Section of the Specification shall be subject to the approval of the Engineer's Representative and shall be maintained in a satisfactory working condition at all times.

The mix-in-place method of construction may be adopted where the use of low viscosity binders, i.e. cut-back or bitumen emulsion are found suitable when approved by the Engineer's Representative.

Where stabilization with penetration grades binders is necessary the stationary plant method of construction will be used.

R6G 05 STATIONARY PLANT METHOD OF CONSTRUCTION

The mixing plant and pavers shall meet the general requirements of Clause R905.

R6G 06 MIX-IN-PLACE METHOD OF CONSTRUCTION

Mix-in-place bitumen stabilization will be subject to the approval of the Engineer's Representative to ensure full control of the bitumen content, the completeness of mixing and processing depth.

Tests with multi-pass equipment of a simple character will be approved by the Engineer's Representative and can involve the use of a bitumen distributor and blade grader only.

Purpose-built single-pass stabilization machines may be used, subject to the availability of a reserve machine in the event of mechanical breakdown, to ensure avoidance of complete stoppage of work.

R6G 07 COMPACTION

Immediately upon completion of the spreading operation and shaping, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until the entire depth and width of the base is uniformly compacted to give soaked unconfined compressive strengths as specified in the Special Specification of Particular application according to the design requirement to meet the traffic loading. The tyre marks can be removed on the final surface by use of a steel-tyred tandem roller.

R6G 08 PRELIMINARY TRIAL

Preliminary trials shall be carried out in accordance with Clause R6E 09.

R6G 09 THICKNESS AND FINISH

The surface finish and thickness of the layers shall conform to Clause R6E 10 as amended.

R6G 10 CURING AND MAINTENANCE

The need for curing will depend upon the type of bitumen binder used and in the case of mix-in-place construction, the stabilized soil may be left uncompacted after pulverization and mixing to allow a period of evaporation of volatiles. Such aeration before compaction increases stability and decreases water absorption particularly in fine grained sands when temperatures are low. Test procedures for stability tests should, when directed by the Engineer's Representative, include a curing period after compaction to allow for evaporation and to ascertain the pattern of behaviour for certain binders during preliminary trials at various temperatures as specified in Clause R6G 03 and the Special Specification for Particular Application.

Lean mixes of bitumen sand shall be primed in accordance with Section R8A for protection against abrasion before surfacing or surface dressing.

R6G 11 WEATHER LIMITATIONS

The laying of bituminous-sand courses shall generally comply with the requirements of Clause R9 12.

R6G 12 SAMPLING AND TESTING

Sand and sandy soils, bitumen and bituminous mixtures shall be tested as frequently as deemed necessary by the Engineer's Representative to check compliance with Clauses 6G 02 and 6G03. Samples of the plant mixtures shall be taken at the plant and/or on the working site as specified to determine if the mixtures conform to the job-mix formula requirements and all temperatures shall be checked.

1. Testing bituminous Binders. *

Cut back bitumen's shall be tested in accordance with the following:—

(i) Sampling	AASHTO T40
(ii) Distillation	AASHTO T78
(iii) Flash Point	AASHTO T79
(iv) Saybolt-Furol Viscosity	AASHTO T72
(v) Kinematic Viscosity	AASHTO T201
(vi) Absolute Viscosity	AASHTO T202

Cationic emulsified bitumen shall be tested in accordance with AASHTO T-59.

2. The preparation of standard specimens of soil- asphalt mixtures suitable for the required test method when using fine grained soils and liquid or emulsified asphalt shall be done according to ASTM D 4223.

Sampling and Testing Bituminous Stabilized Mixtures:—

A minimum of one set of three samples shall be taken from every 2500m² of completed stabilized layer immediately after completion of compaction. Other samples shall be taken as directed by the Engineer's Representative.

The in situ density is to be in accordance with one of the following Standards.—

AASHTO T191 or

AASHTO T205 or

AASHTO T230 or

AASHTO T238

The in situ density shall not be less than 95% of bulk density of the laboratory mix.

The thickness of the stabilized layer shall be checked while determining the in situ density.

For every 5000m² or one day's run of completed stabilized layer the following tests shall be carried out:—

- (i) Composition of the mix by extraction in accordance with AASHTO T164.
- (ii) Compressive strength from samples preferably taken from the un compacted layer.
- (iii) Marshall Stability from samples preferably taken from the un compacted layer.
- (iv) All criteria shall conform to those established for the approved trial area (Clause R6G 03).

R6G 13 MEASUREMENT

The unit of measurement for payment shall be the square meter. The area shall be the square meters of completed and accepted sub grade or sub-base as measured in place.

Measurement will not include any areas in excess of that shown on the Drawings, except the areas authorized by the Engineer in writing.

R6G 14 PAYMENT

The area of sub grade or sub-base, determined as specified in Clause R6G 13 will be paid for at the price tendered per square meter, which payment shall constitute full compensation for the construction and completion of the sub grade or sub-base including surface preparation, the furnishing of all materials, supplies, plant, equipment, tools and labor; the handling, mixing, manipulating, placing, shaping compacting, including the necessary water for compaction, rolling and finishing; correcting unsatisfactory areas and unsatisfactory mixtures; maintenance; and for furnishing of all other labor and incidental necessary to complete the work required by this Section of the Specification.

SECTION R7
BASE COURSES
CRUSHED-LIMESTONE BASE COURSE
CRUSHED GRAVEL BASE COURSE
VIBRATORY-COMPACTED MACADAM STONE BASE COURSE

R7 01 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all plant, labor, equipment and material and in performing all operations in connection with the construction of various types of base courses on a previously constructed subgrade or sub-base, complete, in place and accepted, subject to the terms and conditions of the Contract, in strict accordance with this Section of the Specification and conforming in all respects to the line, grade, thickness and typical cross-section as shown on the Drawings.

The various types of base courses covered by this Section of the Specification are as follows:—

1. Crushed-Limestone Base Course.
2. Crushed-Gravel Base Course.
3. Vibratory-Compacted Macadam Stone Base Course.

R7 02 MATERIALS

The material requirements for various types of base courses shall be as follows:—

1. Crushed-Limestone and Crushed-Gravel Base Course: The material for the crushed limestone or crushed-gravel base course shall be composed of hard sound, durable crushed limestone, particles free from thin elongated, soft and disintegrated material or other objectionable matter. The crushed limestone or gravel shall be produced from the sources shown on the Drawings or from sources selected by the Contractor and approved by the Engineer's Representative. Preliminary approval of sources shall not mean that all material in such sources is acceptable. When the grading and fracture requirements cannot be produced by utilising all of the pit-run material, portions of the raw material, as may be required, shall be removed by mechanical screening prior to the crushing operations.

Boulders encountered in the pit, up to 25cm in the largest dimension, shall be processed by mechanical crushing. The crushed limestone or gravel as finally processed shall comply with the following requirements:

- (a) Grading: The grading as determined by AASHTO Standard Method T27-74 shall be as shown in Table R7/1 below:

US Sieve mm	Size Imperial	Percentage Passing by Weight
37-5	1½in	100
25-0	1in	80-100
12-5	½in	50-80
4-75	No. 4	30-60
0-425	No. 40	10-30
0-075	No. 200	5-15*

*The fraction of the material passing the 0-075mm (No. 200) sieve shall not be more than 60% of the fraction passing the 0-425mm (No. 40) sieve. When using crushed gravel the percentage passing the 0-075 (No. 200) sieve shall be 5-12%.

- (b) Fracture: The fraction of the aggregate retained on the sieve shall contain at least 75% by weight of crushed particles having more than one fractured face.
- (c) Abrasion Loss: The abrasion loss of the crushed limestone as determined by AASHTO Standard Method T96-74 shall not exceed 45%.
- (d) Fines: The fraction of the aggregate passing the 2mm (No. 10) sieve shall consist of limestone or gravel screenings and shall be free of loam, organic or other foreign matter. The material passing the 0-425mm (No. 40) sieve, when prepared in accordance with AASHTO Standard Method T1 46-49 and tested by the appropriate methods, shall conform with the following requirements:

AASHTO Standard Method	Maximum
Liquid Limit T89-68	25%
Plasticity Index T90-70	• 4%

- (e) Gypsum content. The gypsum content of crushed gravel in terms of SO_3 shall not be more than 5% by weight when tested in accordance with BS 1377 test No. 9 .
- (f) The California bearing ratio of the base course when tested in accordance with ASTM D 1883 at 95% modified compaction shall not be less than 80 % .
- (g) The soundness test according to AASHTO T 104 shall, have a weighted loss of not more than 12% when subjected to 5 cycles of the test with sodium sulphate solution , and not more than 18% when subjected to 5 cycles with magnesium sulphate solution.

2. Vibratory-Compacted Macadam Stone Base Course: The requirements for the material to be used for the macadam stone base course shall be as specified under Clause R7 02 1 Crushed-Limestone Base Course with the following exceptions:

The material for the macadam stone base course shall be composed of coarse and fine aggregate. The coarse aggregate shall consist of either crushed limestone, crushed gravel or any other suitable crushed material, composed of clean, tough and durable particles and shall be free from thin elongated particles, soft and disintegrated material or other objectionable matter. If crushed gravel is used, it shall contain 75% of fractured particles. The fine aggregate shall consist of clean, tough, durable particles of crushed stone screenings, and shall be free from dirt and other objectionable material. The material shall be secured from sources shown on the Drawings or from sources selected by the Contractor and approved by the Engineer's Representative. Preliminary approval of sources of material shall not mean that all material in such sources is acceptable. The coarse and fine aggregate shall meet the following requirements:

- (a) Grading: The grading of the material for the vibratory-compacted macadam stone base course, as determined by AASHTO Standard Method T27-74, shall be as shown in Table R7/2 below:-

TABLE R7/2
VIBRATORY-COMPACTED MACADAM STONE BASE MATERIAL

U.S. Sieve Size		Per Cent Passing Coarse Aggregate	by Weight Fine Aggregate
mm	Imperial		
63.0	2½ in	100	—
50.0	2 in	90-100	-
37.5	1½ in	35-70	-
25.0	1 in	0-15	-
12.5	½ in	0-5	-
9.5	¾ in	-	100
4.75	No. 4	-	85-100
0.15	No. 100	-	10-30

The material shall be screened to produce separate stock-piles of material above 10mm.

- (b) Abrasion Loss: The abrasion loss for the material for the vibratory-compacted macadam stone base course, as determined on representative samples of slaked material in accordance with AASHTO Standard Method T96-74, shall not exceed 45%.
- (c) The soundness test according to AASHTO T 104 shall have a weighted loss of not more than 12% when subjected to 5 cycles of the test with sodium sulphate solution and not more than 18% when subjected to 5 cycles with magnesium sulphate solution.

R7 03 SAMPLING AND TESTING

The following requirements for the sampling and testing of the material shall apply to the various base courses:

The sources of material shall be selected in advance of the time when the material will be required in the work, and adequate representative samples submitted to the Engineer for testing and preliminary approval not less than 20 days before such material is required for use in the work. The Employer will sample and test the material of the particular base course or courses, as called for in the Special Specification of Particular Application, and/or the Bill of Quantities, and/or as shown on the Drawings, on the site as frequently as deemed necessary to assure conformance with the requirements of Clause R7 02. Any material found not to conform with the requirements of Clause R7 02 will be subject to rejection. All rejected material shall be removed and replaced with material meeting the requirements of the Clause R7 02 by the Contractor, at no cost to the Employer.

R7 04 EQUIPMENT

All equipment, tools and machines used in the performance of the work shall be subject to the approval of the Engineer's Representative, and shall be maintained in a satisfactory condition at all times. Any machine, combination of machines or equipment, which will handle the material and produce the type of base course as called in the Special Specification of Particular Application, and/or the Bill of Quantities, and/or as shown on the Drawings, such as (a) Crushed-Limestone Base Course, (b) Crushed-Gravel Base Course, or (c) Vibratory-Compacted Macadam Base Course, in accordance with this Specification, may be used on approval. The only exception is the vibratory compactor, which is an essential requirement for the construction of the Vibratory-Compacted Macadam Stone Base Course, but may be used by the Contractor in conjunction with the construction of other types of base course with the approval of the Engineer's Representative.

1. The Blade Graders, Sprinkling Equipment and all compacting equipment shall be as described and specified in Clause R6 04.

2. Mechanical Spreaders: Mechanical spreaders shall be the spreader box type capable of receiving material to be spread by a hopper to an even depth. The spreader shall be adjustable so that the width and thickness of the spread can be set to any dimension required by the Drawings and Specification and for uniform and complete coverage.

The mechanical spreader may be self-propelled or receive propulsion from an outside source.

If self-propelled, the speed of the spreader shall be controllable.

R7 05 OPERATION OF QUARRIES AND PITS

R7 06 STOCKPILING

R7 07 WEATHER LIMITATIONS

R7 08 PREPARATION OF SUB-GRADE

R7 09 GRADE AND ALIGNMENT CONTROL

The requirements for these clauses shall conform to the requirements as specified in Clauses R6 05 to R6 09.

R7 10 CONSTRUCTION METHODS, INCLUDING PLACING, SPREADING AND COMPACTION

1. **Crushed-Limestone Base Course and Crushed-Gravel Base Course:** Where the base course thickness exceeds 12-5cm it shall be constructed in layers of equal thickness, the thickness of no layer shall exceed 12-5cm, except that if a vibratory compactor is used for compaction the thickness of the layers may be increased to a maximum of 25cm providing that satisfactory compaction is obtained.

Each layer shall be compacted until the entire depth of the course is at least 98 per cent of density at optimum moisture as determined by AASHTO T1 80-74, or 98 per cent of the maximum dry density achieved in the BS Compaction Test 4-5kg rammer (Test 12) in BS1377 (1975).

Compaction shall be completed as soon as possible after the material has been spread.

Water shall be applied to the materials during the rolling operations in such amount as may be required to obtain the specified density. Where an appreciable amount of loose materials remains on the surface after rolling as specified above, the layer shall be thoroughly rolled with a pneumatic-tyred roller, with the addition of water where required. Prior to beginning rolling operations on either layer, embankment materials shall be shaped against the edge of the layer in such depth as will permit uniform, simultaneous compaction of the base course layer and the shoulders. In all places not accessible to the rolling equipment, the materials shall be compacted thoroughly with approved mechanical or hand tampers to a density comparable to that obtained by rolling. Each hand tamper shall weigh not less than 23kg. The surface of the final layer shall be finished by balding and by rolling with pneumatic-tyred rollers, with the addition of water as required by the Engineer's Representative, until the surface is smooth and free from waves and irregularities and is true to grade and cross-section. All use of water shall be at the Contractor's expense.

2. Vibratory-Compacted Macadam Stone Base Course: Where the vibratory-compacted macadam stone base course thickness exceeds 25cm, it shall be constructed in two layers of equal thickness.

Each layer shall be compacted until the entire depth of the course is at least 98% of the density at optimum moisture content as determined by AASHTO T180 (modified Compaction) or 98% of the maximum dry density achieved in the BS 1377 Test No. 12 using a 4-5kg rammer.

In advance of placing the coarse aggregate for the base course, a layer of screenings, meeting the requirements for fine aggregate as specified under Clause R702-2 (a), shall be uniformly spread to a thickness as prescribed by the Engineer, which will be one half the amount set by the laboratory on the basis of void age determined.

The spreading and leveling of all the aggregate for the base course shall be performed by the use of approved self-propelled spreading and leveling machines or spreader boxes, equipped with shoes or runners of sufficient length to preclude damage or displacement to the sub grade of sub-base.

Coarse aggregate shall then be spread on the previously spread fine aggregate, to a loose thickness necessary to obtain the required compacted thickness of the layer. The coarse aggregate must be laid and spread by a method whereby the coarse aggregate, as it is laid, precedes the laying device. Running of equipment over or compaction of the previously laid layer of the fine aggregate will not be permitted. The layer of fine aggregate must be kept loose, dry and of even thickness immediately ahead of the laying of the coarse aggregate. In case of moisture in the fine aggregate layer, this layer must be raked and loosened and permitted to dry before application of the coarse aggregate layer.

The coarse aggregate layer, after being laid to a depth to give, when rolled, the proper thickness, shall be given two passes by a smooth wheel roller having a weight per 3cm width of at least 64kg, on at least one roll; the rolling being only sufficient to establish the required profile and level of the stone. Rolling shall start with the rollers at the outer edge of the stone without overlapping the shoulder. Care must be exercised that clay or other undesirable material is not transferred to the stone base by the rollers or by other means.

Before a roller, is placed on the stone, the rollers must be cleaned of any undesirable material. Progression of the rollers shall be longitudinal from side to centre, except on super elevated curves where rolling shall begin on the low side and progress towards the higher side.

Immediately prior to the completion of the rolling of the coarse aggregate and before further fine material or aggregate is applied, the coarse aggregate shall be checked for humps, hollows or other irregularities. Any irregularity which exceeds 6mm in 3m shall be corrected. The defective areas shall be removed or new material added, as may be required, re-rolled and treated as may be necessary to eliminate completely the defects and produce a course of uniform strength throughout and with a surface uniformly smooth, true to crown and grade.

After the surface has been completely checked and corrections satisfactorily made, fine aggregate, meeting the requirements specified, shall be spread uniformly over the surface of the layer with approved spreading' devices, in an amount specified by the Engineer's Representative after determination by the laboratory of the voids.

After the fine aggregate has been satisfactorily placed and is loose and dry, the entire base course shall be compacted with a vibratory plate compactor having a static pressure under the base plate of at least 0- 16kgf per square centimeter or a vibratory roller having a static load per 3cm width of vibrating roll of at least 55kg.

The vibratory compactor shall not make more than two passes, unless otherwise directed by the Engineer's Representative. A pass means one complete non-overlapping coverage of the entire base. Areas which show deficiencies in fine aggregate, shall have fine aggregate added and re-tamped with the vibratory compactor until the entire surface is uniform.

When the base course has been satisfactorily compacted by the vibratory compactor, the surface shall be watered with an approved sprinkling device. The amount of water to be applied shall be so regulated as not to produce puddles or standing water.

Following sprinkling operations, the surface shall be boomed to the extent that all excess fine aggregate is removed, and that the coarse aggregate in the base course is permitted to protrude approximately 6mm above the surface.

After the booming, the surface shall be rolled with a pneumatic-tyred roller sufficiently to re-compact any looseness of the aggregate caused during brooming operations.

During dry weather the completed base shall be watered as directed by the Engineer's Representative.

When more than one layer is required to complete the base course to the thickness as shown on the Drawings, each layer shall be constructed as before prescribed.

R7 11 THICKNESS AND FINISH

The following requirements for thickness and smoothness shall apply to the various base courses:

The tolerance for level shall conform to Table R9/6 as amended. Any areas of base course having waves and irregularities in excess of 1cm in 3m or 2cm in 15m shall be

corrected by scarifying the surface, adding approved material, re-shaping, re-compacting and finishing as specified and as approved by the Engineer's Representative.

Skin patching of an area without scarifying the surface to permit proper bonding of the added material will not be permitted.

R7 12 MAINTENANCE

The following requirements for maintenance shall apply to the various base courses:

The completed base course shall be maintained in an acceptable condition at all times, as directed by the Engineer's Representative until the prime coat is applied. When the base course is to carry traffic for an indefinite length of time before receiving a surfacing or pavement, the Contractor shall maintain the surface until final acceptance and shall prevent raveling by wetting, blading, rolling and the addition of fines as may be required to keep the base tightly bound and, leave a slight excess of material over the entire surface, which must be removed and the finish restored as specified under Clause R7 10 before the application of the prime coat.

R7 13 MEASUREMENT

The following requirements for measurement for payment shall apply to the various base courses:

The unit of measurement for payment shall be the square meters of completed and accepted base course. The area of completed base course shall be determined by the length along the centerline and upon the surface of the road, times the width as shown on the Drawings, plus any areas authorized as measured separately.

R7 14 PAYMENT

The following requirements for payment shall apply to the various base courses:

The area of base course, determined as specified in Clause R7 13, will be paid for at the unit price tendered per square meter in the Bill of Quantities which payment shall constitute full compensation for the construction and completion of the base course, including: preparation of the subgrade or sub-base, the furnishing of all materials, supplies, plant, equipment, tools and labour; the handling, mixing, manipulating, placing, shaping, compacting, including the necessary water for compaction, rolling and finishing; correcting un-satisfactory areas and mixtures; maintenance; and for furnishing all other labour and incidentals necessary to complete the work required by this Section of the Specification.

SECTION R8

DOUBLE BITUMINOUS SURFACE DRESSING

R8 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all labour, equipment and materials, and in performing all operations in connection with the construction of a double bituminous surface dressing on a previously prepared and primed base course, complete, in strict accordance with this Section of the Specification and the applicable Drawings and subject to the Conditions of the Contract.

R8 02 MATERIALS

1. **Aggregates:** The source of aggregate shall be approved by the Engineer's Representative prior to use of the material. Aggregate shall consist of clean, sound, durable pieces of crushed stone, free from adherent coatings and free from an excess of dust, dirt, organic matter, gypsum, or other objectionable foreign matter. The aggregate shall be dry, and drying may be required as directed by the Engineer's Representative. The weighted average magnesium sulphate soundness loss, as determined by AASHTO Standard Method T104-74 shall not exceed 15% and the percentage of wear, as determined by AASHTO Standard Method T96-74, shall not exceed 35%. Grading, as determined by AASHTO Standard Method T27-74, shall be as shown in Table R8/1 below:

TABLE R8/1
AGGREGATE GRADINGS

U.S. Sieve Size		Per cent Passing by Weight	
mm	Imperial	1st Course	2nd Course
19.0	¾in	100	—
12.5	½in	50-80	100
9.5	⅜in	25-55	80-95
4.75	No. 4	5-15	20-50
2.00	No. 10	0-3	0-5
0.85	No. 20	0-1	0-2

The aggregate to be used shall show no evidence of stripping when tested in accordance with AASHTO T182-70.

The use of adhesion promoting agents for control of stripping shall be used if necessary.

The material will be accepted at the latest practical point for testing prior to incorporation into the work.

2. **Bituminous Binder:** The bituminous binder shall be a proprietary cut-back bitumen, subject to the approval of the Engineer's Representative, which meets the requirements of AASHTO M81-70 and M82-73 for rapid and medium curing types respectively. The binder shall comply with the requirements of AASHTO T49-74, T50-69, T78-74 and T79-74 for the selected grades to suit the cut-back as approved by the Engineer's Representative, or cationic bituminous emulsion conforming to AASHTO M208 Grade CRS-2.

Double Bituminous Surface Dressing

R8 03 SAMPLING AND TESTING

The sources of material shall be selected in advance of the time when the material will be required in the work, and adequate representative sample submitted to the Engineer's Representative for testing and preliminary approval not less than 20 days before such material is required for use in the work. The Contractor will supply all samples for testing at his own expense and all tests will be carried out by the Employer at no cost to the Contractor. Sampling of the bituminous material will be in accordance with AASHTO T40 and aggregates in accordance with AASHTO T2. Testing for asphaltic cement shall be in accordance with Table R9/2 and cationic bituminous emulsion in accordance with AASHTO T59 as amended by AASHTO M208. Any material found not to conform with requirements, then or later, will be cause for rejection. All rejected material shall be removed and replaced with material meeting the requirements, by the Contractor, at no cost to the Employer.

R8 04 QUANTITIES TO BE APPLIED

Quantities of bituminous binder and aggregate in the first and second courses may be varied to meet specific field conditions, as directed by the Engineer's Representative, without adjustment of the price tendered, but in all cases the total amount of bituminous binder shall be as follows, and the amounts of binder and aggregate in the first and second courses shall be within the limits shown in Table R8/2:

TABLE R8/2
BITUMINOUS BINDER

	Rate of Application	
	1st Course	2nd Course
Residual Bitumen Content litres/m ²	1.0-2.0	0.75-1.5
Aggregate kg/m ²	12-18	7-12

R8 05 EQUIPMENT

1. All equipment, tools and machines used in the performance of the work covered by this Section of the Specification shall be subject to the approval of the Engineer's Representative, and shall be maintained in satisfactory working condition at all times.

2. **Pressure Distributor:** The distributor shall be self-propelled, pneumatic-tyred and so designed and equipped as to distribute the bituminous binder uniformly on variable widths of surface at readily determined and controlled rates. Distributor equipment shall include an independently operated bituminous binder pump, tachometer, pressure gauges, volume measuring device, a thermometer for reading the temperature of tank contents, a spirit level and a hose and handspray attachment suitable for applying bituminous binder to spots unavoidably missed by the distributor. The distributor shall be equipped for circulation and agitation of the bituminous binder during the heating process.

Double Bituminous Surface Dressing

The Engineer's Representative may require the Contractor to provide a certificate stating that a particular binder distributor has been tested since the previous surface dressing and that the test indicated conformity of the distributor with the requirements of the Employer.

3. Heating Equipment: The equipment for heating the bituminous binder shall consist of steam coils and equipment for producing steam, so designed that steam will not be introduced into the material, or of other suitable means so that no flame comes into direct contact with the material container, and there will be no local overheating of material. If storage tanks are used, an armoured thermometer with a range from 0°C to 120°C shall be fixed to the tank so that the temperature of the bituminous binder may be determined at all times. Bituminous binder which has been heated above 100°C will be rejected. All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating bituminous binder shall be kept clean and in good operating condition at all times, and shall be operated in such manner that there will be no contamination by foreign material. Attention is called to the fact that bituminous binders, particularly cut-back bitumen, are highly inflammable. The utmost care shall be taken to prevent open flames from coming in contact with the bituminous binder or gases therefrom.

The Contractor will be responsible for any fire or accident which may result from heating or handling the bituminous material.

4. Power Rollers: Power rollers shall be self-propelled tandem or three-wheel type rollers, weighing not less than 6 tons and shall be suitable for rolling bituminous pavements.

5. Pneumatic Tyred Rollers: The pneumatic-tyred rollers shall be self-propelled and shall have a minimum contact pressure of 3kgf per cm². The operating contact pressure will be specified by the Engineer's Representative.

6. Power Brooms and Power Blowers: Brooms and blowers of the power type shall be suitable for cleaning the surfaces to be treated effectively.

R8 06 WEATHER LIMITATIONS

The double bituminous surface dressing shall be applied only when the existing primed surface is dry. It shall not be applied when the weather is rainy, or when the atmospheric temperature is below 15°C, unless otherwise directed by the Engineer's Representative.

R8 07 PREPARATION OF SURFACE

Immediately before applying the first course of surface dressing the primed base course surface shall be cleaned of all loose or foreign material, as directed by the Engineer's Representative. The first course of surface dressing will not be placed until the Engineer's Representative has inspected and approved the prepared surface.

R8 08 FIRST APPLICATION OF BITUMINOUS BINDER

The bituminous binder shall be applied by means of a pressure distributor in a uniform continuous spread over the section to be treated.

The range of the spraying temperatures shall comply with the recommendations of the manufacturers of the approved proprietary cut-back bitumen and/or as directed by the Engineer's Representative after any trials.

A strip of building paper at least one metre in width and with a length equal to that of a spray bar of the distributor plus one metre shall be used at the beginning of each spread.

Double Bituminous Surface Dressing

If the cut-off is not positive, the use of the paper may be required at the end of each spread, the paper shall be moved forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junctions of spread shall be carefully made to assure a smooth riding surface. The length of spread of bituminous materials shall not be in excess of that which trucks loaded with cover aggregate materials can immediately cover.

The spread of bituminous binders shall not be more than 15cm wider than the width covered by the cover "material" from the spreading device. Under no circumstances shall operations proceed in such manner that the bituminous binder will be allowed to chill, set up, dry or otherwise impair retention of cover coat. The distributor when not spreading shall be parked so that the spray bar or mechanism will not drip bituminous binder on the surface of the travelled way.

R8 09 APPLICATION OF AGGREGATE

The application of aggregate shall follow the application of bituminous binders immediately after each spray of bituminous binder. The aggregate shall be uniformly spread with a mechanical spreader over the surface in the specified amount or as directed by the Engineer's Representative. Any areas thinly spread with aggregate left by the mechanical spreading machine shall have additional aggregate spread by hand to ensure shoulder to shoulder cover. Aggregate trucks shall be operated backwards so that the bituminous binder will be covered ahead of the truck wheels.

R8 10 BROOMING AND ROLLING FIRST COURSE

Immediately after spreading the aggregate, the surface shall be rolled with pneumatic tyred rollers and rolling shall continue until no more aggregate can be worked into the surface. The surface shall be broom-dragged as soon as possible after rolling, but not until the surface has set sufficiently to prevent excessive marking. Broom-dragging shall continue until the aggregate is uniformly distributed over the surface. Broom-dragging, back-spotting, and rolling with both types of rollers shall continue until the surface is cured and rolled sufficiently to key and set the aggregate, as approved by the Engineer's Representative. In all places not accessible to the rollers, the aggregate shall be adequately compacted with hand-tampers weighing not less than 11kg and with a tamping face area of not more than 320cm². Any aggregate that become coated or mixed with dirt or any other foreign matter shall be removed, replaced with clean aggregate, and re-rolled, as directed by the Engineer's Representative. The Contractor shall maintain and protect the treated area by barricades, if necessary, until the second application of bituminous material is applied.

R8 11 SECOND APPLICATION OF BITUMINOUS BINDER

The second application of bituminous binder shall follow immediately after completion and approval of the first course, or each completed and approved section of the first course, as directed by the Engineer's Representative. It shall be applied in the manner as specified in Clause R8 08.

R8 12 SHOULDERS

Immediately following completion and acceptance of the double bituminous surface dressing, or each section of the surface dressing, as directed by the Engineer's Representative, shoulders shall be formed of approved material similar to that used in embankment construction. The moisture content of the material shall be adjusted if necessary to facilitate compaction in accordance with Clause R5 11-4. After thorough compaction as specified the surface shall be finished by blading and rolling to conform to the sidefall shown on the Drawings, so that the surface of the shoulder abutting the pavement shall be slightly lower than pavement surface in order to permit free drainage.

R8 13 MEASUREMENT

The unit of measurement for payment shall be the square metre. The area to be paid for shall be the square metres of completed and accepted double bituminous surface treatment, as measured along the centre line and upon the surface of the road, times the width as shown on the Drawings, plus any areas authorised and measured separately.

R8 14 PAYMENT

The area, determined as provided in Clause R8 13, will be paid for at the price tendered per square metre, which payment will constitute full compensation for furnishing, delivering and placing all materials; for furnishing supplies, equipment and tools; for preparation of the primed surface; for brooming, back-spotting, compacting, and rolling; for construction of shoulders; for maintenance; and for furnishing all other labour and incidentals necessary to complete the work required by this Section of the Specification.

SECTION R8A

BITUMINOUS PRIME COAT

R8A 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, labor, equipment and materials and in performing all operations in connection with the application of a bituminous prime coat on a previously prepared base course, complete, subject to the Conditions of Contract and in strict accordance with this Section of the Specification and the applicable Drawings.

R8A 02 BITUMINOUS BINDER

The bituminous binder shall be a medium curing cut-back bitumen MC 30 MC70 or MC250 conforming to AASHTO M82-73, produced by fluxing in an approved manner an 85/100 penetration bitumen with GOR "Kerosene". The cut-back bitumen shall be free from water, shall show no separation or curdling prior to use and shall be tested in accordance with the following standard AASHTO methods:

Sampling	T40-67
Water content	T55-70
Viscosity	T72-74
Distillation	T78-74

The approximate composition of the cut-back bitumen is one part kerosene to one and a half parts bituminous cement by volume.

The bituminous binder may also be a cationic bituminous emulsion conforming to AASHTO M208 Grades CSS-1 or CSS-1h.

R8A 03 SAMPLING AND TESTING

All bituminous binder will be sampled and tested as frequently as deemed necessary by the Engineer's Representative for conformance with the requirements of Clause R8A 02 of this Section of the Specification. All test samples shall be supplied by the Contractor at his expense and all tests will be made by the Employer at no cost to the Contractor.

Sampling of cationic bituminous emulsions shall be in accordance with AASHTO T40 and tested in accordance with AASHTO T59 as amended by AASHTO M208. All test samples shall be supplied by the Contractor at his expense and all tests will be made by the Employer at no cost to the Contractor.

R8A 04 QUANTITIES TO BE APPLIED

Bituminous binder shall be applied in quantities of not less than 0.50 litres/m² nor more than 1.20 litres/m² of base course. The exact quantities to be applied, which may be varied to suit field conditions, will be determined by the Engineer's Representative at no change in the price tendered per meter.

Cationic bituminous emulsion shall be applied at such rates as to leave residual bitumen content of not less than 0.60 litres/m² nor more than 1.20 litres/m².

R8A 05 WEATHER LIMITATIONS

The prime coat shall be applied only when the base course is dry, or contains moisture not in excess of that which will permit uniform distribution and the desired penetrations.

It shall not be applied when atmospheric temperature is below 15°C unless otherwise directed by the Engineer's Representative.

R8A 06 EQUIPMENT

1. All equipment, tools and machines used in the performance of the work shall be subject to the approval of the Engineer's Representative, and shall be maintained in satisfactory working condition at all times. 2. Pressure Distributors, Heating Equipment, Power Brooms and Power Blowers shall be as specified in Clause R8 05.

R8A 07 PREPARATION OF SURFACE

The surface of the base course will be inspected and tested for finish in accordance with Clause R7 11.

Immediately before applying the prime coat, all loose material, dirt, or other objectionable material shall be removed from the surface to be primed by power brooms and/or blowers, supplemented by hand brooms as directed by the Engineer's Representative. Prior to application of the prime coat an inspection of the prepared surface will be made by the Engineer's Representative to determine its fitness to receive the bituminous binder, and no primary coat shall be applied until the surface has been approved.

If the surface is excessively dry and/or dusty so that the bituminous surface ravel, it shall be lightly and uniformly sprinkled with water immediately in advance of priming, but bituminous binder shall not be applied until all free surface water has disappeared.

R8A 08 APPLICATION OF BITUMINOUS BINDER

Following the application of prime material, the surface shall be allowed to cure for a period of at least 24 hours without being disturbed or for such additional period of time as may be necessary to attain penetration into the base course and aeration of the volatiles from the prime material. The Contractor shall furnish and spread sufficient approved sand on all areas which show an excess of bituminous material to effectively blot up the excess as directed by the Engineer's Representative.

R8A 09 MAINTENANCE

The primed surface shall be maintained in satisfactory condition until the succeeding layer of pavement has been placed. During this interval the Contractor shall protect the primed surface against damage and shall repair all broken spots.

R8A 10 MEASUREMENT

The unit of measurement shall be the square meter as actually covered by a prime coat in accordance with this Specification unless otherwise called for in the Special Specification of Particular Application. Measurement for payment will not consider any bituminous material placed in excess of the specified maximum rate of application.

R8A 11 PAYMENT

The area of prime coat, measured as specified in clause R8A 10, will be paid for at the price tendered per square meter of prime coat, which payment shall constitute full compensation for furnishing, delivering and applying the materials; for furnishing and spreading absorbent material; for conditioning of base course and preparation of surface; for maintenance; and for all labour and incidentals necessary to complete the work required by this section of specification.

SECTION R8B

BITUMINOUS TACK COAT

R8B 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant labor, equipment, and material, and in performing all operations in connection with the application of a bituminous tack coat on a previously prepared bituminous course, and where required, on a primed base course, complete subject to the Conditions of Contract, and in strict accordance with this Section of the Specification and the applicable Drawings.

R8B 02- BITUMINOUS BINDER

The bituminous binder shall be a rapid curing cut-back bitumen RC 70 or RC 250 conforming to AASHTO M81-70, produced by fluxing in an approved manner an 85/100 penetration bitumen with GOR standard "motor spirit". The cut-back bitumen shall be free from water, shall show no separation or curdling prior to use and shall be tested in accordance with the following standard AASHTO methods:

Sampling	T40-67
Water content	T55-70
Viscosity	T72-74
Distillation	T78-74

The approximate composition of the cut-back bitumen is one part motor spirit to two parts bitumen cement by volume.

The bituminous binder may also be a cationic bituminous emulsion conforming to AASHTO M208 Grade CSS-1 or CSS-1h.

R8 B03-SAMPLING AND TESTING

All bituminous binder will be sampled and tested as frequently as deemed necessary by the Engineer for conformance with the requirements of Clause 1 803 2 of this Section of the Specification. All test samples shall be supplied by the Contractor at his expense and all tests will be made by the Employer at no cost to the Contractor.

Sampling of cationic bituminous emulsions shall be in accordance with AASHTO T40 and tested in accordance with AASHTO T59 as amended by AASHTO M208.

All test samples shall be supplied by the Contractor at his expense and all tests will be made by the Employer at no cost to the Contractor

R8B 04- QUANTITIES TO BE APPLIED

Bituminous binder shall be applied, by means of a pressure hand spray, in quantities of not less than 0.15 litres/m² nor more than 0.50 litres/m² of surface. The exact quantities to be applied, which may be varied to suit field conditions, will be as determined by the Engineer's Representative at no change in the price tendered per square meter.

Cationic bituminous emulsion shall be applied at such rates as to leave a residual bitumen content of not less than 0.10 liters/m² nor more than 0.35 litres/m².

Bituminous Tack Coat

R8B 05-EQUIPMENT

All equipment, tools and machines used in the performance of the work shall be subject to the approval of the Engineer, and shall be maintained in a satisfactory working condition at all times.

1-Hand Power Spray Attachment: A hand power spray attachment to a bitumen pressure distributor or other container having an independently operated bitumen pump, pressure gauge, thermometer for determining the temperature of the asphalt tank contents and a hose connected to a hand power spray suitable for applying the bituminous tack coat in the amounts specified-all to be such as to meet the approval of the Engineer ,shall be furnished.

2-The Heating Equipment, Power Brooms and Power Blowers shall be as specified in Clause R805.

R8B 06- WEATHER LIMITATIONS

The tack coat shall be applied only when the binder course or courses or primed base course is dry and free from dust. It shall not be applied when the atmospheric temperature is below 15C° unless otherwise directed by the Engineer.

R8B 07- PREPARATION OF SURFACE

Immediately before applying the tack coat all loose material, dirt or other objectionable material, shall be removed from the surface to be treated by power brooms and/or blowers, supplemented with hand brooms, as directed by the Engineer.

Prior to the application of the tack coat, an inspection of the prepared surface will be made by the Engineer to determine its fitness to receive the bituminous binder, and no tack coat will be applied until the surface has been approved.

R8B 08- APPLICATION OF BITUMINOUS BINDER

Immediately following the preparation of the surface, the bituminous binder shall be applied by means of a hand power spray at a temperature of 65°C to 85°C, and at the pressure and in the amounts as determined by the Engineer's Representative. The bituminous binder shall be applied so that uniform distribution is obtained over the entire surface to be treated, If necessary, it shall be hand broomed with wire brooms to obtain a more uniform cover. The tack coat shall be applied only a short distance and not more than two hours in advance of placing of the bituminous binder course or surface course so as to provide a thin adhesive film of bituminous binder to ensure a good bond. The solvent shall have evaporated before the bituminous binder (asphaltic cement) is placed. The treated surface shall be maintained by the Contractor in a satisfactory condition until the succeeding layer of pavement has been placed. During this interval the Contractor shall protect the treated surface from traffic, and shall repair all damaged spots.

R8 B 010 – MEASUREMENT

The unit of measurement shall be the square meter as actually covered by a tack coat in accordance with this specification unless otherwise called for in the special specification of particular application. Measurement will not take account of any bituminous binder placed in excess of specified maximum rate of application.

R8 B 011 – PAYMENT

The number of square meter of tack coat, measured as specified in clause R8B 09 above , shall be paid for at the applicable price tendered per square meter of tack coat, which payment shall constitute full compensation for furnishing, delivering and applying the material; for furnishing and spreading absorbent material; and for all labor and incidentals necessary to complete the work required by this section of specification.

SECTION R9

HOT-MIX ASPHALT CONCRETE PAVEMENT

R9 01 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all plant, labour, equipment and materials and in performing all operations in connection with the construction of asphalt concrete pavement on a previously prepared course, complete subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable Drawings and the directions of the Engineer's Representative.

R9 02 MATERIALS

1. **Aggregate:** Aggregates shall be of uniform quality, crushed to size as necessary and shall be composed of sound, tough, durable particles, with or without natural or mineral fillers, as required. All materials shall be clean, free from injurious amounts of clay balls and clay coated particles, gypsum, organic matter and other deleterious substances. The aggregate coarser than (2.36 mm) shall have a percentage of wear not more than 30 for surface course, 35 for binder course and 40 for base course when tested in accordance with AASHTO T96. Deleterious materials as determined in accordance with AASHTO T112 shall not exceed 3% by weight.

The plasticity index shall not exceed 4 as determined by AASHTO T89 and T90 for total aggregate and mineral filler of the fraction passing No.40 sieve (prepared in accordance with AASHTO - T146).

2. **Coarse Aggregate:** That portion of the combined aggregate retained on the 4.75mm (No.4) sieve used for asphalt concrete; binder and surface course shall be crushed stone or crushed gravel of such grading that when combined with other required aggregates fractions and filler in proper proportion, the resultant mixture shall meet the grading required under the composition of mixture for the specific type under contract. The coarse aggregate used for asphalt concrete base course may be crushed, uncrushed or combination of both. The degree of crushing shall be such that at least 90% by weight of the materials retained on the No.4 (4.75mm) sieve has one or more fractured faces, and shall not contain more than 10% of flat and elongated pieces with more than 5 to 1 between maximum and minimum dimensions (ASTM D4791).

The coating shall be above 95% when tested according to ASSHTO T182 or ASTM D2727. The coarse aggregate, when subjected to the five cycles of the soundness test (ASTM C88) shall have a weighted loss not greater than 12% when sodium sulfate is used or 18% when magnesium sulfate is used.

3. **Fine Aggregate:** That portion of the combined aggregate passing the 4.75mm (No.4) sieve shall consist of stone screenings and natural sand. Natural sand shall not exceed 25% of the portion finer than 2.36 mm for surface and binder courses. The gradifg shall be such that when combined with other required aggregate fractions and fillers in proper proportions, the resultant mixture shall meet the grading required under the composition of mixture for the specific type under Contract.

Fine aggregate shall be composed of clean, tough, rough- surfaced and angular grains. If natural sand is used the grains shall be sound, hard, dry and durable and shall not contain injurious amounts of foreign matter, and when tested in accordance with AASHTO T176 shall have a sand equivalent of not less than 45%.

4. **Mineral Filler:** Mineral filler shall consist of limestone or other stone dust, Portland cement, hydrated lime or other inert non-plastic mineral matter from approved sources. The use of specific type or types may be limited by the Engineer's Representative. Mineral fillers shall be thoroughly dry and free from lumps or aggregations of fine particles. It shall conform to the grading requirements shown in Table R9/1.

The plasticity Index as determined by ASSHTO T90 shall not be greater than 4.

The amount of filler to be added shall be only that amount which is necessary to the grading requirements for the completed mixture prescribed.

TABLE R9/1
MINERAL FILLER GRADING

U.S. Sieve Size Mm	Percentage Passing by Weight
0.600 (No. 30)	100
0.300 (No. 50)	95-100
0.075 (No. 200)	70-100

5. **Asphalt Cement:** The asphalt cement shall conform with the requirements shown in Table R9/2A for viscosity-graded asphalt cement used in hot mix asphalt concrete. The requirements for penetration-graded asphalt cement is also shown in Table R9/2B for desired uses. The asphalt cement used shall be a product prepared by refining of crude petroleum, it shall be homogeneous, free from water and shall not foam when heated to 180° C.

The refinery which supplies the asphalt cement shall furnish a certificate of analysis signed by an authorized employee of the refinery for each shipment made to the project. The certificate of analysis shall show the test results for all the specified requirements and in addition the net weight for each shipment. The certificates of analysis shall be furnished to the Engineer's Representative.

TABLE R9/2A
REQUIREMENTS FOR VISCOSITY-GRADED ASPHALT CEMENT
(GRADING BASED ON ORIGINAL ASPHALT)

Property	Viscosity Grade		
	AC-40	AC-30	AC-20
Viscosity, 60 C, poises	4000 ± 800	3000 ± 600	2000 ± 400
Viscosity, 135 °C, Cs-minimum	400	350	300
Penetration, 25 °C, 100g, 5sec. 0.1 mm-minimum	40	50	60
Flash Point, COC, °C-minimum	232	232	232
Solubility in trichloroethylene, percent-minimum	99	99	99
Tests on residue from Thin-Film Oven Test:			
Viscosity, 60 °C, poises-maximum	20000	15000	10000
Ductility, 25 °C, 5 cm per minute cm ² -minimum	25	40	50

TABLE R9/2B

REQUIREMENTS FOR PENETRATION-GRADED ASPHALT CEMENT.

Property	Penetration Grade of Asphalt		
	40/50	50/60	60/70
1. Penetration at 25° C, 100gm, 5sec (1/10mm)	40-50	50-60	60-70
2. Ductility at 25°C, 5cm/min, (cm)	>100	>100	>100
3. Flash point, °C	>232	>232	>232
4. Solubility in trichloroethylene, %	>99	>99	>99
5. Residue from thin-film oven test			
- Retained penetration, % of original	>55	>53	>52
- Ductility at 25°C, 5 cm/min (cm)	>25	>40	>50

6. **Additives:** Hydrated lime or any other approved chemical admixture may be used as an antistripping additive, Hydrated lime shall conform to the requirement of AASHTO M 216, and may be added dry at a percentage of about 1.5% by weight of aggregates. An approved system should be provided in the asphalt plant to uniformly feed the required quantities without arching or intermittent flow.

7. **Source of Supply:** Approval of sources of supply of aggregate and mineral filler shall be obtained from the Engineer's Representative prior to delivery of the material. Samples of each shall be submitted as directed.

Samples of the asphalt material that the Contractor proposes to use in the work shall be submitted and approved before construction begins. No asphalt material other than that represented by the sample submitted shall be used by the Contractor except with the written consent of the Engineer's Representative. Blending of asphalt materials from different refineries will not be permitted.

R9 03 COMPOSITION OF MIXTURES

The asphalt concrete mixtures for base course (type I), binder course (type II) and surface course (type IIIA or IIIB) shall be composed basically of coarse aggregate, fine aggregate, mineral filler (if needed), and asphalt cement. 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 contract. To such composite blended aggregate (considered as 100% by weight) shall be added asphalt cement within the percentage limits set in the specifications for the specific type.

The requirements for the asphalt concrete mixtures shall conform to grading shown in Table R9/3.

TABLE R9/3
ASPHALT MIXTURE GRADINGS

Sieve size	mm	Type I	Type II	Type IIIA	Type IIIB
		Base Course	Binder or Leveling Course	Surface or Wearing Course	
		% Passing by Weight of Total aggregate + Filler			
1½ in	37.5	100			
1	25.0	90-100	100		
¾	19.0	76-90	90-100	100	
½	12.5	56-80	70-90	90-100	100
⅜	9.5	48-74	56-80	76-90	90-100
No. 4	4.75	29-59	35-65	44-74	55-85
No. 8	2.36	19-45	23-49	28-58	32-67
No. 50	300 µm	5-17	5-19	5-21	7-23
No. 200	75 µm	2-8	3-9	4-10	4-10
Asphalt Cement (% weight of total mix)		3-5.5	4-6	4-6	4-6

The aggregate as finally used in the work shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, but shall be uniformly graded.

R9 04 JOB-MIX FORMULA

No asphalt concrete mixture shall be manufactured until a job-mix formula has been submitted by the Contractor and approved by the Engineer's Representative. The formula shall indicate the exact percentage of each sieve fraction and the exact percentage of bitumen to be used in the mixtures and the mix temperature. The Contractor will be allowed the tolerances from the approved job-mix formula shown in Table R9/4.

TABLE R9/4
JOB-MIX FORMULA TOLERANCES

	Tolerance
Aggregate passing sieve 4.75mm (No.4) or larger	±6%
Aggregate passing sieve 2.36mm (No. 8) to 0.3mm (No.50)	±4%
Filler passing sieve 0.075mm (No. 200)	±2.0%
Asphalt cement	±0.3%
Mix temperature	±15°C

The asphalt concrete mixtures shall have the properties shown in Table R9/5 when compacted by 75 blows of a standard Marshall hammer on each face.

TABLE R9/5

PROPERTIES OF ASPHALT CONCRETE MIXTURES

Property	Base Course	Binder Course	Surface Course
Resistance to plastic flow (ASTM D 1559) 75 Blows / End			
- Marshall Stability (KN), min.	5	7	8
- Marshall Flow (mm)	2-4	2-4	2-4
Voids in Marshall specimen (%)	3-6	3-5	3-5
Voids in mineral aggregate (%), min.	12	13	14
Immersion-Compression (ASTM D 1075)			
Index of Retained Strength (%), min.	70	70	70

The Marshall Stability of surface course for Expressway, all bridges and the approaches to bridges for a distance of 200 meters on each side shall be not less than 10KN, if directed by the Engineer.

Should a change in sources of material be made, a new job-mix formula shall be established before the new material is used.

R9 05 EQUIPMENT

1. **Equipment General:** All equipment, tools and machines used in the performance of the work covered by this Section of the Specification shall be either new or in top grade second hand condition and be subject to the approval of the Engineer's Representative and shall be maintained in satisfactory working condition at all times. All equipment, plant and transport shall be in harmony and with a balanced capacity.

2. **Mixing Plant:** the mixing plant shall be designed, co-ordinated and operated so as to produce mixture within the job-mix formula and shall have a sufficient capacity. The plant shall be a weight-batch type. A volumetric-proportioning, continuous mixing type may be substituted for the above type, provided the equipment has demonstrated that it is suitable for producing finished mixtures complying with the job-mix formula specified herein.

The plant shall have proper and approved thermometers and be equipped with a dust collector when located in any area where dust may be objectionable.

The asphalt mixing plants shall meet the requirements of ASTM D 995 (Standard Specification for Mixing Plants for Hot-Mixed, Hot-Laid Asphalt Paving Mixtures).

The inspection of asphalt mixing plant is required to assure that all facilities, production operations, materials handling, required testing and mix product comply with the requirements of ASTM D 290 (Standard Practice for Asphalt Mixing Plant Inspection).

3. **Pavers:** The spreading and finishing equipment shall be by an approved self-propelled paver equipped with electronic or mechanical leveling system to ensure perfect levels irrespective of variation in the layers' thickness and irregularities in the underlying layer. The finishers shall be designed for executing the lane width specified of finished pavement in one working operation. For the executing of the standing lane and/or widening additional auxiliary pavers of 4m operating width, working in staggered echelon shall be used. At least two pavers of each width required shall be available simultaneously on the site. All pavers shall be equipped with edging sleeves.

The main paver shall be equipped with a combined tamper and vibratory screed with an adjustable amplitude at 5 and 9mm. The frequency of tamper and vibratory screed shall be infinitely variable and independently adjustable from each other. The speed of the bar conveyers and the revolutions of the augers shall be infinitely variable and independently controlled for each side. The flow of material shall be additionally controlled by two hydraulically operated gates on the rear hopper wall. The finisher screed shall be heated by gasburner. The crawler unit shall be suspended at three points to permit independent vertical movement of each of the crawler tracks.

The smaller auxiliary paver shall be equipped with the compaction components of the same type as the larger paver and shall be capable of placing a layer of at least 10cm compacted in one single pass.

4. **Compaction Equipment:** The specified compaction shall be carried out by approved smooth-steel wheeled, multi-wheeled pneumatic-tyred, and/or vibrating rollers as specified under Clause R9 11.

R9 06 CONTRACTOR'S PERSONNEL

The Contractor shall employ only such personnel to operate the mixing plant, the self-propelled pavers and the compaction equipment that have had several years' experience in operating such machines and who are approved by the Engineer's Representative.

R9 07 MIXING

The asphalt mixture shall be produced in an approved plant. Crushed aggregates shall be furnished and stockpiled separately and delivered to the dryer in desired proportions. The aggregate shall be heated and thoroughly dried before entering the hot bins. The temperature shall be such that the finished temperature will be within the tolerances of the job-mix formula and always controlled. Filler shall be calibrated so that natural and mineral filler always have the same proportions. All components shall be accurately weighted and conveyed into the mixer and the required amount of bitumen introduced. In no case shall the aggregate be introduced into the mixer at a greater temperature than that of the bitumen. The temperature of both the aggregates and the bitumen at the time of mixing shall be in accordance with the job-mix formula and strictly controlled. All overheated and carbonized mixture or mixtures which foam or show indications of moisture will be rejected.

R9 08 TRANSPORTATION OF ASPHALT CONCRETE MIXTURES

1. **Bin and Hopper:** The mixer shall be equipped with a heated bin for stocking the finished mix which shall be so designed that no segregation of mix can occur and no material remains attached to the walls. 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 the mixture into vehicles shall have an equally satisfactory hopper.

2. **Trucks:** Trucks for hauling asphalt concrete mixtures shall have tight, clean and smooth metal floors that have been sprayed with a minimum amount of soapy water, thinned or emulsified fuel oil, paraffin oil, or lime solution to prevent the mixture from adhering to the floors. Each load shall be covered by canvas or other suitable material of such size as to protect the mixture from the weather. Any truck causing excessive segregation of material by its spring suspension or other contributory factors, that shows serious oil leaks or that causes undue delay shall upon the direction of the Engineer's representative be removed from the work until such faults are corrected. When necessary, in order that the mixture shall be delivered to the site at the specified temperature, all covers shall be securely fastened.

The temperature of the mixture when dumped in the spreader shall be in accordance with Clause R9 10.

Each vehicle shall be weighed before and after each loading at the mixer and a record kept of the gross weight, tare and net weight of each load.

R9 09 PLACING

1. **Preparation of existing surface:** Before applying the asphalt pavement the smoothness of the underlying course shall be tested with a 4m straight edge; it shall not vary by more than 10mm in the case of binder courses or 6mm in the case of surface courses and shall be corrected if necessary.

Where local irregularities in the existing surface are greater than 2cm when measured under a 4m straight edge, the surface shall be brought to uniform contour by patching with asphalt concrete and thoroughly tamping or rolling until it conforms with the surrounding surface. The mixture used shall be the same as that specified for the next course.

- (a) Where the existing roadbed is broken or shows instability, the unstable material shall be removed and disposed of as directed by the Engineer's Representative and be replaced with the same mixture as specified for the next course, compacted to the level of the adjacent surface.
- (b) If the existing course is established, asphalt, or a Portland cement concrete course, and if the edges of the course have become eroded, disintegrated or broken, the edges shall be trimmed back as directed by the Engineer's Representative, the debris removed and disposed of, and the space backfilled with asphalt concrete mixture, gravel or similar approved material, as directed by the Engineer's Representative, and then compacted.
- (c) Immediately before applying the asphalt pavement, the existing surface (upon which the mixture is to be placed) shall be thoroughly cleaned (by sweeping or air blow) of all loose, dirt and other objectionable materials immediately before spreading the mixture.
- (d) The primed binder course or each layer of the asphalt pavement shall only receive a tack coat if required and if so directed by the Engineer's Representative in accordance with Section R8B.
- (e) The tack-coat shall be applied just sufficiently in advance of placing of the asphalt concrete mixture so that a thin adhesive film of asphalt cement ensures a good

binding of the course. It shall be applied in accordance with Section R8B – asphalt Tack Coat.

- (f) Contact surfaces of kerbs, gutters, manholes and other structures shall be painted with a thin uniform coating of hot asphalt binder (or asphalt cement dissolved in a suitable solvent) or cut-back bitumen just before the mixture is placed against it, but after such a time as the solvent shall have evaporated completely. The condition of the existing surface shall have been approved by the Engineer's Representative prior to placing the mixture.
- (g) Before spreading mixture upon a Portland cement concrete surface, all longitudinal and transverse joints and all cracks shall be sealed by the application of an approved asphalt joint sealing compound, such as in BS2499 (1973) Class A Grades I and II. If shown on the plans and called for in the Specification, a tack coat shall be applied to Portland cement concrete base, or approved metal or plastic fabric shall be used, to prevent cracks appearing above the joints or cracks in the cement concrete surface.

R9 10 SPREADING AND FINISHING

The asphalt concrete pavement shall be placed by mechanical means in accordance with the required finished thickness as stated in the Bill of Quantities or shown on the Drawings.

The mixed material shall as soon as possible after arrival at the Site be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated continuously and it shall be so operated whenever practicable.

The rate of travel of the paver and its method of operation shall be adjusted to ensure an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation.

The temperature of the mixed materials when dumped into the spreader shall be as directed by the Engineer's Representative $\pm 10^{\circ}\text{C}$. Mixtures with a temperature of less than 120°C for base course and binder course and 130°C for surface course when dumped into the spreader will be rejected. The spreader shall be adjusted and the speed regulated so that the surface of the course will be smooth and the course of such depth that, when finally compacted, it will conform to the cross section shown on the Drawings. When placing a width in one continuous operation is specified or undertaken or where the width of the lane requires, two finishers shall operate in staggered echelon, the main larger-width paver in front and the smaller auxiliary paver approximately 15m behind. When placing binder course, the larger width paver shall follow the smaller width paver. No single lane shall be laid in advance of the adjoining lane further than will permit a satisfactory hot longitudinal joint between lanes. Where forming a hot longitudinal joint the 15m strip along the edge against which additional material is to be laid shall not be rolled until such additional material is placed except when the work is to be discontinued. After the first lane has been placed and rolled, the adjacent lane shall be placed while the unrolled 15cm strip is hot and in a readily compatible condition. Rolling of the adjacent lane shall begin along the joint. Placing of the mixture shall be as continuous as possible. A sufficient number of experienced shovellers and rakers shall follow the spreading machine, dressing the

surface as required to produce a course of uniform surface texture and the required smoothness.

Wherever practicable, road pavement materials having a bitumen binder shall be spread, leveled and tamped by approved self-propelled pavers.

Hand laying of any asphalt material will be permitted only in the following circumstances:

- (i) for laying regulating courses of irregular shape and varying thickness;
- (ii) in confined spaces where it is impracticable for a paver to operate;
- (iii) for footways;
- (iv) at the approaches to expansion joints at bridges or viaducts;
- (v) for mastic asphalt which shall be laid in conformity with BS1447 (1973).

The loads shall not be dumped any faster than can be properly handled by the shovellers and rakers. Rakers shall not be permitted to stand in the hot mixture.

One layer or course of asphalt material shall not be superimposed upon another course without the approval of the Engineer's Representative.

Surface course shall not be placed in short sections, the length of the section to be executed shall be as directed by the Engineer's Representative but not less than that specified for the particular lane width of the Contract.

R9 11 COMPACTION

Immediately after the mixture has been spread and struck off, the surface shall be checked and irregularities adjusted and then compacted thoroughly and uniformly by rolling.

Materials shall be compacted as soon as rolling can be effective without causing undue displacement of the mixed material such as cracking or rippling and while it has at least the minimum rolling temperature specified.

The material shall be uniformly compacted by an 8,000 to 10,000kg smooth steel-wheeled roller having a width of roll not less than 45cm or by a multi-wheeled pneumatic-tyred roller of equivalent weight except that surface course and binder course material shall be surface finished with a smooth-wheeled roller.

Immediately following the initial rolling, the mixture shall be thoroughly compacted.

Rolling shall begin at the low side and progress toward the high side overlapping each preceding track until the entire surface has been rolled. Alternative strips of the roller shall be terminated in stops at least 1m distant from any preceding stop. The rollers shall be in good condition, capable of reversing without back lash and shall be operated by experience roller-men and must be kept in continuous operation in such a manner that all parts of the pavement shall receive substantially equal compression.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

The roller shall not be permitted to stand on pavement which has not been fully compacted and whose temperature is still more than 70°C. Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matter on the pavement either when the rollers are operating or standing.

When a paver laying binder course or surface course material approaches an expansion joint at a bridge or viaduct, it shall be taken out of use as soon as there is a danger of the material being laid fouling the joint. In laying the remainder of the pavement up to the joint and the corresponding area beyond it by hand, the joint or joint cavity shall not be fouled with surface material.

Hand-raking of surface course material which has been laid by a paver and the addition of such material by hand-spreading to the paved area for adjustment of level will be permitted only in the following circumstances:

- (i) at the edges of the layers of material and at gullies and manholes;
- (ii) at the approaches to expansion joints at bridges or viaducts;
- (iii) where otherwise directed by the Engineer's Representative.

Hand laid work shall conform to all the specification requirements of this clause except those relating to the manner of operating pavers.

Where joints between laying widths or transverse joints have to be made in surface courses, the material shall be fully compacted and the joint made flush in one or other of the following ways, method (iii) always used for transverse joints:

- (i) by heating the joint with an approved joint heater at the time when the additional width is being laid but without cutting back or coating with binder. The heater shall raise the temperature of the full depth of the surface course to a figure within the rolling temperature range specified for the material and for a width not less than 8cm on each side of the joint. In this case, however, the Contractor shall have available for use in the event of breakdown, equipment necessary for operating method (iii);
- (ii) by using two or more pavers operating in echelon where this is practicable and in sufficient proximity for adjacent width to be fully compacted by continuous rolling; or by using a multiple-lane-width paver;
- (iii) by cutting back the exposed joints to a vertical face of not less than the specified thickness, discarding all loosened material and coating the vertical face completely with a grade of hot bitumen suitable for the purpose before the next width is laid.

All joints shall be offset at least 15cm from parallel joints in the layer beneath.

For the surfacing of existing roads the Engineer may direct the application of a tack coat to the requirements of Section R8B to the surface on which laying is to take place.

Along forms, kerbs, headers, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or with mechanical tampers giving sufficient compression. Each hand tamper shall weigh not less than 15kg and shall have a tamping face area of no more than 30cm² skin patching of an area that had been rolled will not be permitted.

The compaction rate of each finished course shall be tested by bulk density (AASHTO T166) on core samples or by nuclear method (ASTM D2950-74). The bulk density of the finished mixture shall not be less than 97% of the laboratory bulk density of the mixture when compacted in Marshall moulds with 75 blows on each face. The bulk density of finished mixture for expressways, all bridges and their approaches for a distance of 200 meters on each side, and all at grade intersections shall not be less than 98% of the laboratory bulk density of the mixture when compacted in Marshall moulds with 75 blows on each face.

The deficient pavement shall be removed and replaced with satisfactory pavement by the Contractor at no additional cost.

R9 12 WEATHER LIMITATION

The laying of asphalt courses shall be avoided as far as practicable during wet weather and shall be suspended when free standing water is present on the surface. Asphalt concrete shall not be laid on any surface which is frozen or covered with ice or snow and laying shall cease when the air temperature reaches 5°C on a falling thermometer. Laying shall not commence until the air temperature is at least 5°C on a rising thermometer unless otherwise directed by the Engineer's Representative, and also if wet weather threatens to be prolonged the manufacture and laying of asphalt concrete shall be suspended.

When the air temperature falls below 15°C special precautions shall be taken in controlling the temperature of the delivered material up to and including the period of compacting.

R9 13 THICKNESS, FINISH AND SURFACE REGULARITY

Smoothness of Pavement Course

After the completion of the final rolling, the smoothness of the course will be checked and any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area as specified and replacing with new pavement without additional cost to the Employer. The maximum tolerances of the cross-fall shall be ± 0.4 per cent.

Thickness of Pavement Course

Courses with thickness less than those specified will be acceptable provided the deficiency does not exceed 3mm. Deficiencies between 3mm and 10mm will be acceptable, but account thereof will be taken in the payment, see Clause R9 17. Any areas with a deficiency in thickness exceeding 10mm shall be cut out and removed, and replaced by a satisfactory pavement without additional cost to the Employer.

Surface Conditions

The surfaces shall be uniformly coarse textured, impermeable and with well compacted joints and smooth connection to existing pavements. Segregation will not be accepted. The pavement shall be stable and without rutting, bleedings, cracking and surface disintegration.

Surface Levels of Pavement Courses

The surface levels of pavement courses shall be determined from the true pavement surface which shall be the surface of the surface courses or calculated from the carriageway vertical profile and crossfalls as shown on the Drawings. The vertical depth below the true pavement surface of any point on the constructed surface of the formation or pavement courses shall be within the appropriate tolerances stated in Table R9/6.

The surface level of the laid surface course at any point shall not deviate vertically from the true pavement surface by more than ± 4 mm. However, the combination of permitted tolerances in different pavement levels shall not result in a reduction of the surface and binder course thickness by more than that specified above in this Clause under 'Thickness

of Pavement Courses'.

For checking compliance with Table R9/6 measurements of surface levels will be taken at points to be selected by the Engineer's Representative at 15m centers longitudinally, 7.5m on transition curves, and at 2m centers transversely. At junctions the grid point spacing shall be as described in the Contract. In any length of carriageway, compliance with the requirements of table R9/6 shall be regarded as met when not more than one measurement in any ten exceeds the tolerances permitted in the Table, but this one measurement shall not exceed the tolerance for the next course below the one being measured.

TABLE R9/6
TOLERANCES IN SURFACE LEVELS OF PAVEMENT COURSES

	Tolerance
Surface Course	$\pm 4\text{mm}$
Binder Course	$\pm 6\text{mm}$
Base Course	$+8\text{mm} -20\text{mm}$
Sub-base	$+10\text{mm} -20\text{mm}$

Surface Regularity

The longitudinal regularity of the surfaces of surface courses and binder courses shall be within the relevant tolerances stated in Table R9/7 within a distance of 300 m.

TABLE R9/7
MAXIMUM PERMITTED NUMBER OF SURFACE IRREGULARITIES

Irregularity * Course	4.0-5.9 mm	6.0-10.0 mm
Surface Course	20	2
Binder or base course	40	3

* An irregularity is a variation in the profile of the road surface as measured by the rolling straight edge. No irregularity exceeding 10mm shall be permitted.

Compliance with Table R9/7 shall be tested by the rolling straight-edge, along any line or lines parallel to the center line to the carriageway.

Carriageway shall be measured transversely for irregularities at points decided by the Engineer's Representative by a 4m long straight-edge placed at right angles to the center line of the road. The maximum deviation of the pavement surface below the straight-edge shall not exceed 3mm.

Rectification.

Where any tolerances in Table R9/6 or R9/7 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 or formation in the manner described below.

Base Course and sub-bases.

With coated macadam or asphalt concrete base courses the full depth of the top layer as laid shall be removed and be replaced with fresh material laid and compacted to Specification. Any area so treated shall be at least 5m long and the full width of the paving laid in one operation.

Alternatively for low areas in asphalt pavements the Contractor may make up with the material of the layer immediately above the one being rectified, when the subsequent layer is laid.

Binder and Surface Courses.

These shall have the full depth of the layer removed and replaced with fresh material laid and compacted to specification.

Where the surface level of a binder course or surface courses is too high or too low the area rectified shall be at least 5m long if binder course, or 15m long if surface course, and the full width of the paving laid in one operation.

R9 14 SAMPLING

- (1) **Sampling:** The sampling shall be carried out as follows under the Engineer's Representative's control and supervision at the Contractor's expense.

- (a) **Samples from plant:** Samples of the plant mixtures will be taken in accordance with AASHTO T168 and tested as frequently as deemed necessary to determine if grading, asphalt content and all mixing conditions conform to the job-mix formula requirements.

The size or weight of the samples taken from the plant shall be as directed by the Engineer's representative, but there shall be a minimum of one sample for every day's run from each mixing plant.

- (b) **Samples from roadway:** Suitably sized samples in accordance with AASHTO T168 for the determination of the compaction rate (density) of the completed pavement shall be cut from the finished work by the Contractor at his expense as often as deemed necessary by the Engineer's representative, but not less than two samples for each day's run. In addition, samples shall be taken whenever a substantial change is made in the job-mix formula. Where samples have been taken, new material shall be placed and compacted satisfactorily by rolling or tamping.

The size of sample shall be governed by the maximum size of particle of mineral aggregate in the mixture, but not less than 30 × 30cm (900cm²). The samples from the

pavement may also be taken by core drilling at a minimum diameter of 10cm.

(c) **Identification of samples:** Each sample shall be accompanied by a description giving the following information:

- (1) Source of sample, name of owner or operator of plant, location of construction site with highway number and name and kilometer reference.
- (2) Location of the point at which the sample was taken, the number of the car from which sampled, the point on the roadway measured transversely from the centerline in centimeters and on which side of the road.
- (3) By whom sampled and date of sampling.
- (4) By whom and to whom submitted with addresses.

R9 15 TESTING

Aggregates, bitumen and asphalt concrete mixtures shall be tested as frequently as deemed necessary by the Engineer's representative to check compliance with Clause R9 02 Materials. Clause R9 03 Composition of Mixture and Clause R9 04 Job-Mix Formula. Samples of the plant mixtures shall be taken at the plant and/or on the working site as specified to determine if the mixtures conform to the job-mix formula requirements and all temperatures shall be checked.

Some quantitative testing (like asphalt content) may be affected by the age of the material tested, with older samples tending to yield slightly lower asphalt content. Best quantitative results are obtained when the tests are made on mixtures and pavements shortly after their preparation.

R9 16 MEASUREMENT

The unit of measurement for payment shall be the square meters of the completed and accepted pavement for both binder course and surface course. The number of square meters of the completed asphalt pavements shall be determined by the length measured along the center line and upon the surface of the road, multiplied by the width as shown on the Drawings, plus the areas of any slip roads, widening, splays and intersections, authorized and measured separately.

R9 17 PAYMENT

The square meters of completed and accepted pavement for the various thickness as called for in the Bill of Quantities, measured as specified in Clause R9 16, will be paid for at the contract price.

No additional payment will be made for any thickness of pavement in excess of the thickness specified in the Bill of Quantities or shown on the Drawings. Payment for pavements with a deficiency in thickness between 3mm and 10mm will be adjusted by multiplying by the square of the ratio of the actual and specified thickness.

Average thickness for one kilometer section is to be used. The number of cores for measuring of thickness depends on the variation in the measurements, but should not be less than two cores per kilometer per carriageway.

The actual thickness of any layer is to be increased by any surplus in the thickness of the upper layers.

Such payment and/or payments shall constitute full compensation for preparing the surface of the road base, furnishing all materials, equipment, plant and tools, handling, mixing, spreading, finishing, compacting, rolling, final finishing and testing, correcting unsatisfactory areas and all labour and incidentals necessary to complete the work required by this Section of the Specification.

SECTION R10

PORTLAND CEMENT CONCRETE PAVEMENT

R10 01 SCOPE

The work covered by this Section of the Specification consist in the furnishing of all plant, equipment, material and labour, and in performing all operations in connection with the construction of a Portland Cement Concrete Pavement, conforming to the lines, grades, and typical sections shown on the Drawings or as ordered by the Engineer, and in strict accordance with this Section of the Specification and the applicable Drawings.

R10 02 MATERIALS

The Contractor shall advise the Engineer immediately after the award of the Contract of the source of all materials to be used in proportioning concrete for the work. If the Contractor later proposes to obtain materials from a different source, he shall notify the Engineer at least 30 days before such materials are to be used.

1. **Cement:** Cement for concrete pavement shall be ordinary Portland cement conforming to AASHTO M85-74 or complying in all respects with the requirements of BS12 (1971). If the Contractor proposes to use more than one brand of cement in the work, written permission shall be obtained from the Engineer. When more than one brand is used, each brand shall be used in separate parts of the project as designated or approved by the Engineer's Representative. Bulk cement may be used subject to the approval of the Engineer's Representative and to such strict requirements as he may deem necessary.

At the site of the project the cement shall be stored in a suitable weather-proof building. Each shipment of cement shall be stored separately to provide for ready identification and inspection. Cement that has deteriorated during storage at the site of the project shall not be used. The Contractor shall keep suitable daily records of cement received and used. The records shall show in such details as the Engineer's Representative may require, the quantity used for each part of the project during the day, and copies of the records shall be furnished to the Engineer's Representative at the close of each day's work. Cement that has remained in store for a period exceeding 3 months shall not be used until it has been tested in the laboratory and found to be suitable for use.

2. **Fine Aggregate:** Fine aggregate shall consist of washed river or pit sand. Washed crushed stone sand may be used at the direction of or with the approval of the Engineer's Representative. Fine aggregate shall be moderately sharp and free from soft particles, clay, shale, loam, cemented particles, mica, salt, juss (calcium sulphate), and organic and other foreign matter. The surface of the particles shall be clean, and the sand shall contain not more than 4 per cent of elutriable material. The sand shall comply with the following grading shown in Table R10/1 when tested in accordance with AASHTO T27-74.

TABLE R10/1
FINE AGGREGATE GRADING

U.S. Sieve Size mm Imperial		Per Cent Passing By Weight
9 · 5	$\frac{3}{8}$ in	100
4 · 75	No. 4	95-100
1 · 18	No. 16	45-80
0 · 30	No. 50	12-30
0 · 15	No. 100	2-10
0 · 075	No. 200	0-3

The sand when subjected to five alternations of the sodium sulphate soundness test as outlined in AASHTO T104-74 shall have a weighted loss not exceeding 10 per cent by weight.

The effect of organic impurities in the fine aggregate on the strength of the cement mortar shall be determined in accordance with AASHTO T 71. The relative strength shall not be less than 95%.

The soluble sulphate (SO_3) Content shall not exceed 0.5% when tested in accordance with BS 1377 Test No. 10.

The grading requirements given above represent the extreme which shall determine suitability for use from all sources of supply. The grading from any one source shall be reasonably uniform and not subject to the extreme percentages of grading specified above. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made on representative samples, submitted by the Contractor from such sources as he proposes to use. Sand from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample submitted by the Contractor may be rejected. The fineness modulus of an aggregate is determined by adding the percentage by weight retained on standard sieves 75mm, 37.5mm, 19mm, 9.5mm, 4.75mm (No. 4), 2.36mm (No. 8), 1.18mm (No. 16), 0.60mm (No. 30), 0.30mm (No. 50) and 0.15mm (No. 100) and dividing by 100.

3. Coarse Aggregate: Coarse aggregate shall consist of either gravel or broken stone. The aggregate shall be separated into two sizes, 4.75mm (No. 4) to 19.0mm and 19.0mm to 37.5mm. These two sizes shall then be combined at the proportioning plant in proportions by weight to produce an aggregate meeting the grading requirements shown in Table R10/2 when tested by the method described in AASHTO T-27-74.

TABLE R10/2
COARSE AGGREGATE GRADING

U.S. Sieve Size		Per Cent Passing By Weight
mm	Imperial	
50.0	2 in	100
37.5	1½ in	90-100
19.0	¾ in	35-70
9.5	⅜ in	10-30
4.75	No. 4	0-5

The physical requirements of the coarse aggregate shall be within the limits given in Table R10/3.

TABLE R10/3
PHYSICAL REQUIREMENTS OF COARSE AGGREGATE

	Maximum Permissible Limits Percent By Weight
Soluble Sulphate Content (expressed as SO ₃) when tested in accordance with BS 1377 Test No. 9	0-5
Sodium Sulphate Soundness, (AASHTO T104 -74) Weighted Loss	12
Wear, L.A. Abrasion (AASHTO T96-74)	40
Friable Particles	3
Coal and Lignite (AASHTO T 113 -70)	0-25
Clay Lumps (AASHTO T 112 -74)	0-25
Material Passing the 0.075mm (No. 200) sieve (AASHTO T 11-74)	1
Elongation Index (determined in accordance with BS 812)	15
Flakiness Index (determined in accordance with BS 812)	25

4. Mixing Water: Mixing water shall be clean and free from oil, acid, salt, alkali, organic matter and other deleterious substances injurious to the finished product. The water shall be tested as prescribed in AASHTO T26-72. Where the source of water is relatively shallow, it shall be maintained at such a depth and the intake shall be so enclosed as not to include silt, mud, grass, or other foreign materials.

5. Reinforcing Steel: Concrete reinforcement shall consist of mild steel bars or wire mesh, as specified below and indicated on the Drawings.

(a) **Mild Steel Bars:** Mild steel bars for concrete reinforcement shall consist of round steel bars as specified in BS4449 (1969) and manufactured by an approved process.

(b) **Steel Fabric:** Steel fabric for the reinforcement of concrete shall conform to either AASHTO M55-73 or BS4483 (1969). It must be supplied in sheets and not in rolls.

6. Polythene Sheeting: Polythene sheeting for placing immediately below concrete slabs shall be 0.065mm thick made from polythene or other approved hydrocarbon thermoplastic resin (produced by the polymerization of ethylene under high pressure and density) and given an anti-static treatment to reduce dust attraction and reduce friction. The sheeting shall have the minimum mechanical properties shown in Table R10/4:—

TABLE R10/4

PROPERTIES OF POLYTHENE SHEETING

	Machine Direction	Transverse Direction
Tensile Strength	140	105
Method ASTM D882-73		
kgf/cm ²		
Elongation at Break %	150	500
Tear Strength		
Elmendorf Method		
ASTM D689-62 (1974)	390	310
g/0.025mm		

7. Joint Filler: Joint filler shall consist of cane or other suitable long fibers of a cellular nature uniformly impregnated with asphalt. The asphalt content of the joint material shall be between thirty and fifty per cent. The joint material will not deteriorate under any weather conditions and is to be of such a character as not to be permanently deformed or broken by moderate twisting, bending or other ordinary handling. Strips of the joint filler which do not conform to the specified dimensions within the tolerance 0 to +2mm for thickness and ± 12 mm for depth are to be rejected. All damaged strips are to be rejected too.

The performed expansion joint filler shall meet the requirements of ASTM D994 or D 1751, or D 1752

8. Joint Sealing Compound: Joint sealing compound shall meet the requirements of ASTM D 1850 for cold –application type , ASTM D 3406 for hot –application elastomeric type and ASTM D 1854 for jet-fuel resistant hot – poured elastic type .

The compound is to be impermeable, is to withstand all weather conditions and is to be capable of adhering to the concrete without cracking, spalling or disintegrating and will not require an impracticable condition of dryness or cleanliness of the concrete slabs.

Where recommended by the manufacturer of the sealing compound, a primer supplied by him is to be used to improve adhesion.

9. Dowel Bars: Dowel bars shall be cut from mild steel bars complying with the requirements of BS4449 (1969), excepting that dimensions shall be at least those shown on the Drawings where they differ from those of the BS. The Contractor's attention is directed to the requirement of Clause R10 10, that one end of each dowel bar in all joints, except bonded construction joints, shall be sawn and not sheared so that no irregularities likely to interfere with its sliding action in the concrete shall occur.

10. Expansion Caps: Expansion caps for dowel bars in expansion joints shall consist of cardboard or pressed metal sleeves plugged at one end by punching the specified joint filler board or a wad of cotton waste of similar compressibility and sealed at the end against entry of mortar. The tube shall have an external diameter permitting sliding on the dowel bar but close enough to prevent entry of mortar.

The thickness of joint filler punching or cotton waste shall be twice the thickness of the joint filler in the joint. The tube shall be 5cm longer than the plug.

11. Darkening Agent: Darkening agent for the top course of concrete pavements if ordered and specified shall be a carbon black; either as an aqueous dispersion containing at least 25% of solids, to be added to the mixing water, or as a self-dispersing powder to be added to aggregate and cement. It shall be either the brand sold by Witco Chemical Company Limited (Bush House, Aldwych, London, W.C.2) as "Gatwick Black " or another brand approved by the Engineer's Representative as non-deleterious and as giving a grey colour at least as dark and as even as that produced by "Gatwick Black" added at the rate of 0.1% by weight of the mixed concrete. The minimum amount of self-dispersing powder shall be 0.025% by weight of the concrete aggregate.

The darkening agent shall be free from sulphur trioxide and from any other matter Deleterious to concrete.

12. Crack Inducing Battens: Crack inducing battens shall be of sound wood or of any other suitable material proposed by the Contractor at the time of tendering and approved of at the award of the Contract or approved by the Engineer at his discretion after the award of the Contract. Battens of highly absorbent wood or other material shall be treated to prevent absorption of water from the concrete. All battens shall be to the cross-sectional dimensions shown on the Drawings, and treated to prevent adhesion between them and the concrete.

13. Air Entraining Admixtures: Air entraining admixtures for concrete shall be in accordance with AASHTO M 154.

14. Concrete Additives: Chemical admixtures for water reduction, set retardation and set acceleration or their combinations shall be in accordance with AASHTO M 194.

15. Sulphates: The amount of sulphate in the concrete mass (expressed as SO_3) shall not exceed 4.5% of the weight of cement in the total concrete mass. The amount of sulphate shall be determined in accordance with BS 1377 Tests 9 and 10 on a representative sample that includes aggregate, cement, admixtures and water.

RIO 03 SAMPLING AND TESTING

All materials shall be approved by the Engineer's Representative prior to use in the work.

Additional samples will be taken and tested by the Employer during the progress of the work to check on the quality of the materials being supplied and/or placed by the Contractor. The results of these tests will be available for the Contractor's use, however they are not intended for construction control purposes. The Contractor should set up his own test facilities or arrange the same from a private laboratory, to assure that his materials and workmanship comply with the Specification.

R 10 04 COMPOSITION AND COMPRESSIVE STRENGTH OF CONCRETE

1. Composition:

(a) All concrete shall be proportioned by weighing and shall conform to the following strength and mix requirements: —

Compressive Strength, 28 days, when tested in accordance with B.S 881 part(3) minimum	300 kgf/cm ²
Cement Content, Sacks (50kg) per cubic meter, minimum	7-2
Water-Cement Ratio, maximum	0-45
Slump, maximum when tested in accordance with AASHTO T119	5cm
Entrained air, per cent when tested in accordance with AASHTO T 196	4.5±1-5%

(b) At least 35 days prior to the start of paving operations and after approval of all materials to be used in the concrete, the Contractor shall submit for approval the mix design he intends to use based on proportioned weights of cement, air entrainment agent, saturated surface dry aggregates, and water. This mix design will be tested by the Engineer's Representative and approval will not be granted unless the average 28-days compressive strength exceeds the minimum strength requirement by at least 15 per cent.

(c) The cement content given in the foregoing table is the minimum, if it is not sufficient to produce concrete of the compressive strength specified, it shall be increased as necessary, without additional compensation under the Contract.

(d) The compressive strength of the concrete will be determined by testing standard cubes made from concrete taken from the mixer. The making, curing and testing of the specimens will be in accordance with B.S 1881 part 3.

(e) During the course of construction, when the source of any material for the concrete is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strengths.

(f) If the concrete mix needs to be more workable during the construction, then the workability of the mix should adjusted by altering the grading or type of aggregate , or by using admixture , rather than by altering the water content. The water/ cement ratio under no circumstances exceeds the value chosen to give the required strength.

2. Consistency: The required consistency of the concrete mixture shall be such that the mixture will be cohesive, uniform and plastic, permitting proper handling and finish. When deposited it shall not flow, but shall remain in a conical pile. There shall be minimum of segregation and surplus water during the process of handling and finishing.

The slump shall be determined by AASHTO T 119-74.

The air content of the freshly mixed concrete shall be determined by AASHTO T152-74.

The cement content shall be determined by means of a yield test in accordance with AASHTO T121-74.

RIO 05 BATCHING AND MIXING

Concrete shall either be batched and mixed at a central batching and mixing plant, or batched at a central batching plant for either mixing in field mixers adjacent to the forms for slabs, or mixed in a truck mixer.

When cement is supplied in bags each batch of concrete shall contain a whole number of bags of cement.

1. Batching equipment: All aggregates and bulk cement for use in pavement shall be batched by weight by means of automatic devices of approved type conforming to the requirement; specified below:—

The batching shall consist of dividing the aggregates into three sizes, each stored in a separate bin, of placing the cement in another bin, and of recombining these ingredients as herein provided.

Material discharged from the several bins shall be controlled by gates or by mechanical conveyors. The means of withdrawal from the several bins and of discharge from the weigh box shall be so interlocked that not more than one bin can discharge at a time; that the order of discharge can be changed as desired by the Engineer's Representative; and that the weigh box cannot be tripped until the required quantity from each of the several bins has been deposited therein. Should a separate weigh box be used for each size of aggregate, all bins may be operated and discharged simultaneously. The discharge shall be so regulated that the amount of material discharged into the weigh hopper from any bin, with weighing devices at rest, will be within 3kg of the weight called for by the scale setting for the bin.

When the discharge from the several bins is controlled by gates, each gate shall automatically lock in an open or partially open position until the required weight is discharged into the weigh box, after which the gate shall automatically close and lock.

Scales utilised in the batching device may be of the springless dial type or of the multiple beam type.

If they are the dial type, the dial shall be of such size and so arranged that it may be easily read from the ground. The automatic weighing device of the dial scale shall be so marked that the number of proportions required may be set on the dial at the same time and that proportions may be changed without delay.

If they are the multiple beam type, the separate beams shall be automatically connected to the hopper or weigh box in sequence. Multiple beam scales shall be provided with an indicator operated by the main beam which will give positive visible evidence of over or under weight. The indicator shall be so designed that it will be operated during the addition of the last seventy kilograms of any weighing. The overtravel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.

The beams or dial of automatic scales shall be so arranged that the weighing units will be in a compartment that may be locked at the requirement of the Engineer.

It is the intention of this Specification that the device shall be automatic to the extent that the only manual operation required for combining the ingredients for one batch shall be a single operation of a switch or a starter.

All receptacles used for weighing materials, together with the scales of any kind used in batching materials, shall be so insulated against the vibration or movement of the rest of the plant due to any operating equipment, that the error in weighing with the entire plant running will not exceed two per cent for any setting nor exceed one and a half per cent for any batch.

Should separate supplies of aggregate materials of the same size group, but of different moisture content, be available at the batching plant, withdrawals shall be made from one supply exclusively and the material therein completely exhausted before starting on another.

The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the batching plant to the point

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of mixing. Aggregates containing excess moisture shall be stockpiled prior to use until sufficiently dry to meet the above requirement.

Except where small quantities of concrete only are to be used, when the Engineer's Representative may permit otherwise, the equipment for batching of concrete materials shall conform to the following requirements:—

The batching equipment shall be substantially constructed on a firm foundation, high enough above trucks being loaded to function properly. It shall have 3 bins and a weighing hopper. The bins shall have a total capacity of not less than 100 tons, and the partitions between them shall extend not less than 1m above the bins. The bins shall be equipped with baffle boards so as to assist drainage of the aggregates and prevent the drained-out water from passing through the outlet gate. A platform shall extend around the weighing hopper for easy means of inspection, adjustment and weighing.

The weighing hopper shall have a single compartment with arrangements for ready removal of excess material, and with a discharge gate opening parallel to the partitions of receiving trucks. The amount of opening of the discharge gate shall be readily controlled. There shall be sufficient clearance at all points for the weighing hopper to function properly. The weighing scales shall be of the beam or springless dial type of standard design and make, and shall be able to record the true weight within 2kg at maximum load. The beam type shall have separate beams for each size of aggregate, and each beam shall have an easily operated locking device. A dial which will show the weight when the load is within 45kg of that required and an approved signal device shall be provided. The weighing scales shall be arranged for ready standardisation, and with each scale shall be furnished a set of standard weights including seven 25kg, two 10kg, two 5kg and two 2kg weights. For batchers of capacity of $1/2\text{m}^3$ or less, the standard weights to be furnished shall be as approved by the Engineer's Representative. The tolerance of these scales shall be within those listed in Table 3 of the US National Bureau of Standards NBS Handbook 44. The standard weights shall be protected against defacement and injury, and shall be easy to handle and attach. All parts of the weighing devices and appurtenances of the batching equipment shall be substantially made and shall be maintained in proper operating condition. If in the opinion of the Engineer's Representative any part or all of the weighing devices or other appurtenances are not satisfactory, they shall be replaced in a satisfactory manner at the Contractor's expense.

In lieu of the automatic devices for controlling the weighing of aggregates and bulk cement as described in the foregoing specifications for batching equipment, the Contractor may be permitted to substitute manually controlled devices, provided approval for such devices is granted by the Engineer's Representative in writing.

2. Unloading and Hauling Equipment: Aggregate shall be transported from the batching plant to field paver mixers in batch boxes, vehicle bodies or other containers of adequate capacity and construction to carry the volume required properly.

Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped. Where cement is stored in bulk, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to mixer, with chute, boot or other approved device, to prevent loss of cement, and arrange to provide positive assurance of the actual presence in each batch of the entire cement specified.

Loose cement shall be transported to the mixer in waterproof compartments carrying the full amount of cement required for the batch or it may be carried in compartments

covered by the aggregate. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within one and a half hours of such contact. Cement in original shipping packages may be transported on top of the aggregates, each containing the number of bags required by the job mix.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss of cement, and when more than one batch is carried on the truck, without spilling of material from one batch compartment into another.

3. Batching to Central Mixing Plant: At a central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from the weighing hopper to the mixer drum.

4. Field Mixing Equipment: The concrete mixer shall be a batch mixer so designed as to ensure positive, uniform distribution of materials throughout the mass. The size and type of mixer used on various classes of work shall be as specified below and shall be approved by the Engineer's Representative. For all work where the volume of concrete to be placed justifies it, the mixer shall have a capacity of not less than one cubic meter, shall be of approved make and acceptable to the Engineer's Representative, and shall comply with the following requirements:— Mixers shall have a locking device preventing the mixture from being discharged before the expiration of the specified mixing time; an automatic locking device preventing materials being placed in the mixer before discharge gate is closed; a regulator that will maintain the rate of speed for which the mixer has been designed; a signal device that will function when water is added; a vertical water tank with an automatic device that will measure and discharge the required volume of water; valves to prevent overflow into the mixing chamber or on to the ground when the discharge valve is closed and into the tank when open; and valves and piping in proper order to prevent any leakage. The automatic device for measuring and discharging the required volume of water shall be arranged to discharge a predetermined volume, to be easily adjusted to discharge a larger or smaller volume, and to register the volume discharged accurately on a gauge or dial, which shall be calibrated before the mixer is used and shall be kept properly calibrated. A by-pass valve shall permit the discharge of all the water into a measuring can for the purpose of calibration. The measuring of the volume of water required shall be done by means of the adjustable discharge device only. The use of wash water as a portion of the mixing water for succeeding batches shall not be permitted. The loading skip of the mixer shall be substantially made and shaped so that wet sand and other materials will not remain in it when it is being discharged. The mixer shall not be used when any of the devices above stated are not functioning properly, or when the blades of the mixer have worn down to 90 per cent of their original width. The Contractor shall furnish a certified statement from the manufacturer as to their original width. The mixer shall be kept clean and free from hardened mortar.

5. Truck Mixers :Truck mixers shall be used only when permitted by the Engineer's Representative in writing. Each transit mixer shall have a watertight drum, suitably mounted and fitted with adequate blades capable of properly combing the mixture. A batch meter and a locking device to prevent discharge prior to completion of mixing shall be provided on each unit. Measuring tanks, equipped with outside taps and valves to facilitate checking their calibration ,shall be provided for the mixing water. All water added to the mixer shall be passed through an approved water meter, located between the water tank and the mixer drum, equipped with indicating dials and totalize, and capable of measuring and discharging a specified mount of water within an accuracy of one per cent.

The device shall provide means of readily verifying the amount of water added to the mix. An

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electrically actuated revolution counter which shall indicate the amount of mixing shall be provided on each mixer. An inspection opening shall be provided on each mixer, to permit ready determination of the consistency of the concrete being placed in the forms. When pick-up and throw-over blades are worn down 2cm or more in depth, they shall be replaced with new blades. The Contractor shall furnish a certified statement from the manufacturer as to the original depth of the blades.

R10 06 FORMS

Side forms shall be made of metal or other approved material; they shall be of approved construction and provided with adequate devices for secure setting so that when in place, they shall withstand the impact and vibration of the compacting and finishing equipment with settlement not exceeding 1.5mm in 3m. Form sections are to be tightly joined by a locked joint free from play in any direction.

Side forms for machine placing shall have rolled section steel rails which shall be of adequate stiffness to carry the laying, compaction and finishing machines. These machines shall not run on folded sheet metal form tops.

The rails and top faces of the forms shall not depart from a 3m straight edge by more than 1.5mm. The top faces of the forms are to be carefully cleaned and maintained in this condition.

Bent, twisted or battered forms are to be removed from the Site. Repaired forms are not to be used unless approved by the Engineer's Representative.

The depth of the forms used shall be the same as the thickness of the slab being laid.

The width of the bases of steel forms shall be not less than their height except that the steel forms having a base not less than two-thirds of their height and meeting all other requirements herein may be used for manual laying of non-rectangular bays. The forms shall be of approved section without horizontal joints and with flange braces extending outward on the base not less than two-thirds the height of the form. Each stake pocket shall be equipped with a positive non-detachable wedge. These forms shall be placed by using at least three steel pins of the size and length herein specified for each length of form. They shall be equipped with positive locking devices which will permit neat tight joints which will not deform under impact, vibration or thrust.

Pins for staking forms in place shall be made of steel at least 2cm in diameter and at least 75cm in length, except that shorter length pins may be used if permitted by the Engineer's Representative after demonstration that the 75cm pins are impractical for use. If it is found impractical to hold the forms securely in place by use of pins 75cm in length, longer pins, as may be required, shall be used.

Wooden forms may be used for curves having a radius of less than 50m. They shall be made of two 2.5cm well-seasoned surfaced planks fastened together and shall be attached securely to a wooden base 20cm in width. All wooden forms shall be braced at least every 60cm with steel pins of the size and length herein specified.

Straight forms shall be set out as chords to concave edges and as tangents to convex edges, but payment will not be made for concrete outside the curved edges shown on the Drawings.

The side forms shall be placed to true vertical alignment by reference to a piano wire stretched between level pins placed not more than 15m apart on a line adjacent to the forms.

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The forms shall be held firmly in place and shall have no vertical or horizontal movement in excess of 2mm when subjected to the load of the finishing machine, or from any other construction operation. The forms shall be checked for vertical alignment between the placing of the top course of concrete and the finishing of this course, and such adjustments shall be made as are necessary in order that the forms may conform thereto.

Special forms or other supporting devices, meeting the approval of the Engineer's Representative, shall be used to support the joint filler at transverse control joints when concrete is to be placed on only one side of the filler.

The support under the forms shall be firm and cut true to grade so that the form when set upon it will be firmly in contact for its entire length and width, and accurately set to line and grade. Any support which at the form line is found below the required grade shall be filled to grade with bitumen sand as specified for base-course for a distance of 40cm on each side of the base of the form and thoroughly re-rolled or, if the length of such low support is less than 90cm, it may be compacted, to the satisfaction of the Engineer's Representative, by pneumatic or vibratory tampers. Alternatively, and for a deficiency after patches, as described, hollows to 1cm depth under the forms may be filled with mortar made of Rapid Hardening Portland or Aluminous cement. Forms so supported shall not be used until the mortar is hard.

At all times sufficient forms shall be used and set to the required alignment and elevation to provide for a least 1,200m² of pavement, and in no case provide for less than 2001in.m of pavement, immediately in advance of the paving operations. The forms shall be shaded from the sun for several hours before the concrete is poured .

Forms shall not be removed until at least 12 hours after laying the concrete.

The forms shall be cleaned thoroughly and oiled each time they are used before concrete is placed against them.

RIO 07 BASE-COURSE TESTER

The base course tester shall span the width being paved and be supported on the side forms. It may be power or hand operated with scratch teeth or pins which can be adjusted readily to the required section and supported in a frame of sufficient weight and strength to withstand the loads.

RIO 08 BASE-COURSE PLANER

The base-course planer (if employed) shall span the width being paved and shall be supported on the side forms by rollers. It shall be mechanically or power drawn, of heavy, rigid construction to withstand the loads required accurately to plane off the base-course to the section for the bottom of the pavement. Cutting blades shall be supported in a manner to permit ready adjustment at all times.

Base-course planning machines which have unflanged wheels operating on the concrete surface of pavements shall have those wheels run on rubber belting 6mm in thickness, placed over the concrete to protect it from damage as the wheels pass.

The plain wheels shall be so placed that they will operate at least 15cm from the edge of the concrete pavement. The wheels operating on side forms shall have two flanges in such cases.

The base-course planer shall be used as necessary to remove high spots from the base course and this work shall be verified by use of the base-course tester, low spots in the base course shall be brought to proper level as necessary with bitumen stabilized sand

mixed and compacted in accordance with Section R7A, but containing no particles retained on a 4.75mm (No. 4) sieve.

R10 09 POLYTHENE SHEETING

Immediately before any concrete is placed, polythene sheeting as specified above shall be laid on the base-course over the entire area, care being taken that the sheeting is not torn or damaged when the concrete is placed thereon. The sheeting shall be lapped at least 30cm and any damaged sheeting shall be replaced at the Contractor's expense.

At the time of placing polythene sheeting, the surface of the bitumen stabilised sand base-course shall be in accordance with the requirements of Sections R7 and R7A. Any stickiness of the surface shall be eliminated by dusting it with dry fine sand and/or silt, any surplus of which shall be removed before the polythene sheeting is laid.

R10 10 JOINTS

1. Longitudinal Joints: Longitudinal joints shall be of two types, namely – longitudinal construction joints (Type B) and longitudinal dummy joints (Type F).

- (a) Longitudinal construction joints are to be used wherever one longitudinal strip of the pavement is to be constructed against another separately laid strip of pavement.
- (b) Longitudinal dummy type joints are to be used only when the Contractor is permitted to construct the pavement to its full width in a single construction operation.

2. Transverse joints: Transverse joints shall be of five types: A, C, D, E and F, details of which are shown on the Drawings. Transverse joints shall be generally formed to the Type sequence E F F E F F E at 5m interval, Type E being replaceable by Type A, C and D and the interval being variable by 1m as necessary. No part of any slab shall be less than 1.5m wide and no angle shall be less than 70°.

Dummy construction joint Type E shall be provided by introducing a corrugated asbestos sheet, this sheet shall be held firmly by a special welded steel frame of 3mm thick plates.

3. Crack Inducing Battens: Crack inducing battens shall be laid for Type F joints on the polythene sheeting covering the base.

- (a) Without any gap underneath which will not close under the weight of the concrete mix.
- (b) Without any gap exceeding 1cm between the battens and form or adjacent slab, or between separate lengths of batten or between longitudinal and transverse battens.
- (c) In lengths of not less than 2m.
- (d) With ends at intersection of longitudinal and transverse joints mitred in plan (4 ends) or in elevation (2 ends).
- (e) In straight lines on the lines of joints with a tolerance of ± 1 cm.

4. Dowel Bars: All dowel bars shall be placed at the depth, spacing and position relative to the line of the joint in accordance with the Drawings with a tolerance of 1cm on each of these dimensions.

Dowel bars for expansion and contraction joints (Types A, C and D) shall be placed on an axis parallel to the surface of the slab and to the centre line of the slab (parallel

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to the side form in the case of transverse joints and at 90° to it for longitudinal joints) with a tolerance (measured at one end) of up to 0.42mm for each 10mm of length.

The parts of the lengths of straight dowel bars in expansion and contraction joints (Types A, C and D) which are to be in the slab of concrete laid second shall:

- (a) be coated with oil, grease or bituminous paint immediately before laying the concrete.
- (b) be straight and free from indentations or other deformations of cross-section.
- (c) have sawn ends.
- (d) be coated with a corrosion inhibitor. Oil coat shall not be applied until the inhibitor has completely dried.

Tie bars for construction/bounded joints (Type B) shall be placed as specified above but with a tolerance up to 0.1mm for each centimeter of length.

Dowel bars for construction joints (Types A, B and C) shall be rigidly held by the form and rest on steel chairs during the laying of the concrete.

Dowel and filler boards for expansion joints (Type D) shall be rigidly held by the form during the placing of the concrete outlined by broken lines on the cross-section of this joint shown on the Drawings. This concrete, together with a folded strip of the mesh reinforcement, shall be placed 24 hours before the concrete of the slabs is due to be placed, and it shall be removed and replaced, with a similar delay, if the slabs are not cast within 36 hours of laying it. This preplaced concrete shall be of the same mix as the slab or as specified for hand placing; it shall be compacted by vibratory poker and plate (10-15cm diameter or square) compactors, and left with rough faces free from laitance and voids.

Bottom course concrete of the slabs shall be placed carefully for at least 1m on both sides of the pre-placement concrete immediately before the normal placing of concrete reaches the joint.

Bottom course concrete shall be carefully placed and compacted by immersion vibrators between the dowel bars and for at least 1m on each side of the line of joints (Types C and D) immediately before the normal placing of concrete.

5. Filler Boards: Filler boards shall be placed:

- (a) vertically or perpendicular to the pavement surface with a tolerance of 1°.
- (b) on the line of the joint with a tolerance approved by the Engineer's Representative.
- (c) without any overlap, (excepting overlaps to stagger joints in assemblies of two or more layers), and (d) with no gaps below it, between individual lengths, or between it and the form, or previously laid concrete, or with such gaps sealed by adhesive tape or other approved means to resist the entry of concrete or mortar.

Filler board shall extend to 1cm below the surface of the pavement in transverse expansion joints and to either the same surface or the underside of a groove-forming strip of wood or metal in longitudinal expansion joints. There shall be no gap between the filler and any such strip.

6. Sealing Grooves: Grooves for sealing construction joints shall be formed either by a strip of steel, hardwood or other approved material secured to the form or by cutting as described below.

Grooves for contraction and warping joints and for sealing transverse expansion joints (other than construction / expansion joints) shall be formed by cutting the concrete after it has hardened sufficiently for this to be done without risk of cracking or spalling.

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Grooves for transverse contraction joints shall be cut within 48 hours of laying the concrete and those for transverse and longitudinal warping joints shall be cut within 96 hours of laying the concrete. The position of each transverse joint shall be marked on the forms or form and the adjoining slab before the concrete is laid and it shall be marked on the plastic concrete by plucking a stretched piano wire.

A cut or groove may be made in the plastic concrete on the line of longitudinal warping joints provided that this does not result in any weakening of the concrete and provided that any disturbance of the adjacent surface is remedied.

All grooves shall have square corners.

The outside edges of pavements (except kerbed edges) shall be finished with a 6mm radius.

As an alternative to the cut and sealed groove a premoulded synthetic rubber strip of cross-section similar to that shown on the Drawings may be used in transverse expansion joint (Type D), provided that details and a sample of the proposed strip are submitted to and approved by the Engineer's Representative. The strip shall be a tight fit on the filler board and there shall be no gap between separate lengths of strip. The concrete between the top fins shall be removed immediately after it has finally set.

RIO 11 PROTECTIONS FROM WEATHER

Exposed tanks and pipes for water for concrete, cement storage buildings or silos, top and vertical walls of mixer discharge hoppers and sides of bodies of trucks carrying batched aggregate or mixed concrete shall be painted white or silver. Weighing hoppers, mixer drums and the tops of mixer discharge hoppers shall be shaded from the rays of the sun above a temperature of 30° and they shall be protected from drying winds by screens.

Mechanical concrete laying compaction and finishing operations and curing shall be carried out until at least 9 p.m. local time on the day of laying under a train of tents moving on the forms (or form and adjoining slab) with the compaction machine, but giving the spreading machine and any separate final finishing machine freedom for independent movement. Separate trains of tents may be used for all sets of machines laying the layers of concrete, but they shall be linked by a flexible or telescopic section to provide continuous shade. The top and bottom surfaces of the roofs of tents shall be white or silver coloured and excepting for gaps on one side for the entry of materials, they shall have side walls of the same colour which shall be continuous in length and extend from the roof to not more than 3cm above the pavement surface level. Tents providing protection, but not working space, shall have their ceilings not more than 20cm and 50cm above the surface of the concrete at their sides and ridge respectively and they shall have two end walls.

RIO 12 WEATHER CONDITIONS

1. General: Any concrete placed during hot weather or during cold weather shall be at the Contractor's risk and any damaged concrete shall be removed and replaced at the Contractor's expense.

2. Work in Hot Weather: The temperature of concrete shall not exceed 30° C at the time of laying, unless the Contractor incorporates in the mix a plasticiser, of a make and in a proportion which he has shown by laboratory tests and full scale trial to be to the satisfaction of the Engineer's Representative, to eliminate detrimental effects of high tempera-

ture without introducing any other detrimental effect, and for which he takes full responsibility in these two respects.

The following may be used to keep the temperature of concrete below the above limitations:

- (a) chilling of concrete water by heat exchange coils or by addition of broken ice, provided that the water shall be free from ice at the time of entry into the mixer.
- (b) cooling of coarse aggregate by watering, provided that the water content of the aggregate so cooled shall be uniform.
- (c) reclaiming of aggregate from stockpiles by the tunnel method to avoid using the surface layer of the stockpile, with shade and wind protection of conveyor elevating to batching plant
- (d) night work provided that (a) and (b) and (c) are proved inadequate or unsatisfactory in their results and providing also that the Engineer's Representative has no other reason for refusing permission for night work.

The Engineer's Representative shall have power to order the suspension of concrete production and/or laying when the shade temperature exceeds 30°C if he is not satisfied that the precautions being taken or intended by the Contractor are adequate to (a) prevent the temperature of the concrete rising above 30°C or (b) avoid any detrimental effect in the use of a plasticiser. The possession of this power by the Engineer's Representative shall not relieve the Contractor of any of his responsibilities.

Under no circumstances will the Contractor be entitled to receive any additional payment for complying with the requirements of this Clause.

3. Work in Cold Weather: Except by written approval of the Engineer's Representative, concreting operations shall not be continued when a descending air temperature in the shade and away from artificial heat falls below 5°C , nor resumed until an ascending air temperature in the shade and away from artificial heat reaches 2°C . In such cases the mixing water and/or aggregates shall be heated to not less than 21°C nor more than 66°C , prior to being placed in the mixer, and may be heated after being placed in the mixer by an approved type of heating device so that the temperature of the concrete shall not be less than 10°C , nor more than 27°C , at the time of placing. The materials shall be heated in such a manner as to preclude the possible occurrence of overheated areas. No materials containing frost shall be used. Cement or fine aggregate containing lumps or crusts of hardened materials shall not be used.

R10 13 PLACING OF CONCRETE AND MESH REINFORCEMENT

1. Mechanical and Manual Spreading, Compaction and Finishing: Concrete mixed in central plant shall be transported without delay from the mixing plant to the position for laying and any concrete which, in the opinion of the Engineer's Representative, has been mixed too long before reaching the work will be rejected and shall be removed from the Site.

Trucks delivering concrete shall not run on polythene sheeting nor shall they run on completed slabs until at least 14 days after placing the concrete.

When concreting operations are about to start, the polythene sheeting on the base shall be in a finished condition, shall be free of all foreign and unsuitable materials, shall not be muddy, and shall be free from dust and dry earth or any rucking.

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Concrete is to be placed and compacted in two layers except that some hand-laid concrete is to be placed in three layers as specified hereafter. Different concrete mixes shall be used for the upper layer and for the lower layer or layers, as specified in Clause R10 04-1.

The lower layer(s) of concrete shall be deposited, spread and compacted so that the surface of this (these) layer(s) is at the depth shown on the Drawings for the fabric reinforcement. Care shall be taken to avoid damaging the polythene sheeting during the laying of the lower or lowest layer.

The surface of the lower layer, after compaction, shall be rough, free from laitance and free from surplus water to ensure complete bond with the upper layer. The sequence and method of operations shall be so timed and executed that the bond between the upper and lower layers of concrete is perfect with no laitance between the two layers and so that the joining of the two layers in no way creates a plane of weakness in the concrete pavement slab.

Concrete adjacent to expansion and construction joints shall be compacted with immersion vibrators inserted in the concrete unless the Engineer's Representative is satisfied that such concrete can be compacted by the vibratory compactor as dense as concrete away from such joints. This exception shall not apply to keyed joints. The vibrators are not to come in contact with the joint filler or the base.

Steel fabric reinforcement, as specified and shown on the Drawings, shall, where it is required by the Drawings, be placed on the surface of the lower layer of concrete with longitudinal and transverse overlaps not less than 40 times the diameter of the bars transverse to the overlapped edge of the sheet, or 15cm, whichever is the greater.

The upper layer of concrete shall be placed before initial set develops in the lower layer; lower layer concrete initially set before placing the upper layer shall be entirely replaced. The upper layer of concrete shall be deposited, spread and compacted, and finished to the required surface levels and finishes.

In order to secure adequate compaction, the concrete is to be spread with a surcharge above the finished level of the layer.

The concrete is to be deposited in such a manner as to require as little rehandling as possible.

Spreading, compacting and finishing operations are to be completed without delay. Any concrete, which has been in place too long before completion of these operations, is to be removed from the Site.

The total time taken from the addition of the water to the mix until the completion of the surface finishing operations shall not exceed 30 minutes when the shade or mix temperature exceeds 27°C, or 40 minutes when less than 27°C.

The mixing and placing of the concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The top of the forms shall be kept free from accumulation of concrete or foreign material. The Contractor shall not permit the accumulation of laitance along the edge of a slab poured adjacent to one previously placed. Any accumulation of laitance shall be removed and replaced with fresh concrete.

As soon as the side forms are removed the edges of the slab shall first be inspected by the Engineer's Representative and any minor honeycombed areas shall then be filled in

with mortar composed of one part of cement to two parts of fine aggregate, under the supervision of the Engineer's Representative.

2. Mechanical Laying: All slabs with parallel longitudinal sides, excepting those less than 3.33m wide in short lengths alongside slabs of irregular shape at junctions, shall be spread, compacted and mechanically finished by self-propelled machines, complying with and operated in accordance with the following requirements.

The machines shall consist of a spreader and a finisher for the lower layer (excepting as described below) and a spreader and one or two finishers for the upper layer. The exception is that the lower layer of lanes less than 100m long between two slabs of irregular shape, or one of these and one end of a road, may be laid with the spreader and a finisher used for the upper layer provided that this pair of machines alternates between the upper and lower courses sufficiently frequently to the approval of the Engineer's Representative.

The spreaders shall be of the hopper box type and of the paddle type designed to spread the concrete uniformly and without irregular pre-compaction across the entire width of the lane, with means of adjusting the strike-off height.

The finishers shall have (a) a distributor, either of the reciprocating, or preferably of the rotating paddle type, suspended from the frame with height adjustment means, and (b) a vibratory compactor, of either the screed type or of the pan type, suspended from the frame with means of adjusting the height at each end. The screed shall be at least 45cm wide and it shall have a front nose of at least 5cm radius. The vibratory compactor shall be vibrated at a frequency of at least 3,500 impulses per minute with a uniform force sufficient to compact the thickness of the layer concerned. A tachometer shall be provided to indicate the frequency of impulses.

The vibratory compactor shall not be permitted to come into contact with any joint assembly or the side forms. In no case shall the vibratory compactor be operated for more than five seconds in any one location.

The finisher for the upper layer shall, in addition, have a shuttle smoother equipped with vibrators, and suspended, with means of adjusting its height, either (a) from an independent carriage running on the form rails, or (b) diagonally from a frame supported at one end on the main frame and at the other on an independent carriage running on the form rails. A shuttle smoother suspended as in (b) may be used as the final finisher, but a separate final finisher must be used if the shuttle smoother is suspended as in (a).

The final finisher, if it is a separate machine, shall be either (a) a diagonal shuttle smoother mounted between two carriages running on the rails, or (b) a longitudinal finisher with a float at least 30cm wide and at least 3.5m long, mechanically operated to move transversely across the slab with adequate longitudinal lapping of traverses.

Shuttle smoothers and longitudinal floats shall be of sufficient weight and power to produce the required surface finish to the concrete.

All machines shall have a sufficient number of wheels to spread their weight so that excessive settlement of the form rails does not occur. After laying the first lane with the machines running on the rails of two rows of forms, the machines shall be operated with either solid rubber tyred wheels on one side running on the previously laid concrete at least 15cm from the edge of the slab or with flangeless steel wheels or one side running on either hard rubber belting or steel strips each at least 6mm thick laid on the earlier concrete.

Details of all machines intended for use shall be submitted by the Contractor with his Tender and only machines approved by the Engineer shall be used.

Machines shall be operated efficiently to produce concrete as densely compacted as possible, free from honeycomb voids, free from segregation, and with the surface either complying with the requirements concerning levels and smoothness, or sufficiently close to these requirements to necessitate the minimum of hand finishing to achieve the specified levels and smoothness.

The spreader shall be operated to strike off each layer of concrete uniformly to a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of the spreader shall strike off each layer of concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. The vibratory compactor shall be set to strike-off the lower layer to the required level, but it shall be set to strike off the upper layer slightly proud so that it is cut down to the required level by the shuttle smoother if this is the final finisher or to a level still very slightly proud if this is necessary for efficient working. Concrete mix which is surplus after each striking-off process shall be removed and the Engineer's Representative may prohibit its re-use. The final finisher shall be used to finish the surface to the required level and smoothness to the best of its ability. The finishers shall make as many passes as are necessary to compact and finish the concrete as specified, but care shall be taken to avoid bringing mortar to the surface excessively by over-working; the vibratory compactor or the shuttle smoother shall be raised clear of the surface when only the other of them is required and the impulse frequencies of vibrators shall be reduced when necessary to avoid such over-working. The last movement over each area shall over-lap the previously finished concrete which is not yet initially set. Particular care shall be taken to eliminate any waves caused by joint materials.

3. Manual Laying: Concrete which is inaccessible to the self-propelled machines shall be dumped and spread manually in a manner which will minimise segregation and aeration, and will ensure even compaction. Flexible concrete junction slabs shall be laid in three layers. The first layer shall be the bottom half thickness of the slab; this shall be compacted by a vibratory beam or plate, but its surface shall be made rough after compaction to remove any laitance and ensure bond. The second layer shall be to the level described above for machine laying and the third shall be the top layer. The whole depth of the slab shall be compacted by vibratory beam tampers moved manually to compact and strike off the concrete to the required levels and contours.

If it is necessary to adjust the mix slightly to give increased workability, within the limits specified, any addition of water is to be accompanied by a corresponding increase in the cement content as necessary to maintain a water/cement ratio not exceeding that specified in Clause R10 04.

Vibratory tamping beams are to be designed for the width of bay being laid and should a narrow bay be formed, a vibratory tamping beam designed for a wider bay will not be allowed.

The spare vibratory tamping beam of each required length shall be available at all times. The vibratory tamping beams shall be moved forward with a combined longitudinal and transverse shearing motion always in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process.

Any cambered slabs shall be constructed manually by use of a cambered vibratory tamping beam used transversely or by a straight vibratory tamping beam used longitudinally on cambered transverse forms, according to the shape of the slab.

The dimensions of manually laid slabs in the direction of tamping shall not exceed 4m.

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gap greater than 3mm between the bottom of the straightedge and the surface of the pavement anywhere below the straight edge. In addition to the above requirement, there shall not be any deflection exceeding 1cm from a straight line between any two points 30m apart longitudinally.

The above two deflections are absolute maxima and the Contractor's aim shall be to endeavour to achieve a longitudinal profile which does not depart vertically from a straight line between any two points by more than:

- (a) 1.5mm between any two points 3m apart, and
- (b) 4mm between any two points 30m apart.

These two requirements are referred to as the high standard of surface profile in the Bill of Quantities items providing for extra over rates payable on their attainment.

No variation from the true level will be permitted across any joint in the pavement.

Isolated high spots in the final road pavements, not exceeding 2m² each, which depart by more than 1cm from the levels indicated, or by more than 3mm from a 3m straightedge shall be ground down, if the total area to be ground does not exceed 10m² in any 1,000m² section of concrete surfacing. When correction of the surface in excess of this allowance is necessary to bring it within these specified limits, and where the longitudinal profile departs by more than 1cm in 30m, the concrete shall be cut out and replaced by the Contractor at his own expense to the nearest joints (or edge) beyond the defective area.

The above smoothness tolerances apply to straight profiles, equivalent smoothness tolerance shall be applied on vertical curves.

- (ii) **Surface Texture:** The surface of the concrete shall have a smooth finish, textured by drag brooming as specified to produce the surface texture described.

R10 15 REMOVAL OF FORMS

Side forms shall not be removed within twelve hours after the concrete has been placed. As soon as the forms are removed any honeycombed areas shall be corrected to the satisfaction of the Engineer's Representative. Transverse expansion joints shall be opened along pavement edges for the entire depth promptly after the side forms have been removed. After removal of the forms, the Contractor shall protect the base at the edge of the slab from erosion or any other damage and any damage which may occur shall be repaired as the Engineer's Representative may direct.

R10 16 CURING AND WEATHER PROTECTION

The concrete is to be thoroughly cured in the following manner:

Within ten minutes after the completion of finishing operations the surface of all concrete excepting concrete which is to receive bituminous surfacing, is to be sprayed with an approved curing compound so as to produce an impervious coating.

Immediately after the side forms are removed:

- (a) the curing compound if it fulfils the requirements on vertical surfaces, or

(b) a bituminous compound, shall be used on the vertical faces for the period of exposure before the next lane of concrete is laid.

Before new concrete of an adjacent slab is placed, the surface of the hardened concrete of the Type B joint shall be wire brushed, cleaned, and, if necessary, picked to within 10cm of the surface, to ensure a good bond between the old and the new concrete.

All joints which have eventually to be filled with sealing compound are to be protected in a manner which will ensure that no curing liquid enters the groove, e.g. by the use of wet hessian, polythene sheeting, waterproof paper or other approved means, and the method used is to ensure proper curing of the portion of the slab adjacent to joints.

This protection is to remain in place until the covering specified below is laid, or for at least 7 days.

The liquid is to be applied by a mechanical sprayer which is arranged to traverse the concrete lanes both longitudinally and transversely. In order to prevent wind blown losses the nozzles are to be as close to the surface of the concrete as is convenient to ensure even coverage. The spraying of curing compound on concrete laid by machine shall be carried out in a travelling working tent in the train of low protective tents. Where such machines cannot operate due to irregular bay sizes, suitable hand-operated sprayers are to be used.

Approved stand-by facilities for curing concrete pavement are to be provided at a readily accessible location at the Site of the Work for use in the event of mechanical failure of the spraying equipment or any other conditions which may prevent correct application of the curing compound at the proper time.

Concrete which is to receive bituminous surfacing shall be cured by either:

- (a) spraying with bituminous emulsion to produce impervious coating within 10 minutes of completion of finishing operations; or
- (b) laying on it wet hessian sheeting covered by polythene sheeting within 10 minutes of completion of finishing operations.

Such concrete shall be protected from non-bituminous curing compound. Bituminous emulsion cured concrete shall not be exposed to the sun until 28 days have elapsed.

Concrete laid by machine shall be protected by the travelling tents described in Clause R10 11, until at least 9 p.m. on the day of laying; thereafter these may be replaced by the movable covers described below.

Concrete shall be protected by travelling tents or movable covers for at least 7 days in the months November to March inclusive, and for at least 4 days in the months April to October inclusive. The movable covers shall consist of white or silver painted hessian or other approved material supported by a frame which shall rest on the forms or form and adjoining slab, the roof sheeting shall be not more than 4cm and 35cm, above the concrete at the edges and ridge respectively. The hessian or alternative shall extend down to the form or concrete on both sides of the lane and at both ends of a row of frames.

Loose straw at least 20cm thick or staw mats at least 10cm thick may be used in lieu of these frames from the second to the seventh day during the months November to March inclusive. Straw shall be removed from the Site after use and none shall be burnt on any pavement or sub-base.

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During the months April to October inclusive, the travelling tents or movable covers shall, after their removal at 4 days, be replaced by the following alternatives for the periods scheduled below:

- (a) a layer of loose sand or silt 5cm thick and free from gypsum and any other matter deleterious to the concrete;
- (b) Polythene or other approved clear or light coloured waterproof sheeting laid with its edges over strips of material to retain with a freeboard of at least 1cm, a pond of water at least 1cm deep at the high edge of the slab, and weighted against the wind.

When the shade temperature exceeds 20°C

- (i) the sand or silt shall be kept damp, or
- (ii) the ponds shall be kept filled to a depth of at least 5mm at the high edge until the following periods after laying the concrete have elapsed:

April and second half October – 14 days

1st May to 15th June and 15th September to 15th October – 21 days

15th June to 15th September – 28 days

Water shall not be permitted to flow from sand or silt or ponds on to other slabs or the base or sub-base or adjoining earthworks. Sand or silt shall be removed after use; it shall not be permitted to dry sufficiently for it to be blown about by the wind, it shall be covered by polythene sheeting or building paper weighted down during the laying, compaction and finishing of adjacent concrete. The exposed vertical side of concrete sprayed with bituminous covering compound shall be shaded from the sun by paper or other light coloured material.

Travelling tents, movable covers, sand or silt and ponds may be removed for the cutting and sealing of joint grooves only when the shade temperature is between 2°C and 35°C and it is not liable to change outside these limits. The slabs shall be exposed only for the minimum period required for the work. Any joints which are not sealed immediately after cutting shall be protected from entry of sand or silt and they shall be blown clean immediately before sealing.

The Contractor shall at his own expense cut out and replace any concrete damaged by frost or by incomplete curing, or cracked on a line other than that of a contraction or warping joint before the groove of the joints is cut.

R10 17 JOINT SEALING

All joint grooves in the concrete pavement (excepting any joints incorporating synthetic rubber strip) shall be filled with a joint sealing compound as previously specified in Clause R10 02-8 according to the requirements and locations shown on the Drawings.

Before any sealing compound is poured:

- (i) care is to be taken that the groove extends across the bays from form to form in the case of transverse joints and is continuous in the case of longitudinal joints;
- (ii) in the case of expansion joints, the filler material is to be exposed for the full length of the joint;

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- (iii) all joint grooves are to be dry and free from dust, concrete fragments or other deposited material and they shall be offered for inspection by the Engineer's Representative before they are filled. Compressed air jets, wire brushes and such additional equipment as may be necessary to clean openings and dry the contact faces of the joints shall be used.

The joints are then to be primed as necessary and filled with sealing compound as indicated in accordance with Clause R10 02-8. The compound is to be heated and poured in accordance with the procedure recommended by the manufacturer or his agent, particular care being taken not to exceed the maximum temperature specified by the manufacturer.

The compounds are to be melted in mobile appliances by indirect heating methods at the temperatures recommended by the manufacturer. These appliances are to incorporate mechanical agitation of the compound during heating and means of ensuring strict temperature control.

Pouring shall be done by the use of hand-pouring pots, mechanical methods or any other method which will give results satisfactory to the Engineer's Representative. Pouring shall be done in such a manner that the sealer will fill the prescribed space to the levels given below so that sealer will not be spilled on exposed surfaces of the concrete. Any excess sealer or any sealer on the surface of the concrete pavement shall be removed immediately and in a manner which does not discolour nor injure the concrete or the remaining sealer.

All joints are to be sealed as soon as practicable as the work progresses and in sufficient time for the seal to harden before traffic is permitted on the pavement. Expansion joints shall be sealed 6.5mm below surface level; contraction joints shall be sealed 3mm below surface level; tied construction and warping joints shall be sealed level with the surface.

R10 18 TESTS FOR THICKNESS OF PAVEMENT AND DEGREE OF COMPACTION AND COMPRESSIVE STRENGTH

1. **Thickness of Pavement:** The Employer will not be liable for payment of any excess in thickness or depth of pavement. During the progress of the work the thickness or depth of pavement will be determined by the Engineer's Representative from cores cut from the concrete pavement by the Contractor. The cost of cutting and recovering all the cores described in this Clause and the following paragraph 2 below shall be deemed to be included in the rates and prices for Portland Cement Concrete Pavement entered by the Contractor in the Bill of Quantities.

Cores, from the concrete pavement shall be taken in accordance with AASHTO T24. The measured length of the core shall be in accordance with AASHTO T148 and the compressive strength in accordance with AASHTO T24.

Unsatisfactory work shall be repaired, replaced, or will be paid for at an adjusted price, as follow:

- (a) One 15cm diameter core will be removed by the Contractor from each lane, at such locations as the Engineer's Representative may direct, and shall represent not more than 1000m² of pavement. A lane shall be considered the pavement surface between longitudinal joints, or a longitudinal joint, and pavement edge.
- (b) If any core measurement is deficient more than 6.5mm from the required thickness a core measurement shall be taken at each 30m interval in both directions longitudinal from the first deficient core in the same lane, as defined herein, until the thickness of the pavement is found to be not more than 6.5mm deficient from the

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required thickness. Each deficient core shall be considered as representing the condition in the same lane or longitudinal section, as above defined, for a distance of 15m, in each direction longitudinally from the core.

- (c) Sections of pavement which are deficient in thickness, as determined by cores, by an amount more than 1.3cm shall be removed and replaced with pavement of the specified thickness at the expense of the Contractor. The removal and replacement shall start at the determined point of deficiency and proceed longitudinally as hereinafter specified, until the pavement is found to be not more than 6.5mm deficient from the required thickness. The old reinforcing steel shall be left extended a sufficient distance so as to allow the new reinforcement steel to be lapped with the old the required distance specified in Clause R10 13 or to be welded to the satisfaction of the Engineer's Representative.
- (d) The removals and replacements of pavements shall extend transversely the full width of each lane in which such deficiency is found.
- (e) All pavements within 2m of the deficiency spot shall be removed, except that when any joint is more than 2m, all pavements shall then be removed to the next joint.
- (f) Sections of pavement which are deficient in thickness, as determined by measurement of cores in accordance with AASHTO T148-49, by an amount more than 6.5mm, but not more than 1.3cm, will be paid for at an adjusted price as specified in Table R10/5 below:

TABLE R10/5
DEFICIENCY IN THICKNESS AS DETERMINED FROM CORES

Thickness	Proportional Part of Contract Price to be Allowed
0.0mm to 6.5mm	100%
6.5mm to 13mm	75%

2. Degree of Compaction: The cores that have been cut from the concrete pavement according to the requirements of 1 above shall be examined by the Engineer's Representative to check the degree of compaction achieved through the slab and to check the effectiveness of the bond between the top and bottom course concrete.

Should any core reveal that any part of the slab has not been adequately compacted by revealing honeycombed or segregated concrete and should the bond between the top and bottom layers of concrete be such that a plane of weakness is present, then additional cores shall be taken to check the areas of defective concrete pavement according to the procedure laid down in 1 above for determining the areas of concrete pavement deficient in thickness by more than 6.5mm.

Any areas of defective pavement concrete so found shall be replaced with new concrete in accordance with this Section.

The Engineer's Representative reserves the right to carry out crushing tests on any or all of the concrete cores taken in accordance with this Clause, and should these tests show that any area of pavement concrete has failed to meet the strength requirements of the

Specification, then such areas of concrete shall be removed and replaced with new concrete, mixed, laid, compacted and finished to the requirements of this Section.

3. Refilling of Holes: Holes in the pavement created by the cutting of cores shall be thoroughly coated on the inside with a neat cement grout and shall then be filled with concrete of the same mix as used in the pavement. The filling shall be in two equal layers and each layer shall be rodded 25 times to its full depth. The surface shall be finished flush and broomed. The surface shall be kept thoroughly wet for 72 hours thereafter.

RIO 19 REPLACEMENT OF DEFECTIVE CONCRETE

Any concrete not complying with the Specification shall be cut out and replaced in accordance with the Specification over the full width of the slab between longitudinal construction joints and over a length extending between two transverse joints each of a type other than a warping joint.

The finished pavement should be protected against damage from the construction operations and traffic until final acceptance.

No traffic shall be permitted until the joints have been sealed.

RIO 20 MEASUREMENT

The unit of measurement for payment shall be the square meters of the completed and accepted Portland Cement Concrete Pavement, as measured in place. The number of square meters of the completed Portland Cement Concrete Pavement shall be determined by the length measured along the centre line and upon the surface of the road, times the width as shown on the Drawings plus the areas of any widening on curves, turnouts and intersections, authorised and measured separately. Measurement of pavement thickness will also be made in order to determine the basis of payment.

The unit of measurement for Bridge Approach Slabs shall be the square meters of the area actually constructed in accordance with the Drawings or as directed in writing by the Engineer.

RIO 21 PAYMENT

The number of square meters of Portland Cement Concrete Pavement, measured as specified in Clause RIO 20 above, will be paid for, at the price tendered per square meter in the Bill of Quantities, adjusted as specified for deficiency in thickness, which price shall include the cost of constructing, finishing, curing, protecting and cleaning the pavement as above described; the preparation of sub-base to receive the pavement; the construction of all joints of whatever type; cutting of cores and filling of holes therefore; all materials, including joint filler and other material, reinforcement steel; equipment, labour and all else necessary therefore, and all other work in connection therewith and incidental thereto in accordance with the Specification and Drawings.

The number of square meters of Bridge Approach Slabs, as specified in Clause RIO 20 above, will be paid for at the price tendered per square meter in the Bill of Quantities, which price shall include the cost of constructing, finishing, curing, protecting and cleaning the slab as above described; the preparation of the sub-base to receive the slab; the construction of all joints of whatever type; all materials, including joint filler and other joint material, reinforcement steel; equipment, labour and all else necessary therefore, and all other work in connection therewith and incidental thereto in accordance with the Specification and Drawings.

SECTION R11

CONCRETE KERBS AND CONCRETE CHANNELS CAST-IN-PLACE

R11 01 SCOPE

This Specification shall apply to the following items:

1. Concrete kerb (cast-in-place).
2. Monolithic kerb and channel (cast-in-place).

R11 02 DESIGN

Kerbs and channels shall be of the designs shown on the Drawings.

The locations at which kerbs and channels are to be installed and the type or design to be used at each location shall be as indicated on the Drawings or the Special Specification of Particular Application, or as ordered by the Engineer's Representative.

R11 03 PROVISIONS OF PART II, SECTION B8 TO APPLY

The kerbs and channels shall be constructed in accordance with the specification for "Structural Concrete" as given in Part II Section B8, to such extent as the provisions of that specification are applicable and are not in conflict with the provisions which follow.

R11 04 CLASS OF CONCRETE

Unless otherwise specified, the concrete to be used in kerbs and channels shall be Class D/20.

R11 05 LINES AND GRADES

Kerbs and channels shall be constructed to lines and grades shown on the Drawings or as approved by the Engineer. Curved sections shall be constructed at street intersections, and either curved sections or depressed sections shall be constructed at driveway connections and elsewhere, when shown on the Drawings or ordered by the Engineer's Representative.

R11 06 TRANSVERSE EXPANSION JOINTS

Transverse expansion joints shall be provided opposite all expansion joints in abutting concrete pavement and at each tangent point in the kerb or channel alignment. Additional transverse expansion joints shall be provided at other locations as required to confine the expansion joint spacing to a maximum of 14m.

Expansion joints shall be filled with preformed filler material of the kind specified for use in transverse expansion joints in Portland Cement Concrete Pavement (see Clause R10 02 (7)).

The thickness of the expansion joint filler shall be not less than 1cm and, in joints opposite expansion joints in abutting pavement, the thickness shall be not less than the thickness of the filler in the pavement joints.

Concrete Kerbs and Concrete Channels Cast-In-Place

Each expansion joint shall be accurately set at right angles to the kerb or channel and shall provide the complete separation of the concrete which is intended.

R11 07 DOWELS AT EXPANSION JOINTS IN CHANNELS

At expansion joints in channels and in the channel portion of kerbs and channels built monolithically, dowel bars shall be provided as a load transfer medium. The dowel bars shall be as shown on the Drawings, and they shall be painted and provided with "slip sleeves". The means used in the installing of the dowels shall be such as will ensure accurate placing and as will positively avoid displacement of the bars during the placing and finishing of the concrete.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the channel and accurately at right angles to the expansion joint.

R11 08 CONTRACTION JOINTS

Transverse contraction joints shall be provided opposite all contraction joints in abutting concrete pavement and at other locations as required to confine the contraction joint spacing to a maximum of 4m.

The contraction joints shall be of the weakened-plane type and shall be provided by forming grooves in the face and surface of structures at right angles to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section, 5cm deep by 5mm wide. The grooves shall be formed in the top of all kerbs, in the batter side of independent type kerbs, in the exposed roadway face of kerbs and in the channel surface of monolithic type kerbs and channels and in the surface of channels. The edges of joints shall be tooled and the joints shall be left clean, neat and of the specified width and depth.

R11 09 STEEL TIE BARS

When shown on the Drawings, concrete channels shall be tied to the abutting pavement by means of steel tie bars. The size, length and spacing of the bars shall be as indicated on the Drawings.

R11 10 CURING OF CONCRETE

During the 72-hour period following the placing of concrete, the kerbs and channels shall be protected against premature drying by covering with suitable cotton or hessian mats and by frequent sprinkling with water, with liquid membrane-forming compounds or with waterproof paper as set forth in Clause R10 16, or by other curing methods approved by the Engineer's Representative.

R11 11 BACKFILLING

After the forms have been removed and the concrete has been cured as specified, the excavations shall be backfilled with suitable materials tamped solidly into place.

Where the verge, shoulder or footpath at the back of the kerb has been disturbed by kerb construction such areas shall then be graded and shaped to the specified crosssection or to lines and slopes designated by the Engineer's Representative.

Concrete Kerbs and Concrete Channels Cast-In-Place

Excess excavation materials shall be disposed of in a manner satisfactory to the Engineer's Representative.

R11 12 MEASUREMENT

The unit of measurement for concrete kerbs shall be the linear metre. The number of linear metres shall be the accepted lengths of concrete kerbs as measured in place. Measurement will not include any areas in excess of those shown on the Drawings, except for any areas authorised by the Engineer in writing.

R11 13 PAYMENT

Payment for the construction of concrete kerbs and/or channels will be made at the price tendered per linear metre for the item "Concrete Kerbs", "Concrete Channels", or "Concrete Kerbs and Channels", as may be applicable.

Unless otherwise specified, the price tendered per linear metre shall be understood to include payment for the furnishing of all materials and the performing of all work specified to be done, including the furnishing and placing of metal tie bars, dowel bars or the making of necessary excavation, and preparation of foundations including all materials unless otherwise provided for in the Bill of Quantities. No extra payment will be made for horizontal and vertical curved sections.

Payment for expansion joint filler material used in the transverse expansion and contraction joints in kerbs and channels will be understood to be included in the price tendered per linear metre for the kerbs and channels, and will not be paid for separately.

SECTION R11A

PRECAST CONCRETE KERBS AND FOOTWAY PAVING SLABS

R11A 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour, and in performing all operations in connection with constructing and placing all precast concrete kerbs and footway paving slabs, complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the applicable Drawings.

R11A 02 MATERIALS

1. **Cement:** Portland Cement shall conform to the requirements of BS12: Part 2 (1971) Portland Cement (ordinary and Rapid Hardening) unless otherwise provided in the Special Specification of Particular Application.

2. **Aggregates:** Aggregates shall conform to the requirements of Structural Concrete Section B8, except that the requirement for grading need not apply to the coarse aggregate fraction.

3. **Mixtures:** The aggregates shall be so sized, so graded and proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water as will produce a homogeneous concrete mixture of such quality that the kerbs and footway paving slabs will conform to the test requirements. In no case, however, shall the ratio of aggregate to cement, by weight, be greater than 4 to 1 for kerbs nor 3 to 1 for paving slabs.

R11A 03 KERBS

1. **Dimensions:** Precast concrete kerbs shall be manufactured to the dimensions shown on the Drawings. The moulds shall be accurate in size, shape and form, and the inner surfaces shall be clean and true.

2. **Moulding:** The kerbs may be made by any approved process. Where they are compacted under hydraulic pressure, the pressure employed shall be not less than 70kg/cm². The escape of the finer particles of cement during the process of pressing shall be prevented as far as practicable.

3. **Tolerances:** The following tolerances from the dimensions shown on the Drawings shall not be exceeded.

Length	Width	Height
±6mm	±3mm	±3mm

4. **Freedom from Defects:** All angles of the kerbs with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arrises shall be clean and sharp. The wearing surfaces shall be true and out of winding. On being fractured, the interior of the kerbs shall present a clean homogenous appearance.

5. **Volume Weight:** A sample which has been dried to constant weight at 100°C shall not weigh less than 2,240kg/m³.

Precast Concrete Kerbs and Footway Paving Slabs

6. Maturity: Kerbs shall be sampled and tested in accordance with BS 340. The date of manufacture shall be stamped on one end face. No kerbs shall be laid until samples from the same batch have passed the test requirements of BS 340.

7. Laying: The kerb foundations shall be cast in-situ concrete to the sizes shown on the drawings between vertical formwork and in lengths not exceeding 10 (ten) metres and separated by expansion joints of bituminised fibreboard. (Clause R10 02(7)). The concrete shall be Class DY/20 (Table B8/5 page B8-6). The kerbs shall be laid to true line and level and any kerbs deviating by more than 3mm in 3m shall be broken out and relaid.

The kerbs shall be laid and bedded in a layer of cement mortar not less than 12mm and not more than 30mm thickness. The cement mortar shall be composed of one part by volume of cement and two parts by volume of fine aggregate. Concrete Class DY/20 shall be used for backing and haunching kerbs.

The vertical joints between kerbs shall be filled with the same class of mortar as used for the bedding, pointed and cleaned with hessian. The constituent materials for the mortar shall be accurately gauged and mixed in an approved manner. Cement mortar shall be mixed in suitable small quantities only as and when required, and any mortar which has begun to set or which has been mixed for a period of more than 30 minutes shall be rejected.

In cases where concrete backing to kerbs is not possible or not shown on the Drawings, and as an alternative bonding for kerbs laid on bituminous pavement basecourses, an approved synthetic resin mortar may be used if directed by the Engineer's Representative after agreement on payment.

Similarly in cases where it is undesirable to break out an existing carriageway, such as kerbing for temporary traffic diversions or experimental traffic islands, synthetic resin mortar may be used as an adhesive when approved by the Engineer's Representative.

When the kerb foundation is acting as a haunch for bituminous pavement bases and basecourses the Engineer's Representative may, at locations where rapid kerbing progress is essential, authorise the kerbs to be set on a 'windrow' of fresh concrete. This method will not be regarded as a general practice and will only be authorised provided adequate concrete strength is achieved and the cross-sectional area of the foundation exceeds the rectangular section shown on the Drawings, since it enables rapid progress because it avoids the necessity to fix sideforms and eliminates the mixing and placing of the mortar bed. The approval of the use of the 'windrow' method of kerb foundation construction will also be subject to the Contractor using suitable truck mixers to deliver the concrete, so that the foundations can be deposited straight from the delivery chute of the truck along the line of the kerb and that the kerbs are bedded directly therein without delay.

R11A 04 FLAGSTONES (CONCRETE PAVING SLABS)

1. Dimensions: The flagstones shall be 50cm x 50cm x 5cm or as otherwise shown on the Drawings or as directed by the Engineer's Representative.

2. Moulding: The flagstones may be made by any approved process.

3. Strength: The flagstones when supported with the wearing surface uppermost on horizontal, hard, un-yielding bearers, each 6mm wide on the supporting surface, placed parallel to each other and 45cm apart shall support a load of 830kg for one minute after the full load has been applied without cracking. The load shall be applied to a space 5cm wide in the centre of the flagstone, extending the whole width and parallel to the bearers, and shall be applied at a uniform rate not exceeding 10kg per second.

Precast Concrete Kerbs and Footway Paving Slabs

4. Rate of Wear: The samples shall be dried at not more than 37° C and then tested by an apparatus which consists of two end-plates mounted on a shaft so as to form, with four samples, a rectangular drum with the samples as sides. A charge of 1000 balls of hard steel or chilled cast iron, each with a diameter of 13mm to 11mm is placed in the drum, which is then revolved for 24 hours at a regular speed of 60 R.P.M. in one direction, and a further 24 hours in the opposite direction. The wear on the faces of the samples shall be uniform, and when the faces have been dried as before and the faces brushed free of dust, the loss in weight shall not exceed 1.4kg.

5. Absorption: Flags shall be sampled and tested in accordance with B.S 368 (Appendix C) and the result should be according to the following table.

Age of the sample at test	Maximum average absorption by weight
Month up to	%
1	4.0
2	3.5
3	3.3
4	3.2
5	3.1
6 and over	3.0

6. Volume Weight: A sample, dried to a constant weight at 100°C, shall weigh not less than 2,240kg/m³.

R11A 05 LAYING FOOTWAYS

The foundation for the footway shall be granular sub-base (complying with Section R6) and to the pattern shown on the drawings or as approved by the Engineer's Representative on a full bed of sand/cement mortar in accordance with Clause R11A 03 (7) not less than 2cm thickness.

R11A 06 MEASUREMENT

The unit measurement will be the linear meter in place for kerbs and the square meter in place for footways.

R11A 07 PAYMENT

The unit price tendered for each linear meter of kerbs and for each square meter of footways shall be full compensation for furnishing all labour, materials, tools and equipment necessary to complete the kerbs and footways according to the Drawings and Specification, including the furnishing and placing of the in-situ concrete, the sub-base material and the required mortar, and such excavation as is required.

SECTION R11B

EXTRUDED CONCRETE KERBING AND CHANNEL

R11B 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour, and in performing all operations in connection with constructing and placing extruded concrete kerbing or combined kerbing and channel, complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the applicable Drawings.

R11B 02 MATERIALS

1. **Cement:** Portland Cement shall conform to the requirements of BS 12: Part 2 (1971) Portland Cement (Ordinary and Rapid Hardening) unless otherwise provided in the Special Specification of Particular Application.

2. **Aggregates:** Aggregates shall conform to the requirements of Structural Concrete Section B8, except that the requirement for grading will depend upon both the type of extruding machine and the type of aggregate. Rounded coarse aggregates are preferable to crushed aggregates and the maximum size should not exceed 20mm with smaller sizes for auger machines. To achieve a well sealed surface the sand content will usually need to be between 45 and 55% depending upon the sand grading and type of machine.

3. **Mixtures:** The aggregates shall be so sized, so graded and proportioned and thoroughly mixed in a batch mixer with such proportions of cement and water in a mix designed to suit the extruding concrete machine and the result of trial lengths of kerbing. With auger extruders the workability of the concrete shall be maintained between 3 and 15mm slump, with the slip form type of machine the slump should be within the range 2.5 to 10cm. With all extruders strict control of workability is essential to ensure a uniform surface and a finished shape free of slumping.

Class D concrete with aggregate size to suit the extruder shall be used unless otherwise specified on the Drawing or Special Specification of Particular Application.

R11B 03 EQUIPMENT

The type of concrete extruding machine will be approved by the Engineer's Representative only after a satisfactory trial length of kerbing has been constructed and the precise concrete mix, workability and machine operators of adequate skill have been approved.

Types of concrete extruding machines acceptable for trial are the screw-auger extruder (running either on rails or on a prepared surface) and the line-guided slip form extruder (fitted with paddles or vibrators for compaction.)

Rail-mounted kerb extruders will not be used on radii less than 15m, for radii of 15 to 60m the track should be laid in 1.5m lengths and for over 60m radius track lengths of 3m will be accepted.

When concrete kerb extruders are supplied by truck mixer, the mixer drum shall be powered by a separate engine to ensure a slow discharge rate independent of the truck speed.

Extruded Concrete Kerbing and Channel

R11B 04 PREPARATION OF BASE

Extruded kerbing combined with an extruded concrete channel is of sufficient width to insert tie bars in a plastic concrete base when shown on the Drawings, but tie bars will not be used for bonding of kerbing in narrow widths where the operation of the extruding machine is so affected as to result in unsatisfactory extruded concrete kerbing. Any resin curing agent on concrete slabs shall be removed before the kerb is extruded.

When the Drawings show an extruded concrete flush kerb (beam edge) for bituminous pavements and the edge detail is used as a datum for carriageway levels, the formation must be trimmed well in advance of the extruder. In such cases the mean formation level should be lower than the design depth of the edge detail to ensure that the extruder has no problems in negotiating high spots.

R11B 05 EXPANSION AND CONTRACTION JOINTS

Expansion joints are required for extruded concrete kerbing on concrete pavement, including steel tie bars and curing of concrete all in accordance with Section R11 – Concrete kerbs and Concrete Channels Cast-in-Place.

Expansion joints are formed in freshly extruded concrete minutes after laying by cutting through the edge of the kerbing with a hacksaw, the extruded section being supported by metal formers placed on each side of the required position of the joint. A filler board should then be placed in position in the gap.

Contraction joints at about 15m centres are formed by a similar method to expansion joints except that the extruded kerb is only cut to one-third to one-half its depth.

When using an auger extruder machine the finish should be left as extruded. In the case of wetter-mix concretes extruded by a slip form machine a brush finish may be applied if directed by the Engineer's Representative.

R11B 06 MEASUREMENT AND PAYMENT

Measurement and Payment for the construction of extruded concrete kerbing and/or edging will be in accordance with Section R11 – Concrete Kerbs and Concrete Channels Cast-in-Place.

SECTION R11C

EXTRUDED ASPHALT KERBING

R11C 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour, and in performing all operations in connection with constructing and placing extruded asphalt kerbing or combined kerbing and channel, complete, subject to the terms and conditions of the Contract, and in strict accordance with this Section of the Specification and the applicable Drawings.

R11C 02 MATERIALS

1. **Asphaltic Cement:** The asphaltic cement shall comply with the general requirements for asphaltic cement contained in Section R9 Hot Mix Asphaltic Concrete Pavement.

2. **Aggregates:** Aggregates shall conform to the requirements of Materials in Section R9 Hot Mix Asphaltic Concrete Pavement, except that the requirement for grading will depend upon both the type of extruding machine and the type of aggregate. The coarse aggregate should not exceed 20mm nominal size. The fine aggregate should be a sand complying with BS594 (1973) for wearing courses.

3. **Mixture:** The composition of the mix for asphalt kerbing shall be determined from trials with the type of asphalt extruder it is proposed to use.

The percentage constituents of the mix shall be approximately as follows:

Asphaltic Cement: Bitumen (85-100 pen.)	6.0 to 9.0
Crushed Stone or Gravel Aggregate complying with Clause R9 02	20.0 to 35.0
Filler	10.0 to 13.0
Sand	50.0 to 58.0

Within the above limitations, the mix shall be designed by the Contractor, who shall make trial mixes of the asphaltic composition and carry out tests using the same plant as will be used in the Works to ascertain that the mixes and plant are entirely satisfactory for the work. 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 agreement of the Engineer's Representative who may require further tests to be made.

The materials shall be weighed and measured into a mechanical mixer and thoroughly mixed so that all particles of the aggregate are completely and uniformly coated. The mixing temperature shall be such that the temperature of the mixed material laid on site shall be within the range 140°C to 180°C.

R11C 03 EQUIPMENT

The type of asphalt automatic extruding kerbing machine will be approved by the Engineer's Representative only after a satisfactory trial length of kerbing has been constructed and the precise asphaltic mix, workability and machine operators of adequate skill approved.

Extruded Asphalt Kerbing

The kerbs shall be closely compacted with regular sides, edges, arrises and chamfers finished to a fine surface free from blow holes and dragging and shall be impervious. The mould to the extruding machine shall be heated if necessary and any cracks appearing in the hot kerb close to the machine shall be closed with a trowel immediately after extrusion.

RIIC 04 PREPARATION OF BASE

The asphalt extruding machine will run directly on the basecourse or preferably the wearing course of asphaltic concrete pavements. The surface must be clean and it may be necessary to use a tack coat as Section R8B or an approved cationic bitumen emulsion to ensure a good bond. The kerbing should be laid as soon as practicable after the completion of the surface on which it is to be laid.

RIIC 05 SURFACE REGULARITY

Asphalt kerbing shall be laid without joints. The surface regularity of the top of kerbs shall comply with the requirements for the surface regularity of the pavement courses on which the kerbs are laid.

The horizontal alignment shall not depart from that shown on the Drawings by more than $\pm 3\text{mm}$ nor deviate from the straight by more than 3mm in 3m.

The vertical alignment of the top of the kerb shall not depart from that shown on the Drawings by more than $\pm 6\text{mm}$ and at any point the maximum deviation of the top of the kerb under a straight edge shall not be greater than 3mm in 3m.

RIIC 06 MEASUREMENT AND PAYMENT

Measurement and payment for the construction of extruded asphalt kerbing and/or edging will be in accordance with Section R11.

SECTION R12

FENCING

R12 01 SCOPE

Under this Specification, the Contractor shall construct barbed wire, woven wire or combination barbed and woven wire fence on metal posts at such locations as shown on the Drawings or directed by the Engineer.

R12 02 DESIGNS AND TYPES

The fence shall be constructed in accordance with the designs shown on the Drawings or as set forth in the Special Specification of Particular Application. The type to be used at any given location shall be as the Drawings or Specification indicate or as the Engineer's Representative orders.

Galvanizing shall be in accordance with AASHTO M232. Painting shall be in accordance with Clause R14 12.

R12 03 POSTS

Fence posts shall be of metal as indicated on the Drawings or as set forth in the Special Specification of Particular Application. They shall conform with the following requirements:

Metal posts and bracings shall be new and shall be the standard products of reputable and recognised manufacturers. They shall be either galvanised or painted with a durable and protective paint. End, corner, gate and line or intermediate posts, wire and metal bracing shall be as called for on the Drawings or in the Special Specification of Particular Application.

R12 04 BARBED WIRE

Barbed wire shall be new, standard, galvanised barbed wire of two main strands of steel wire with 2-point barbs of steel wire wrapped twice around one of the main strands at intervals of approximately 10cm. Unless otherwise indicated on the Drawings or stated in the Special Specification of Particular Application, the main strands shall be of 2.5mm wire and the barbs shall be 2mm wire. Barbed wire shall be in accordance with ASTM A1.

R12 05 WOVEN WIRE

Woven wire shall be new standard, galvanised rectangular-woven wire comprised of horizontal or bar wires and vertical or stay wires. The spacings of the horizontal and vertical wires shall be as indicated on the Drawings or as set forth in the Special Specification of Particular Application. Unless otherwise indicated on the Drawings or stated in the Special Specification of Particular Application, the top and bottom horizontal wires shall be 3.15mm and the intermediate horizontal wires and all vertical wires shall be 2.5mm. Woven wire shall be in accordance with ASTM A116.

Fencing

R12 05A CHAIN LINK FENCING

Chain link fencing shall be in accordance with BS 1722 (Part 1) and as shown on the Drawings or as stated in Special Specification of Particular Application.

R12 06 STAPLES, FENCE STAYS AND TIE WIRES

Fence staples, stays and tie wires shall be new, standard, galvanised materials conforming to the following requirements:

Staples shall be made from 3.15mm or heavier wire and shall be at least 4cm in length. Tie wires shall be made from 2mm or heavier wire and shall be of sufficient length to be tied effectively.

R12 07 CONCRETE FOOTINGS

When called for by the Drawings or in the Special Specification of Particular Application, metal end posts, metal corner posts, metal gate posts, metal post braces and certain of the metal line posts shall be set in concrete footings. The footings shall be of Class E concrete furnished and placed in accordance with the applicable provisions given in Section B8.

The concrete footings may be either poured in place or precast, as the Contractor may elect. If the Contractor elects to pour the footings in place, the footings for posts and braces shall not be less than 30cm across and to a depth as shown on the Drawings. The concrete shall be poured around the posts or brace ends after the posts and braces have been brought to and firmly held in proper central position. The surface of the concrete shall be struck off to a slope of 15° from the horizontal and to a reasonably smooth surface near the ground level and shall be allowed to cure for at least 7 days before the posts and braces are subjected to strain or use.

If the Contractor elects to precast the footings, they shall have round or square top dimensions of not less than 20cm., depths the same as above given for poured footings and round or square bottom dimensions of not less than 45cm., with the posts and braces placed in the centre of the footings. The precast footings shall be allowed to cure for at least 7 days before being used.

R12 08 GATES AND GATE FASTENINGS

Fence gates shall be galvanised, steel frame, plain top, single drive gates of the clear opening width, height and weight and construction called for on the Drawings or in the Special Specification of Particular Application.

Gates, hinges, latches and fastenings shall be the product of a recognised gate manufacturer and shall be sturdy and of good workmanship throughout.

R12 09 DETAILS OF CONSTRUCTION

Post holes and excavations for footings and anchors shall be excavated on the lines approved by the Engineer's Representative and to the depths and cross-sections shown on the Drawings or set forth in the Special Specification of Particular Application. Metal posts which are not set in concrete footings may be driven. All post hole filling and all backfilling work shall be in 10cm., layers and each layer shall be solidly tamped and compacted as it is placed.

All trees, shrubs, bush, rocks and other obstacles which interfere with the proper construction of the fence shall be removed by the Contractor and the materials so removed shall be disposed of in a manner satisfactory to the Engineer's Representative.

Unless otherwise specified, line posts shall be set at 5m centers, measured horizontally.

End, corner and gate posts shall be set at the locations directed by the Engineer's Representative. Corner posts shall be set with two braces, end and gate posts shall be set with one brace and line posts shall be set with two braces at such intervals along the fence that no run of fence will be supported on unbraced posts for a distance of more than 200m.

After the posts, braces and footings have been firmly set and established, the woven wire and/or barbed wire shall be placed, tightly stretched and fastened to the posts.

When and as called for by the Drawings or in the Special Specification of Particular Application, vertical fence stays shall be placed; the spacing of woven wire, barbed wire and fence stays shall be also as shown on the Drawings.

At grade depressions and alignment angles where stresses tending to pull posts from the ground are created, the wire fence shall be struted or guyed at the critical points by 2 trends of 5mm galvanized wire attached to each horizontal line of fence wire and the end of the combined strands being firmly attached to a "dead man" weighing at least 50 kg and buried not less than 60cm in the ground at a point which will serve best to resist the pull of the wire fence. The "dead man" shall be a single rock, Portland cement concrete block or other object or thing providing the specified weight and suitable for the intended purpose.

Gates shall be installed at the locations shown on the Drawings or in the Special Specification of Particular Application.

Upon completion, the fence shall be true to line and grade, all posts shall be vertical and firm, all wire shall be taut and the completed fence shall be first class in all respects.

R12 10 MEASUREMENT AND PAYMENT

Payment for the construction of barbed wire fence, woven wire fence or combination barbed wire and woven wire fence and chain link fence will be made at the price tendered per linear meter for "Fence" of the type constructed. Payment at the price tendered shall be understood to include payment for the furnishing and installing of all materials (except gates) and the performance of all work involved in the construction of the fence including necessary excavation and backfill in accordance with the Drawings and Specification.

The pay length of the item "fence" of the type constructed will be determined by measurement along the grade of each section of that type of fence as constructed, the pay quantity to be to the nearest meter. For the furnishing and installing of gates as specified, payment will be made at the price tendered for each for "Metal Gates" of the size or sizes furnished and installed in accordance with the Drawings or in the Special Specification of Particular Application.

SECTION R13

FURNISHING AND PLANTING TREES, SHRUBS AND GROUND COVERS

R13 01 SCOPE

Under this Specification, the Contractor shall furnish and plant trees, shrubs, vines, ground covers and other plants, shall prepare and finish planting beds, and shall perform maintenance and other incidental planting procedure work, all as necessary to complete the planting operations in a workmanlike manner according to the provisions of this Specification and to accepted horticultural practice.

Trees, shrubs, vines, ground covers and other plants will herein be referred to collectively as "plants" or "plant material".

R13 02 KINDS, SIZES, QUANTITIES AND LOCATIONS OF PLANTS

The kinds, sizes and quantities of plants to be furnished and planted and the locations at which they are to be planted shall be as called for on the Drawings and the Special Specification of Particular Application, or as designated by the Engineer.

R13 03 QUALITY OF PLANT MATERIAL

1. **General:** All plant material shall comply with Iraqi Laws with respect to inspection for plant diseases and infestation, and such inspection certificates as are required by Law shall accompany each shipment and be filed with the Engineer's Representative. All plants shall be first-class representatives of their normal species or varieties, and shall have average or normal well-developed branch or cane systems together with vigorous root systems. Plants cut back from larger sizes to meet specified sizes will not be acceptable. Plants shall be free from disfiguring knots, sun scald, abrasions of the bark, wind or freezing injury or other disfigurements. Plants shall show the appearance of normal health and vigour and shall bear evidence of proper top and root pruning. Unless otherwise set forth in the Special Specification of Particular Application or indicated on the Drawings, all plants shall be nursery-grown.

2. **Trees:** Trees shall have straight trunks, well-branched with symmetrical top, and intact leader. They shall have no cuts of limbs over 2cm diameter which have not completely healed over. Each tree shall possess the characteristics for its variety and growth typical of such trees in the region.

3. **Shrubs:** Each shrub shall possess the characteristics of the variety and growth typical of such shrubs in the region.

4. **Vines, Ground Cover and Other Plants:** Vines, ground cover and other plants, such as perennials, which are furnished in pots or other containers and which have been acclimatised to outside conditions will be acceptable provided they are equal to field grown stock.

5. **Collected Plants:** Collected, wood-grown or natural seedling plants, if permitted for use by the Special Specification of Particular Application or by indication on the Drawings, shall conform in quality, size and grade with the respective requirements herein given for nursery-grown stock. In all cases, such collected, wood-grown or natural seedling plants shall be of recognised first quality, clean, sound stock free from decayed or decaying stumps and free from fire injury.

R13 04 HANDLING AND SHIPPING

Immediately prior to shipping, all plants shall be dug, handled, prepared and packed for shipment with reasonable care and skill, in accordance with recognized standard practice for the kind of plant concerned, and in compliance with provisions 1 to 4 which follow:

1. General: The root systems of all plants shall not be permitted to dry out at any time and they shall not be exposed to artificial heat or to freezing temperatures. During transportation, all plants shall be packed adequately to insure protection from the sun, wind and climatic or seasonal injuries. Tarpaulins or other covers shall be placed over plants when they are transported by trucks or in open freight cars for considerable distances. All bare-root plants shall have their root systems protected by wet shingle, tow, moss or other suitable material. All earth balls shall be firm and intact and none shall be "made" balls. All balled and hessian-covered plants shall at all times be handled by the ball, and not by the plant.

2. Trees: All evergreen trees shall be balled and hessian covered, except that small trees will be acceptable in suitable containers. The ball shall be firm and the hessian shall be sound at the time of delivering and placing the tree on the project.

Deciduous trees supplied in bare-root condition, shall have had their root systems puddled in a clay solution of sufficient density as to adhere to all parts of the root system. Deciduous trees may be supplied earth balled and hessian covered or in containers if the Contractor so desires.

The head of each tree shall be carefully tied to prevent fracture of branches.

3. Shrubs: All evergreen shrubs shall be earth balled and hessian covered or in suitable containers as above provided for evergreen trees. Deciduous shrubs may be supplied bare root earth balled and hessian covered or in suitable containers as provided above for deciduous trees.

When collected, wood-grown, natural seedling stock or other non-nursery grown shrubs are permitted or called for or permitted by the Special Specification of Particular Application, or the Drawings, they will be specified as "clumps" of various classifications. Collected plants shall be taken from soil which has produced a fibrous root system typical of the nature of the plant. The clumps shall be dug with earth and incidental vegetation adhering to the roots. If the soil or habit of the root growth is such that the roots are not adequately protected, the root systems shall be wrapped in hessian or other suitable material.

4. Vines, Ground Covers, Perennials, etc.: Vines, ground covers, perennials and other similar plant material supplied in pots, tins, and other suitable containers, will be referred to collectively as pot-grown plants. They shall be supplied as specified in the Special Specification of Particular Application or as indicated on the Drawings. The root systems must be well protected and the plant supplied in accordance with the Specification of quality and protection set forth above. Pot-grown plants shall be well developed and have sufficient roots to hold the earth together intact after removal from the containers and at the same time not be root-bound.

R13 05 LABELLING OF PLANT MATERIAL

Legible labels shall be attached to each plant which is delivered to the site as a separate unit and to each box, bundle, bale or container containing one or more plants. The labels shall give the approved horticultural name, size, age or other detailed data required to identify the plant as conforming to Specification and, when not attached to separate plants, the label shall show the quantities of each specified plant contained in the box, bundle, bale or container.

R13 06 INSPECTION AND REJECTION

All plants intended for use on the project shall be subject to inspection by the Engineer's Representative at any place and at any time. The Contractor shall inform the Engineer's Representative at the earliest practicable date as to the sources of plant materials to be furnished on the project, and shall give the Engineer's Representative at least 48 hours' notice prior to delivery of plant material at the site of the planting operation.

After arrival at the site of the work and prior to the time of planting, each plant will be inspected by the Engineer's Representative for conformance to the Specification, Special Specification of Particular Application and Drawings, and such plants as do not conform thereto will be marked or otherwise identified as "rejected." All rejected plant material shall be removed from the project and shall be replaced by the Contractor with plant material conforming to all specified requirements, all at the Contractor's expense.

R13 07 SUBSTITUTION OF PLANTS

No substitutions of plant material will be permitted unless it is proved to the satisfaction of the Engineer's Representative that specified plants are not available during the normal planting season occurring within the Contract period. If substitution of plant material is thus permitted, it shall be made only with the prior approval of the Engineer's Representative and shall be subject to adjustment, either for or against the Contractor, in such amount as the Engineer may consider to be fair and equitable.

R13 08 TEMPORARY STORAGE

After being dug and prior to planting on the project, all plant material shall be properly protected against injury at all times. Plants which are not planted or which are not to be planted within one day after arrival on the project shall be given special protection as follows:

Bare-root plants shall be "heeled-in" in trenches with the bundles opened, the plants spaced separately, and all roots covered and kept moist.

Earth-balled and hessian-covered plants shall have their earth balls protected by earth, straw or other suitable material which shall be kept damp or wet to prevent drying out of root systems.

All plants shall be protected from excessive heat or cold and shall be stored in a well-ventilated and shaded place, protected from wind and sun.

R13 09 LAYOUT OF PLANTING AREAS

Plant locations and outlines of planting areas shall be marked out and staked by the Contractor. The planting layouts will be subject to the approval of the Engineer's Representative prior to commencement of the planting operations.

R13 10 PREPARATION OF AREAS FOR PLANTING

Areas on which planting is to be done shall be brought to pleasing contour and to the lines and grades directed by the Engineer, after which they shall be cultivated to a depth of 15cm. All weeds and other vegetation growth, large clods, rocks and other debris encountered in the cultivating work, and any excess earth shall be removed and disposed of in a manner approved by the Engineer's Representative.

Excavation or pits for individual plants shall be made in accordance with provisions 1 to 4 which follow:

1. **General:** Topsoil shall be kept separate from subsoil and shall be rendered loose and friable. Alkaline soil, gravel, stones or other materials or matter encountered in the excavations and which are detrimental to plant growth shall be separated from the soil and disposed of at locations approved by the Engineer's Representative.

2. **Trees:** Pits for trees shall be at least 45cm greater in dimension than (1) the diameter of earth ball, or (2) the spread root system of bare-root trees. Depths of pits for trees shall be not less than 80cm deep and as much deeper as may be necessary to provide a depth of at least 20cm below the bottom of earth ball or root system of the tree when placed at the proper level.

3. **Shrubs:** Pits for shrubs shall be at least 30cm greater in dimension than (1) the diameter of earth ball or (2) the spread root system of bare-root shrubs. Depths of pits for shrubs shall be not less than 30cm and as much deeper as may be necessary to provide a depth of at least 15cm below the bottom of the earth ball or root system of the shrub when placed at the proper level.

4. **Vines, Ground Covers and Other Plants:** Pits, pockets or trenches for vines, ground covers and similar types of plant materials shall be of such dimensions as will provide space for the spread root systems of the plants. In general, the pits, pockets or trenches shall be wider and deeper than the actual space required, as above provided, by such amount as the Engineer's Representative may determine as being necessary to provide a space of not less than 15cm around and beneath the root systems, in which space good quality topsoil and plant nutrient shall be in place at the time of planting.

R13 11 PLANTING

All planting work, including backfilling, shall be performed by experienced workmen and in accordance with the recognised best horticultural practice. Plants shall be set plumb and at such a level or elevation that after settlement they will bear the same relation to the level of the surrounding ground as they bore to the ground from which they were dug. All plants shall be planted on and in good quality topsoil to which fertilisers and soil conditioners shall be added and uniformly mixed as called for in the Special Specification of Particular Application. The prepared topsoil used in filling under and around the plant and in backfilling the planting holes, pits or trenches shall be thoroughly and properly conditioned and settled by careful tamping and watering. For spring planting, a shallow

Furnishing and Planting Trees, Shrubs and Ground Covers

saucer capable of holding water shall be formed about each plant on the surface of the completed backfill.

Earth-balled and hessian-covered plants shall have all cloth, ropes, etc., removed from the tops of the earth balls, but no cloth shall be pulled out from under the balls. Prepared topsoil shall be carefully tamped around and under the base of each ball to fill all voids.

Bare-root plants shall have their roots spread out in a natural position and the prepared topsoil shall be carefully placed under and among them to fill all voids. Any roots which are broken or frayed shall be cleanly cut off from the plant.

In removing plants from containers, especially those of metal, care shall be taken to prevent disturbance of the root systems or ball of earth therein.

If topsoil of suitable quality is not obtainable for planting area preparation in sufficient quantity for the planting work, the Contractor shall make up any deficiency. Insofar as such is available and can be taken without detriment to the highway development, the Contractor will be permitted to obtain suitable topsoil from areas within the jurisdiction of the Employer, subject to the directions of the Engineer's Representative as to the location, depth, line and grade to which excavations thereof shall be made. The right to take materials from sources not under the jurisdiction of the Employer shall be acquired by the Contractor at his own expense.

Subsoil, and topsoil in excess of the amounts required for filling and backfilling work on the planting areas shall be disposed of by the Contractor in a manner satisfactory to the Engineer's Representative.

R13 12 PRUNING, GUYING AND STAKING

After being planted, all plant materials shall be pruned in conformance to the best horticultural practice appropriate to the type of plant. Pruning shall be such as will remove injured twigs and branches and as will compensate for loss of roots during planting operations. Pruning shall produce clean cuts without bruising or tearing the bark, shall be in living wood and where the wound can heal over properly. Cuts over 2cm in diameter shall be painted with an approved tree-wound paint.

All deciduous trees over 2m in height shall be staked or guyed at the time of planting. The stake shall be placed in the plant excavation and driven securely into the ground prior to planting operations. The tree shall be placed not to exceed 10cm from the stake and fastened tightly to the stake at a point approximately two-thirds the height of the tree by means of 2.5mm wire. At the point of contact with the tree, the wire shall be covered with a length of rubber hose adequate to protect the bark from chafing and injury. The tie wire shall cross between the tree and stake and be securely fixed at the specified height.

Deciduous trees over 2½m high, but less than 4m high, shall be staked in a similar manner. In all cases, the stakes shall be cut off to present a uniformly pleasing appearance as directed by the Engineer's Representative.

Trees of 4m or greater height shall be guyed with 3 guy cables, each consisting of 2 strands of 2.5mm or heavier wire extending from approximately two-thirds the height of the tree to a stake or deadman anchored securely in the ground at a distance from the trunk of about three-quarters the height of fastening. The tree shall be protected by rubber hose or similar means. Evergreen trees or other hessian covered shrubs over 1½m in height shall also be guyed with 3 cables in a similar manner.

R13 13 CULTIVATION OF PLANTING AREAS

An area having a diameter of not less than 90cm and lying around each planted tree and shrub and an area having a diameter of not less than 30cm and lying around each planted vine or ground cover shall be loosened and brought to friable condition for a depth of not less than 8cm. Where plant materials are planted in groups in which the plants are so closely spaced as to justify treatment of the area as a unit, the entire area so occupied and extending 60cm beyond the outer ends of the branches or canes shall be cultivated as above provided.

Prior to any planting operations, the planting areas shall be brought to the lines, grades and cross-sections indicated on the Drawings or as directed by the Engineer. If the areas are to have mulching material placed thereon, as indicated on the Drawings or called for by the Special Specification of Particular Application, grades shall be adjusted and established to provide space for the mulch. At edges of walks, pavements and driveways the finished surface shall be approximately 3cm below the surfaces thereof. At edges of lawn areas, the finished surface shall be approximately 5cm above the normal height of grass. The edges of adjoining lawn areas shall be neatly trimmed with a sharp edging tool.

The cultivating work shall include the removal of weeds, the breaking up or removing of clods, the removal of objectionable stones, litter and debris, as well as the removal and disposal of excess soil. Disposal of these materials shall be in a manner satisfactory to the Engineer's Representative.

If mulching is required, as indicated on the Drawings or called for by the Special Specification of Particular Application, the planting areas may be left in a reasonably smooth condition and with irregularities in surface grade and cross-section not exceeding 3cm.

R13 14 MULCHING

Planting areas shall be mulched after cultivation with materials of the appropriate kind and placed to the depths indicated on the Drawings or set forth in the Special Specification of Particular Application. Mulch materials shall be spread uniformly over the areas to be mulched and shall be finished to a smooth and uniform surface.

R13 15 FERTILISERS AND SOIL CONDITIONERS

Fertilisers and soil conditioners shall be mixed with topsoil used in the planting operations and used elsewhere as directed by the Engineer's Representative. Mixing of these materials with soil, mulch and other materials shall be thorough and complete. They shall be incorporated in the work as directed by the Engineer's Representative.

Fertiliser shall consist of an approved compound containing not less then:
10 per cent Nitrogen
15 per cent Phosphoric Acid
10 per cent Potash
or similar approved composition.

The Contractor may add with the approval of the Engineer's Representative any additional plant nutrients which he considers the constitution of the soil to warrant.

R13 16 MAINTENANCE

Until such time as all work to be done under the Contract is completed by the Contractor and has been finally accepted by the Engineer, the Contractor shall maintain all plant materials and all planting areas efficiently. Maintenance shall consist of keeping plants in a healthy, growing condition by watering, pruning, spraying and other necessary operations. Maintenance shall also include the keeping of planting areas free from weeds, grass, litter and debris, as well as keeping the areas smooth, neat and attractive.

In the event of an infestation from insects or disease, the plants shall be treated by preventative or remedial measures approved for good horticultural practice.

If "healed-in" plant materials have to be held over until a later planting season, such plant materials shall be lifted and replanted in nursery rows. Such emergency storage and maintenance of held-over stock shall be at the sole risk and expense of the Contractor.

R13 17 GUARANTEE AND REPLACEMENT

Until such time as all work to be done under the Contract is completed by the Contractor and during a maintenance period of one year after acceptance of the planting, the life and satisfactory condition of all plants furnished by the Contractor shall be guaranteed by the Contractor.

During this period, all plants which, in the opinion of the Engineer's Representative are in an unhealthy or badly impaired condition shall be replaced with satisfactory material. After the conclusion of the planting operation and prior to the completion of all normal work to determine the condition of the plantings, all plants then not in a healthy growing condition will be noted for replacement and shall be promptly removed by the Contractor. As soon as seasonal conditions permit, all plants to be replaced shall be replaced by the Contractor with the same kinds and sizes and in the same manner as originally specified and at no extra cost to the Employer.

R13 18 MEASUREMENT AND PAYMENT

Payment for the furnishing and planting of trees, shrubs, vines, ground cover and other plant materials will be made at the price tendered for each for "furnishing and planting" the various types of plants, as set forth in this Specification, in the Special Specification of Particular Application, and on the Drawings.

The price tendered for each for the specified and listed pay items tendered shall be understood to cover and include payment for all labour, materials, planting, maintenance, replacement work, transportation and placing of fertilisers, mulching materials and soil conditioners, and the performance of all other items of work necessary to complete the work in accordance with the Specification, and for which separate payment is not specifically provided.

The quantity to be paid for at the applicable price tendered for a given type of plant material shall be the number of plants of that type furnished in place as specified and finally accepted by the Engineer.

No separate payment will be made for the furnishing of fertilisers, mulching materials and soil conditioners.

SECTION R14

GUARD RAILS AND SAFETY FENCING

R14 01 SCOPE

Under this Section of the Specification, the Contractor shall construct highway guard rails and safety fencing at such locations as the Drawings indicate or the Engineer designates.

The term "guard rail" refers to the complete structure composed of posts, rail members and pieces, brackets, fittings, fastenings, etc., as shown on the Drawings and specified in Clauses R14 03 to R14 07 below.

R14 02 GUARD RAILS, DESIGNS AND TYPES

Guard rails shall be constructed in accordance with the designs shown on the Drawings. The type of guard rail to be used at any given location shall be as indicated on the Drawings or as set forth in the Special Specification of Particular Application.

R14 03 METAL POSTS

Metal posts shall be either (a) 15cm x 15cm wide-flange beam structural steel members weighing approximately 23kg/m, or (b) not less than 35kg/m standard railway flat bottom rails; as the Contractor may elect. New materials will not be required, provided that the posts are straight, structurally sound and free from rust and scale. Each post shall be given one coat of a standard rust inhibitive primer prior to delivery at the site of the work.

Each metal post, either the 15cm x 15cm wide-flange beam type or the railway rail type, shall be provided with a steel bearing plate centred on and welded or bolted to the head of the railway rail posts and to the back flange of beam-type posts as installed.

Each metal end post shall be provided with an additional steel bearing plate welded or bolted transversely to the alignment of the guard rail as erected.

The steel bearing plates shall have a thickness of not less than 6mm and a surface area of not less than 750cm². The least dimension of their width or length shall be 25cm and they shall be placed on the post with the greater dimension transverse to the longitudinal axis of the post. The tops of the bearing plates shall be 70cm from the tops of the posts.

Each post shall be drilled to provide holes of proper size and at proper location to permit the attaching of the rail member or bracket intended for use therewith. The holes shall be in one flange of the beam-type post and in the base of the rail-type post and as near the centre of the posts as is practicable. Unless the posts can be and are set accurately to grade and line after drilling, the drilling of holes shall be performed after the posts are installed.

Metal posts are to be painted in the field as provided below.

Metal posts shall be tested in accordance with AASHTO T 65.

R14 04 METAL RAIL MEMBERS AND FITTINGS

Metal rail members shall be of open hearth or electric furnace steel of 2.5mm fabricated and shaped into beams having a width (vertical projection when in place) of not less than 30cm nor more than 35cm and having a depth (horizontal projection when in place) of not less than 8cm nor more than 10cm.

Guard Rails and Safety Fencing

Rail members which are designed to make contact with the post at their centre and also within 40mm of their top and bottom edges (as installed) may be attached directly to the posts.

Rail members which are so designed that they do not make contact with the post within 4cm of their top and bottom edges as well as at their centres shall be attached to the posts either (a) by suitable rigid metal brackets which shall provide such edge support and centre contact, or (b) by suitable resilient spring steel offset brackets which will support the rail 13 to 18cm from the post.

Rail members shall be provided with slotted holes to permit expansion and contraction, and they shall have rolled or rounded edges free from sharpness and burrs. The projecting heads of bolts shall be rounded and shallow so as not to obstruct or impede the sliding of vehicles when in contact therewith.

Unless otherwise called for on the Drawings or in the Special Specification of Particular Application, metal rail members and brackets shall be clean and shall be given one coat of a standard rust inhibitive primer prior to delivery at the site of the work.

If galvanised rail members and brackets are called for, they shall be galvanised (610g/m² coating) in conformance to the AASHTO M111-74 Zinc (Hot Galvanised) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip.

Bolts, nuts, washers, and other fittings shall be galvanised (381g/m² coating) by the hot dip process, AASHTO M232-74 Zinc Coating (Hot Dip) on Iron and Steel Hardware.

Non-galvanised rail members, brackets and fittings shall be painted in the field as specified below.

Brackets, bolts and other fittings required in conjunction with the installing of the rail member shall be of steel and of proper design for use with the type of rail member to be used on the project.

Where rail members with resilient spring steel offset brackets are used, the brackets shall have full bearing over an area of not less than 130cm² where attached to the posts.

R14 05 BOLTS, WASHERS AND HARDWARE

Bolts, washers, nails, spikes and other hardware required for guard rail construction shall be of the sizes and kinds called for on the Drawings or if not there shown shall be of such sizes and kinds as are consistent with first class workmanship and of recognised adequacy. All shall be galvanised by the hot dip process, AASHTO M232-74.

R14 06 CONSTRUCTION OF GUARD RAIL

The construction of the guard rail shall be in accordance with recognised standard practice for the type furnished and as recommended by the manufacturer, except as otherwise set forth in this Specification. The posts shall be placed at intervals of not more than 4m centre to centre unless otherwise specified.

Post holes shall be excavated to the lines on grades and depths shown, on the Drawings. No posts shall be set until the lines and grades of the holes have been checked by the Engineer's Representative. After the posts are properly set, the holes shall be backfilled to within about 10cm of final ground surface, to permit the backfilling material being solidly compacted as it is placed below ground level.

Guard Rails and Safety Fencing

Metal posts may be set by driving, when practicable, provided they are thus installed to vertical position, true to line and grade. The flange of the metal beam-type post and the base of the railway rail-type post shall face the roadway and shall be the respective faces to which the rail member or its support bracket is to be attached. Intermediate metal posts shall be set with the bearing plate on the "off-roadway" side.

The rail members shall be erected with a smooth roadway face free from protrusions which would constitute a hazard to vehicles in moving contact therewith. Provision for expansion and contraction in metal rail members shall be made. In no case shall the top of posts extend above the top of the rail members.

Each end of each continuous installation of metal rail member shall be finished with a standard rail member and piece, or in lieu thereof the metal rail member shall be turned back on a smooth curve so that its end will project a minimum of 18cm back from the front face of the rail and ending not less than 45cm beyond the centre of the end post.

After the rails, brackets, braces and other parts of the structure are in place, the guard rail shall be accurately aligned, bolts and other fastenings securely tightened, and the entire structure brought to smooth, taut and well-finished condition, after which the painting shall be carried out.

R14 07 SAFETY-FENCES – OVERALL REQUIREMENTS

General

1. Safety fences shall comprise beams, posts or mounting brackets and means for fixing, post footings, anchorages and ancillary fittings as shown on the Drawings and detailed in the Contract. They shall be so constructed as to provide a flowing visual alignment, failing which the Contractor shall make good by adjusting the alignment of any beam as directed by the Engineer's Representative.

Beams

2. Except where shown on the Drawings beams shall be straight and of approved cross-section within manufacturing tolerances.

3. Beam sections shall be connected by lap (or butt) joints and to posts or mounting brackets using bolts, nuts, screws, washers and fish plates or other approved means as shown on the Drawings.

4. All beams shall be shaped and all bolts and screws so located that the whole assembly presents no sharp edges or projection to traffic. Lap joints shall be made in the direction of adjacent traffic.

Posts

5. Metal posts shall be driven or set in concrete footings as shown on the Drawings. Driven posts shall be provided with a mild steel distribution plate welded to one flange, the bottom of the plate being above the bottom of the post.

Post sockets in concrete footings shall be so constructed that the posts can be easily withdrawn from them for replacement purposes. Overdig of post holes shall be made up to the level of the post butt with Class E concrete.

Treatment of Ends

6. The ends of safety fences shall terminate in:

Guard Rails and Safety Fencing

- (i) a terminal section, which may be flared away from the line of the fence, ramped down to an anchorage; or
- (ii) a connection with another type safety fence by means of a transition piece; or
- (iii) a full height anchorage; or
- (iv) a direct connection with a bridge parapet by means of an approved connection, or
- (v) an expansion joint assembly, as shown on the Drawings.

Concrete in Footings and Anchorages

7. Concrete in footings and anchorages shall be Class 230.

Assembly

8. The overall length of beam sections and posts and spacing of posts or mounting brackets shall be as shown on the Drawings.

9. Other than at a flare or ramp or as shown on the Drawings:

- (i) The horizontal alignment of fences shall not depart from the road alignment by more than 3cm nor deviate from the straight or required radius by more than 1cm in any two successive section lengths.
- (ii) The beam shall be at the specified height above the edge of the nearest adjacent carriageway, hardshoulder or hardstrip, or if the fence is located more than 1.5m from the carriageway, hardshoulder or hardstrip above the level of the surface vertically beneath the fence face within a tolerance of $\pm 3\text{cm}$. In addition the deviation from the straight grade shall not exceed $\pm 5\text{mm}$ in any two successive section lengths.

10. No site drilling or cutting of beams and posts will be permitted without the prior approval of the Engineer's Representative and unless otherwise approved special closure pieces shall be fabricated prior to galvanising. Under no circumstances will flame cutting be permitted to form holes or cut beams.

Galvanising

11. All steel parts shall after fabrication be galvanised by the hot-dip process in accordance with BS729 (1971).

R14 08 TENSIONED CORRUGATED BEAM SAFETY FENCE

Beams

1. Corrugated beams shall be of mild steel and not less than 30cm in depth and so formed that the traffic face has a central trough at least 7.5cm deep. Each section shall be 3.5m long. When the section is freely supported over a span of 3m with the road face uppermost and centrally loaded with a point load of 1,000kgf the deflection measured at the centre of the span shall not exceed 4cm.

2. Beam sections shall be connected by lap joints using bolts, nuts and washers manufactured in accordance with BS970: 080M40 (normalised). The strength in tension of the beams and the joints between beams shall be not less than 33,000kgf.

Posts

3. Posts shall be manufactured from 5mm mild steel plate in accordance with BS4360 Grade 43A formed into Z section 100mm x 32mm x 6kg/m. The overall length and spacing of posts and the length breadth and thickness of distribution plates on driven posts shall be as shown on the Drawings. Posts shall be mounted in concrete footings where shown on the Drawings or directed by the Engineer; otherwise they may be either driven or mounted in concrete footings.

R14 09 TENSIONED RECTANGULAR HOLLOW SECTION BEAM SAFETY FENCE

Beams

1. Rectangular hollow section beams shall be rolled to BS4 Part 2 0969) shall be either 100mm x 100mm x 5mm thick and made of high yield steel in accordance with BS4360 (1972) Grade 50c or 200mm x 100mm x 5mm thick and made of mild steel in accordance with BS4360 (1972) Grade 43c. Each section shall be not more than 4.8m long unless otherwise approved by the Engineer.

2. Beam Sections shall be joined by means of internal mild steel plates as shown on the Drawings.

Posts

3. Posts and the method of ground fixing shall be the same as specified in Clause R14 08 for tensioned corrugated beam safety fences.

R14 010 - OPEN BOX BEAM SAFETY FENCE

Beams

1- Open Box beams shall be made of mild steel and of trapezoidal cross-section as shown on the Drawings. Each section shall be 4.8m long except on radii less than 107m when they shall be 2.4m long. When a 4- 8m long section is freely supported over a span of 3m with the road face uppermost and centrally loaded with a point load of 2,000kgf the deflection at the centre of the span shall not exceed 12mm.

2. Beam sections shall be joined by fish plates using bolts, nuts and washers manufactured in accordance with BS970:080 M40 (normalized).

Posts

3. Posts and the method of fixing shall be as specified in Clause R14 09 for tensioned corrugated beam safety fences except that the Z-section shall be 110mm x 50mm x 8 kg/ m.

Adjuster platforms shall be provided where shown and detailed on the Drawing to maintain the alignment of the fence at curved piers.

Assembly

1. Beams shall be bolted directly to the posts or where shown on the Drawings shall be off-set from the posts by means of spacers. Where spacers are used at the posts to separate the beams of a double sided fence, stiffeners shall be inserted at and midway between the fishplate joints.

Guard Rails and Safety Fencing

R14 011-PAINTING

Where galvanized guard rails or safety fences are to act as a chevron marked warning sign, the beams shall be painted as specified below.

For un galvanized guard rails the surfaces of metal posts, metal rail members and metal brackets from which the primer com has been removed by handling or by erection shall be repainted with one coat of a standard rust inhibitive primer.

All exposed surfaces of erected metal posts, metal members, metal brackets and fastenings shall be given two coats of a special white, alkyd type, paint for metal surfaces. The paint to be furnished and used shall be in accordance with Section BI2.

The exposed surface of each erected concrete post shall be painted one coat with one of the following: (a) a mixture of 85 percent Portland cement and 15 percent hydrated lime with sufficient water to give a creamy consistency.

All paint shall be applied by brush or spray. No paint shall be applied on damp, dusty or un-clean surfaces, and no painting shall be done during rainy weather. No coat of paint shall be applied over a preceding coat until the preceding coat is entirely dry and not within 3 days of the preceding application unless otherwise authorized by the Engineer.

R14 012-FINISHING OF CONSTRUCTION

After the painting is completed and the paint has dried, the guard rail embers and fittings shall be finally adjusted, and the backfilling of post holes shall be complete to the ground surface.

The site of the work shall then be cleaned up, all excess excavated materials and all construction debris being disposed of in a manner satisfactory to the Engineer's Representative.

R14 013- WORKMANSHIP

Only high-grade workmanship will be accepted. All joints shall be accurately fitted, and the completed guard rail shall be true to the lines and grades to which it was ordered by the Engineer to be constructed.

R14 014-MEASUREMENT AND PAYMENT

For the construction of given type of guard rail and safety fences in accordance with the foregoing Specification, payment will be made at the price tendered per linear meter for the appropriate type of guard rail or safety fence.

The key lengths will be determined by measurement along the guard rail as constructed and from end to end of the rail member of each section (run) of completed guard rail.

The price tendered per linear meter for the applicable item tendered as set forth above shall be understood to include payment for all excavating and backfilling work, the furnishing and placing of end pieces and the painting work, as well as the furnishing and placing of all materials and the performance of all other work required.

R15

TRAFFIC SIGNS

R15 01 SCOPE

The work covered by this Section of the Specification consists in the furnishing of all labour, equipment, supplies and materials and in performing all operations in connection with traffic signs, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R15 02 GENERAL

1. The term "Traffic Signs" refers to the complete structure of all kinds of traffic signs including foundations, posts, sign plates and all fittings as shown on the Drawings or detailed by the manufacturer. The type of traffic sign to be used at any given location shall be as indicated on the Drawings or as directed by the Engineer's Representative.

2. Traffic signs shall be either externally or internally illuminated, reflectorised or non-reflecting as described on the Drawings or in the Special Specification of Particular Application and shall comply with Part II Chapter II of 'European Rules concerning Road Traffic, Signs and Signals' agreed by the European Conference of Ministers of Transport and dated February 1974 and any amendments and extension thereof or any Regulation, Direction and Rules of Design issued by the Government of Iraq. Inscriptions on traffic signs shall be in the Arabic and English* languages, with the Arabic inscription located either above or on the right of the English inscription.

3. The quality of traffic signs shall in general comply with B.S 873 Part I (1970).

4. All sign faces shall be of the type, colour, design and size shown on the Drawings.

Direction signs for expressways shall be in white lettering on a blue background and for Primary Routes in white lettering on a green background and for other roads black lettering on a white background with a blue border. All in accordance with the latest edition of "The Traffic Signs Regulations and General Directions" published by H.M.S.O. London. All other signs shall be in the colours shown in the 'European Rules' document quoted in sub-clause 2 above.

5. The Contractor shall determine the actual size of the sign for fabrication in accordance with the Contract and submit to the Engineer's Representative for approval drawings of all special sign faces and all sign faces bearing legends, showing the design and/or arrangement and spacing in both languages. The edges of signs shall follow the shape of the border and not be squared off.

6. Existing signs and posts which are taken up shall be disposed of as directed by the Engineer's Representative. Posts shall be removed or cut off at ground level, leaving a level surface with no projections above ground level.

R15 03 POSITIONING

1. Signs shall be positioned laterally at the mounting height shown on the Drawings or as directed by the Engineer's Representative.

2. The Contractor shall stake out the location of the sign support in accordance with the Drawings and shall be responsible for the proper elevation, off-set, level and orientation of all signs he erects, which will be subject to the approval of the Engineer's Representative. He shall exercise due care in the preservation of stakes for his and the Engineer's Representative's use and if any stakes are lost, damaged, displaced or removed, the Contractor shall have them reset at his expense.

3. Signs shall normally be set as least 45cm from the edge of the carriageway. This shall be increased to 60cm where there is a severe camber or cross fall and where signs are mounted on the central reserve of dual carriageways. On Class AA dual carriageway roads the clearances should be at least 120cm and where there is a hardened verge, the nearest edge of the sign should not be less than 60cm behind the edge of the hardening.

4. Where possible the lower edge of traffic signs shall be between 90cm and 150cm above the highest point of the carriageway alongside. The higher mounting shall be used where excessive spray or dust is likely to soil the signs. In built-up areas where the signs are erected over footways the mounting height shall be at least 210cm to allow sufficient headroom for pedestrians.

5. In rural areas to avoid specular reflection from headlamp beams, signs which face along the carriageway shall be set 95° away from the line of the carriageway where it is straight or on right-hand curves. On left-hand curves, signs shall be set 95° away from a line joining the edge of the carriageway at the sign with a point on the carriageway edge 200m in advance of the sign.

R15 04 SIGN PLATES

1. Sign plates for externally illuminated and non-illuminated signs shall be manufactured from the following materials and the grade of material proposed shall be subject to the approval of the Engineer. Signs over 3m² in area shall be manufactured from sheet aluminium or extruded aluminium sections unless otherwise agreed by the Engineer.

- (a) Sheet aluminium of not less than 3mm thickness to BS1470 (1972) or to ASTM B 209 - 74 grade 6061-T6 degreased.
- (b) Extruded Aluminium Planks to BS1474 (1972). These may be either self-locking or bolted together.
- (c) Cast Aluminium Alloy to BS1490 (1970).
- (d) Steel Sheet or Strip of not less than 1.25mm to BS1449 Part 1 (1972), BS2989 (1975) or ASTM A366-72.
- (e) Cold Formed Steel Sections to BS1449 Part 1 (1972) or BS2989 (1975). These should be plank-type steel sections bolted together through flanges.
- (f) Cast Iron of not less than 4.75mm thickness to BS1452 (1961). Due to its weight this is suitable only for smaller signs.

2. In constructing Signs from sheet aluminium it will not be acceptable to have a large number of small plates riveted together and the largest size sheets available shall be used in all cases. Where more than one sheet is used to make up a sign face, separate sheets

shall be of rectangular shape and of approximately the same shape and size. Care must also be taken to ensure against electrolytic corrosion where dissimilar metals are in contact. All sign plates shall have clean cut edges, be free from warp, and shall have a smooth, even finish.

The temporary signs and sign plates shown on the Drawings and in the Schedules shall be made either from the same materials as for the permanent signs or from hardboard or plywood. Plywood shall be to BS1455 (1972) Grade 1 with WBP (weather and boil proof) adhesive. Hardboard shall be of high quality and suitably treated to prevent deterioration by weathering.

3. Non-reflective Signplates shall be covered with non-reflective plastic sheeting, of a type approved by the Engineer's Representative and in accordance with BS873 Part 1 (1970), over the whole front surface to the specified colours, and with grey non-reflective plastic sheeting or plastic coating over the back surface or such other material to the approval of the Engineer's Representative.

4. Reflectorised Signplates shall be covered with the appropriate combination of reflective and non-reflective plastic sheeting, in accordance with BS873 Part 1 (1970), over the whole front surface to the specified colours, and with grey non-reflective plastic sheeting or plastic coating, or such other material as the Engineer may approve, over the whole back surface. The front faces of traffic signs may require to be reflectorised even if they are illuminated.

5. Internally illuminated sign faces shall be in accordance with BS873 Part 1 (1970). They shall be fabricated from a strong material such as GRP (glass reinforced plastic) or other material approved by the Engineer.

6. All plastic sheeting shall be affixed to the signplate with heat activated or pressure sensitive adhesive properly applied in accordance with the sheeting manufacturer's specification and instructions. All joints in the sheeting shall be overlapped and in the case of horizontal joints the lap shall be from the top – no butt joints will be permitted. Overlaps shall not be less than 6mm and sheeting applied to extruded sections shall extend over top and bottom edges and down side edges for at least 3mm. Vertical joints shall be avoided. The Contractor shall submit samples of each colour of plastic sheeting to the Engineer's Representative for approval, prior to ordering materials.

The faces and edges of each signplate shall have a coat of clear lacquer applied at the time of fabrication of the sign. The lacquer shall be of a type specified by the manufacturer of the sheeting material for use on that particular material. Full adhesion of all materials including letters, symbols and borders is essential. There shall be no air bubbles, creases or other blemishes. All sign faces, wherever practicable shall be formed from a single sheet of film. Edge sealing with the appropriate clear lacquer shall be continuous along all letters, symbols and border edges. Clear lacquer coating shall be uniform and continuous. All surfaces shall be hard and free from blemishes such as runs, drips and crazing. All bolt holes shall be edge sealed with the appropriate clear lacquer to prevent ingress of moisture to the sign face.

7. On all signs the stiffening and framing shall be constructed in accordance with BS873 Part 1 (1970). The Contractor shall submit details of the type of framing and stiffening for the approval of the Engineer.

8. Where brackets are used in the construction of signs, they may be manufactured from stainless steel, strip aluminum alloy, extruded aluminum alloy sections, cast aluminum alloy, or mild steel plastic coated or nylon dipped after shot blasting.

9. Screws, bolts, nuts and washers shall be of stainless steel to ASTM A 276-73 except that washers in contact with surfaces, which may be permanently damaged by over tightening of nuts or bolts, shall be of Neoprene, nylon, or other approved soft and weather resisting material.

10. Rivets or other devices used for fixing signs to their framework shall be of stainless steel, aluminium or other approved material and be of sufficient size to prevent failure due to differential expansion or wind pressure.

Where sign plates are drilled or riveted, clear lacquer as previously specified shall be applied to the perforations to prevent the ingress of moisture to the sign face.

The spacing of rivets shall be uniform on the outside edge of any plate or section of plate and shall not exceed 15cm. On cross braces the spacing shall not exceed 30cm.

Rivets brought through to the sign face shall not detract from the legend. Their heads shall be coloured to match the appropriate part of the sign face.

11. Holes in sign plates, framing or posts shall be drilled before painting and they shall be accurately located.

12. The finish of all signs shall be capable of passing the test described in the appropriate appendices of B.S 873 Part 1 (1970).

13. At all stages of production, delivery and erection, signs shall be protected to avoid damage.

R15 05 SIGN POSTS

1. The Contractor shall furnish posts to support the signs as shown on the Drawings.

The load on the sign plate due to wind pressure may be taken as equivalent of 15 millibars (153kg/m^2).

2. All tubular or rolled hollow sections shall be complete with cap and base plate, which should incorporate an anti rotational device for signs on a single post.

3. The posts may be of the following types or finish:

(i) Tubular or rolled hollow section steel posts or British Standard Beams complying with ASTM A 53-73, BS4 Part 2 (1969) or BS1775 (1964) rust proofed and finished before delivery by one of the following methods:

(a) An approved self-color plastics coating material of a thickness not less than 0.08mm. All posts shall be shot-blasted prior to the application of plastic coating in accordance with BS 873.

(b) Galvanized to BS729 (1971), degreased with an approved solution, and painted one coat metallic lead, one undercoat, and finished with one coat grey alkyd paint.

(c) Zinc sprayed-which is to include grit blasting ,zinc spraying to 0.08mm thickness, etch primed and once coated with zinc chromate primer, one undercoat and finished one coat grey alkyd paint; each complete with matching cap

and base-plates (where appropriate). Base-plates shall have a minimum area of 0.05m².

(ii) Reinforced or pre-stressed reinforced concrete – complying with BS1308 (1970) and Sections B8 and B9.

4. The length of posts below ground level shall be in accordance with the Drawings.

5. Where specified on the Drawings, or required by the Engineer, traffic sign posts in the verges, but not in the central reserve of dual carriageways, shall be of tubular steel fitted with breakaway (or frangible) joints which will break upon impact by a colliding vehicle. The breakaway joint shall be fitted 7.5cm above ground level and consist of a break in the tubular steel post joined with bolts through notches in flanges and a steel retaining gasket, as developed by the British Transport and Road Research Laboratory, or other form of joint approved by the Engineer.

R15 06 HOUSING OF ELECTRICAL EQUIPMENT

1. All illuminated sign assemblies shall be provided with one large-base post to accommodate the necessary electrical equipment.

The Base Housing compartment may be circular or rectangular in section and shall be fitted with an earthing stud. If circular, the compartment shall be not less than 16.5cm internal diameter. If rectangular, the sides shall be not less than 13cm in width and a depth from front to rear (measured from front of switchboard) of not less than 10cm. The compartment shall have an aperture not less than 30cm x 13cm fitted with a weather-proof metal access door having a tamper-proof lock with key. A hard wood panel of a size not less than that of the aperture, 12mm thick, shall be securely fixed to the back of the compartment for mounting the electrical equipment. The post shall be provided with holes for the cable entry below ground level and also at the top of the post to suit the lighting units.

2. Side-slung Service Boxes to house the electrical equipment may be attached to a standard post as an alternative, except adjacent to footpaths. The Boxes shall be of approved design constructed of materials of adequate strength to withstand all normal conditions and usage and fitted with an earthing stud. Each Box shall be provided with an aperture not less than 30cm x 13cm fitted with a weather-proof metal access door having a tamper-proof lock with key. A hardwood panel of a size not less than the access door, 12mm thick, shall be securely fixed to the back of the box for mounting the electrical equipment. The dimensions of the Box shall be such that the overall width shall be at least 6cm greater than the width of the post to which it is attached. The depth of the box shall not be less than 11cm and the height should not be less than 30cm.

The Box shall be secured to the post by means of not less than two stainless steel "U" bolts of a suitable size. The "U" bolts shall pass completely round the post and shall be secured by stainless steel nuts and washers within the Box. The Box and all bolt holes shall be weather-proof and a drain hole shall be provided in the base of the Box. Any external cable shall be fitted in conduit or alternatively the cable may be SWA and securely clipped to the post. All cable access holes shall be weather-proofed. The exterior and interior of the Boxes and all holes for cables, bolts, access, etc., shall have a smooth finish without any sharp edges. If the Contractor wishes to use any other method for securing the Box to the post, full details shall be provided and the Engineer's prior approval obtained.

3. Base Housings and Service Boxes or side slung boxes shall be rust-proofed by one of the methods detailed in Clause R15 05-3 (i) above.
4. Posts which incorporate lighting cables shall be fitted with a pull-out device designed to isolate the post electrically in the event of a collision.

R15 07 FIXINGS

1. Clips used for fixing signs to posts shall be manufactured from stainless steel, strip or extruded aluminum alloy sections, cast aluminum, or mild steel treated as specified below.

Instead of standard type clips, the use of one of the proprietary type stainless steel banding systems is acceptable, providing the strength requirements specified below are provided.

All clips up to and including 7 • 5cm shall be in stainless steel. Half clips and brackets shall be bolted to the sign framework. Clips for larger posts, if made of mild steel, shall be plastic coated or nylon dipped after shot blasting.

Each clip assembly shall be of sufficient size to prevent failure due to expansion or a wind pressure of 15 millibars (153 kgf/m²) on either side of the sign. The Contractor shall submit for the Engineer's Representative's approval samples of each type of clip, stating, in the case of clips for steel posts, the maximum surface area of sign per clip to be used.

The Contractor shall state in the case of plate signs the method whereby the sign plate will be fixed to purlins and the purlins fixed to the post, and detail on the working drawings called for as part of the Contract the type of fixing clips to be used. A connection shall be made at every point where a purlin crosses a post.

The minimum number of clips required for each supporting post shall be as Table R15/1.

TABLE R15/1**MINIMUM NUMBER OF CLIPS**

Depth of Sign (meters)	No.
0 - 1.5	2
1.5 - 3.0	3
3.0 - 4.5	4
4.5 - 6.0	5
over 6.0	6

On plank signs, every plank shall be fixed to each post by at least one clip. The above table does not apply to plank signs which shall be erected strictly in accordance with the manufacturer's instructions.

2. Where signs are supported on concrete posts, purlins made from 5cm O/D 4mm thick with ends sealed, shall be furnished. The purlins shall be attached to each vertical member of the sign frame and shall be complete with clips for attachment to the posts. The distance of the top and bottom purlins from the sign edges shall not exceed 45cm. The intermediate purlins shall be spaced equally and the distance vertically from centre to centre shall not exceed 1.5m. The purlins shall be rust - proofed by one of the methods detailed in Clause

R15 05-3(i) above. A neoprene strip or similar approved insulating material shall be provided to prevent contact between purlins and aluminium framing.

R15 08 LIGHTING

1. Where the lighting of signs is specified, the manufacture and performance of the units supplied shall be to the requirements of BS873 Part 1 (1970). Internally illuminated signs shall be provided only where so specified.

2. Where the illumination of signs is required, the units supplied shall be suitable for illumination of the signs concerned as shown on the Drawings.

3. All lighting units shall be fitted for either fluorescent lighting and be complete with switch gear, starters, ballasts, capacitors, etc. and all ancillary electrical cells, or Mercury Vapour, or Quartz Halogen, or Tungsten Halogen.

When Mercury Vapour, or Quartz Halogen, or Tungsten Halogen lighting is furnished such units shall be complete with the necessary control switch gear and shall meet with the approval of the local electricity authority.

All units shall be complete with wiring to accept a simple supply connection via a fused cut-out located in the base housing or service box, the cut-out to be supplied and fixed with the lighting unit. The wiring and connections shall be to the standards and satisfaction of the electricity authority.

4. In the case of signs illuminated with top-mounted lighting units, the signs shall be extended vertically to be level with the top of the lighting fitting to avoid extraneous light being observed from the rear of the signs. This extended section of the sign shall be finished to conform with that for the back of the sign of which it forms part.

5. Where photo-electric control units are required they shall be designed to switch on and off at the light levels specified by the electricity authority. No control unit will be required on lighting units that are to be operated on a 24-hour basis.

R15 09 STORAGE

In order to ensure that sign components do not suffer damage, deterioration from weather or theft, the Contractor shall arrange for adequate storage facilities, off ground and under cover, to the satisfaction of the Engineer's Representative. Any sign or sign component that is damaged, discoloured or defaced during transportation, storage or erection will be rejected.

R15 10 ERECTION

1. During the erection of traffic signs on any section of road already in use, the Contractor shall ensure the free and safe passage of vehicular traffic and pedestrians and the Contractor where directed by the Engineer's Representative shall furnish and erect all necessary warning signs, traffic cones, etc. All signs, cones, etc., shall be removed clear of the road by the Contractor immediately on completion of the work.

2. The Contractor shall be responsible for the furnishing, erection and removal of any temporary staging and ladders, use of lifting gear and other plant.

3. Posts shall be erected vertical and where two or more are used for one sign their tops shall be at the same level and below the top of the sign, except where they are required

Traffic Signs

to support overhead lighting units. Signs shall be correctly aligned and attached to their posts in a vertical plane with the tops and bottoms of the rectangular and triangular signs horizontal. Circular signs shall be erected so that the legend is at the correct inclination.

4. In the case of illuminated signs, particular attention shall be given to the siting of the posts. Wherever practicable, the post having the control base housing or Service Box should be that one furthest from the edge of the carriageway. Where this is not possible, the control access opening should always face away from the carriageway.

5. The Contractor shall include for the erection and installation of the whole of the foregoing equipment, together with any materials and work which may not be expressly specified but which is implied and necessary for the satisfactory completion of the installation. Only workmen who have been trained or already have had experience in the erection of traffic signs shall be employed on this work.

6. When signs occur on embankments or in cuttings, the posts will vary in length and the Contractor will be required to provide posts of appropriate lengths to suit this variation. Post centres will be shown on the Drawings.

7. Signs erected before the opening of the new sections of road will in certain cases need masking. The prices quoted must include for masking by hessian securely fixed to obliterate the legend or part of the legend. The use of masking tape stuck on any part of the sign will not be allowed. Where instructed, the masking shall be hardboard on 4cm x 2cm timber battens or equal approved. Hardboard shall be weatherproofed with one coat grey undercoat.

R15 11 FOUNDATIONS

1. The posts other than those for which a reinforced concrete foundation is detailed shall be set in mass concrete Class E which shall fill completely the cavity for the post foundation.

2. Reinforced concrete foundations shall be constructed as detailed on the Drawings in concrete Class 150 and shall conform to Section B8.

3. All excavations for foundations for signs in excess of 10m², for sign posts with a diameter in excess of 10cm and for reinforced concrete foundations shall be subject to the approval of the Engineer's Representative before the sign is erected and immediately prior to the placement of the concrete.

4. Concrete shall be placed in post foundations immediately after mixing, well tamped down and levelled off, and where applicable, a chase or duct to receive an electricity cable shall be formed in wet concrete below the position for a Service Box to facilitate connection to electricity service.

5. The top level of mass and reinforced concrete foundations shall be 20cm below ground level. This last 20cm shall be reinstated to the original levels and fall in such a manner as to match the adjacent areas.

6. Excavation of foundations for steel posts shall include for taking out any material including breaking out concrete obstructions where necessary and disposal of the surplus excavated material off site. For all foundations reinstatement of grass verges shall be carried out by replacing top soil and seeding with approved grass seed, where applicable.

7. The Contractor shall protect and support during the progress of the Works all pipes, mains, cables, overhead lines and apparatus which might be endangered by his operations and will be responsible for making good any damage.

8. The Contractor shall reinstate trenches and excavations. The surface of the ground around posts shall be reinstated to levels and falls, and with material to the satisfaction of the Engineer's Representative, and the site shall be left in a safe and tidy condition.

R15 12 TEST AND DEFECTS

Before despatch to the site, the signs shall be assembled and erected at the manufacturer's works and tested there for general operation. At this stage the complete signs may also be inspected for general finish, workmanship, and to ensure that all details satisfactorily comply with the Specification.

All tests will be witnessed by the Engineer's Representative and shall only be carried out at times agreed in advance. The Manufacturer shall provide all plant, instruments, and labour in connection with tests.

Subsequent to the works test the signs shall not be installed until written permission is given.

The Contractor shall on completion take earth resistance, insulation resistance and continuity tests, the accuracy of which shall be demonstrated to the satisfaction of the Engineer's Representative. A record of all tests specified above shall be made for each length and duplicate copies shall be supplied to the Engineer's Representative within 14 days of the completion of the installation.

R15 13 BOLLARDS

Internally illuminated traffic bollards shall be in accordance with BS873 Part 3 (1970).

R15 14 DELINEATORS OR MARKER POSTS

Delineators and marker posts shall be fixed at the locations, spacings and offset from the carriageway as shown on the Drawings, or as directed by the Engineer's Representative. They shall either be made of steel as specified in Clause B10 03 or of approved moulded plastic. They shall be painted or coloured in the manner shown on the drawings and be complete with any reflectors and numerals, which shall be fixed in an approved method.

R15 15 OVERHEAD TRAFFIC SIGNS

Overhead Traffic Signs shall be located where shown on the Drawings and mounted on gantries constructed in accordance with Sections B3, B10 and B12.

R15 16 MEASUREMENT

Traffic signs shall be measured by the unit for each type as installed and accepted by the Engineer's Representative, and shall include all excavations and backfilling, concrete, reinforcement, anchor bolts and plates, posts, plates and all fittings according to the Drawings.

Traffic Signs

R15 17 PAYMENT

Payment of traffic sign will be made per number in accordance with the unit prices of the various items stated in the Bill of Quantities, and shall constitute full compensation for the furnishing of all equipment and labour and for performing all operations necessary to complete the work in accordance with this Section of the Specification.

SECTION R16

ROAD MARKINGS

R16 01 SCOPE

The work covered by this Section of the Specification consists in the furnishing all plant, labour, equipment and materials and in performing all operations in connection with the construction of Road Markings complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

R16 02 GENERAL

1. Road markings shall comply with Part II Chapter IV of 'European Rules concerning Road Traffic, Signs and Signals' agreed by the European Conference of Ministers of Transport and dated February 1974 and any amendments and extensions thereof or any Regulations and Directions issued by the Government of Iraq.

2. The markings shall be white or yellow continuous or intermittent lines, letters, figures, arrows or symbols of thermoplastic material or paint laid to the required dimensions as shown on the Drawings. The road markings shall be white, except that zigzag lines showing places where parking is prohibited and continuous or broken lines on the kerb or on the edge of the carriageway to show that standing or parking is prohibited or restricted shall be yellow.

3. The pavement shall be finished in the following manner to receive road marking materials which shall only be applied to surfaces which are clean and dry. Immediately before the application of the road markings, the surface to receive them shall be brushed, chipped if necessary, and airblasted clean and free from oil, surplus bitumen, mud, dust and other loose or adhered material.

- (i) On concrete carriageways the transverse texturing shall be carried across the full width of the pavement under the marking which shall be freed by wire brushing or other approved means from all traces of curing compound.
- (ii) On bituminous carriageways, chippings applied to the surface shall extend over the area to be covered by the marking.
- (iii) On surface dressing, all loose chippings shall be removed from the surface before applying markings.

Carriageway centre lines, lane lines and edge lines shall be laid by approved mechanical means to a regular alignment. Other markings may be laid by hand, hand propelled machine or by self-propelled machine as approved or directed by the Engineer's Representative.

Markings shall be free from raggedness at their edges and shall be uniform and free from streaks.

R16 03 THERMOPLASTIC MATERIAL

1. Material

- (i) Thermoplastic material shall be made by an approved manufacturer, well visible by day and night, durable and resistant to skidding. It shall be suitable for the type and location of application. The material shall possess adequate thermoplastic

Road Markings

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. It must also give a marking which is effective for at least 18 months under normal traffic conditions. It shall comply with the requirements of BS3262 (1976) except as follows:

- (a) The softening point measured in accordance with Appendix C shall not be less than 95°C.
- (b) The luminance factor of white material shall be measured in accordance with Appendix D and shall be not less than 75 for material as delivered by the manufacturer and not less than 70 for material obtained from an applicator or melter on site after remelting.
- (c) After the Heat Stability is tested in accordance with Appendix E, the luminance factor shall be measured in accordance with Appendix D and shall not be less than 70.
- (d) In testing the Flow Resistance, a cone made and tested in accordance with Appendix F at a temperature of 40°C $\pm$ 2°C for 48 hours shall not slump by more than 25%.
- (e) When tested in accordance with Appendix G, the skid resistance of newlylaid marking prepared under the stated conditions shall not be less than 55.
- (ii) The open flash point shall be over 230°C and the temperature of mixing and application shall be within the range 200°C to 225°C. At 20°C ambient temperature the material shall set within 2 minutes.
- (iii) Where specified reflectorisation shall be by the incorporation of ballotini (small transparent glass spheres having optical properties such that when backed by a suitable medium, incident light is reflected back in the general direction of the source.) The grading and proportions of the ballotini shall be as specified in BS3262 (1976.).
- (iv) The material shall be supplied in sealed metal containers which do not contaminate the contents and which protect them from contamination.
- (v) Each container shall be clearly and indelibly marked with the manufacturer's name, batch number, date of manufacture, reflectorisation (if applicable), colour, chemical type of binder and maximum safe heating temperature.
- (vi) The material shall be stored in accordance with the manufacturer's instructions and any material that is in damaged containers of which the seal has been broken, or of which the age is over 10 years since manufacture shall not be used unless agreed by the Engineer's Representative.
- (vii) The Contractor shall satisfy the Engineer's Representative that the material he proposes to use has the required properties, stating the maximum and minimum proportions and grading of the constituents, the acid value of the binder, the setting time, the maximum safe heating temperature, the temperature range of the apparatus and the proposed method of laying.

2. Preparation

- (i) 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 material and such that local overheating will 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 thermoplastic material which has natural resin binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.

- (ii) 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.
- (iii) On concrete carriageways a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

3. Laying

- (i) Thermoplastic material shall be laid hot by screeded or sprayed application to the following thicknesses:

(a) Screed Markings	$4 \pm 1\text{mm}$
(b) Sprayed markings other than yellow lines	$2 \pm 0.5\text{mm}$
(c) Sprayed yellow edge lines	$1 \pm 0.2\text{mm}$

These thicknesses are exclusive of surface applied ballotini. The method of thickness measurement shall be in accordance with Appendix H of BS3262 (1976).

Thermoplastic markings on expressways, Class AA roads and other roads as specified shall be screed or spray applied incorporating ballotini and also have a surface application of ballotini applied evenly at the rate of 400 to 500g/m².

- (ii) Thermoplastic material shall not be inset in the road surfacing unless expressly authorised by the Engineer's Representative. Where permitted the surfacing shall be cut to the depth specified by an approved milling machine.

R16 04 ROAD MARKING PAINT

1. Material: Road marking paint shall be made by an approved manufacturer. It shall be suitable for applying by brush or mechanical means to cement concrete or bituminous pavement to give a chemically stable film of uniform thickness and shall be either chlorinated rubber, one pack epoxy or alkyd based.

White paint shall contain not less than 6 per cent by weight of titanium dioxide as a pigment, conforming to type A (anatase) or type R (rutile) specified in BS1851 (1967). Yellow paint shall be the standard colour and contain not less than 6 per cent by weight of a suitable yellow pigment.

The paint shall be supplied fresh and ready for use in sealed containers and stored in accordance with the manufacturer's instructions.

2. Application: The paint shall be applied without the use of thinners or other additives.

Paint shall be applied at a covering rate recommended by the manufacturer and approved by the Engineer's Representative. Where markings are to be reflectorised with ballotini it shall be sprayed uniformly on to the wet paint film at the rate of 400 to 500g/m². Ballotini shall comply with the requirements of BS3262 (1976) Clause 15.

Road Markings

R16 05 REFLECTING ROAD STUDS

Reflecting road studs shall be "Unistuds" as made by Prismo Ltd. or similar set into the carriageway surfacing or corner cube road studs set on the road surface, of the type and at the centres shown on the Drawings and all as approved by the Engineer's Representative.

Road studs for lane lines shall be white bi-directional unistuds and for the nearside edge of carriageways red uni-directional unistuds, unless otherwise approved by the Engineer's Representative.

On expressways only road studs for the offside edge of carriageways shall be amber bi-directional corner cube road studs and across merging or diverging tapers at junctions green uni-directional unistuds, unless otherwise approved by the Engineer's Representative.

All road studs shall be set in or on the carriageway in accordance with the manufacturer's instructions. The adhesive for corner cube road studs shall be that recommended by the manufacturer which has been tested and approved by the Engineer's Representative.

R16 06 MEASUREMENT

The unit of measurement for road marking lines shall be the linear metre of each type of line as completed and accepted. In the case of broken lines, the overall length shall be measured.

The unit of measurement for hatched markings shall be the square metre and for letters, figures, arrows and symbols the number as completed and accepted.

The unit of measurement for road studs shall be the number of each type as completed and accepted.

R16 07 PAYMENT

Payment will be made in accordance with the unit prices in the Bill of Quantities for the various items in accordance with the Specification, and shall constitute full compensation for furnishing all material, equipment and labour and for performing all operations necessary to complete the work. The provision, delivery of material to the Site, handling and storage and all incidentals shall be included in the unit prices for the various items and, where authorised, the cutting of recesses by a milling machine for inset thermoplastic markings and the cutting of recesses for catseyes by an approved method.

PART II

BRIDGES

PART II

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SECTION B1

STRUCTURES GENERAL

B1-01 SCOPE

The provisions of this Section of the Specification relate to certain structural features and incidental items which are either common to all types of structures or which may apply to any one of them.

The provisions herein outlined shall apply whenever they are relevant to any structure, in addition to the detailed specifications which apply only to the particular type or kind of structure under consideration and in addition to the requirements of conformity with the lines, grades, dimensions and details shown on the Drawings.

B1 -02 MATERIALS

The materials furnished and used shall comply with the provisions of the Specification Pertaining to the various materials and Contract items which enter into and form a part of the completed structure.

B103 CONSTRUCTION REQUIREMENTS

All construction details shall be in accordance with the detailed requirements described in this Section, shown on the Drawings and with the Specification for the various Contract items involved.

1. Bridge Drains: The Contractor shall furnish and install drains in the roadway slab, of the type specified on the Drawings and in the locations shown thereon.

Bridge drains shall be made of cast steel or cast iron conforming to the requirements outlined in Section B18, or of structural steel sections conforming to the requirements of Section B10.

Grating covers shall be fitted to the individual drain casting with which they are to be used and shall be ground to rest evenly and without rocking. Each grating cover shall be fastened to the drain casting with a 6mm galvanized iron chain of a length sufficient to allow the cover to be lifted from the casting and rotated to a vertical position. One end of the chain shall be welded to the end of the casting and the other end shall be welded to the inside face of the end grating web as shown on the Drawings. To each drain casting there shall be a shop welded short piece of standard galvanized steel pipe of the size and length shown on the Drawings.

After welding, the drain castings and grating cover shall be coated inside and outside with an asphaltic based black paint. This coating shall extend over that portion of the galvanized steel adjacent to the casting far enough to cover the welds and any of the galvanizing which has been damaged by welding.

2. Inspection Chambers: The Contractor shall furnish and install inspection chambers and covers at each abutment of the type specified on the Drawings and in the locations shown thereon. Inspection chambers shall be constructed as shown on the Drawings.

No separate payment will be allowed for inspection chambers and their costs shall be included in the price tendered in the Bill of Quantities for concrete.

Structures General

3. Granular Fill to Structures: Granular fill to structures shall be as Clause R5 06-13.

4. Filling to Pipe Bays on Bridges: Unless otherwise described in the Contract, filling to pipe bays on bridges shall be well-graded granular material not exceeding 20mm size containing not more than 3 per cent material passing a 0.075mm (No. 200) sieve, laid and compacted in accordance with Clause R4 21 or as otherwise agreed by the Engineer's Representative. The material shall not contain more than 0.2 per cent of total sulphate (as SO_3) when tested in accordance with Test No. 9 of BS1377 (1975)

5. Ducts: Pipes used for service ducts shall comply with Clause R4 11. Each duct shall be fitted with a pigmented, stranded polypropylene draw rope of 540kgf breaking load, the ends of which shall be made fast as described in the Contract. Immediately after laying, the position of ducts shall be marked and the ends sealed by removable stoppers. Permanent markers shall be provided as described in the Contract.

6. Reflectors: The Contractor shall furnish and install reflectors of the size and type shown on the Drawings. Reflectors shall be set in the positions shown on the Drawings and in such manner as to be most effectively visible to approaching traffic.

Payment shall be made for reflectors under the item for such as entered in the Bill of Quantities.

7. Clearing of Site: The Contractor shall clear the site of the proposed structure of trees, bush, stumps and debris, in the manner outlined in Section R2 Clearing and Grubbing-up. Unless payment is otherwise specifically provided, the cost of such clearing shall be included in the price bid for the various items in the structure. Special clearing of the Site such as removal of existing bridges, buildings, concrete pavements, etc., will generally be paid for at prices tendered for these items, but where no such prices are provided for in the proposal, all costs in connection with this special clearing shall be included in the price tendered for the various items in the structure in the Bill of Quantities.

Removal or re-location of public or private utilities such as telephone and telegraph lines, power lines, sewer and water pipe lines, railway tracks and their appurtenances, etc., shall, in general, be in accordance with Clause R1 18 and as provided for on the Drawings or in the Special Specification of Particular Application.

8. Foundation Data: Foundation data including the locating of all boreholes, together with condensed records of the ground conditions encountered, have been obtained from soil investigation by test boring, test pits or other sources and represent the best information in the possession of the Employer as to the character of the underlying material at the locations where the tests, were actually taken. Clause 11 of the Conditions of Contract will apply to such data.

Copies of the reports by any specialist contractors who may undertake the drilling and subsequent soil and/or rock testing would be available for inspection when tendering at the offices of the Employer or the Engineer. These data, when presented, are only for the purpose of providing such information to the Contractor as may be conveyed without implication of representative character or accuracy and without any guarantee or obligation of any kind whatsoever on the part of the Employer or the Engineer, neither of whom shall be held liable for any error or inaccuracy in this information.

It is the Contractor's responsibility to ensure by additional investigations at the very beginning of the construction work that the foundation levels given in the Drawings coincide with the local requirements. The extent of this additional investigation will be given in the Special Specification of Particular Application or as directed by the Engineer's

Representative. The results of this investigation shall be precisely recorded. This record and the derived final foundation level shall be submitted to the Engineer's Representative for approval before any soil excavation may be undertaken. The Contractor shall provide for all this investigation including all necessary equipment at no additional cost to the Employer.

9. Alignment and Grades: Structures on vertical curves, structures which have superelevated roadways because of horizontal curves and those spans on which a definite finished camber is necessary in order to form a uniform grade line, all require special care and attention in regard to the elevation and alignment of their railings and kerbs.

All structural members such as prefabricated girders, cast in-situ deck slabs, cast in-situ superstructures, bridge railings including kerbs, wheel guards, safety fencing (collision rails) shall be so constructed and placed that the finished vertical alignment or grade shall be as shown on the Drawings.

Rails, sidewalks, and kerbs on the curved portion of a structure shall be constructed, in so far as possible, after the completion of the entire superstructure slabs. In such cases, the heights of rails, side walks and/or kerbs may be varied with respect to the grade line of the slabs in order to produce the desired appearance.

All costs in connection with the adjustments above mentioned shall be included in the price tendered for the various contract items involved.

10. Approach Spans to Preformed Drop-in Spans: The final deck slabs for approach spans adjacent to preformed drop-in spans of minor structures shall not be completed until the construction and erection of the beams and decking of the drop-in span is complete and adjusted in its final position, all in accordance with the approval and direction of the Engineer's Representative.

11. Erection Methods: Before moving any construction equipment to the Site the Contractor shall submit for approval an outline of the method he proposes to follow in the erection of the structure.

The method of erection finally decided upon and approved shall be adhered to in its essential details but approval by the Engineer's Representative shall not relieve the Contractor from his responsibility for the sufficiency of the method used.

12. Navigable Streams: The channels of navigable streams shall be kept clear for the safe passage of water traffic. The Contractor shall provide and maintain all necessary lights and signals in accordance with the navigation authority's requirements. All lights provided by the Contractor shall be placed or screened so as not to interfere with any navigation lights or with any traffic or signal lights of any local or other authority. The Contractor shall satisfy himself upon the reliability of all information shown on the Drawings regarding records of flood levels and seasonal stream velocities. The Contractor shall pay due regard to the hazards of river flow during periods of intense rainfall and allow for the effects on all new and temporary works, of floating or semisubmerged debris, or all other such factors referred to in the Special Specification of Particular Application. All material deposited in the channel shall be removed to the required depth and clearance lines.

13. Pollution and Debris in Streams: The Contractor shall not discharge into any river or stream any oil, solid, noxious or floating materials, and all water discharged into rivers or streams shall be reasonably free from impurities. The Contractor shall remove from the water at his own expense any debris therein arising out of the construction of the Works.

14. Architectural Features: Architectural treatment of the various parts of concrete structures requires that the concrete be of uniform texture and colour. It is therefore essential that the same type of formwork and finish, including mould oils, etc., shall be used and that the Contractor shall obtain all cement for the structure from the same manufacturing plant unless otherwise authorized in writing by the Engineer's Representative.

15. Approval of Materials: Soon after the approval of the Contract, the Contractor shall in accordance with Clause R1 05, submit to the Engineer a list or lists showing the names of the firms or manufacturers from whom he proposes to obtain the various materials.

This requirement shall apply particularly to fabricated structural steel and machinery where early information regarding the fabricator is essential in order that mill and shop inspection may be arranged.

16. Final Cleaning:

Upon completion of the structure, the Contractor shall clean up the site, remove all temporary buildings, false work, cofferdams, piling, timber, equipment and debris.

He shall level off and rake all excavated material not used for backfill, level and rake around all piers, bents, abutments, and on side slopes. The decks of the structures shall be swept and washed clean.

The whole of the site and structure shall be left in a clean and workmanlike condition. No specific payment for cleaning up shall be made but the cost shall be included in the prices shown in the Bill of Quantities.

BI 04 TEST LOADING OF STRUCTURES

1. Scope: Upon completion of any major bridge structure, or the completion of certain minor structures as may be selected by the Engineer, and before granting the Certificate of Completion, the Contractor shall apply test loading to the structure and/or structures and/or any part thereof as ordered by the Engineer, and shall satisfy the Engineer as to the sufficiency of the structure and/or structures to carry the design loading by measuring strains and deflections in accordance with arrangements to be approved by and to the full satisfaction of the Engineer.

2. Procedure: The test loading shall be provided by:—

- (a) Applying previously measured wheel loads at pre-determined points of application; or,
- (b) Loading the structure, as directed, with sand and gravel, bagged cement or other materials of known density; or,
- (c) A combination of (a) and (b) above.

The Contractor shall supply for the complete duration of the test and/or tests, all mechanical or other strain gauges of approved types, accurate dial gauges measuring to 1/100mm, and all other special testing instruments as may be required for the test and listed specifically in the Special Specification of Particular Application, together with all necessary fixing devices, temporary staging, scaffolding, labor and assistance required for the attachment of instruments to the structure and for recording the measurements under load.

The Contractor shall submit the Test Loading Proposal according to international acceptable Standards (adequate stoical calculation including deflections and strains) and the Engineer will approve the method of application and increments of loading and the position at which strains or deflections are to be measured. The Engineer will make an analysis of the Test Loading Results worked out by the Contractor during and after the test.

3. Remedying Defects: Should the Engineer notify the Contractor after interpretation of test results that, as a result of the test, any member of a structure or any part of the structure appears inadequate due to any reason whatsoever other than from a design consideration, then the Contractor shall, at his own expense, rectify all defects and inadequacy by demolishing and rebuilding, or by strengthening the structure member, or part thereof in an approved manner, all to the entire satisfaction of the Engineer.

B1 05 MEASUREMENT

Measurement of the several items forming part of the completed structures shall be in accordance with the Specifications for the various items.

B1 06 PAYMENT

Payment will be made in accordance with the prices in the Bill of Quantities for the various items, in accordance with the Specification and shall constitute full compensation for furnishing all equipment, materials and labour, and for performing all operations necessary to complete the work.

Where Daywork rates cannot be applied to the provision, placing, moving and removal of the test load, or for the provision of labour, assistance and materials required for temporary staging or scaffolding in connection with the test loading, then payment shall be made at agreed rates out of the Provisional Sum allowed for "Load Testing of Structures" in the Bill of Quantities. Depreciation on special testing instruments, such as strain gauges and dial gauges, (but excluding normal surveying instruments and like) shall be allowed out of the said Provisional Sum at the rate of 10 per cent of the original purchase price per complete test of a structure, together with any freight charges or import duties levied thereon. The Contractor shall supply authenticated documentary evidence in support of the reimbursement of such amounts and expenses.

SECTION B2

CONCRETE STRUCTURES GENERAL

B2 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour in performing all operations in connection with all concrete structures (except concrete pipes) including box culverts, retaining walls, concrete sub-structures, composite structures of concrete and steel, or concrete and timber. Such structures shall be as indicated on the Drawings and in conformity with the lines, grades, dimensions and details there shown. They shall also be in accordance with the provisions of the Specification pertaining to the various materials and Contract Items which enter into and form a part of the complete structure and with the directions of the Engineer's Representative.

B2 02 MATERIALS

The materials furnished and used shall be those prescribed for concrete in Section B8, and other Sections for the various items which are to constitute the complete structure. The classes of concrete shall be as shown on the Drawings, and/or as prescribed in the Bill of Quantities.

B2 03 CONSTRUCTION REQUIREMENTS

1. All construction details shall be in accordance with the requirements prescribed in Section B8, and all formwork and surface finish for structures as prescribed in Section B6.

2. Waterproofing for structures shall be in accordance with Section B11.

3. **Bridge Bearings and Movement joints:** All bridge bearings shall be in accordance with Section B13 and Bridge Movement Joints in accordance with Section B15.

4. **Bridge Railing:** Bridge Railing including metal parapets, hand railings and safety fencing, guard or collision rails shall be in accordance with Section B14.

5. **Excavation and Backfill:** Backfilling around and over concrete structures and behind retaining walls shall not be done until the concrete has set at least 21 days.

6. **Drainage of Structures:** The filling material to back of abutments, retaining walls and wing walls shall be thoroughly and effectively drained by means of tiling, trench or rock drains, and weep holes or other adequate construction all to the details and dimensions as noted on the Drawings. All material to the back of the abutments or wall shall be graded filter material as specified in Clause R5 06-13 and to the dimensions shown on the Drawings.

7. **Opening to Traffic:** Bridges having decks made with Portland Cement Concrete shall remain closed to all traffic subject to the results of tests made of the concrete for not less than 21 days after placing of concrete. If Rapid Hardening Cement Concrete is specified, the opening time shall depend on the results of tests made of the concrete, but in no case shall the time before opening to traffic be less than seven days after the concrete is placed.

The above time of opening to traffic is applicable when the temperature is above 10°C. When the temperature is below 10°C, the time of opening to traffic shall be increased at the discretion of the Engineer's Representative.

Concrete Structures General

Bridges with concrete decks shall not be opened to traffic without the approval of the Engineer's Representative.

B2 04 MEASUREMENT

Measurement of the various items involved in the construction of "Concrete Structures" shall be made in accordance with the specifications for the several items involved.

B2 05 PAYMENT

Payment for the various items involved in the construction of "Concrete Structures", will be made in accordance with the Specification, at the price tendered in the Bill of Quantities for the several items involved. Any item not included in the Bill of Quantities which is shown on the Drawings or called for by the Specification shall be understood to be included in the rates quoted for other items.

Payment shall include the furnishing of all materials, labour, equipment and all items required to complete the work. The construction of weep holes and drains and the back-filling with coarse gravel or rock as specified above, shall be included in the price tendered in the Bill of Quantities per cubic metre for concrete in place.

SECTION B3

STEEL STRUCTURES GENERAL

B3 01 SCOPE

This Section of the Specification shall apply to all steel structures, including composite structures of steel and other materials, and all structures in which fabricated metal, except steel reinforcing bars, is used.

B3 02 MATERIALS

The materials furnished and used shall be those prescribed in Section B10, and other Sections of the Specification for other items involved.

B3 03 CONSTRUCTION REQUIREMENTS

All construction details shall be in accordance with the requirements prescribed in this Section, Section B 10, and other Sections of this Specification for the various items involved.

1. **Method of Erection and Equipment:** Before starting work the Contractor shall obtain the approval of the Engineer as to the method of erection he proposes to adopt, to the addition of any temporary or permanent stiffeners or other material required on the structures and the amount and character of the equipment he proposes to use. Approval shall not relieve the Contractor from the responsibility of carrying out the work in accordance with the Drawings and Specification.

2. **Storage in Field:** All material shall be stored in such manner as to prevent deterioration by loss or rust of minor parts. No material shall be piled so as to rest upon the ground or in water but must be placed on suitable skids or platforms.

3. **Falsework:** All falsework shall conform to the specifications for falsework as specified under Section B6.

4. **Handling Members:** The field assembling of the component parts of a structure shall involve the use of methods and appliances not likely to produce damage by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until its defects are corrected, and members seriously damaged in handling shall be rejected.

5. **Alignment and Camber:** Before completing permanent connections by welding, bolting or riveting at Site, the structure shall be adjusted to correct grade and alignment and the elevations of panel points properly regulated. For truss spans a slight excess camber will be permitted while the bottom chords are being connected, but the correct camber and relative elevations of panel points shall be secured before connecting the top chord joints, top lateral system and sway bracing.

No permanent bolting or riveting shall be done at compression joints until the blocking has been adjusted so that there will be full and even bearing over the entire joints.

6. **Straightening Bent Material:** The straightening of bent edges of plates, angles and other shapes shall be done by methods designed to avoid damage to the material. The metal shall not be heated unless permitted by the Engineer's Representative in which case the heating shall not be to a higher temperature than that producing a dark cherry red colour.

After heating, the metal shall be cooled as slowly as possible. No quenching will be allowed. Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of incipient fractures or other damage.

7. Assembling and Riveting or Friction Grip Bolting: All field connections and splices shall be securely drift pinned and black bolted before riveting or friction grip bolting. Important connections in trusses, girders, floor system, etc., shall have at least 50 per cent of the holes filled. A sufficient number of drift pins shall be used to locate accurately the parts and prevent slipping at joints and splices. Structures erected by the cantilever method shall be field black bolted and pinned to 75 per cent full strength unless otherwise permitted by the Engineer's Representative.

The results obtained in the field assembling and riveting or friction grip bolting of the members of a structure shall conform to the requirements for shop assembling and riveting or friction grip bolting. Field driven rivets shall be inspected and accepted before being painted.

Field riveting or friction grip bolting shall be done before the falsework is removed, unless special permission to the contrary is given by the Engineer's Representative.

Friction grip bolting shall be in accordance with the Special Specification of Particular Application.

Railings may be erected but shall not be adjusted until after the falsework has been released and the deck placed.

8. Pinned Connections: The pins shall be inserted into the pin holes so that the members bear fully and evenly upon them. Retaining nuts shall be fully tightened and when required by the Engineer's Representative shall be locked in place by an approved method. All pins shall have sufficient thread to allow the nuts to be tightened and locked.

9. Setting Anchor Bolts: Anchor bolts shall be set in the concrete in accordance with requirements specified under Section B2. Anchor bolts shall be grouted in after the bearings have been set and the span is completely erected to line and camber.

10. Placing Superstructures: No superstructure load shall be placed upon finished piers or abutments until the Engineer's Representative directs. In general, a minimum time of 21 days shall be allowed for hardening of concrete before the superstructure load is placed thereon.

11. Setting Bridge Bearings: All bridge bearing shall be installed as specified in Section B13.

12. Killing and Draining Pockets: Pockets in trusses or other members in which water or debris can be retained shall be avoided as far as possible. Where such pockets are unavoidable, they shall be provided with sufficient drain holes to drain all water from the pockets. All such pockets shall be painted with one coat of bitumen of 85-100 penetration applied hot and the pockets then filled with asphalt of approved proportions and materials. Where drain holes have been provided, they shall be plugged before the asphalt is placed. The top of the asphalt shall be well rounded so that water will drain away from the bearings.

All costs in connection with filling pockets and providing drain holes shall be included in the price tendered in the Bill of Quantities for Structural Steel or Cast Steel.

13. Painting: All structural steel and all other metal parts except steel surfaces embedded

in concrete, unless otherwise provided, shall be painted in accordance with the require-

ments outlined in Section B12, except that the paint shall be applied to 1cm inside the steel/steel or steel/concrete interfaces.

Steelwork of all roadway expansion joints shall receive full protective treatment and painting shall be completed a sufficient time in advance of opening to traffic to allow the paint to become thoroughly dry. The types and colours of paints shall be as shown on the Drawings, specified in Section B12 or in the Special Specification of Particular Application.

The tops of all non-composite floor beams over which a slab joint occurs shall be coated on the top and edges of the flange with a heavy top coat of bitumen of 85-100 penetration applied hot and a protective covering of 3-ply, bitumen saturated roofing felt. This coating shall be applied over the shop paint and will take the place of the field coats of paint specified for other parts of the structural steel. The required shop coat of paint shall be applied to the structural steel at the fabricating plant before delivery to the job site.

The surfaces of all bearings shall be treated in accordance with Section B 13.

B3 04 MAINTENANCE AND INSPECTION CRADLES

Major steel bridge structures on navigable waterways, on high piers or across deep ravines, etc. may require special provision for routine inspection to enable regular maintenance including painting.

The Special Specification for Particular Application, will include, when required, details of such provision which shall be in accordance with the following general requirements.

Maintenance and inspection cradles shall be provided to give permanent access to all parts of the steel structure. Each cradle shall be capable of carrying three men and shall be traversed manually. Cradles outside the trusses, box or fabricated girders shall be supported on rubber wheels running on the handrail or on the edge of the bridge deck, unless special rails are provided. Cradles between the trusses and boxes or girders shall be supported on suspended beams. They shall be capable of being lowered to ground level at the abutments. Where necessary an access bridge shall be provided to span between the cradles to give access for maintenance and inspection of box girder soffits.

B3 05 MEASUREMENT

Measurement of the various items entering into the construction of "Steel Structures General" shall be made in accordance with the Specification for the several items involved.

B3 06 PAYMENT

Payment for the various items entering into the construction of "Steel Structures General" will be made in accordance with this Specification, at the prices tendered in the Bill of Quantities for the several items involved.

Payment shall include the furnishing of all materials, labour, equipment and all items required to complete the work.

The cost of providing locking plates required for rocker or roller bearings during transport or erection shall be included in the price tendered for bearings and shall not be paid for separately.

SECTION B4

PILING FOR STRUCTURES

B4 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all materials, plant, equipment and labour and in performing all operations in connection with the execution of piles, including test piles complete, subject to the Conditions of Contract and in strict accordance with this Section of the Specification, the applicable Drawings and the Special Specification for Particular Application.

B4 02 GENERAL

1. Piling shall conform in all respects with the principles contained in BS Code of Practice CP 2004 (1972) Foundations.

2. In addition to submitting the records required under Clause B4 07, the Contractor shall report immediately to the Engineer's Representative any circumstance which indicates that the ground conditions differ from those expected by the Contractor from his interpretation of the soil survey so as to affect materially the bearing capacity of the pile.

3. Where piles have not been positioned within the limits described in the Contract, no method of forcible correction will be permitted.

4. **Order List:** All piles which are intended to remain in place in the completed structure shall be furnished by the Contractor in accordance with an itemised list, which will be supplied by the Engineer. This list will show the number and length of piles required and will be based on information secured from the driving of test piles or other data available to the Employer. The lengths shown on this list shall be the lengths required below cut-off and the Contractor shall, at his own expense, increase the lengths the necessary amount to provide for stripping of reinforcing steel, fresh heading and to reach from the cut-off level up to the position of his driving equipment.

5. **Piling Ordered and Not Driven:** Piling furnished in accordance with the Engineer's itemised list, but not incorporated in the finished works, shall be immediately delivered to the Employer and shall become his property. The furnishing of additional piles or piles of a greater length than those shown on the Engineer's list shall be at the Contractor's risk.

6. **Piles Destroyed in Handling or Driving:** Any pile which is damaged or destroyed before or at the time it is being driven shall be replaced by the Contractor at his own expense.

7. **Preparation for Driving:** Foundation pits, including the construction of cofferdams or cribs where required, shall be excavated in accordance with Section R5 before the driving of foundation piles is begun unless otherwise approved by the Engineer's Representative. Allowance for upheaval of the pit bottom, due to driving the piles, shall be made, the amount of allowance depending upon the character of the material through which the piles are to be driven. Any material forced up between the piles to above the level shown for the bottom of the foundation pit shall be removed to the correct level before the foundation concrete is placed. If too great an allowance is made for upheaval due to driving of piles, backfilling with gravel will normally be permitted to raise the pit bottom to the correct level.

8. Elevation of Cut-off: The tops of all piles shall be sawn, cut or stripped to a true plane as shown on the Drawings and at the level fixed by the Engineer. Piles which support timber caps or grillages shall be sawn to the exact plane of the superimposed structure and shall fit it exactly. Broken, split or misplaced piles shall be withdrawn and properly replaced entirely at the Contractor's expense.

9. Piles Driven Below Cut-off: Piles driven below the cut-off- level without the Engineer's authority shall be withdrawn and replaced by new and, if necessary, longer piles or shall be extended as directed by the Engineer's Representative all at the expense of the Contractor.

10. Equipment for Driving:

(i) **Hammers:** Timber piles shall be driven with drop hammers, diesel, steam or air driven hammers, or a combination of water jets and hammer. Underwater hammers may be used subject to approval of the Engineer. Drop hammers shall weigh not less than 1350kg for piles less than 15m long and not less than 1800kg for piles over 15m long. If a drop hammer is used for driving timber piles, it is preferable to use a heavy hammer and operate with a short drop. The maximum height of drop shall be 3m. Steam or air driven hammers for timber piles shall develop not less than 1 100kg of energy per blow.

Precast concrete piles, metal shells for cast-in-place concrete piles and steel piles, shall be driven with approved diesel, steam or air hammers developing not less than 1 100kgfm of energy per blow or by a drop hammer of weight and type approved by the Engineer's Representative.

The Contractor shall furnish the Engineer's Representative with the manufacturer's specifications and catalogue for all diesel, steam or air hammers used, showing all the data necessary for computing the bearing value of piles driven.

Gravity or drop hammers shall be weighed in the presence of the Engineer's Representative, or a certificate of weight shall be furnished to the Engineer's Representative. Hammers so weighed shall have the exact weight stamped on them.

(ii) **Leads:** Fixed lead pile drivers shall be used when driving all bearing piles.

The use of hanging or swinging leads will not be allowed unless they are so constructed that they can be held in a fixed position during the driving operations. Leads shall be sufficient length so that the use of a follower or dolly will not be necessary. Leads adapted to the driving of batter or raking piles shall be employed for trestle construction or for foundation work involving inclined piles.

(iii) **Water Jets:** Water jets shall not be used unless, in the opinion of the Engineer's Representative, such use is necessary or desirable. When water jets are used, the number of jets and the volume and pressure of the water at the jet nozzles shall be sufficient to erode freely the material adjacent to the pile. The plant shall have sufficient capacity to deliver at all times at least 630 liters per minute through a 2cm jet nozzle. Before the desired penetration is reached and at a level determined by the Engineer's Representative the jetting shall be stopped and the piles driven with the hammer to secure the final penetration and bearing value. Piles previously driven that become loosened due to the use of the water jets shall be re driven in place or pulled and a new pile driven. A careful check shall be made during driving of piles to determine if the piles are becoming loosened, by attempting to re drive at least one pile in every five. No allowance will be made for cost to the Contractor for re driving of loosened piles due to the use of water jets.

All costs resulting from the use of water jets shall be included in the price tendered in the Bill of Quantities for driving piles and no additional compensation will be allowed, unless specific provision is made in the Bill of Quantities.

11. Test Piles: When specified on the Drawings or ordered by the Engineer's Representative, the Contractor shall drive test piles to determine the lengths of piling required to obtain the necessary load carrying capacity or penetration. These piles shall be driven at the locations designated by the Engineer's Representative and shall be of sufficient length to provide for any variation in soil conditions. Test piles shall be of the same material as the permanent piles which are to be driven. Steel shells or casings used as test piles for cast-in-place concrete piles and precast concrete and steel test piles shall have the same cross-section and other characteristics as the permanent piles. Driving equipment used to drive test piles shall be the same as that to be used for driving the permanent piles.

12. Loading Tests: When specified or required by the Engineer, the size and number of piles shall be determined by actual loading tests. These tests shall consist of the application of test loads, together with suitable apparatus for accurately determining the superimposed weight and the settlement of the pile under each increment of load. The minimum test load shall be at least twice the design load or as indicated on the Drawings and shall be applied and removed in increments as determined by the Engineer. Final settlement after each increment shall be recorded. The minimum time between load increments and settlements readings shall be not less than three hours or longer at the discretion of the Engineer. Pile tests shall be carried out in accordance with British Code of Practice CP 2004 – Foundations.

In the absence of loading tests the safe bearing value of bearing piles shall be determined by a substantiated adequate pile driving formula specified by the Engineer.

B4 03 PRECAST CONCRETE PILES

1. General: The manufacture, storage, handling and lengthening of reinforced concrete and prestressed concrete piles shall comply in all respects with Sections B6, B7, B8 and B9 and:

- (i) Piles shall be supported, handled and pitched, as described in the Contract.
- (ii) Each pile shall be marked indelibly to show its identification number, length and date of casting. Prestressed concrete piles shall be marked with the prestressing force applied.

2. Materials: The concrete, cement, fine and coarse aggregate, water and additives and mixing, transporting, placing and curing shall conform to Section B8. Concrete Group A shall be used unless shown otherwise on the Drawings.

The reinforcing steel shall conform to Section B7.

3. Forms: Forms for precast concrete piles shall conform to the general requirements for concrete formwork, as provided under Section B6. Forms shall be accessible for tamping and consolidation of the concrete.

4. Reinforcement: Reinforcing bars, hoops, shoes, etc., shall be placed as shown on the Drawings. All parts shall be well wired and tied together and placed to the spacings shown. All reinforcement shall be in place in the forms before any concrete is placed.

5. Casting: Piling shall be cast in a horizontal position, in approved forms supported on a suitable platform. Special care shall be exercised to vibrate and tamp the concrete

Around the reinforcement to secure complete compaction. The use of internal vibrating tampers will be required when placing concrete in forms. Concrete shall be placed continuously in each pile, special care being exercised to avoid horizontal or diagonal cleavage planes, and to see that the reinforcement is properly embedded in the concrete. Lifting holes shall be formed during casting in the position and in accordance with the details shown on the Drawings. Other holes shall be formed in the position approved by the Engineer.

6. Finishing: Trestle piling exposed to view shall be finished above the ground line in accordance with the provisions governing the finishing of concrete columns. Foundation piling, that portion of trestle piling which will be below the ground or low water surface, and piles for use in salt water or alkali soils shall not be finished.

7. Curing: Precast concrete piling may be cured either with water or with steam. If cured with water the concrete shall be kept continuously wet for a period of not less than 10 days after casting. Under weather conditions favorable for curing, side forms may be removed at any time not less than 24 hours subsequent to placing concrete, but the entire pile shall remain supported for at least 10 days and shall not be subjected to any handling stress until the concrete has set for at least 14 days. In cold weather a longer period may be required before handling is allowed. The additional time will be determined by the Engineer's Representative.

If the piling is to be cured with steam, the casting bed shall be completely enclosed by a canvas supported on framework or by some other type of housing, tightly constructed so as to prevent the ready escape of steam and exclude the outside air. After the concrete has been allowed to take its initial set, from two to three hours after pouring, steam may be applied over a period of at least 36 hours. During this period the steam may be applied intermittently, but must be applied for a total of at least 24 hours and must not be turned off at any one time for more than 8 hours. The temperature within the enclosure shall be between 52° C and 65 °C during the time the steam is being applied and shall not be allowed to drop below 27 °C while the steam is turned off.

Piling cured with steam shall not be removed from the forms for at least 48 hours after the concrete has been poured. Test cubes shall be cast for each 10 No piles that are cast or per day whichever is the greater. If the piles are to be steam cured, the cubes shall be cured with the piles and if the cubes do not develop the same strength for concrete of the class used in the piling when tested at 28 days, the required curing time will be extended until the specified strength is reached.

8. Storage and Handling: The method of storing and handling shall be such as to eliminate the danger of fracture, by impact or undue bending stresses, in curing or transporting the piles from the forms and into the leads. When piles have to be stored they shall be placed on sufficient supports on firm ground to avoid damage. In general, concrete piles shall be lifted by means of a suitable bridle or sling attached to the pile at points over 6m apart and not more than 3m from the ends of the pile. In no case shall the method of handling be such as to induce stresses in the reinforcement in excess of 800kgf/cm²,

allowing 100 per cent of the calculated load for impact and shock effects. In handling piles for use in sea water or alkali soils special care shall be exercised to avoid injury to the surface of the pile.

9. Age Before Driving: Precast concrete piles cured with water shall not be driven for at least 21 days after casting. In cold weather a longer period may be required in order for the concrete to attain the necessary strength and toughness.

Precast concrete piles, cured with steam, shall not be driven for at least 72 hours after being cast subject to satisfactory strength of the test cubes.

10. Protection of Head: The heads of all precast concrete piles shall be protected during driving by caps of approved design, preferably having a rope or other suitable cushion next to the pile head and fitting into a casting, which in turn supports a timber shock block.

The size of the inside of the cap shall be determined before the pile is cast and the head of the pile shall be formed to make a loose fit inside the cap.

11. Driving: Piles shall not be driven until they have complied with sub-clause 9 of this Clause.

The Engineer's Representative shall be notified 24 hours before the commencement of driving. Piles shall be driven to the set or depth and in the sequence of driving approved by the Engineer's Representative. The set shall be taken in the presence of the Engineer or his Representative unless permission to the contrary has been obtained in writing.

12. Lengthening of Piles:

- (a) **Reinforced Concrete Piles:** The main reinforcement shall be exposed for a distance of 40 diameters with the final cut perpendicular to the axis of the pile. Main reinforcement of the same size and grade as the original pile shall be securely tied in position. Alternatively, subject to the approval of the Engineer's Representative, the main reinforcement may be exposed for a minimum distance of 30cms and the additional main reinforcement welded in place with full strength butt welds.

The stirrups shall conform in size, grade and spacing as used in the original pile.

The formwork shall be grout tight. The concrete shall be the same quality as used in the original pile except that Rapid Hardening Portland Cement may be used when permitted by the Engineer's Representative. Just prior to placing concrete the top of the pile shall be thoroughly wetted with neat cement grout.

- (b) **Pre stressed Concrete Piles:** Pre stressed concrete piles may be lengthened by means of a suitable steel sleeve as shown on the Drawings or approved by the Engineer's Representative.

13. Driving shall not be resumed until:

- (i) The cube strength of the concrete in the extension is at least equal to the specified 28 day cube strength of the concrete in the pile, and
- (ii) the approval of the Engineer's Representative has been obtained.

14. Removal of Surplus Length: Any length of pile surplus to that required for incorporation in the substructure shall be cut off and removed.

15. Risen Piles: Piles which have risen as a result of driving adjacent piles shall be re driven to the requirements of the Engineer's Representative.

16. Shoes: Shoes bases shall consist of "Chill-hardened" cast iron of clean, grey tough metal, free from sand, honeycombing or porous places, air holes or other defects. Straps shall be of 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.

B4 04 CAST-IN-PLACE PILES

1. Cast-in-place piles shall be formed to the dimensions and depth shown on the Drawings or as directed by the Engineer's Representative. A complete record of the construction of each pile shall be kept by the Contractor and this record shall be submitted to the Engineer's Representative for inspection as and when required.

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2. The Contractor shall supply the complete details of the system of cast-in-place piling which he proposes to use, including a specification of the materials and method of construction of the piles. Prior approval of the Engineer shall be obtained in writing before any such piling is used. The Contractor shall arrange for his representative in charge of operations on the Site to be given written instructions including, as applicable, the method of boring, under-reaming or driving, length or set to be obtained, method of inspection, details of the concrete mix, the minimum time between the completion of one pile and the commencement of the next and the pattern of construction. A copy of these instructions shall be supplied to the Engineer's Representative and no piling may begin until his approval has been given.

3. **Materials:** The concrete, cement, fine and coarse aggregate, water and additives and mixing, transporting, placing and curing shall conform to Section B8. Concrete Group A shall be used unless shown otherwise on the Drawings.

The reinforcing steel shall conform to Section B7.

If permanent metal shells or casings are used they shall conform to the requirements of ASTM A252-77a Grade II or BS4360 (1972).

4. **Inspection:** Where practicable and unless otherwise agreed by the Engineer's Representative, all pile excavations or casings shall be inspected for their full length before concreting. The Contractor shall provide all the apparatus necessary for the inspection.

5. **Reinforcement:** Reinforcement shall be maintained in its correct position during the concreting of the pile. Where it is made up into cages, they shall be sufficiently rigid to enable them to be handled without damage.

6. **Concreting:** Immediately after the excavation has been completed, the Engineer's Representative's approval to the commencement of concreting shall be sought and, when this has been obtained, concreting shall start forthwith and continue without interruption. All concrete for cast-in-place piles shall be compacted to produce a dense homogeneous mass by a method agreed by the Engineer's Representative. In a pile excavation which contains water the concrete shall be placed by means of a tremie tube.

7. The top of the pile shall be brought above the required finished level and any defective concrete removed to ensure satisfactory bonding of the pile head to the structure.

8. **Withdrawal of Casings and Linings:** When casings and linings are withdrawn as concreting proceeds, a sufficient head of concrete shall be maintained to prevent the entry of ground water or reduction of cross-section of the pile excavation.

9. **Driven Cast-in-Place Piles:** Formers or shells for cast-in-place piles shall be driven in true alignment at the locations shown on the Drawings or as directed by the Engineer's Representative and shall be vertical or raked as indicated on the Drawings. The top of any shell shall be protected with a combination driving head and pilot of proper size to ensure a properly distributed blow and to prevent damage to the shell during driving. Care shall be taken when extracting formers or non-permanent shells that no disturbance nor damage is caused to the concrete or reinforcing already placed.

10. When piles are formed within a tube which is subsequently withdrawn, the sequence of driving shall be such as to avoid damage to any unfilled pile excavation or completed pile. Precast concrete sections or steel tubes in which concrete is to be placed shall be free from damage before being installed.

11. If permanent metal shells or casings are used in cast-in-place piles they shall conform to the requirements of BS4360 (1972).
12. **Inspection:** The Contractor shall provide a suitable light on the site of the work at all times for the inspection of each permanent shell or casing. Any shell which is cracked, kinked, bent or otherwise deformed to an extent which, in the opinion of the Engineer's Representative, will impair the strength or efficiency of the completed pile shall be pulled and replaced.
13. **Bored Cast-in-Place Piles:** When required by the Engineer's Representative, the Contractor shall take from the pile excavation undisturbed soil samples in accordance with BS 5930 Code of Practice for Site Investigations. Such samples shall be tested in an approved laboratory.
14. Excavations shall not be exposed to the atmosphere longer than is necessary and shall be adequately covered at all times when work is not in progress. The Contractor shall take all the precautions necessary to prevent the ingress of surface water or foreign matter. Lining tubes shall be provided for sufficient depth to ensure the stability of the pile excavation during boring and concreting operations.
15. **Large Diameter Cast-in-Place Piles:** Bored cast-in-place piles exceeding 60cm diameter, are commonly known as large diameter bored piles and shall comply in all respects with the BS Code of Practice CP 2004 (1972). See Section B5 giving additional construction specification for large diameter bored piles which may vary to suit a particular location and are therefore subject to the Special Specification for Particular Application.
16. **Placing Concrete:** In the construction of cast-in-place piles, care shall be taken to ensure that the concrete is thoroughly compacted and that a minimum cover of 5cm to the main reinforcing bars is maintained throughout. Concrete shall be placed continuously in each pile and all debris and water shall be removed from the permanent shell before concrete is placed. Unless otherwise directed by the Engineer's Representative, concrete shall not be placed until all percussion pile driving within a radius of 4.5m has been completed or until all shells in any one bent have been driven.
17. **Testing:** Where cast-in-place piles have been guaranteed by the Contractor to carry a certain load, the Engineer's Representative may direct that a test load be applied to certain selected piles. Details of the test to be applied will be supplied by the Engineer's Representative. During the progress of the works and where piles fail to satisfy this test, the Engineer's Representative may direct that additional piles are to be formed and no extra payment will be made for the additional piles nor for testing. If the piles prove satisfactory, payment for carrying out the actual test will be made under daywork or as specified in the Special Specification of Particular Application.

B4 05 STEEL PILES

1. **Protection, Storage and Handling:** The protection, storage, handling and lengthening of steel piles shall comply with the following:
 - (i) Piles shall be supported, handled and pitched as described in the Contract and in such a way as to avoid damage and, where piles have to be stored, they shall be placed on sufficient supports on firm ground to avoid damage by excessive bending.
 - (ii) Bent or kinked piles which, in the opinion of the Engineer's Representative, cannot be straightened without damage to the metal will be rejected.

Piling for Structures

- (iii) Each pile shall be marked indelibly to show its identification number, grade of steel and length.
- (iv) Before despatch from the Manufacturer's Works, the piles shall be protected in accordance with the method described in Clause B12 12.

2. **Materials:** Steel piles shall be of the section shown on the Drawings and shall be structural steel meeting the requirements of ASTM A36-77a or BS4360 (1972).

The Contractor will be required to furnish the Engineer with two certified copies of the records of ladle analysis and physical test, as reported by the manufacturer, to meet the requirements of ASTM A6-77b or BS4360 (1972).

3. Steel for H piles and fabricated sections shall comply with that for structural steel and comply with the requirements of BS153 Part I (1972) and BS4360 (1972). In addition, structural steel hot-rolled sections and structural steel hot-rolled hollow sections shall comply with the requirements of BS4 Part 1 (1972) or Part 2 (1969).

4. **Driving:** The Engineer's Representative shall be notified 24 hours before the commencement of driving. Piles shall be driven to the set or depth and in the sequence of driving approved by the Engineer. The set shall be taken in the presence of the Engineer or his Representative unless permission to the contrary has been obtained in writing.

5. Steel piles shall have square-cut ends and the heads shall be protected during driving by a metal cap made to fit the head of the pile.

Steel piles shall be driven in true alignment at the locations shown on the Drawings and shall be plumb or battered as indicated thereon.

6. **Splicing:** Splicing of steel piles will, in general, be permitted subject to the approval of the Engineer's Representative as to the necessity for splicing and the manner in which the splice is to be made.

7. **Lengthening of Piles:** Full penetration butt welds shall be used for all pile lengthening. Sections to be joined shall be maintained in true alignment and position. After welding, the affected area shall be thoroughly cleaned and protected in the same way as adjacent surfaces.

8. **Capping:** When specified on the Drawings, steel piles shall be capped with a steel plate, after being cut off at the required level. In such case the pile top shall be cut square and as smooth as practicable. The pile cap shall consist of a steel plate of the size and shape shown on the Drawings. The method of attachment of the pile cap shall be by electric welding in the amount and in the manner shown on the Drawings.

9. **Determination of Bearing Values:** The bearing values of steel piles shall be determined by means of the loading tests specified in Clause B4 02-12 when directed by the Engineer.

10. **Surplus Length of Piles:** Any length of pile surplus to that required for incorporation in the substructure shall be cut off and removed.

11. **Risen Piles:** Piles which have risen as a result of driving adjacent piles shall be redriven to the requirements of the Engineer's Representative.

B4 06 SHEET PILING

1. **Scope:** The provisions of this Clause cover only sheet piling shown on the Drawings, or ordered by the Engineer, to be left in place so that it becomes a part of the finished work.

2. Materials:

- (i) **Timber Sheet Piles:** The timber, unless otherwise noted on the Drawings, may consist of any species which will satisfactorily stand driving.
- (ii) **Concrete Sheet Piles:** Concrete used in all concrete sheet piling shall be in accordance with Clause B403.
- (iii) **Steel Sheet Piles:** Steel sheet piling shall consist of structural steel shapes of the section shown on the Drawings or as otherwise specified. The steel shall conform to the Specifications for Steel in Bridges, ASTM A36-77a or BS4360 (1972).

3. Construction Requirements

- (i) **Timber Sheet Piles:** Timber sheet piling shall be sawn or hewn with square corners and shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, or other defects which might impair its strength or tightness.

The piles shall be of the dimensions shown on the Drawings either cut from the solid material or made by building up the piles from three planks securely fastened together.

The piles shall be drift sharpened at their lower ends so as to wedge the adjacent piles tightly together.

The tops of the piles shall be cut off to a straight line at the level indicated and shall be braced with waling strips, properly lapped and joined at all splices and corners.

The Wales shall preferably be in one length between corners and shall be bolted near the tops of the piles.
- (ii) **Concrete Sheet Piles:** Concrete sheet piling shall conform to the dimensions and details shown on the Drawings. Manufacture and installation of concrete sheet piling shall conform, in general, to the requirements governing precast concrete piles in Section B4.
- (iii) **Steel Sheet Piles:** Steel sheet piling, when in place in the completed structure, shall be watertight at the joints. Painting of steel sheet piling shall conform to the requirements of Section B12.

B4 07 PILE RECORDS

1. A record of all piles driven or installed shall be kept by the Contractor and a copy of the record of the work done each day shall be given to the Engineer's Representative within 24 hours. The piling records shall be in the form shown on record Forms B407 A or B407B.
2. On completion of the piling, the Contractor shall deliver to the Engineer's Representative a drawing recording the final depths of all piles relative to the Government Trigonometric Survey Datum (G.T.S.) or the agreed site datum.

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B4 08 PILE LOAD TESTING

Loading tests on piles will be carried out where specified in accordance with Section 7.5 (Bearing Capacity and Test Loading) of BS Code of Practice CP 2004 (1972).

B4 09 MEASUREMENT AND PAYMENT

Payment will be made for each of the following items as are included and shown in the prices tendered in the Bill of Quantities.

1. Provision of pile driving equipment will be measured on the lump sum basis.
2. Provision of precast concrete piling will be measured per linear metre for each size of pile.
3. Provision of cast-in-place concrete piling will be measured per linear metre from the toe of the pile to cut off level.
4. Provision of proprietary cast-in-place concrete piling will be measured per pile to the minimum penetration and load bearing capacity stated in the Bill of Quantities.
5. Provision of steel piling will be measured per metric tonne.
6. Driving precast concrete piling in place will be measured per linear metre from the toe of the pile to cut off level.
7. Driving casings for cast-in-place concrete piling in place will be measured per linear metre from the toe of the casing to cut off level.
8. Driving steel piling in place will be measured per linear metre.
9. Pile splices (steel) will be measured per number.
10. Pile load testing will be paid for as a lump sum per number of piles in accordance with the respective items of the Bill of Quantities, which payment shall constitute full compensation for all equipment, materials, labour and all incidentals for carrying out pile load testing, as specified under Clause B408.
11. The cost of stripping pile reinforcement and disposal of heads shall be deemed to be included in the Bill of Quantities.
12. Payment for timber and reinforced concrete sheet piling shall include the cost of furnishing, driving and cutting off. Payment will be made on the basis of the price tendered per cubic metre of piles driven as approved by the Engineer, except that a deduction from the payment will be made in the amount tendered per cubic metre for the salvage value of the material cut off after driving if any.
13. Payment for steel sheet piling shall include the cost of furnishing, driving and cutting off. Payment will be made on the basis of the price tendered per metric tonne of the piles driven as approved by the Engineer except that a deduction will be made in the amount tendered per metric tonne for the salvage value of the material cut off.

Form B4 07 A

DAILY RECORD FOR DRIVEN PILES

PILING CONTRACTOR _____ RIG NO. _____
PROJECT _____ STRUCTURE _____
PILE TYPE/SIZE _____ PILE NO. _____

GENERAL

Rig moved from Pile No. _____
Existing Ground Level _____
Required Cut-off Level _____
Cross Section of Pile or Casing Driven _____
Length of Pile or Casing Driven _____
Weight (or Material) of Pile or Casing Driven _____

HAMMER

Type and Weight _____
Type and Condition of Pile Head Packing _____
Type and Condition of Helmet Dolly _____

DRIVING

Single Acting Drop or Double Acting Frequency of Hammer for
a) Normal Driving _____ b) Final Driving _____
Final Set _____
Length of Shaft below cut-off _____
Reason for any Delay during driving _____
Details of any Redriving _____

RECORDS

Level of theoretical pile top _____
Level of cast pile top _____
Pile centre deviations _____
 Δx _____ Δy _____

REMARKS (Including further details required by the Engineer)

SUPERVISOR'S SIGNATURE

DATE _____

Piling for Structures

Form B4 07 B

DAILY RECORD FOR BORED PILES

PILING CONTRACTOR _____ RIG TYPE/NO. _____
PROJECT _____ STRUCTURE _____
PILE SHAPE/SIZE _____ PILE NO. _____

GENERAL

Rig moved from Pile No. _____
Existing Ground Level _____
Required Levels: Cut-off _____ Toe _____
Under-ream Shape/Size _____
Cross Section of Pile _____
Length of Pile _____

STRATA

Depth	Soil/rock Description	Sampler/Tests

Ground Water Observations _____
Date boring commenced _____
Reason for any delay during boring _____

REINFORCEMENT _____

CONCRETE Mix Type _____ Quantity used _____
Slump _____ Test Cubes No. _____

Casing Pull _____

Concrete Drop _____

Level of theoretical pile top _____
Level of cast pile top _____
Pile centre deviations _____
 Δx _____ Δy _____

REMARKS (Including further details required by the Engineer)

SUPERVISOR'S SIGNATURE
DATE _____

SECTION B5

LARGE DIAMETER PILES – FOUNDATION CYLINDERS

B5 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all materials, plant, equipment and labour and in performing all operations in connection with the execution of large diameter piles-foundation cylinders, subject to the Conditions of Contract and in strict accordance with this Section of the Specification, the applicable Drawings and the Special Specification of Particular Application.

This section is to be read in conjunction with Section B4, and all piling shall conform in all respects with the principles contained in BS Code of Practice CP 2004 (1972) Foundations.

B5 02 MATERIALS

1. The concrete, cement, fine and coarse aggregate, water and additives shall conform to Section B8. The cement content shall not be less than 375kg per cubic metre of concrete. Cement shall be of the sulphate resisting low alkali type.
2. The reinforcing steel shall conform to Section B7.

B5 03 SINKING OF FOUNDATION CYLINDERS

Foundation cylinders shall be sunk vertically within a tolerance of a 3cm deviation from the true vertical in any 150cm of depth. At the underside of the cylinder cap the centre of each cylinder shall not deviate from the location shown on the Drawings by more than 15cm except where a different tolerance is given in the Special Specification for Particular Application.

Before commencing any piling work the Contractor shall submit to the Engineer for his approval detailed plans and description of his proposed piling method with particulars of all equipment to be used. Notwithstanding any approval of the Contractor's proposals by the Engineer the Contractor shall be and remain solely responsible for the successful installation of the piles.

If the Contractor wishes to construct cylinders with diameter different from the one shown on the Drawings, he shall submit to the Engineer for his approval detailed plans and calculations. If approval is given to use cylinders with a diameter that will necessitate enlarging the foundations, the cost of such enlargements shall be the sole responsibility of the Contractor.

The method of sinking proposed by the Contractor shall conform with the following requirements of the Engineer:-

1. Boring and excavation for a cylinder shall not be commenced until 24 hours after completion of the concreting of any cylinder within a radius of 5m centre to centre.
2. No material from outside the cylinder shall be removed except as specified in the Special Specification of Particular Application and where casing is used this shall be maintained at such level relative to the excavation as to satisfy the Engineer's Representative that this requirement is being fulfilled.

Large Diameter Piles – Foundation Cylinders

3. The boring and pressing down of the steel casing shall be done without disturbing the adjacent soils and without causing hydraulic ground failure at the bottom of the hole.

If a soil "Plug" develops at the bottom of the casing with a tendency to follow the casing, such a plug shall be excavated before sinking of the casing is continued. The casing shall be kept full of water at all times, with the water level inside the casing higher than the ground or water level outside by pumping water into the casing as necessary. If excavation is done by grabbing care shall be exercised not to create suction at the underside when lifting the grab. The final stage of excavation shall be done in such a way and with such equipment that the soil beneath the bottom of the pile is not disturbed. The bottom of the completed borehole shall have a horizontal surface.

4. Should the Contractor's method of installing the cylinders involve driving or otherwise working the casing tubes through obstructions or into rock, a hardened steel cutting edge shall be fitted to the lower edge of the steel casing which, if necessary, shall also be appropriately thickened.

5. On reaching a rock level defined in the Special Specification for Particular Application, sinking of the excavation, though not necessarily any temporary or permanent casing, shall be continued to a depth which will be determined by the Engineer to form a socket in rock which is of such solidity as will positively locate and maintain the base of the cylinder in place. The depth of the socket is unlikely to be less than 1 or 2 diameters below the rock level, but in determining the depth of the socket the Engineer will in no way be bound by these dimensions and the Contractor is required to provide a rate for sinking in rock to any penetrations below the rock level. The final shape of the socket as determined by observation of the operation of the sinking tools shall be cylindrical with vertical walls and horizontal floor.

6. After cleaning the bottom of the borehole the Contractor shall perform at least two Standard Penetration Tests in each borehole, using a 5cm Split Tube Sampler. The equipment and method of performing the tests are subject to approval by the Engineer, and the tests shall be performed under his supervision. Based upon the results of the Standard Penetration Tests the Engineer will approve the borehole or decide that it must be sunk to a deeper level. In the latter case cleaning and testing shall be repeated at the new bottom level.

7. The piling equipment shall be of a type that employs continuous semi-rotary motion while pressing down a pile casing tube with thick walls and a hard metal cutting edge. Splices in the casing shall present smooth faces both on the inside and outside. The diameter of the cutting edge shall be not more than 2cm larger than the diameter of the casing tube. Boring and excavation shall be done without disturbing the soils adjacent to the pile.

8. The equipment provided by the Contractor for excavating rock shall include hammer grabs and heavy rock chisels as defined below or similar approved equipment which the Contractor shall demonstrate as being capable of fulfilling the same function. Hammer grabs shall be of a well-established and proven design, manufactured by a firm specialising in the manufacture of heavy shaft-sinking equipment. They shall be of the size and weight recommended by the manufacturers for sinking shafts of the required diameter into hard rock. Heavy rock chisels shall have an H, T or X cross-section which ensures that the effect of each blow extends to the periphery of the hole. The jaws of grabs and the cutting edges of chisels shall be inspected regularly to check sharpness and base dimension and as

required they shall be built up with an approved steel alloy weld metal to maintain their original dimension.

9. When sinking into the wet, on reaching the final depth and after removal of coarse sediment, the water or bentonite fluid in the casing shall be allowed to remain undisturbed for 12 hours, or such shorter period as will be determined by the Engineer, so that sediment may settle out and be removed by pumping, suction, bailing or other approved method. A positive head of fluid of not less than 1m shall be maintained above the ground water or prevailing sea or river level during the removal of sediment, which shall continue to the satisfaction of the Engineer's Representative until the founding surface of the rock is free of deleterious matter.

10. The reinforcing steel shall be fabricated into a cage on shore and lowered into position prior to the commencement of concreting. The concrete cover over the spiral reinforcement shall be not less than 7cm as measured from the inner face of the casing tube. Positive means shall be provided to ensure proper cover. A few additional bars shall be provided, extending well above the water level inside the casing, to facilitate observation and registration of possible movements of the reinforcing steel during concreting operations. The reinforcing steel shall be prevented from following the steel casing when this is being withdrawn.

11. The concrete which shall contain a retarder shall have a consistency such that it will flow evenly. Concreting shall commence as soon as possible after approval of the bottom of the borehole and after the reinforcing cage has been installed. If concreting has not been started within four hours after cleaning the bottom of the borehole then cleaning shall be repeated.

Concreting of a cylinder shall be done without construction joints. Concreting done under water shall be by the tremie method. The water level inside the casing shall be kept at a constant level, well above ground or water level outside the casing. The tremie tube shall be filled with concrete while slowly lowering a valve or plug. The tremie tube shall at all times be kept full of concrete to the bottom of the hopper and the discharge end shall be kept sufficiently submerged (2 to 6m) in already deposited concrete to prevent water from surging into the tube. The location of the discharge end of the tremie tube relative to the surface of deposited concrete shall be kept under close surveillance at all times. If by accident the concrete in the tremie tube sinks below the bottom of the hopper then the tube shall be refilled in such a way that no air or water is trapped in the tube.

The first 0.5 to 1.0m³ of concrete to be deposited in a cylinder may consist of grout, with a consistency and quality corresponding to the rest of the concrete in the pile.

While concreting, the pile casing shall be slowly withdrawn without lifting the reinforcement out of position. The surface of concrete inside the casing shall at all times be kept at a sufficiently high level above the bottom of the casing in order to prevent squeezing ground to cause "Necking", i.e. reductions of the concrete cross-section of the pile and also to prevent ground water flowing into the casing. When deciding at what distance the surface of the concrete shall be kept above the bottom of the casing, consideration must be given to the fact that the concrete area below the casing will be larger than inside the casing.

The quantity of deposited concrete shall be recorded and when extracting the casing a record shall be kept showing the level of the surface of concrete inside the casing before and after each lifting stage.

Large Diameter Piles – Foundation Cylinders

Any concrete at the top of the cylinder which is of an inferior quality shall be cut out and removed. It is the sole responsibility of the Contractor to continue concreting until the surface of deposited concrete is sufficiently high above the theoretical cut-off level, as shown on the Drawings or decided by the Engineer's Representative, to ensure that all concrete below cut-off level is of a satisfactory quality. Concreting shall not be discontinued until the surface of concrete is at least 40cm above cut-off level.

When concreting of a cylinder is completed with the surface of concrete more than 1.0m below ground level, a sand layer not less than 50cm thick shall be deposited on top of the concrete before removing the pile casing.

When applicable the cylinder shall be cut at theoretical cut-off level after the foundation bottom seal has cured sufficiently and after the cofferdam has been dewatered.

The Contractor shall test the consistency and measure the temperature of the concrete at least once for each 4m³ of concrete. Testing of the compressive strength of the concrete shall be performed as specified. If required by the Engineer's Representative the Contractor shall test and record the air content, specific weight, setting and curing time and other properties of the concrete.

Before commencing the piling work the Contractor shall have on the Site approved equipment and trained personnel for drilling cores for the full length of the piles. The Engineer's Representative shall decide if and when core drilling is to be performed. Core drilling will be required when the concrete or irregularities during the execution of work indicate that the quality of the pile may be below the required standard. Testing of the cores shall be performed as directed by the Engineer's Representative. Independent of the requirement to drill cores the total length of some of the cylinder core drilling in the top of several cylinders will be required, as ordered by the Engineer's Representative.

If applicable drilling of cores in the cylinders of a foundation shall be done before construction of the cofferdam for that foundation.

12. Any cylinder is liable to rejection if it does not meet the specified requirements, or when irregularities during the execution of work gives the Engineer's Representative reason to suspect that the cylinder is of an inferior quality. A rejected cylinder shall be substituted by one, or two, additional cylinders. The number of additional cylinders, their location and any increase in the size of the foundation due to the additional cylinder shall be as determined by the Engineer. The cost of such additional work shall be the sole responsibility of the Contractor.

13. The Engineer will approve each cylinder in writing when he is satisfied with all test results. No consecutive work on any one foundation shall be commenced until all cylinders in that foundation have been approved.

B5 04 INSPECTION OF BORES

1. Where temporary casing of the bore to the full depth is not necessitated by ground conditions, a loose fitting sleeve of appropriate length and strength shall be made available and shall be fitted into the bore as a safety measure when personnel are down the bore below the temporary casing.

2. The bores of all foundation cylinders sunk in the dry will be inspected by the Engineer's Representative immediately on completion of the boring, and in the case of an enlarged base when the under-reaming has been completed and all spoil has been removed. If as a result of the inspection, the bottom proves to be unsatisfactory, the Contractor may

be required to increase the diameter of the undercut section or the depth after which the bore will be re-inspected by the Engineer's Representative.

3. For inspection purposes, the Contractor shall provide a suitable cage so that personnel can be lowered down the shaft in safety. The Contractor shall submit his design for this cage together with his proposals for safety precautions which shall be enforced during the inspection of the shafts. The Contractor's proposals shall include details of the crane to be used for lowering and raising the cage.

B5 05 GROUTING BELOW CYLINDER FOUNDATIONS

1. In the case of cylinders founded on fissured rock, the rock mass supporting the cylinders may be required to be solidified with cement grout as directed by the Engineer's Representative. Any grouting required shall, in general, be completed before the foundation is carrying a significant proportion of its final dead loading.

2. Grout holes may be drilled by any approved method and the depth required to be drilled below the maximum penetration of individual cylinders in the foundation will be as directed by the Engineer's Representative. The diameter of grout holes shall be not less than 2.8cm. Holes shall be cased through the ground above the rock and the casing shall be effectively sealed into the rock to preclude entry of soil into the grout hole. An approved 'packer' shall be inserted at one or more locations in the hole in the rock and after flushing out with clean water, cement grout shall be injected by means of a positive displacement reciprocating pump at pressures up to a maximum of 3.6kgf/cm².

3. Cement grout shall be a mixture of neat cement and water with an approved retarding agent added in proportions recommended by the manufacturers. The water: cement ratio of the grout shall in general be 0.5, but this may be varied according to the openness of the formation. The grout shall be mixed in an approved mixer to a uniform smooth creamy consistency and it shall be continuously agitated before entering the pump.

4. Grouting shall be undertaken only by experienced personnel and the supervisor shall prepare a record for each hole indicating depths of injection, quantity and rate of cement injected and injection pressure with particular note of any abrupt changes of pressure.

B5 06 OBSTRUCTIONS ENCOUNTERED

1. When in the opinion of the Engineer, rock-like resistance to cylinder sinking is encountered at a level above the general indication of rock level given by the exploratory boreholes nearest to the cylinder, the Contractor will be reimbursed in accordance with a tendered rate for breaking through obstructions. This rate shall apply from the level of first encountering the resistance until in the opinion of the Engineer's Representative the obstruction has been penetrated or until rock level had been reached. The rate for breaking through obstructions shall include all measures necessary to enable the cylinder casing to be taken through the obstructions and continued down to rock level or such depth as will be determined by the Engineer's Representative.

2. The level at which any casing employed is unable to be taken deeper will not be regarded as an indication of rock level, unless at the Engineer's discretion it has been demonstrated in adjoining cylinders that it might be so regarded.

Large Diameter Piles – Foundation Cylinders

B5 07 RECORDS AND MEASUREMENT

During boring and excavation for the cylinders the Contractor shall keep record of the soils that he penetrates in order to check the types and thicknesses of the various layers and he shall perform at least two Standard Penetration Tests in each borehole.

The piling records shall be in the form shown on record Forms B407A or B407B as described in Clause B4 07. These shall be given to the Engineer's Representative within 24 hours.

Piles will be measured as the length from the theoretical cut-off point to the bottom of the casing and in accordance with the dimensions entered in the piling record forms. Any variation in the format of piling records is to be subject to the approval of the Engineer.

B5 08 PAYMENT

Piles will be paid per linear metre for the appropriate items in accordance with Clause B5 07 and with any special items shown in the Bill of Quantities. This payment shall include the cost of all labour, materials excluding reinforcement, but including all equipment and testing, and performing all operations in connection with the execution of large diameter piles-foundation cylinders. The reinforcement will be measured and paid for separately.

SECTION B6

FORMWORK AND SURFACE FINISH FOR STRUCTURES

B6 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the falsework, formwork and shuttering for all concrete structures (except concrete pipe), including box culverts, retaining walls, concrete substructures and composite structures of concrete and steel or concrete and timber. All work shall also be in accordance with the provisions of the Specification pertaining to the various materials and contract items which enter into and form part of the complete structure and with the directions of the Engineer's Representative.

B6 02 MATERIALS

1. Shuttering to Concrete: All formwork, forms or shuttering with supporting falsework, struts and stagings shall be of suitable quality timber or of other approved material and of such substantial strength with ample scantlings as will ensure that the shuttering remains rigid and without distortion throughout the placing, ramming, compacting and setting of the concrete.

2. Timber Formwork: All timber shuttering or moulds used for forming the face of exposed concrete shall be 'wrought' timber, that is to say smooth planed. All wrought shuttering shall be provided with angle fillets so as to form 2.5cm by 2.5cm splays on internal and external angles unless otherwise directed by the Engineer's Representative.

Unless otherwise approved it shall be tongued and grooved timber of good quality 3cm minimum thickness, free from loose knots, shakes or warped surfaces, dressed, i.e. 'wrought' on one side and two edges, with the exception of the use of plywood, or plywood or hardboard backed with rough timber of the thickness and with studding or bracing as approved by the Engineer's Representative.

3. Metal Forms: The Materials Specifications for the design, mortar tightness, filleted corners, levelled projections, bracing and alignment of timber formwork shall apply. The metal used for forms shall be of such thickness that the forms remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used.

4. Internal Ties or Spacers: The use of approved internal steel ties or steel or plastic spacers will be permitted with the approval of the Engineer's Representative. All fittings for metal ties shall be of such a design, that upon their removal, the cavities which are left will be of the smallest possible size.

5. Timber for General Purposes (Falsework): Sawn and laminated timber shall be of an approved structural grade having a moisture content and standard of green and dry basic timber stresses as approved by the Engineer's Representative for the particular structural use specified.

Timber in the round shall be as described in the Contract, sound, straight and well seasoned, free from rot, worm, beetle, decayed knots or other defects.

B6 03 CONSTRUCTION REQUIREMENTS

General

1. Formwork shall include all temporary or permanent forms required for forming the concrete, together with all temporary construction required for their support.

2. All formwork shall be so constructed that there will be no loss of material from the concrete.

After hardening, the concrete shall be in the position and of the shape, dimensions and surface finish described in the Contract.

False work

3. The Contractor shall submit to the Engineer's Representative for approval detailed plans for false work or centering in accordance with the requirements of Clause R1 16 Temporary Staging for Structures.

In addition to Clause R1 16, the Drawings submitted for approval shall show the proposed method of construction, the dimensions of all temporary steelwork, timber scantlings, etc. of all structural members, including foundation details with piling, if necessary, together with details of wedges, packing, collars, bolts or other fittings.

The design of false work footings and the bearing capacity of the foundation soils (stabilized if necessary) shall be such that a uniform ground loading is attained on all bases to the temporary staging involved.

The design of the false work shall not only allow for the dead load of the fresh concrete but shall include for wind loading and accidental impact loading. Reference should be made to the Concrete Society technical Report No. 4 — False work.

False work and forms shall not be constructed until drawings have been approved by the Engineer's Representative, but approval by the Engineer's Representative shall not relieve the Contractor of responsibility for the sufficiency of the false work and forms.

4. False work or centering shall, after allowance for shrinkage and settlement, give the finished structural camber indicated on the Drawings.

Any settlement of false work and footings will be measured and recorded during concreting and provision made for the appropriate use of hydraulic jacks where directed by the Engineer's Representative.

5. For calculating the strength of false work or centering, a weight of 2600 kg/m^3 shall be assumed for green concrete.

6. The cost of compaction or piling for footings or any other incidental works shall be included in the price tendered in the Bill of Quantities and no additional compensation will be allowed.

Formwork

7. The Contractor shall submit his designs for formwork in duplicate for approval, not less than 14 days before the proposed commencement of the work and work shall not start until the Engineer's Representative's approval in writing has been received.

The design of the shuttering shall, be such as to enable it to be struck and removed without damage to the concrete. No shutter fixings or supports, other than certain internal ties, will be allowed to be incorporated in the finished concrete.

All formwork and shuttering shall be as nearly water tight as possible and standing water will not be permitted in the forms.

8. All joints in shuttering or moulds shall be in either horizontal or vertical planes to an agreed pattern and shall be of such a design as to ensure that there is no loss of fine materials or cement during the placing or consolidation of the concrete.

9. Shuttering for walls, sloping members and thin sections of considerable height shall be provided with temporary openings which will permit inspection and cleaning out before placing of concrete. The location of these openings shall be agreed with the Engineer's Representative and can include loose lower form boards.

10. Shuttering shall be provided for all slopes exceeding 15° to the horizontal to enable the concrete to be properly compacted.

Structural concrete shall not be poured against vertical or inclined rubble fill or earth surfaces in lieu of shuttering.

Where any approved internal metal ties or spacers are permitted, they or their removable parts shall be extracted without damage to the concrete. Any holes in the surface of the concrete caused by ties or spacers shall be neatly filled with cement mortar or the same mix and consistency as the parent class of concrete. No permanently embedded metal part shall have less than 5cm cover to the finished concrete surface or the specified cover to the reinforcement, whichever is the greater.

B6 04 FORMED SURFACES – CLASSES OF FINISH

1. In addition to the Specification for formwork and shuttering as Clauses B6 03-7 to 10 the requirements for surface finish of structures shall be graded to provide the class of finish described in the Contract as follows:

Class F1 No additional specific requirement.

Class F2 The irregularities in the finish shall be no greater than those obtained from the use of wrought thickened square edged boards arranged in a uniform pattern. The finish is intended to be left as struck but imperfections such as fins and surface discolouration shall, if required, be made good by methods approved by the Engineer's Representative.

Class F3 The formwork shall be lined with a material approved by the Engineer's Representative to provide a smooth finish of uniform texture and appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source throughout any one structure. The Contractor shall make good any imperfections in the finish as required by the Engineer's Representative. Internal ties and embedded metal parts will not be allowed.

Class F4 The requirements for Class F4 are as for Class F3 except that internal ties and embedded metal parts will be permitted. The ties shall be positioned only in rebates or in other positions as described in the Contract or as agreed by the Engineer's Representative.

2. Permanently exposed concrete surfaces to Classes F2, F3 and F4 finish shall be protected from rust marks and stains of all kinds.

Formwork and Surface Finish for Structures

3. Unless otherwise described in the Contract, all formwork joints for exposed surfaces of concrete to Class F2, F3 and F4 finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.
4. Other classes of formwork for special effects shall be as described on the Drawings, Bill of quantities or the Special Conditions of Particular Application.

B6 05 PREPARATION OF FORMWORK BEFORE CONCRETING

1. The shuttering shall be cleaned out prior to concreting and the bottom thoroughly freed from sawdust, shavings, rust, dirt, mud or other debris, and special removable sections of shuttering shall be provided to facilitate this, all to the Engineer's Representative's approval.

2. To prevent concrete adhering to the shuttering, a thin coat of a chemical release agent approved by the Engineer's Representative shall be applied to the inner surface of the shutters before concrete is placed.

Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement of prestressing tendons and anchorages. Different release agents shall not be used in formwork to concrete which will be visible in the finished Works.

3. When absorbent timber forms are used in high temperatures they shall be thoroughly wetted on both sides in advance of placing the concrete.

4. Forms for concrete can also be oiled with form oil acceptable to the Engineer's

Representative. The oil shall be applied several days before the concrete is placed and shall be in such quantity that it will be fully absorbed by the wood and will not discolor the surface of the concrete.

5. Metal forms which do not present a smooth surface or line up properly, shall not be used.

Special care shall be exercised to keep metal forms free from rust, grease or other foreign matter such as will tend to discolor the concrete.

6. No concrete shall be placed until the formwork or shuttering has been inspected and approved by the Engineer's Representative.

After concreting, the exposed surfaces of the shuttering shall be cleaned of all adhering concrete before depositing fresh concrete.

B6 06 REMOVAL OF FORMWORK

1. The Engineer's Representative shall be informed in advance when the Contractor intends to strike any formwork.

The removal of formwork and shuttering shall be effected in such a manner as will ensure that no damage to the concrete occurs. No formwork shall be removed before the concrete has attained sufficient strength, so that the concrete shall at no time be subjected to loading including that (from its own weight) 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 provisions of Clause B9 10 Post- Tensioning Procedure are an exception to this sub clause.

2. For the purpose of this Clause, the assessment of the strength of the concrete and the stresses produced by the loads shall be subject to the agreement of the Engineer's Representative.

The minimum periods which shall elapse between the placing and compacting of the concrete and the removal of the formwork for various types of faces and parts of the structure are given as a guide in Table B6/1 but this will not relieve the Contractor from his obligation to delay removal of the shuttering until the concrete has attained sufficient strength, and the Contractor shall be held responsible for making good at his own expense all injury and damage arising from premature removal of the shuttering. A small portion of the shuttering shall be removed to ascertain that the concrete has set sufficiently hard before the whole area of the shuttering is removed. The provision of suitable curing methods should immediately follow the removal of the vertical formwork at from 12 hours to 1 day and the concrete should be protected from low or high temperatures by means of suitable insulation.

**TABLE B6/1
MINIMUM PERIODS FOR REMOVAL OF FORMWORK**

Type and position of formwork	Constant Surface Temperature	
	16° C to 27° C	Above 27° C
	Approximate Times	
Vertical side faces of foundation plinths and precast items	1-2 days	12 hours
Side faces of beams, walls, columns, piles and soffits of secondary slabs (props left in)	4 days	3 days
Arch centres, wedges eased	8 days*	7 days*
Soffits of beams and slabs, and removal of props of secondary slabs	10 days	8 days
Removal of props to beams and main slabs	14 days	11 days
Arch centering struck	21 days*	21 days*

* These periods shall commence from the time of the completion of the last shrinkage key.

3. The periods indicated above assume that the structure is carrying normal dead loads only and are the approximate minimum number of days that shall have elapsed after the placing of the concrete. The exact number of days subsequent to placing the concrete is dependant upon curing conditions, including the average temperature (16°C minimum allowed in Table B6/1) and the use of normal Portland Cement. The removal of formwork periods given in Table B6/1 shall be increased up to double if necessary, when the temperature of the concrete in the hardening period has been predominantly below +5°C. If frost occurs during hardening, the formwork removal and falsework striking periods for unprotected concrete shall be increased by at least the period of the duration of the frost.

Formwork and Surface Finish for Structures

4. The Contractor shall ensure that no loads of such an intensity as will cause damage are applied to newly constructed work. Any damage caused by such overloading shall be made good by the Contractor at his own expense to the satisfaction of the Engineer's Representative.

5. Formwork shall be constructed so 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, these props shall not be disturbed during the striking. The removal of side forms for inspection of column concrete shall occur before the release of supports to girders or of the formwork to beams.

6. For prestressed units the side forms shall be eased as early as possible and the soffit forms shall be designed to allow for the deformation of the member when the prestress is applied.

7. Falsework under all structure spans shall be completely released before parapet railings, pipework, footpath surfacing and kerbs are placed.

8. All forms shall be removed, whether above or below the ground line or water level. Inside forms of hollow piers, girders, abutments, etc. shall be removed through openings provided for that purpose if they consist of material apt to rot or to cause any other injurious influence on the structure and when shown on the Drawings.

9. If on the removal of the shuttering there is any honeycombing or other defect apparent in the concrete, the Engineer's Representative shall be informed immediately. No making good or other treatment shall be carried out except with the approval of the Engineer's Representative. Any concrete, the surface of which has been treated before being inspected by the Engineer's Representative, shall be liable to rejection.

10. After completion of the structure, all forms and falsework shall be completely removed; but no forms or falsework shall be removed without the consent of the Engineer's Representative.

B6 07 UNFORMED SURFACES – CLASSES OF FINISH

1. **Class U1.** The concrete shall be uniformly levelled and screeded to produce a plain, textured or ridged surface as described in the Contract. No further work shall be applied to the surface unless it is used as the first stage for a Class U2 or Class U3 finish.

2. **Class U2** After the concrete has hardened sufficiently, the concrete Class U1 surface shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

3. **Class U3** When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 surface shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

4. In addition, surface finish which is to receive deck waterproofing shall be to an accuracy such that when tested with a 3m straight-edge, the maximum depressions shall not exceed 10mm.

Finish to Remedial Patching or Pointing

5. Any patching or pointing, in mortar or concrete as remedial work to holes or depressions shall, in accordance with Clause B6 06-9, only be allowed when and as directed by the Engineer's Representative. It shall initially include wetting and rubbing down with a carborundum stone or similar abrasive to bring a paste to the surface. The method and materials for carrying out such remedial work including final finishing and approved matching colour shall be agreed with the Engineer's Representative after a trial operation.

Treatment of Concrete Surface

6. Bush hammering or other methods of removal of surface laitance to give a special treated surface finish shall be as described in the Special Specification for Particular Application.

B6 08 MEASUREMENT

The unit of measurement for formwork when included in the Bill of Quantities shall be the square metre. The measurement shall be the number of square metres of formwork which is in contact with the finished concrete measured over the face of openings 1m² or less.

The various items for formwork shall be deemed to be inclusive of all the requirements shown on the Drawings.

B6 09 PAYMENT

Payment for the various items of formwork when included in the Bill of Quantities will be made in accordance with the Specification at the price tendered in the Bill of Quantities for the several items involved according to the type, position and class of formwork. Any item not included in the Bill of Quantities which is shown on the Drawings or called for in the Specification shall be understood to be included in the rates quoted for other items.

Payment shall include for the furnishing of all materials, labour, equipment and all items required to construct and remove the formwork, including all costs of leaving in place for the stipulated periods.

SECTION B7

STEEL REINFORCEMENT FOR STRUCTURES

B7 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with steel reinforcement, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B7 02 STANDARD SPECIFICATIONS AND TEST METHODS

Steel reinforcement for structures shall consist of hot rolled steel bars, cold worked steel bars, deformed bars—hot rolled or cold worked (can be ribbed or twisted steel bars respectively), hard drawn steel wire and steel fabric reinforcement as shown on the Drawings and reinforcement schedules.

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the British Standard Institution's listed publications.

BS Code of Practice CP110 Part 1 (1972) The Structural Use of Concrete.

BS4449 (1969) Hot rolled steel bars, etc.

BS4461 (1969) Cold worked steel bars, etc.

BS4482 (1969) Hard drawn mild steel wire, etc.

BS4483 (1969) Steel Fabric, etc.

BS4466 (1969) Bending dimensions and scheduling of bars, etc.

BS5400 (1978) Steel, concrete and composite bridges

Generally steel reinforcement will be in accordance with British Standard but where stated on the Drawings or in the Special Specification of Particular Application steel reinforcement to other Standards will be permitted.

B7 03 MATERIALS

All mild steel bars shall consist of round steel of cross sectional area, weight and density, process of manufacture, chemical composition and quality as specified in the appropriate British Standards in Clause B7 02 as follows.

1. Hot rolled mild steel bars and hot rolled high yield bars shall comply with the requirements of BS4449 (1969).

2. Cold worked steel bars shall comply with the requirements of BS4461 (1969).

3. Hard drawn mild steel wire shall comply with the requirements of BS4482 (1969).

4. Hot rolled or cold drawn deformed bars are bars which have been so shaped that their bond with concrete exceeds that of a plain round bar. The bond strength of deformed bars, as defined in BS4449 (1969) and BS4461 (1969), shall exceed that of a plain round bar by 40 per cent or more when tested in accordance with BS Code of Practice CP 110 Part 1 (1972) Appendix E.

Deformed bars can be ribbed or twisted for hot rolled or cold worked steel bars respectively.

Steel Reinforcement/or Structures

5. Steel fabric reinforcement shall comply with the requirements of BS4483 (1969), and shall be delivered to the Site in flat mats.
6. In the case of bars complying with the requirements of BS4449 (1969) or BS4461 (1969) the Contractor shall provide a certificate confirming that samples, taken from the bars delivered to the Works, pass the rebend test. The frequency of sampling and the method of quality control shall be in accordance with Table 4 and Clause 20 respectively of these British Standards.

TABLE B7/1
TENSILE PROPERTIES OF REINFORCEMENT

Type and Size	Characteristic Yield Strength kg/cm ²	Minimum Elongation %
Hot Rolled Bars Grade 250 All sizes	2500	22
Hot Rolled Bars Grade 460/425 6mm up to & incl. 16mm	4600	12
Hot Rolled Bars Grade 460/425 Over 16mm	4250	14
Cold Worked Bars Up to & incl. 16mm	4600	12
Cold Worked Bars Over 16mm	4250	14
Hard Drawn M.S. Wire Up to & incl. 12mm	4850	—

B7 04 CONSTRUCTION REQUIREMENTS

1. General: In general bar lists and bending schedules with diagrams will be included in the Contract Documents, but the Contractor shall be responsible for satisfying himself of the correctness of all detail in accordance with the Drawings and the quantities, before placing orders.

2. Protection of Materials: Steel reinforcement shall be protected at all times from damage and when placed in the structure shall be free from dirt, loose mill scale and rust scale, paint, oil or other foreign substance.

3. Bending: Reinforcement shall be bent to the dimensions given in the Bar Schedules which shall comply with BS4466 (1969).

All reinforcement shall be bent at temperatures in the range of 5°C to 100°C.

Cold worked bars and hot rolled high yield bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement projecting from the concrete, the internal radius of bend shall be not less than twice the diameter of the bar.

4. Placing: Reinforcement shall be placed and firmly maintained in the position shown on the Drawings. Unless otherwise permitted by the Engineer's Representative, all bar intersections shall be tied together and the ends of the tying wire shall be turned into the main body of the concrete. 1.2mm diameter stainless steel wire shall be used for in-situ members having exposed soffits. 1.6mm diameter soft annealed iron wire shall be used elsewhere.

No splices shall be made in the reinforcement except where described in the Contract or where approved by the Engineer's Representative.

5. Cover Blocks: Precast concrete cover blocks required for ensuring that the reinforcement is correctly positioned shall be as small as possible consistent with their purpose of a shape acceptable to the Engineer's Representative and designed so that they will not overturn when the concrete is placed.

The blocks, which may be reinforced, shall be short enough to permit their ends to be covered with concrete. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks will not be permitted. Reinforcement in any member shall be placed, inspected and approved before any concrete is placed. Concrete placed in violation of this provision will be subject to removal.

They shall be made of concrete with 10mm maximum aggregate size and the mix proportions shall comply with Table B8/6 of Clause B8 07 to produce the same strength as the adjacent concrete. Tying wire complying with the requirements of Clause B7 04-4 shall be cast in the block for the purpose of tying it to the reinforcement.

The use of purpose made asbestos-cement spacer blocks will be permitted subject to the approval of the Engineer's Representative and that they are of adequate contact area to ensure that they do not punch into the formwork. The use of plastic spacer blocks will not be permitted.

6. Welding: Reinforcement in structures shall not be welded except where permitted in the Contract. All welding procedures shall be subject to the prior approval of the Engineer's Representative in writing and shall comply with any appropriate sections of Clause B1004-7.

B7 05 MEASUREMENT

All steel reinforcement will be measured by the computed weight of all metal actually in place as shown on the Drawings and as listed in the bar lists, or as ordered additionally by the Engineer's Representative. No allowance will be made for finishers, form blocks, wire clips or other fastenings, which must be furnished by the Contractor as and where ordered by the Engineer's Representative. When laps are made other than specified in Clause B7 04-4, no allowance will be made for the extra steel required. When steel is required at construction joints which are not shown on the Drawings and which are permitted for the Contractor's convenience, no allowance will be made for the additional steel required.

For the purpose of computing weights of steel reinforcement, the following Table B7/2 shall be used.

The availability of various sizes of steel bars will vary according to the country in which the steel is manufactured, so consequently there could be minor variations in weight/metre and cross sectional area. The payment to the Contractor for steel bars shall therefore be based upon the weights in the following Table B7/2, unless the Special Specification for

Particular Application or a decision by the Engineer's Representative permits a variation in the allowance for weight per linear meter.

TABLE B7/2
PLAIN ROUND & DEFORMED STEEL BARS

Diameter mm	Area cm²	Weight/Meter kg	Diameter mm	Area cm²	Weight/Meter kg
6	0.283	0.222	25	4.909	3.854
8	0.503	0.395	26	5.309	4.168
10	0.785	0.616	28	6.158	4.834
12	1.131	0.888	30	7.069	5.549
14	1.539	1.208	32	8.042	6.313
16	2.011	1.579	34	9.079	7.127
18	2.545	1.998	36	10.179	7.991
20	3.142	2.466	38	11.341	8.903
22	3.801	2.984	40	12.566	9.864
24	4.524	3.551	50	19.635	15.413

B7 06 PAYMENT

Payment for steel reinforcement will be made at the price tendered per metric tonne for Steel Reinforcing Bars and steel fabric in place.

Payment for steel reinforcement and steel fabric shall include the cost of furnishing, fabricating and placing the reinforcement. No allowance will be made for clips, wire or other material used for fastening reinforcement in place.

SECTION B8

STRUCTURAL CONCRETE

B8 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the materials used for the storing, measuring and handling of materials, for the proportioning and mixing, and unless specified elsewhere in other Sections of this Specification, for the conveying, placing, forming, curing and finishing of all structural concrete for bridges, box culverts, concrete piling and other incidental concrete construction, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B8 02 STANDARD SPECIFICATIONS AND TEST METHODS

Except as modified by this Specification, the following standard specifications, codes of practice and test methods shall govern in all cases and reference must be made accordingly to the listed British Standards Institution publications or to the publications of the American Association of State Highway and Transportation Officials.

BS Code of Practice CP 110 Part 1 (1972) The Structural Use of Concrete.

BS12 Part 2 (1971) Portland Cement (Ordinary and Rapid Hardening).

BS4027 Part 2 (1972) "Sulphate Resisting Portland Cement".

BS4228 Super Sulphated Cement.

BS1377 Test No. 10—Sulphate content in Aggregates.

BS5400 (1978) Steel, concrete and composite bridges.

American Association of State Highway and Transportation Officials.

T11-74: Material finer than 0.075mm sieve in aggregate.

T21-74: Organic impurities in sands, etc.

T22-74: Compressive strength of concrete cylinders.

T23-73: Making and curing concrete specimens in the field.

T27-74: Sieve analysis of aggregates.

T96-74: Los Angeles abrasion of coarse aggregate.

T104-74: Soundness of aggregates by use of sodium or magnesium sulphate.

T106-72: Compressive strength of mortar.

T112-74: Clay lumps in aggregate.

T119-74: Slump test of concrete.

T141-74: Sampling fresh concrete.

T142-74: Surface moisture in fine aggregate.

M85: Portland Cement

B8 03 MATERIALS

1. **Aggregate:** The combined aggregate should be as coarse-grained and dense-graded as possible. The maximum particles size should be so chosen as to be compatible with mixing, handling, placing and working the concrete. Its normal size shall not exceed one third of the smallest dimension of the component to be concreted. With closely spaced reinforcement or small concrete cover the greater part of the aggregate shall consist of particles smaller than the distance between adjacent bars and between the bars and form-work.

The aggregate shall be well graded, between the limits and the size or sizes specified below unless otherwise directed by the Engineer's Representative.

The aggregate shall be free from salt or vegetable matter. It shall not contain more than 0.25 per cent by weight of sulphate expressed as SO_3 not more than 0.5 per cent by weight of clay lumps.

When subjected to the colorimetric test for organic impurities, it shall not show a colour darker than the standard.

2. Fine Aggregate: Fine aggregate shall consist of natural sand or, subject to the approval of the Engineer's Representative, of a combination of not more than 50 per cent by weight of stone screenings and natural sand, having hard, strong, durable particles, and shall conform to the following test requirements:

- (a) Fine aggregate from different sources of supply shall not be mixed or stored in the same pile nor used alternatively in the same class of construction or mix without written permission from the Engineer's Representative.
- (b) When subjected to the test for mortar-making properties, using Rapid Hardening Cement, the fine aggregate shall develop a compressive strength at the age of 3 days of not less than 90 per cent of the strength developed by a mortar prepared in the same manner with the cement and graded standard Ottawa sand having a fineness modulus of 2.40 ± 0.10 .

Organic impurities shall be determined in accordance with AASHTO T21. Where this test shows that organic impurities are present the effect of these in the fine aggregate on the Strength of mortar shall be determined in accordance with AASHTO T71, the relative strength shall not be less than 95%.

- (c) The fine aggregate shall be well-graded from coarse to fine and when tested by means of laboratory sieves shall conform the following requirements given in Table B8/1 below:

TABLE B8/1

FINE AGGREGATE GRADING

U.S. Sieve Size		Percentage passing by weight
mm	Imperial	
9.5	3/8in	100
4.75	No. 4	95 - 100
1.18	No. 16	45 - 80
0.30	No. 50	10 - 30
0.15	No. 100	2 - 10

- (d) The amount of material passing a 0.075mm (No. 200) sieve shall not be more than 3 per cent.
- (e) The grading requirements listed above represent the extreme limits which shall determine suitability for use from all sources of supply.

The grading from one source shall be reasonably uniform and not subject to the extreme percentages of grading specified above. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor, from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative samples submitted by the Contractor may be rejected.

NOTE: The fineness modulus of an aggregate is determined by adding the cumulative percentages by weight retained on the sieves listed in Table B8/2 and divided by 100.

TABLE B8/2
SIEVES FOR FINENESS MODULUS

U.S. Sieve Size	
mm	Imperial
9.5	3/8 in
4.75	No. 4
2.36	No. 8
1.18	No. 16
0.60	No. 30
0.30	No. 50
0.15	No. 100

- (f) The sulphate radical SO_3 shall not be more than 0.5% when tested in accordance with BS 1377 Test No. 9.
- (g) The soundness test of the fine aggregate when tested in accordance with AASHTO T 104 shall have a weighted loss of not more than 10 % when subject to 5 cycles of the test with sodium sulphate solution.

3. Coarse Aggregate: Coarse aggregate shall consist of crushed gravel or other approved inert materials of similar characteristics, or combinations thereof, free from adherent coatings and conforming to the following requirements:

- (a) The amount of deleterious substances shall not exceed the limits given in Table B8/3 below:

TABLE B8/3
COARSE AGGREGATE DELETERIOUS SUBSTANCES

	Maximum Permissible Limit % by Weight
Friable particles (AASHTO T 112).....	2.0
Clay lumps	0.25
Material passing 0.075 (No. 200) sieve.....	1.0
Flakiness Index (BS 812 Part 1).....	25.0
Elongation Index (BS 812 Part 1).....	15.0
Sulphates expressed as SO_3	0.25

When subjected to the Los Angeles American Test it shall have a percentage of wear of not more than 35 per cent according to AASHTO T96-74 Los Angeles abrasion of coarse aggregate.

- (b) It shall be well-graded, between the limits specified, and the size or sizes specified shall conform to the requirements given in Table B8/4 below:

TABLE B8/4
COARSE AGGREGATE GRADING

US mm	Sieve Size Imperial	Percentage Aggregate by weight passing		
		19mm	US Sieve Size 37.5mm	63mm
75.0	3 in	-	-	100
63.0	2 ½ in	-	100	90-100
37.5	1 ½ in	100	95-100	60-90
19.0	¾ in	95-100	35-70	25-55
9.5	¾ in	20-55	10-30	10-25
4.75	No. 4	0-10	0-5	0-5

- (c) When the coarse aggregate consists of the 37.5 mm or the 63 mm maximum sizes it shall be delivered to the site and stored in two or more separate sizes in different stacks or hoppers.
- (d) The soundness test of the coarse aggregate when tested in accordance with AASHTO T 104 shall have a weighted loss of not more than 12 % when subject to 5 cycles of the test with sodium sulphate solution.

B8 04 MIXING WATER

1. A thorough chemical water analysis shall be made before using water from any particular source for concrete mixing. Testing shall be in accordance with AASHTO T 26.

Mixing water for use with cement shall be reasonably clean and free from injurious amounts of oil, acid, alkali, salt, organic matter, or other deleterious substances.

When comparative tests are made with distilled water of known quality, any indications of unsoundness, marked change in time of set (not exceeding 30 mins.), or reduction of more than 10 per cent in mortar strength shall be sufficient cause for the rejection of the water under test.

The Contractor shall not take water for use in concrete from shallow, muddy or marshy sources unless provision is made for the intake of the suction pipe to be enclosed in such manner as to exclude silt, mud, grass and other foreign materials. The depth of the water shall be maintained at least 60cm below the intake of the suction pipe.

2. The chloride content of the mixing water shall not exceed 300mg CL' per liter, for prestressed concrete, 600mg CL' per liter for reinforced concrete, and 1500mg SO₄ per liter for un-reinforced concrete.

In special cases where it is impossible to find mixing water complying with the above stated requirements within reasonable distance, the water available must be analyzed and judged by a concrete technologist as directed by the Engineer's Representative.

The conditions apply only for mixing water but not for water used for washing the aggregates and curing the concrete.

B8 05 CEMENT

1. All cement to be used shall comply with the requirements of the Standard Specifications listed in Clause B8 02 or other similar approved standards.

2. Blast Furnace Cement shall not be used without the written permission of the Engineer whose acceptance will be governed by the supplier's analysis and test results in the country of manufacture. There would also be limitations upon its use for certain types of structural concrete.

Super sulphated cements shall not be mixed with any other type of cement.

Masonry cement must not be used in structural concrete.

B8 06 ADMIXTURES AND ADDITIVES

Unless agreed by the Engineer in writing neither admixtures nor cement containing additives shall be used.

Any agreement by the Engineer to the use of additives will only be given if they do not adversely affect the hardening of the cement, the strength and durability of the concrete and the corrosion protection of the reinforcement.

Only admixtures which comply with BS5075 Part 1 (1974) will be considered for acceptance and then only after satisfactory preliminary tests with the concrete to which they are to be added. This stipulation shall also apply to a latently hydraulic or a pozzolanic additive which may be reckoned as constituting part of the cement content.

B8 06A Contents of Chlorides and Sulphates

The amount of chlorides in the mass of concrete shall be according to B.S 8110 part 1 which specified three maximum percentages of chloride ion by mass of cement used in the concrete depending on the type and use of cement and concrete as shown below.

TABLE B8/4A
LIMITS OF CHLORIDE CONTENT OF CONCRETE

Type or use of concrete	Maximum percentage of chloride ion by mass of cement (inclusive of p.f.a.or g.g.b.f.s when used)
Prestressed concrete	
- Heat cured concrete containing embedded metal -	0.1
Concrete made with cement complying with B.S 4027 (Sulphate resistance Portland cement)or B.S 4248 (Super sulphated cement).	0.2
- Concrete containing embedded metal and made with cement complying with B.S 12(ordinary and rapid hardening Portland cement),B.S 146 (Portland blast furnace cement) , B.S 1370 (Low heat Portland cement)B.S 4246 (low heat Portland blast furnace cement)or combination with g.g.b.f.s or p.f.a.	0.4

The amount of Sulphates expressed as SO_3 in the mass of the concrete shall not exceed 4.5 % of the weight of cement in the concrete .

The above mentioned calculation shall be carried out by approved laboratory analysis of the cement, aggregate, water and additives or by analysis of the mixed concrete.

The limits in the Iraqi standard specification No. 45 can be followed.

B8 07 CONCRETE MIX DESIGN

1. Mixes for the classes of concrete shown in Table B8/5 shall be designed by the Contractor and are designated under Concrete Group letters and maximum aggregate sizes, together with the corresponding strength class for each Group letter.
2. Alternatively strength classes 330 and 230 for Standard Mixes as in Table B8/6 may be used unless otherwise required in the Contract. The class of concrete is denoted by the minimum 28 day works cube strength and the maximum size of aggregate.

3. The cement content in any mix shall not exceed 540kg/m³ of concrete.

The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the required location.

4. Durable concrete of suitably low permeability shall be obtained by the use of strong dense aggregates, a sufficiently low water: cement ratio, complete compaction and proper curing methods to ensure sufficient hydration of the cement.
5. Table B8/7 gives the minimum cement content required when using Portland cement concrete to provide acceptable durability under appropriate conditions of exposure. The reduced minimum cement contents given in Table B8/7 should only be used when trial mixes (para. 8-10) have verified that a concrete with a maximum free water: cement ratio not greater than that given for the particular condition can be consistently produced and that it is suitable for the conditions of placing and compaction.
6. The concrete shall not be made with a water: cement ratio higher than that established in the preliminary tests. If the concrete with this consistency is found to be of insufficient workability for placing in difficult situations and if, with the approval of the Engineer's Representative, the water content must therefore be increased, the cement content shall be increased in the same ratio by weight. Both increases shall be effected at the mixer.
7. Maximum free water: cement ratios are given in Table B8/7 for various exposure conditions.

In general, for reinforced concrete the water: cement ratio shall not exceed 0.65 if concrete of Strength Class 230 is used, and shall not exceed 0.55 if the concrete is of Strength Class 330 or higher.

See also Clause B8 08 for the requirements for Concrete with Special Properties.

TABLE B8/5

DESIGNED MIXES BY CONTRACTOR

Concrete Group mm	Strength Class kgf/cm ²	Minimum cement content in concrete kg/m ³	Minimum cube compressive strength 28 days after mixing		Modulus of Elasticity Tonnes/mm ²
			Preliminary Test kgf/cm ²	Works Test kgf/cm ²	
A/37.5	550	375	640	550	350
A/20	550	405	640	550	
A/10	550	450	640	550	
B/37.5	480	345	550	480	330
B/20	480	360	550	480	
B/10	480	390	550	480	
C/37.5	400	320	480	400	310
C/20	400	335	480	400	
C/10	400	365	480	400	
D/37.5	330	300	400	330	285
D/20	330	315	400	330	
D/10	330	345	400	330	
DX/37.5	230	280	330	230	255
DX/20	230	305	330	230	
DY/37.5	150	260	230	150	240
DY/20	150	285	230	150	

Note: The Modulus values given are indicative not mandatory.

TABLE B8/6
STANDARD MIXES

Class of Concrete denoted by 28 day minimum works cube strength		Weight of dry sand per 50kg cement	Weight of dry gravel of crushed rock coarse aggregate per 50kg of cement (kg)					
kgf/cm ²	kg	Maximum size 10mm	Maximum size 20mm			Maximum size 37.5mm		
Workability Slump (mm) Compacting factor		Low only	Low	Medium	High	Low	Medium	High
		0-6	12.5-25	25-50	50-125	25-50	50-100	100-175
		0.80-0.86	0.82-0.88	0.88-0.94	0.94-0.97	0.82-0.88	0.88-0.94	0.94-0.97
330	65	100	145	115	90	170	135	115
230	100	Not required	190	160	135	225	190	170

NOTES

- (i) If the specific gravity of either the coarse or the fine aggregate differs significantly from the value of 2.6, the weight of each type of aggregate shall be adjusted in proportion to the specific gravity of the materials.
- (ii) The weights are based on the use of sand having a grading within the limits of Zone 2 in BS882 Part 2 (1973).
- (iii) If crushed stone, sand or a crushed gravel sand is used instead of sand, the weight of the coarse aggregate shall be reduced by at least 10kg without altering the weight.
- (iv) The weight of the fine aggregate shall be decreased by at least 10kg if its grading is within the limits of Zone 3 of BS882 Part 2 (1973) and increased by at least 10kg if its grading is within the limits of grading Zone 1 of BS882 Part 2 (1973). Therefore the weight of coarse aggregate shall be increased or decreased, respectively, by the same amount so that the total weight of aggregate remains the same.

B8 08 CONCRETE WITH SPECIAL PROPERTIES

1. General Requirements: The prerequisite conditions for producing concrete with special properties is the durability and impermeability requirements as paragraphs 3-5 in Clause B8 07.

2. Waterproof Concrete: BS5337 (1976) is a Code of Practice for the structural use of concrete for retaining aqueous liquids. It does not cover dams, reinforced concrete and prestressed concrete aqueducts and other structures for the conveyance of liquids. The design information for reinforced and prestressed concrete reservoirs is intended for the guidance of chartered engineers qualified in the use of these materials. The Code is mainly for the storage of water at ambient temperatures, although the standards for durability and impermeability are the main factors influencing the resistance of concrete to leaching, chemical attack, erosion or frost damage and the protection of embedded steel from corrosion are covered for Severe Exposure in Table B8/7 and Table B8/8.

3. No general provision is included for percolation or permeability tests on concrete specimens, since it is difficult for such tests to be performed with truly representative results of the watertightness of the structure. With a cement content not less than the minimum specified the following concrete strengths will give the degree of impermeability adequate for ordinary purposes.

- (a) Concrete Groups A-D in Table B8/5 with nominal maximum size of aggregate to suit reinforcement spacing and cover and not more than 20mm.
- (b) Standard Mix Concrete strength 330 of Table B8/6 with aggregate as (a) and (c).
- (c) Any concrete strength in Table B8/7 using a nominal maximum size of aggregate of 20mm or less as for 'Severe Exposure', when used for the type of concrete listed.

4. Concrete with High Frost Resistance: Concrete which is exposed to alternate freezing and thawing in a moisture saturated condition shall have the minimum cement content and maximum free water:cement ratio as listed under 'Severe Exposure' in Table B8/7.

Frost-resistant aggregates shall be used and the requirements for waterproof concrete as 2 and 3 above apply.

For air-entrained concrete when approved by the Engineer's Representative to be used for concrete roofs, bridge decks or similar exposed structures subject to wear and necessitating resistance to frost damage, the average air content of the fresh concrete with natural aggregates shall be as follows:

- 40mm nominal maximum size 4%.
- 20mm nominal maximum size 5%
- 14mm nominal maximum size 6%
- 10mm nominal maximum size 7%.

The method of adding the air-entraining agent and mixing air-entrained concrete shall be as Clause B8 12-9.

5. Concrete with High Resistance to Chemical Attack. The conditions for ensuring resistance of concrete to chemical attack are the same as given in paragraph 1 above.

For concrete to have a high resistance to 'weak' chemical attack (as Class 1 in Table B8/8) waterproof concrete as Concrete Group D/20 and D/10 as Table B8/5 is required.

For "strong" chemical attack, concrete as Class 2 to 4 in Table B8/8 is required. Concrete which is exposed to 'very strong' chemical attack for a considerable length of time shall

be protected by approved protective coating and the minimum cement content and maximum free water:cement ratio shall be as for "strong" chemical attack concrete.

6. The requirements of the Iraqi Cement Industries for protection regarding Aggressivity to Concrete include specified type of cement, the cement content and that the aggregate shall be 20mm size.

The requirements for dense, fully compacted concrete as Table B8/8 for nominal maximum size of aggregate of 20mm, will give slightly greater protection than the equivalent Iraqi Cement Industries Table.

7. Concrete with High Wearing Resistance. Concrete which is exposed to severe mechanical action, e.g. due to intensive traffic, sliding of bulk materials, frequent impact blows or movements of heavy objects, or due to fast-flowing water carrying solids, or other causes, shall possess high wearing resistance and correspond at least to strength class 400. The cement content should not exceed 350kg/m^3 for a maximum aggregate particle size of 32mm.

The aggregate shall be hard, durable and clean and comply with the requirements of BS1201 Part 2 (1973) Aggregates for Granolithic Concrete Floor Finishes.

The concrete shall be as stiff as possible, in order that when tamped or vibrated there will be no concentration of cement slurry or water in the top layer. The concrete shall be kept moist for at least 7 days after placing.

TABLE B8/7

**MINIMUM CEMENT CONTENT REQUIRED IN PORTLAND CEMENT CONCRETE TO
ENSURE DURABILITY UNDER SPECIFIED CONDITIONS OF EXPOSURE**

Exposure	Reinforced concrete				Prestressed concrete				Plain concrete			
	Nominal maximum size of aggregate (mm)				Nominal maximum size of aggregate (mm)				Nominal maximum size of aggregate (mm)			
	40	20	14	10	40	20	14	10	40	20	14	10
<i>Mild:</i> e.g. completely protected against weather, or aggressive conditions, except for a brief period of exposure to normal weather conditions during construction.	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³
	220	250	270	290	300	300	300	300	200	220	250	270
<i>Moderate:</i> e.g. sheltered from severe rain and against freezing whilst saturated with water. Buried concrete and concrete continuously under water.												
	260	290	320	340	300	300	320	340	220	250	280	300
<i>Severe:</i> e.g. exposed to sea water, moorland water, driving rain, alternate wetting and drying and to freezing whilst wet. Subject to heavy condensation or corrosive fumes.												
	320	360	390	410	320	360	390	410	270	310	330	360

When the maximum free water:cement ratio can be strictly controlled (see Clause B8 07-5) these values may be reduced to:

Exposure	Reinforced concrete				Prestressed concrete				Plain concrete						
	Nominal maximum size of aggregate (mm)			Maximum free water cement ratio	Nominal maximum size of aggregate (mm)			Maximum free water cement ratio	Nominal maximum size of aggregate (mm)			Maximum free water cement ratio			
	40	20	14		10	40	20		14	10	40		20	14	10
	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³		
Mild	200	230	250	260	0·65	300	300	300	300	0·65	180	200	220	240	0·70
Moderate	240	260	290	310	0·55	300	300	300	310	0·55	200	230	250	270	0·60
Severe	290	330	350	370	0·45	300	330	350	370	0·45	240	280	300	320	0·50
Salt used for de-icing	240	260	290	310	0·55	300	300	300	310	0·55	220	250	280	300	0·55

TABLE B8/8
REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK

Class	Concentration of sulphate expressed as SO ₃			Type of cement	Requirements for dense, fully compacted concrete made with aggregates complying with the requirements of BS882			
	In soil		In ground water		Minimum cement content			Maximum free water:cement ratio
	Total SO ₃	SO ₃ in 2 : 1 water extract			Nominal maximum size of aggregate (mm)			
					40	20	10	
1	% Less than 0·2	g/l —	Parts per 100 000 Less than 30	Ordinary Portland	kg/m ³ 240	kg/m ³ 280	kg/m ³ 330	0·55
2	0·2 to 0·5	—	30 to 120	Ordinary Portland	290	330	380	0·50
				Sulphate-resistant Portland	240	280	330	0·55
				Supersulphated	270	310	360	0·50
3	0·5 to 1·0	1·9 to 3·1	120 to 250	Sulphate-resistant Portland or supersulphated	290	330	380	0·50
4	1·0 to 2·0	3·1 to 5·6	250 to 500	Sulphate-resistant Portland or supersulphated	330	370	420	0·45
5	Over 2	Over 5·6	Over 500	Sulphate-resistant Portland or supersulphated plus adequate protective coatings	330	370	420	0·45

NOTE 1. This table applies only to concrete made with aggregates complying with the requirements of BS882 Part 2 (1973) placed in near-neutral groundwaters of pH 6 to pH 9, containing naturally occurring sulphates but not contaminants such as ammonium salts. Concrete prepared from ordinary or sulphate-resistant Portland cement would not be recommended in acidic conditions (pH 6 or less). Supersulphated cement has given an acceptable life provided that the concrete is dense and prepared with a free water:cement ratio of 0.40 or less, in mineral acids down to pH 3.5.

NOTE 2. The cement contents given in Class 2 are the minima recommended by the manufacturers. For SO₃ contents near the upper limit of Class 2 cement contents above these minima are devised.

NOTE 3. Where the total SO₃ in column 2 exceeds 0.5% then a 2:1 water extract may result in a lower site classification if much of the sulphate is present as low solubility calcium sulphate.

NOTE 4. For severe conditions, e.g. thin sections, sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of water:cement ratio and, if necessary, an increase in cement content to ensure the degree of workability needed for full compaction and thus minimum permeability.

NOTE 5. The prescribed mixes given in Table B8/5 may be used where appropriate to meet the requirements of this table and for this purpose the maximum free water:cement ratios of Classes 230 and 330 shall be taken as 0.52 and 0.42 respectively.

Structural Concrete

B8 09 CONCRETE FOR ANCILLARY PURPOSES (CLASS E)

1. Class E concrete shall be composed of ordinary Portland cement and aggregates complying with BS882 Part 2 (1973), including all-in aggregate within the grading limits of Table 3 of the British Standard.
2. The ratio of the combined or all-in aggregate to the cement shall not be more than 8 : 1 by volume or 10 : 1 by weight. No account need be taken of bulking.
3. The concrete shall be mixed by machine or by hand to uniform colour and consistency before placing. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the required location.
4. The concrete shall be compacted by hand or by mechanical vibration.

B8 10 TRIAL MIXES

1. No structural concrete shall be placed in the Works until the relevant mix has been approved by the Engineer's Representative.
2. When the Contractor designs the mix, he shall, at least 35 days before the commencement of concreting, have trial mixes prepared in a laboratory to be approved by the Engineer's Representative. The concrete from each mix shall be tested in accordance with Clause B8 24 and must satisfy the strength requirements of Table B8/5.
3. When the mix has been approved, no variations shall be made in the proportions, the original source of the cement and aggregates, or in the type, size and grading zone of the latter without the consent of the Engineer's Representative who may require further tests to be made.
4. The Engineer's Representative may also require practical tests to be made on the Site by filling trial moulds to confirm the suitability of the mix for the Works. In these tests, the type of plant used for mixing, the method of compaction used, and the formwork face to the mould shall be similar in all respects to those intended for use in the Works.
5. When the Contractor intends to purchase factory-made precast concrete units, the Engineer's Representative may dispense with trial mixes and laboratory tests provided that evidence is given which satisfies him that the factory regularly produces concrete which complies with the Specification. The evidence shall include details of mix proportions, water/cement ratio, workability and strengths obtained at 7 and 28 days.

B8 11 DELIVERY AND STORAGE OF MATERIALS

1. Aggregate for concrete shall not be contaminated by other materials during transport and during storage on site. Aggregates shall be stored on areas covered with tightly laid wood planks, sheet metal, hard compact gravel, or other hard and clean surfaces, and in such a manner that will preclude the inclusion of foreign material. If aggregates are stored on the ground, the bottom layer of aggregates shall not be disturbed or used without recleaning.
2. Coarse aggregate, unless otherwise agreed by the Engineer's Representative, shall be delivered to the Site in separate sizes (2 sizes when the maximum size is 20mm and 3 sizes when the maximum size is 37.5mm or more).
3. All aggregates brought on to the Site shall be kept free from contact with deleterious matter and in the case of aggregates passing a 5mm sieve they shall be deposited on the

site of mixing for not less than 8 hours before use. Aggregates of different sizes shall be stored in different hoppers, or different stockpiles which shall be separated from each other. Stock piles of coarse aggregate shall be built in horizontal layers not exceeding one metre in depth to avoid segregation. Should the coarse aggregate become segregated it shall be remixed to conform to the grading requirements given.

4. Fine aggregate from different sources of supply shall not be mixed or stored in the same stockpiles nor used alternatively in the same class of construction or mix without written permission from the Engineer's Representative.

5. Cement shall be protected from moisture during transport and storage. Bulk transporter vehicles and bins or silos for cement shall not contain any residues of a different type, or of a lower strength class or of any other materials; in doubtful cases this should be carefully checked before filling.

6. Cement shall be stored immediately at the time of delivery at the site of the work in a dry weatherproof shed with a raised wooden floor or in a silo and shall be delivered in quantities sufficient to ensure that there is no suspension or interruption of the work of concreting at any time. If stored in sheds, each consignment shall be kept separate and distinct. Cement in sacks shall be stored in a suitable weatherproof structure which shall be as airtight as practicable: floors shall be elevated above the ground a distance sufficient to prevent the absorption of moisture. Sacks shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls; the manner of storage shall permit easy access for inspection and identification of each shipment. Bulk cement shall be transferred to elevated airtight and weatherproof bins. At the time of use all cement shall be free-flowing and free of lumps. Cement that has been in storage so long that there is doubt of its quality will be tested by standard mortar test to determine its suitability for use and such cement shall not be used without approval.

On small jobs, storage in the open may be permitted by written authorisation from the Engineer's Representative, in which case a raised platform and ample waterproof covering shall be provided.

B8 12 MIXING CONCRETE

1. The weighing and water-dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in BS1305 (1974) and checked against accurate weights and volumes when required by the Engineer's Representative.

2. The weight of cement and each size of aggregate indicated by the mechanisms employed shall be within a tolerance of 2 per cent of the respective weight per batch agreed by the Engineer's Representative. The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in them. The water to be added to the mix shall be reduced by the quantity of free water contained in the fine and coarse aggregates, which shall be determined by the Contractor by a method approved by the Engineer's Representative immediately before mixing begins and further as the Engineer's Representative requires.

3. Unless otherwise agreed by the Engineer's Representative concrete shall be mixed in a batch type mixer manufactured in accordance with BS1305 (1974) or in a batch type mixer, a specimen of which has been tested in accordance with BS3963 (1974) and having a mixing performance within the limits of Table 6 of BS1305 (1974). Where appropriate, the batch capacity method of loading, mixing time and drum speed shall conform to the details

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furnished in accordance with the requirements of BS3963 (1974) for the mix which corresponds most closely to the mix proportions being used. The mixing blades of pan mixers shall be maintained within the tolerances specified by the manufacturer of the mixer and the blades shall be replaced when it is no longer possible to maintain the tolerances by adjustment.

4. The entire contents of the mixer shall be removed from the drum before materials of a succeeding batch are placed therein. The materials composing a batch shall be deposited simultaneously in the mixer. No mixer having a rated capacity of less than 1-bag batch shall be used nor shall a mixer be charged in excess of its rated capacity.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Unless otherwise agreed by the Engineer's Representative the first batch of concrete through the mixer shall contain only two-thirds of the normal quantity of coarse aggregate. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another. Concrete which has developed initial set or partially hardened shall not be used or re-mixed.

5. The temperature of water and cement when added to the mix shall not exceed 80°C and 65°C respectively. If the temperature of the water exceeds 60°C it shall be mixed with the aggregates before the cement is added.

6. Concrete shall not be mixed when the air temperature in the shade is below 3°C unless special precautions are taken which have been approved by the Engineer's Representative. No frozen material or materials containing ice shall be used.

7. During hot weather the Contractor shall ensure that the constituent materials of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position.

8. When air-entrained concrete is specified or authorised by the Engineer to meet the requirements for frost resistant concrete as included under Concrete with Special Properties as Clause B8 08 the average air content shall be as specified in that Clause.

9. The air content shall be determined at least 6 times per day by a pressure type air meter approved by the Engineer's Representative including all such times as test specimens are made to determine compliance with Clause B8 08. If any such determination of air content gives a result outside the permitted range, a further test shall be made immediately and the average and range of the two results shall be calculated. If the average air content is greater or less than the limits specified or the individual values vary by more than 5 per cent, before any further concrete is used in the Works, the Contractor shall take such steps as may be agreed with the Engineer's Representative to adjust the air content of the concrete or improve its uniformity.

The air-entraining agent shall be added at the mixer, batched in solution in a portion of the mixing water by means of a mechanical batcher capable of dispensing the agent in quantities varying by not more than 5 per cent quantities required and in such a manner as to ensure uniform distribution of the agent throughout the batch during the time of mixing. Before commencement of concreting operations, the Contractor shall demonstrate to the Engineer's Representative the capability of the apparatus to dispense the agent accurately and the capability of the agent to produce the specified air content. The accuracy of the dispensing apparatus shall be checked each day before concrete mixing starts and mixing shall not commence until the apparatus is working accurately.

10. Mixing at a central plant shall conform to the requirements of this Clause. Hand mixing when authorised by the Engineer's Representative shall be on a watertight platform.

B8 13 READY-MIXED CONCRETE

1. Ready-mixed concrete, batched off the Site, may be used only with the agreement of the Engineer's Representative and shall comply with all requirements of the Contract.

2. The concrete shall be carried in purpose-made agitators, operating continuously, or truck mixers. The concrete shall be compacted and in its final position within 1 hour of the introduction of cement to the aggregates, unless a longer time is agreed by the Engineer's Representative. The time of such introduction shall be recorded on the delivery note together with the weight of the constituents of each mix.

3. When truck-mixed concrete is used, water shall be added under supervision, either at the Site or at the central batching plant, as agreed by the Engineer's Representative but in no circumstances shall water be added in transit.

4. Unless otherwise agreed by the Engineer's Representative, truck mixer units and their mixing and discharge performance shall comply with the requirements of the Employer.

B8 14 TRANSPORT AND PLACING

1. The method of transporting and placing concrete shall be to the approval of the Engineer's Representative. Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.

2. All formwork and reinforcement contained in it shall be clean and free from standing water, snow or ice immediately before the placing of the concrete and all sawdust, construction debris and other extraneous matter removed.

3. Concrete shall not be placed in any part of the structure until the Engineer's Representative's approval has been given.

4. If concreting is not started within 24 hours of approval being given, approval shall again be obtained from the Engineer's Representative. Concreting shall then proceed continuously over the area between construction joints. Fresh concrete shall not be placed against in-situ concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with Clause B8 17. When in-situ concrete has been in place for 4 hours, or less as directed by the Engineer's Representative, depending upon the mix, type of cement and weather conditions, no further concrete shall be placed against it for a further 20 hours.

5. Concrete, when deposited, shall have a temperature of not less than 5°C and not more than 32°C. It shall be compacted in its final position within 30 minutes of discharge from the mixer unless carried in purpose-made agitators, operating continuously, when the time shall be within 2 hours of the introduction of cement to the mix and within 30 minutes of discharge from the agitator.

6. Except where otherwise agreed by the Engineer's Representative, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 45cm where internal vibrators are used or 30cm in all other cases.

7. Unless otherwise agreed by the Engineer's Representative, concrete shall not be dropped into place from a height exceeding 2 metres. When trunking or chutes are used they shall be kept clean and used in such a way as to avoid segregation.

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8. No concrete shall be placed in flowing water. Underwater concrete shall be placed in position by tremie tube, or by pipeline from the mixer. Full details of the method proposed shall be submitted in advance to the Engineer's Representative and his approval obtained before placing begins. Where the concrete is placed by a tremie tube, its size and method of operation shall be in accordance with BS Code of Practice, CP2004 (1972), Foundations. During and after concreting under water, pumping or dewatering operations in the immediate vicinity shall be suspended until the Engineer's Representative permits them to be continued.

B8 15 PUMPING CONCRETE

1. Placement of concrete by pumping will be permitted only if specified in the Special Specification of Particular Application and in the Bill Of Quantities, or if authorised by the Engineer's Representative in writing after approval of a modified mix design and preliminary trials as specified.

2. Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work and shall be so arranged that no vibrations result which might damage freshly placed concrete. The operation of the pump shall be such that a continuous stream of concrete remaining in the pipeline, where it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

B8 16 COMPACTION OF CONCRETE

1. All concrete, during and immediately after depositing, shall be thoroughly compacted to produce a dense homogeneous mass. Unless otherwise agreed by the Engineer's Representative it shall be compacted with the assistance of mechanical vibration subject to the following provisions:

2. The vibration shall be internal unless special authorisation for an alternative method is given by the Engineer's Representative in writing. In special places external vibrators may be prescribed by the Engineer's Representative.

Vibrators shall be of a type and design approved by the Engineer's Representative. They shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4,500 impulses per minute. The intensity of vibration shall be such as visibly to affect a mass of concrete of 5cm slump over a radius of at least 45cm.

A sufficient number of vibrators in serviceable condition shall be on site so that spare equipment is always available in the event of breakdown.

3. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity thoroughly to compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localised areas of grout are formed. Where immersion type vibrators are used, contact with reinforcement and all inserts shall be avoided, so far as is practicable.

Vibration shall not be applied by way of the reinforcement to sections or to layers of concrete which have hardened to the degree that the concrete ceases to be plastic under

vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.

Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete, along surfaces and in corners and locations impossible to reach with the vibrators.

Concrete shall not be subjected to vibration between 4 and 24 hours after compaction.

4. The provisions of this clause shall also apply to precast members except that, if approved by the Engineer's Representative, external vibration or manufacturer's methods of vibration may be used.

B8 17 CONSTRUCTION JOINTS

1. The position and detail of any construction joints not described in the Contract shall be subject to the approval of the Engineer and shall be so arranged as to minimize the possibility of the occurrence of shrinkage cracks.
2. The upper surface of lifts of concrete walls and columns shall be horizontal unless otherwise described in the Contract and if the formwork extends above the joint on the exposed face it shall be cleaned of adhering concrete before the next lift is placed.
3. Where a construction joint contains a formed surface, that surface shall be roughened to expose the aggregate without damaging the aggregate and the arrises of the joint.
The roughened surface shall then be washed with clean water to remove loose particles.
4. Where sections of the work are carried out in lifts, the reinforcement projecting above the lift being cast shall be adequately supported so as to prevent movement of the bars during the casting and setting of the concrete.
5. Wherever possible, laitance and all loose material shall be removed while the concrete is still green and no further roughening shall then be required. Where this is not possible, it shall be removed by mechanical means provided the concrete has been in position for more than 24 hours.

The roughened surface shall then be washed with clean water.

6. To avoid joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a 'feather edge' might be produced at a construction joint, as in the sloped top surface of a wing wall, an insert formwork shall be used to produce a blocked out portion in the preceding layer which shall produce an edge thickness of not less than 15cm in the succeeding layer. Work shall not be discontinued within 45cm of any surface face unless provision is made for a coping 45cm thick, in which case, if permitted by the Engineer's Representative, the construction joint may be made at the underside of the coping.
7. Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed on the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddle into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.
8. Construction joints in concrete for retaining aqueous liquids do not usually require water stops, but the joint may be sealed on the water face if required by the Engineer's Representative. If complete continuity cannot be obtained at a construction joint, it should be treated as a movement joint in accordance with the detail shown on the Drawings.

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When a sealing hammer or other mechanical device is used to remove laitance, care should be taken to avoid the use of excessively powerful hammers as these are likely to damage the concrete by dislodging or fracturing the aggregates.

B8 18 CURING CONCRETE

1. Immediately after compaction and for 7 days thereafter, concrete shall be protected against harmful effects of weather, including rain, rapid temperature changes, frost and from drying out.

The methods of curing and their duration should be such that the concrete will have satisfactory durability and strength and the member will suffer a minimum of distortion, be free of excessive efflorescence and will not cause, by its shrinkage, undue cracking in the structure. To achieve these objectives, it may be necessary to insulate the concrete so that it is maintained at a suitable temperature, or so that the rates of evaporation of moisture from the surfaces are kept to appropriate values, or both. Different curing or drying treatments will be appropriate to different members and products. Where necessary special care should be taken to ensure that similar components are cured as far as possible under the same conditions.

2. Curing usually consists of maintaining the formwork in place and covering the concrete with a material such as straw, hessian, sand, polyethylene sheet or a curing compound or with an absorbent material which is kept damp. The type of covering provided shall be that which in the judgement of the Engineer's Representative is best suited to the conditions.

Where structural members are of considerable depth or bulk or have an unusually high proportion of cement or are precast units subjected to special or accelerated curing methods, the method of curing shall be as directed by the Engineer's Representative.

For prestressed concrete the period of curing may have to be extended until sufficient prestressing force has been applied.

3. As membrane curing compounds may affect the subsequent treatment or finish of the surface of the concrete, their use requires to be approved by the Engineer's Representative before they are adopted. On concrete surfaces which are to be waterproofed, curing membranes shall not be used.

The higher the rate of development of strength in concrete, the greater the need to prevent excessive differences in temperature within the member and too rapid loss of moisture from the surface. Alternate wetting and drying should be avoided, especially in the form of cold water applied to warm concrete surfaces. In order to avoid surface cracking, cold water should not be applied to relatively massive members immediately after striking the formwork while the concrete is still warm.

Alternatively the Engineer's Representative may approve accelerated curing (which includes steam curing) and consists of curing the concrete in an artificially controlled environment, in which the humidity and the rate of temperature rise and fall are controlled, to speed up the rate of increase in strength. For elevated-temperature curing 4 hours must elapse from the completion of the placing of the concrete before its temperature is raised. The rise in temperature within any period of 30 minutes shall not exceed 10°C and the maximum temperature attained shall not exceed 70°C. The rate of subsequent cooling shall not exceed the rate of heating.

4. For supersulphated cement, curing in low pressure steam up to a maximum temperature of 50°C is acceptable. Curing above 50°C should only take place if evidence of satisfactory performance is available.

Concrete containing embedded metal or calcium chloride should not be cured above 60°C.

5. If in exceptional conditions and in the judgement of the Engineer's Representative, it becomes necessary to use direct water spray on formwork to ensure curing, the Contractor shall provide a suitable pump, piping, hose, and a sufficient number of sprinkling heads so that all forms shall be thoroughly and continuously sprinkled with water for at least 12 hours before placing concrete therein. The sprinkling system shall be so arranged that the outside of all forms can be kept damp for a period of seven days after the placing of concrete inside the forms, it being the purpose of this Specification that the form be kept damp enough so that no moisture is taken away from the concrete by forms.

Details of all curing methods to be used shall be subject to the approval and direction of the Engineer's Representative.

B8 19 EARLY LOADING

1. Except for the provisions of Section B9, concrete shall at no time be subjected to loading, including its own weight, 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.

2. For the purpose of this Clause, the assessment of the strength of the concrete and the stresses produced by the loads shall be subject to the agreement of the Engineer's Representative.

B8 20 HANDLING, PLACING AND STORAGE OF PRECAST REINFORCED MEMBERS

1. Members shall be lifted or supported only at points described in the Contract and shall be handled and placed without impact.

2. When members are stored, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses.

B8 21 MANUFACTURE OF PRECAST REINFORCED MEMBERS OFF THE SITE

1. The Engineer's approval to the method of manufacture shall be obtained before work is started. When the method has been approved, no changes shall be made without the consent of the Engineer.

2. The Contractor shall inform the Engineer's Representative in advance of the date of commencement of manufacture and casting of each type of member.

3. A copy of all 28 day cube test results relating to the work shall be sent to the Engineer's Representative as soon as they become available.

4. Where the Engineer's Representative requires tests to be carried out, no members to which the tests relate shall be despatched to the Site until the tests have been satisfactorily completed.

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5. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast and, if they are of symmetrical section, the face which will be uppermost when the member is in its correct position in the Works.

The markings shall be so located that they are not exposed to view when the member is in its permanent position.

B8 22 POROUS NO-FINES CONCRETE

1. No-fines concrete shall be composed of ordinary Portland cement and 37 • 5mm single size aggregate complying with BS882 and 1202 Part 2 (1973)
2. The ratio of aggregate to cement shall be 8 : 1 by volume or 10 : 1 by weight.
3. The concrete shall be mixed by machine or by hand to a uniform colour and consistency before placing. The quantity of water used shall not exceed that required to coat all of the aggregate particles without forming excess grout.
4. The concrete shall be compacted by hand only.

B8 23 SAMPLING CONCRETE

1. For approval of sources and types of material and plant, the provision of Clause R1 05 will apply.

Sampling shall be in accordance with the requirements given in BS1881 Part 1 (1970).

A single batch sampling procedure shall be adopted and the number, frequency and location of batches to be sampled shall be decided by the Engineer's Representative.

B8 24 TESTING OF CONCRETE FOR STRUCTURES

1. Where a batch has been sampled for the purpose of making cube tests, 1 cube shall be made from each of the 3 samples for test at 28 days. The cubes shall be made, cured and tested in accordance with BS1881 Part 3 (1970). They shall be tested in a laboratory approved by the Engineer's Representative who shall receive certified copies of the results of all tests.
2. The appropriate strength requirements for each set of 3 cubes shall be satisfied if none of the strengths of the 3 cubes is below the cube strength specified in Tables B8/5 or B8/6 or if the average strength is not less than the specified cube strength and not more than one cube in each set of three cubes has less than the cube strength specified by more than 20%.
3. Where a batch has been sampled for the purpose of determine the workability of the concrete, 1 test shall be made on each sample by compacting factor apparatus or 'V-B' consistometer slump test in accordance with BS1881 Part 2 (1970) or other method approved by the Engineer's Representative. For a designed mix, the workability of the concrete shall correspond to that of the accepted trial mix within the following limits:

Compacting factor ± 0.03

'V-B' consistometer ± 3 seconds or ± 15 per cent of the average time, whichever is the greater.

Slump test ± 10 mm.

For standard mixes the workability tolerances shall be as described in Table B8/6.

4. The methods of testing of, fresh concrete, making and curing test specimens, concrete for strength and hardened concrete for other than strength, shall be in accordance with the requirements given in BS1881 Parts 2, 3, 4 and 5 (1970) and 6 (1971), respectively.

B8 25 INSPECTION AND TESTING OF PRECAST CONCRETE UNITS

1. The inspection and testing of precast concrete units shall be in accordance with BS Code of Practice CP116 (1969) The Structural Use of Precast Concrete. Special tests for pretensioned beams which are to be used in composite construction shall comply with Clause B9 17.

B8 26 SPRAYING OF MORTAR AND CONCRETE

1. **General:** This clause deals with mortar and concrete applied pneumatically through a suitable nozzle otherwise known as Guniting or Shotcrete using suitable equipment and competent operators.

2. **Materials:** Fine aggregate shall consist of washed sand and shall be hard, dense, durable, clean, sharp and graded in accordance with BS882 Part 2 (1973) Zone 2. Where Zone 2 sand is not available, the use of Zones 1 and 3 may be permitted if it can be demonstrated that the material is suitable. In no circumstances shall the amount of material passing 0.2mm sieve exceed 5%.

Coarse aggregate shall also comply with BS882 Part 2 (1973) and the maximum size used shall be compatible with the machinery being used.

3. **Mix Proportions:** Unless otherwise specified in the Special Specification for Particular Application, the mix proportions shall be as follows.

Sprayed Mortar/Guniting shall consist of 1 part of cement to 3½ parts of sand proportioned by weight.

Sprayed Concrete/Shotcrete shall consist of 1 part cement to 1 part coarse aggregate and 3 parts of Zone 2 sand of Table BS882 Part 2 (1973).

4. Unless otherwise specified the minimum compressive strength at 28 days shall be 300kgf/cm².

5. **Reinforcement:** The provision of Section B7 Reinforcement for Structures will apply, together with the following requirements.

Bar, mesh or fibre reinforcement shall be included or omitted as required by the Engineer and shall be securely fixed in place as indicated by the Specification or on the Drawings.

The minimum cover shall be 15mm from any formwork, concrete and masonry and 25mm from the finished sprayed surface or specified by the Engineer and the minimum clearance between parallel bars shall be 4 diameters and at splices 2 diameters, but not less than 30mm.

No bar in excess of 25mm diameter shall be used and all fibre reinforcement shall be proportioned, mixed and placed in accordance with the suppliers instructions.

6. **Equipment:** The mixing equipment and its maintenance shall be in accordance with Clause B8 12 and the operating and placing equipment shall be to the following requirements:

A properly operating air compressor of ample capacity is essential to a satisfactory guniting operation. The Contractor's compressor shall maintain a supply of air adequate to maintain sufficient nozzle velocity for all parts of the work while simultaneously operating a blowpipe for clearing away rebound if required.

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The delivery equipment shall be of a pneumatic feed type and shall be of a design and size which has given good results in similar work. The equipment shall be capable of delivering a continuous smooth stream of uniformly mixed material at the proper velocity from the discharge nozzle at all heights of the work.

The delivery equipment shall be thoroughly cleaned at the end of each shift. Equipment parts, especially the nozzle liner and water ring, shall be regularly inspected and replaced as required.

The discharge nozzle shall be equipped with a manually operated water injection system (water ring) for directing an even distribution of water to the sand/cement mixture. The water valve shall be capable of ready adjustment to vary the quantity of water and shall be convenient for the nozzleman.

Water pressure shall be maintained at a uniform level which shall be at least 1 kgf/cm² above operating pressure and sufficient to ensure adequate hydration at all times.

The nozzle shall be capable of delivering a conical uniform discharge stream. Distortion of this stream shall be remedied by examination of the nozzle and any malfunction rectified by replacement of defective parts before further work is carried out.

7. Trial Testing Panels: When specified in the Contract and subject to the approval and direction of the Engineer's Representative four test panels 60cm x 80cm x 10cm thick, will be constructed, one of which shall contain a layer of reinforcement if specified. Two panels will be shot vertically and two overhead. One panel from each plane will be cut out to examine the compaction and rebound factors before final set. The other two panels will be stored, cured and tested at seven days. Only when the operator has demonstrated his expertise will he be permitted to carry out permanent work.

8. Only nozzlemen who have satisfied the initial test panel requirements will be permitted to carry out spraying. For the purpose of routine quality, control of test panels will be limited to one per nozzleman per week or one per 100 cubic metres of material placed as required by the Engineer's Representative. The test panels shall be constructed alongside the area of placement and at the same angle and shall be made by each nozzleman in rotation so that the tests shall represent the quality of the Guniting/Shotcrete being placed by each nozzleman. The test panels will be marked, cured and tested in accordance with the requirements of the Employer.

The Contractor shall employ a supervising working foreman full time on the work. He shall have adequate experience in and full knowledge of spraying techniques and shall preferably have had at least five years specialist spraying experience including two years as a nozzleman.

9. Spraying of Guniting/Shotcrete: The reinforcement shall be cleaned of any previously deposited rebound material which might prevent a proper bond and immediately prior to the application of spraying, all surfaces shall be thoroughly cleaned with a strong blast of air, or air and water.

The thickness and the alignment of the sprayed material shall be controlled whether by screed boards or guide wires or other means agreed with the Engineer's Representative.

10. Each layer of Guniting/Shotcrete shall be built up by making several passes of the nozzle over the working area. The Guniting/Shotcrete shall emerge from the nozzle in a steady uninterrupted flow. Should the flow become intermittent for any cause the nozzleman shall direct it away from the work until it again becomes constant.

11. The distance of the nozzle from the work shall be between 60cm and 150cm. It shall, as a general rule, be held perpendicular to the application surface. However, when shooting through reinforcing bars the nozzle shall be held closer and at a slight angle in order to permit encasement and facilitate the removal of rebound material.

12. For vertical and near vertical surfaces application shall commence at the bottom. The first layer shall at least completely embed the reinforcement. Layer thickness shall be governed mainly by the requirement that the material should not sag. Where thick layers are applied it is important that the top surface be maintained at a slope of approximately 45 degrees.

Where necessary a layer of Guniting/Shotcrete may be covered by succeeding layers, but it shall first be allowed to take its initial set. All laitance, loose material and rebound must first be removed. Any laitance which has been allowed to take final set shall be removed by grit blasting. The surface shall be finally cleaned and wetted using a strong blast of air and water.

13. The area of placement shall be kept free of rebound at all times. Where necessary an air jet will be employed. Rebound pockets, sags or other defects shall be cut out and made good to the Engineer's Representative's satisfaction. Under no circumstances shall rebound material be worked back into the construction.

14. Construction Joints, Surface and Weather. Construction joints shall be tapered to a thin edge at approximately 30 degrees or cut back square to the reinforcement and then tapered at 30 degrees, unless specifically instructed by the Engineer's Representative. No square joints will be allowed. The entire joint shall be thoroughly cleaned and wetted prior to the placement of adjacent sprayed material.

15. Suitable screening of the nozzle and the application surface shall be provided during periods of windy or draughty conditions.

The surface of Guniting/Shotcrete should be left as shot. Any finishing of the surface may change the characteristics and be detrimental to its strength. If another, special, surface texture is required, a second working process is to be used by applying a layer of mortar, reworked and finished to the desired texture.

16. No Guniting/Shotcrete shall be placed when the air temperature is below 1°C rising or 2°C falling. All aggregates shall be protected from frost.

17. Guniting/Shotcrete shall be cured in accordance with the recommendations set out in BS Code of Practice CPI 10 Part 1 (1972).

Spraying of mortar or concrete for tunnel linings, rehabilitation works such as covering over, or strengthening of concrete slabs, concrete masonry and brickwork, or repairs to a reinforced concrete structure will be subject to additional clauses as the Special Specification of Particular Application.

B8 27 MEASUREMENT AND PAYMENT

The payment for concrete of the various classes shall include compensation for all equipment tools, materials, falsework, forms (unless items for formwork are included in the Bill of Quantities), bracing, labour, normal surface finish, unless special items for finish are provided in the Bill of Quantities and all other items of expense required to complete the concrete work shown on the Drawings, with the exception of reinforcement steel, metal expansion plates, or other metal incorporated in the work.

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Payment will be made on the basis of the actual cubic metres, except for members which are measured per square metre or per number (as prefabricated girders), or linear metre (as box culverts), within the net lines of the structure as shown on the Drawings or revised by written authority of the Engineer's Representative, except that deductions shall be made for the volume of embedded structural steel. No deductions will be made for the volume of metal reinforcement. Unless otherwise provided in the Bill of Quantities, payment for concrete will include for waterproofing, joint filler, or other similar materials shown on the Drawings or called for in the Specification. Payment for pneumatically applied mortar or concrete shall include compensation for all equipment, tools, materials, labour and incidentals necessary to complete the work and shall include metal reinforcement unless otherwise provided.

SECTION B9

PRESTRESSING FOR STRUCTURES

B9 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour, and in performing all operations in connection with prestressing, complete subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B9 02 PRESTRESSING SYSTEMS

1. The Contractor shall be free to choose the prestressing system or systems, provided he introduces no changes in the position of the centroid of the total prestressing force over the length of the member and in the magnitude of the final effective prestressing force as prescribed on the Drawings. The prestressing system chosen by the Contractor shall have been indicated in the Tender. In all cases the following conditions shall have to be fulfilled:

- (i) Before concreting any part of the structure destined to be prestressed, the Contractor shall submit the full details of the method, the material and the equipment he intends to use in the prestressing operations for the approval of the Engineer's Representative.
- (ii) Such details shall comprise the construction and operational procedure, indicate the full specification of the prestressed steel, anchorages, type of sheaths, accessories, other components and all remaining data relative to the prestressing operations.

2. The Contractor shall place at the disposal of the Engineer's Representative, free of charge, a team specialised in the proposed prestressing method, including at least one higher grade expert in order to furnish the necessary help and instructions during the whole construction period of the structure.

3. The final prestressing forces indicated on the Drawings represent the required stresses independently from the losses due to the prestressing system.

If the system proposed by the Contractor requires any modification in the number, form or dimensions of the detailed reinforcement, he shall have to present sufficiently detailed drawings and calculations for the approval of the Engineer's Representative. In all cases the indispensable condition is that the total cost of the steel involved does not exceed the original as detailed taking into account any additional expenditure by the Employer in checking the system.

4. Independently from the prestressing system to be applied, the following points have to be ensured.

- (i) The safety of the anchorages of the prestressing tendons and their suitability for the transmission of forces to the concrete under all loads whatsoever.
- (ii) That the actual losses due to friction coincide with the calculated ones for the prestressing.
- (iii) The suitability of the proposed steel for the chosen prestressing system.

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- (iv) The length of transmission of the force to the concrete and the minimum strength of the latter necessary for prestressing in systems where the prestressing elements are fully or partially anchored to the concrete through bond and friction.
- (v) The suitability of measures taken to protect prestressing tendons from corrosion until the final tensioning is carried out.

An Agreement certificate for the prestressing system shall be submitted and approved by the Engineer's Representative before any structural member to be prestressed may be tensioned; this Agreement certificate must be issued by an authorised testing laboratory. Otherwise the Engineer's Representative may order such an Agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this Agreement certificate hereinafter are subject to the approval of the Engineer's Representative.

B9 03 STANDARD SPECIFICATIONS

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the listed British Standards Institution's publications.

BSCP116 (1969) The Structural Use of Precast Concrete.
BS12 Part 2 (1971) Portland Cement (Ordinary and Rapid-hardening) and Part 6 (1971).
BS1881 Parts 1-5 (1970) Methods of Testing Concrete.
BS4447 (1973) The Performance of Prestressing Anchorages, etc.
BS2691 (1969) Steel wire for Prestressed Concrete.
BS4486 (1969) Cold Worked High Tensile Alloy Steel Bars, etc.
BS4757 (1971) Nineteen-wire Steel Strand, etc.
BS3617 (1971) Seven-wire Steel Strand, etc.
BS5400 (1978) Steel, Concrete and Composite Bridges.

B9 04 MATERIALS AND EQUIPMENT

1. Steel Tendons for Prestressed Concrete:

- (i) Steel wire shall comply with the requirements of BS2691 (1969).
- (ii) Cold worked high tensile alloy steel bars for prestressed concrete shall comply with the requirements of BS4486 (1969).
- (iii) Stress relieved seven-wire strand shall comply with the requirements of BS3617 (1971) or have properties which are not inferior.
- (iv) Nineteen-wire steel strand shall comply with the requirements of BS4757 (1971).
- (v) Where directed by the Engineer's Representative, the Contractor shall arrange for samples of the steel intended for use in the Works to be tested at an approved independent testing laboratory.
- (vi) Wire and strand shall be supplied in coils of sufficient diameter to ensure that they lie out straight.
- (vii) Only prestressing steel and prestressing systems shall be used which have previously been approved by the Engineer.
- (viii) For each shipment, consignment or delivery of prestressing steel the supplier shall provide packing and identification metal tags giving the details, test results and method of ordering as listed in BS2691 (1969), 3617 (1971), and 4486 (1969).

- (ix) Steel and tendons without adequate identification and test certificates shall not be used and will be removed from the site within 24 hours.

2. Sheaths for Prestressed Concrete: All sheaths shall be either as described in the Contract or of form, gauge and dimensions appropriate to the prestressing system employed, subject to the approval of the Engineer.

3. Jacks for Prestressing:

- (i) All jacks used for prestressing shall be of the type applicable to the system adopted.
- (ii) The accuracy of all load measuring equipment shall be checked to the satisfaction of the Engineer's Representative at the start of work each day it is to be used and whenever the equipment is moved to a different jack.

4. Anchorages: The Contractor will obtain from the anchorage supplier and submit to the Engineer's Representative, a statement giving details of the anchorages and that they comply with the minimum requirements of BS4447 (1973).

5. Grout for Ducts

- (i) Unless otherwise directed or agreed as a result of grouting trials, the grout shall:
 - (a) consist only of ordinary Portland cement to BS12 Part 2 (1971) as fresh as possible and preferably not more than 1 month old, and water.
 - (b) have a water:cement ratio as low as possible consistent with the necessary workability, and under no circumstances shall the water:cement ratio exceed 0.45.
 - (c) not be subject to bleeding in excess of 2 per cent after 3 hours or 4 per cent maximum when measured at 18°C in a covered glass cylinder approximately 10cm diameter with a height of grout of approximately 10cm, and the water shall be re-absorbed after 24 hours.

The compressive strength of hardened grout shall not be less than 170kgf/cm² after 7 days at a temperature 18°C when making preliminary trials for quality.

- (ii) Admixtures containing chlorides or nitrates shall not be used; other admixtures may be used only with the written permission of the Engineer's Representative and shall be applied strictly in accordance with the manufacturer's instructions.
- (iii) The grout shall be mixed for a minimum of 2 minutes and until a uniform consistency is obtained.
- (iv) The maximum unrestrained expansion shall not exceed 10%.

6. Plant for grouting of ducts:

- (i) The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a sensible constant pressure up to 7kgf/cm² and shall include a system of circulating or agitating the grout whilst actual grouting is not in progress. All baffles to the pump shall be fitted with sieve strainers of 1.0mm nominal aperture size to BS410 (1969).
- (ii) The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a nozzle which can be locked off without loss of pressure in the duct.

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- (iii) The pressure gauges shall be calibrated before they are first used in the Works and thereafter as required by the Engineer's Representative. All equipment shall be thoroughly washed with clean water at least once every 3 hours during the grouting operations and at the end of use for each day.

B9 05 GENERAL

1. Prestressing operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use. In addition to the normal precautions against accident which should be taken at all times for the whole of the Works, special precautions shall be taken when working with or near tendons which have been tensioned or are in the process of being tensioned.

2. During the prestressing operations, standing behind or under the jack will not be permitted in order to ensure that no one is injured by the flying spindle, tendon or the jack in the event of a break occurring.

3. On continuous structures work on adjacent bays must be stopped during the stressing operations unless baffle walls are built to protect the workman. The cost of baffle walls is to be included in the rates for prestressing.

B9 06 TRANSPORTING AND STORAGE

1. When tendon materials are to be transported by ship to the Site, they shall be crated or wrapped, and for road transport the vehicles shall be closed or covered by waterproof canvas. Trucks and containers used to transport tendons must be carefully cleaned before tendons or tendon materials are loaded into them. Care must also be taken in loading or off-loading to ensure that they are not damaged.

2. For each shipment of prestressing steel the suppliers shall furnish a certificate, signed by an authorised employee and/or laboratory. The certificate of analysis shall show the test results for all the specified requirements and in addition the net weight for each shipment. The certificates shall be submitted to the Engineer's Representative.

Each shipment of prestressing steel shall be identified with a metal tag, which shows the manufacture, the steel quality, the dimensions, the smelting number, the project number and the date.

Steel and tendons without a certificate shall not be used and shall be removed from the site within 24 hours.

3. The storage place shall be prepared in advance and the protection of materials before tendon fabrication and installation will be as follows:

Wire, strand and bars from which tendons are to be fabricated shall be stored off the ground and under cover in a clean, dry condition. Any covers for this purpose must not touch the steel. Special care shall be taken of all bar threads.

4. Prestressing components shall be stored in clean dry conditions. They shall be clean and free from loose rust and loose mill scale at the time of fixing in position and subsequent concreting. Slight rusting of the steel is acceptable, but the surface shall not be pitted.

Tendons and metal sheathing stored on site shall be periodically examined for damage and corrosion, normally at monthly intervals and before starting tendon fabrication and any damage made good and corrosion protection maintained.

5. Protection from Mechanical Damage: Storage facilities and the procedures for transporting material into or out of store shall not permit the tendons to be kinked or notched.

When materials for use in non-bonded construction are supplied with, for example, a plastic or a wrapped paper cover, the storage and handling, and the initial packing procedures shall not cause nor permit damage to the coating.

Wire and strand shall be stored in large diameter coils which enable the tendon to be paid out straight. The diameter of coils should not generally be less than $200d$ where 'd' is the diameter of the wire, or of the largest wire in the strand.

6. Protection from Chemical and Electro-Chemical Corrosive Attack: The storage facility shall preferably have a concrete floor. It shall be provided with sufficient ventilation to minimise condensation or, particularly where storage for a long period is required, it shall be maintained at a minimum temperature of 15°C when necessary by dry heating (i.e. by heated air with humidity of about 70%). Alternatively where technically acceptable, greases, oils, sodium silicate or vapour-phase inhibiting materials may be used.

Where specified for the purpose of giving protection from corrosion and reducing friction, tendon materials shall be coated with a water-soluble oil such as Shell Dromus B, Caltex Soluble RGBF, Mobil Solvag 1535 or other approved not containing harmful additives. The oil shall be applied whilst the steel is in a bright condition.

Exposure to sunlight for long periods may cause the oil to oxidise and solidify making subsequent removal difficult.

The coated steel shall be maintained in a clean condition during handling, transporting and storing, and shall not be exposed to rain or high humidity.

7. Anchorages: The handling and storing procedures must maintain the anchor components in a condition in which they can subsequently perform their functions satisfactorily. Components shall be handled and stored so that mechanical damage and corrosion are prevented.

Loose corrosion products are detrimental. Only light corrosion deposits are permissible on threaded components. Corrosion of the gripping and securing systems must be prevented. The instructions of the system supplier regarding storage of gripping components must be followed.

The use of correctly formulated oils or greases, or of other corrosion inhibiting material is recommended where prolonged storage is required. Such protective material should be guaranteed by the manufacturer to be non-aggressive and non-degrading.

Anchor components shall be periodically examined, say at three-monthly intervals. Any deterioration or removal or corrosion-inhibiting material shall be made good.

B9 07 PRESTRESSING TENDONS

1. Tendons shall be built into the Works strictly in accordance with the system which is being employed.

Procedures for tendon fabrication must include methods of marking and documentation which maintain the identification of all materials.

Prestressing steel delivered with the manufacturer's guarantee and certificate shall be identified against such documentation before use. If such identification cannot be established, acceptance tests shall be carried out on samples.

Prestressing for Structures

All materials shall be checked before use. After prolonged site storage, or where there is any other doubt in serviceability, the tendon material shall be checked to show that its properties have not been significantly impaired.

If tendon material for non-bonded work already carries a sheath of paper, plastic or similar, the integrity of this coating shall also be checked and any damage made good.

Tendons must not be bent tightly during or after fabrication. Adequate safety precautions must be maintained. In particular, care must be taken when releasing the ends of wire or strand coils or packs.

The fabrication procedures must not cause any mechanical damage to the tendons.

Any tendon material found to be bent or kinked at fabrication shall not be straightened, but shall be rejected unless tests are made which show that the damage is not detrimental. No strand which has become unravelled shall be used in the Works.

Normally tendon materials are cut by shear, saw or abrasive disc, but if oxy-acetylene flame cutting is permitted, an excess length of 12 times the diameter of wire or strand shall be provided sufficient to ensure that the material which will be under stress has not been metallurgically affected.

Fabrication shall be carried out clear of the ground and under cover.

Tendon material shall be maintained in a clean condition.

Where required for a particular system for both bonded and non-bonded work, the ends of the tendon shall be prepared at fabrication for subsequent stressing and anchoring.

B9 08 SHEATHS AND EXTRACTABLE CORES

There must be sufficient concrete between parallel ducts to prevent the flow of grout from one duct to the other. If the distance between crossing cores used to form ducts is small, a metal strip or similar shall be placed between them.

On completion of the installation of the ducts and immediately before concrete is placed, sheathing shall be inspected for any signs of damage which could permit the ingress of concrete materials into the duct, or could otherwise cause subsequent difficulties in stressing or grouting.

All sheaths and cores shall be maintained in their correct positions during the placing of the concrete. Care must be taken to ensure that the centroid of the cable as stressed lies at the correct ordinate and offset and the position of the sheath must be adjusted to allow for this. Where members are made up of units stressed together, the ducts in the joints between the units shall be in alignment.

Where sheaths are used, the number of joints shall be kept to a practicable minimum and each joint adequately sealed against the ingress of any material.

Sheaths shall be kept free of any matter detrimental to the bond between the sheath and the grout and, except for material sealing a sheath joint, between the sheath and the concrete.

Particular attention shall be paid to joints between sheathing sections and to connections between sheathing sections and to connections between sheathing and anchorages. Joints in adjacent sheaths shall be staggered by at least 30cm.

Unless the detail at these points is designed specifically to prevent the ingress of concrete materials, these joints shall be sealed.

When the customary oversleeves are used at connections between lengths of sheathing, equal overlaps shall be provided on each side of the joint. Any damaged sheathing must be replaced, taped or otherwise satisfactorily repaired to the approval of the Engineer's Representative. Sealable vents to the upper or lower surface of the concrete are to be provided at all high and low points along the length of the sheath. These are to enable the progress of the grout to be observed and to eliminate air pockets forming along the length of sheath.

Unbonded tendons shall be examined after installation, and any parts damaged shall be re-coated and sealed with an approved waterproof tape.

Extractable cores shall be coated with a release agent only with the approval of the Engineer's Representative.

Cores shall not be extracted until the concrete has hardened sufficiently to prevent it being damaged.

The ends of all ducts and tendons shall be respectively sealed and protected until the tendon is threaded through and the stressing operations are commenced.

The concrete placing techniques must not result in damage to the sheathing or the wrapping of unbonded tendons.

B9 09 ANCHORAGES

Anchor cones, blocks and plates shall be positioned and maintained during concreting so that the centre line of the duct passes axially through the anchorage assembly.

All bearing surfaces of the anchorages shall be clean prior to concreting and tensioning.

Anchorage which are to remain permanently in place shall be properly protected with a site-applied cover to prevent the ingress of water or of any aggressive agents likely to corrode the tendon or the anchorage.

B9 10 POST-TENSIONING PROCEDURE

1. Tensioning shall be carried out only in the presence of the Engineer or his Representative unless permission has been obtained to the contrary.

2. Immediately before tensioning, the Contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the application of prestress.

3. Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which two test cubes taken from it attain the specified transfer strength. The test cubes shall be made and tested in accordance with BS1881 Part 3 (1970) but shall be cured in similar conditions to the concrete to which they relate. The Contractor shall cast sufficient cubes to demonstrate that the required strength of the concrete at transfer has been reached.

4. Where members consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.

5. The Contractor shall establish the datum point for measuring extension and jack pressure to the satisfaction of the Engineer's Representative.

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6. The Contractor shall add to the forces described in the Contract an allowance for anchorage friction, wedge pull-in, jack losses and friction due to duct alignment and curvature. The total forces and calculated extensions shall be agreed with the Engineer's Representative before stressing is commenced.

7. Immediately after anchoring, the stresses in the prestressing tendons shall not exceed 65 per cent of their ultimate tensile strength. During stressing the value shall not exceed 70 per cent.

8. The tendons shall be stressed at a gradual and steady rate. The force in the tendons shall be obtained from readings on two load cells or pressure gauges incorporated in the equipment. The extension of the tendons under agreed total forces shall be within 5 per cent of the agreed calculated extension. If there is appreciable variation between the calculated extension and that found in practice the Engineer's Representative should be notified before proceeding with further tensioning.

9. Stressing shall be from both ends unless otherwise required in the Contract or agreed by the Engineer's Representative.

10. When stressing from one end only, the pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.

11. When the prestressing has been applied to the satisfaction of the Engineer's Representative, the tendons shall be anchored. The jack pressure shall then be released in such a way as to avoid shock to the anchorage or tendons.

12. If the pull-in of the tendons at completion of anchoring is greater than that agreed by the Engineer's Representative, the load shall be released at a gradual and steady rate and tensioning carried out afresh.

13. If it is necessary to cut the tendons to enable the ducts to be grouted, this shall be delayed as long as practicable up to the time of grouting. In all other cases, unless agreed otherwise by the Engineer's Representative, the tendons shall not be cropped less than 3 days after grouting.

Any surplus length of tendon shall be cut off by an approved method which will not affect the strength of the stressed tendon, with particular care if the use of spark erosion or oxy-acetylene burning methods of cutting are approved by the Engineer's Representative.

14. The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings and the amount of pull-in at each anchorage and all such data observed during the tensioning operation shall be immediately recorded. Copies of these records shall be supplied to the Engineer's Representative within 24 hours of each tensioning operation.

The tendons shall be maintained in such a condition that they can be restressed, until the Engineer's Representative has given final approval after inspecting the tensioning log.

B9 11 GROUTING OF DUCTS

1. Grouting trials shall be undertaken when required by the Engineer's Representative.

2. Ducts shall not be grouted when the air temperature in the shade is lower than 3°C. When grouting under high temperatures, suitable arrangements shall be made to cool the mixing water and if necessary the structural members.

3. All ducts shall be thoroughly cleaned by means of compressed air at the beginning and end of each day and thoroughly within 3 hours before grouting.

4. Ducts formed without sheathing shall be filled with water unless otherwise required by the Engineer's Representative. Where ducts have been filled with water it shall be blown out by compressed air. All anchorages shall be sealed before grouting.

5. Ducts shall be grouted as soon as practicable after the tendons in them have been stressed and the Engineer's Representative's permission to commence has been obtained. Grout shall be injected in one continuous operation and allowed to flow from the vents until the consistency is equivalent to that being injected.

6. When grouting will not be carried out for a long period, having regard to the prevailing environment, temporary protection against corrosion shall be provided by the use of vapour-phase inhibitors, emulsifiable oils, by ventilating with dry air, or by some other means.

7. The ducts shall be completely filled with grout and when practicable grouted from the lower ends. The grout shall be injected within one hour after first mixing.

8. Vents shall be sealed consecutively in the direction of flow and the injection tube sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Engineer's Representative to ensure that they are not subjected to shock or vibration for 1 day and that the temperature of the grout in them does not fall below 3°C for 3 hours after its injection. 2 hours after grouting, the level of grout in the injection and vent tubes shall be inspected and made good if necessary. Grout which has flowed out of a duct must not be re-used and grout which has remained unused for half an hour after it was made shall not be used.

9. If frost is present, a frost-resistant grout must be used. If there is a possibility of the temperature in the duct falling below 4°C within 48 hours, no grouting should be carried out unless the work is protected.

10. The Contractor shall keep full records of grouting including the date each duct was grouted, the proportions of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer's Representative within 3 days of grouting.

11. Where required by the Engineer's Representative, the Contractor shall provide facilities and attendance for the radiographic testing of ducts.

B9 12 STORAGE OF PRESTRESSED MEMBERS

1. When members are stored, they shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses.

B9 13 HANDLING AND PLACING OF PRESTRESSED MEMBERS

1. Members shall be lifted or supported only at the points described in the Contract and shall be handled and placed without impact.

B9 14 PRETENSIONED MEMBERS

1. Where tendons are described in the Contract as debonded from the concrete, they shall be covered with sleeves of PVC or other material approved by the Engineer's Representative. The ends of the sleeves shall be taped to the tendon to prevent the ingress of grout.

2. Unless otherwise agreed by the Engineer's Representative, tendons shall be stressed in accordance with the requirements of Clause B9 10.

3. Members shall be free to accommodate the horizontal and vertical movements due to the application of prestress.

4. When the concrete has attained the age specified in Clause B9 10-3 the load shall be transferred gradually without severance of the tendons. The tendons shall then be trimmed back flush to the face of the concrete and the protection described in the Contract applied to their ends.

5. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast, the load applied and, if they are of symmetrical section, the face which will be uppermost when the member is in its correct position in the Works. The markings shall be so located that they are not exposed to view when the member is in its permanent position.

B9 15 MANUFACTURE OF PRESTRESSED MEMBERS OFF THE SITE

1. The details of the method of manufacture shall be approved by the Engineer's Representative before work is started. When the method has been approved no changes shall be made without the consent of the Engineer's Representative.

2. The Contractor shall inform the Engineer's Representative in advance of the date of commencement of manufacture and the dates when tensioning of tendons, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

3. The Contractor shall send to the Engineer's Representative not more than 7 days after the transfer of stress, a certificate showing the force and strain in the tendons immediately after they were anchored, the strength and age of the test cubes cast in accordance with Clause B9 10 and the minimum age in hours of the concrete at the time the stress was applied to the member. A copy of all 28 day cube test results relating to the work shall be sent to the Engineer's Representative as they become available. Records shall be kept so that the identity of those who stress the tendons, cast the concrete and transfer the stress on any member or line of members can be traced.

4. Where the Engineer's Representative requires tests to be carried out, no beams to which the tests relate shall be despatched to the Site until the tests have been satisfactorily completed.

B9 16 COMPOSITE SLAB BRIDGES

1. The manufacturing tolerances for the precast members shall nowhere exceed those given for length, cross-section and straightness in BS Code of Practice CP116 (1969) The Structural Use of Precast Concrete. In addition, where beams are laid side by side in a deck:

- (i) The difference in soffit level between adjacent units before the in-situ concrete is placed shall nowhere exceed 5mm for units up to 5 metres nor 10mm for longer units.
- (ii) The width of the deck soffit shall be within +25mm of that described in the Contract.
- (iii) In adjacent spans, the continuity of line of the outside beams shall be maintained.
- (iv) The width of the gap between individual beams shall not exceed twice the nominal gap described in the Contract.
- (v) The alignment of transverse holes shall permit the reinforcement or prestressing tendons to be placed without distortion.

2. The in-situ concrete shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports.

3. Beams shall be prevented from moving laterally during the placing of the in-situ concrete.

B9 17 SAMPLING AND TESTING

1. Testing of Pretensioned Beams

- (i) Any beam required by the Engineer's Representative to be subjected to a load test will be selected after transfer and wherever possible before the beam has been removed from the casting yard to the storage area. The Contractor shall not proceed with a load test until he has obtained the approval of the Engineer's Representative to the detailed arrangements. Except where otherwise agreed by the Engineer's Representative, the load test shall be carried out not less than 28 days after casting.
- (ii) The beam shall be supported at its design points of bearing. The specified test loads shall be applied equally at the third points of the span in not less than 10 approximately equal stages. The maximum load shall be sustained for 5 minutes and then removed in not less than 5 approximately equal stages. The mid-span deflection relative to a straight reference line joining the points of support shall be measured for each value of the load and 5 minutes after removal of the load.
- (iii) Loads shall be measured with an accuracy of ± 2 per cent or 50kgf and deflections with an accuracy of ± 0.5 mm.
- (iv) The load-deflection graph shall be plotted from these values and shall show no appreciable variation from a straight line. If after 5 minutes of removal of the load the beam does not show a recovery of at least 90 per cent of the maximum deflection recorded during the test, the test loading shall be repeated. The beam will be considered to have failed the test if the recovery 5 minutes after removal of the test load for the second time is not at least 90 per cent of the maximum deflection recorded during the second test.

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- (v) The result of the test shall be deemed to apply to the other beams cast in the same production line but in the event of failure any additional beam may be separately tested at the Contractor's option.
- (vi) The Contractor shall supply to the Engineer's Representative record sheets of the test showing the age of the beam at the time of the test, loads, deflections, load deflection curves and calculated value of Young's Modulus of Elasticity (E).
- (vii) In addition the record sheets supplied by the Contractor to the Engineer's Representative shall show the temperatures of the top and bottom surfaces of the beam measured at the time of the test.

2. Testing of Prestressing Anchorages: Anchorages for post-tensioning shall be tested in accordance with the procedure described in BS4447 (1973). For each anchorage system used in the Works, the characteristic value for anchorage efficiency shall be not less than 90 per cent.

B9 18 MEASUREMENT AND PAYMENT

1. Measurement and payment for the various items in prestressed concrete work shall be made in accordance with appropriate items in Sections B6, B7 and B8.

2. All prestressing steel shall be measured by the computed weight of the final installed length of tendons in place as shown on the Drawings or as ordered by the Engineer's Representative. No allowance will be made for related materials, labour, tools, equipment and other work necessary to furnish, fabricate, place, prestress and grout the prestressing tendons including anchorages, ducts, couplers, chairs, grout and all other incidentals which are used or installed when completing the work by the Contractor or which are ordered by the Engineer's Representative and as specified herein.

3. Payment for prestressing steel will be made at the price tendered per metric tonne for steel in place according to the Drawings or as ordered by the Engineer's Representative. Payment for prestressing steel shall include the cost for all related materials, work and incidentals as mentioned above.

SECTION B10

STRUCTURAL STEELWORK

B10 01 SCOPE

The work covered by this Section of the Specification comprises in furnishing all plant, equipment, material and labour and in performing all operations in connection with structural steelwork. It is entirely subject to the terms and conditions of the Contract, and is to be executed in strict conformity with this Section of the Specification, with the Drawings and the direction of the Engineer's Representative.

Two copies of all detailed working drawings prepared by or on behalf of the Contractor shall be submitted to the Engineer's Representative for his approval, but this approval shall in no way relieve the Contractor of his responsibilities for the work under the Contract.

B10 02 STANDARD SPECIFICATIONS AND TEST METHODS

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the listed British Standards Institution's publications.

- BS153 Parts 1 & 2 (1972) Steel Girder Bridges.
- BS4360 (1972) Weldable Structural Steels.
- BS4 Parts 1 & 2 (1972 & 1969) Structural Steel Sections.
- BS970 Parts 1-6 (1970-1973) Wrought Steels, etc.
- BS18 Parts 1-4 (1970 & 1971) Methods for tensile testing of metals.
- BS5135 (1974) Metal arc welding of carbon steels, etc.
- BS4872 Part 1 (1972) Approval testing of welders, etc.
- BS709 (1971) Methods of Testing fusion welded joints, etc.
- BS2789 (1973) Iron castings, etc.
- BS916 (1953) Black bolts, screws and nuts.
- BS2708 (1956) Unified black square and hexagonal bolts, etc.
- BS4190 (1967) ISO metric ditto.
- BS1083 (1965) Precision ditto.
- BS1768 (1963) Unified Precision hexagon bolts, etc.
- BS4395 Parts 1-3 (1969 & 1973) ditto (metric)
- BS4604 Parts 1-3 (1970 & 1973) The use of ditto (metric)
- BS3410 (1961) Metal washers, etc. (imperial).
- BS4320 (1968) ditto (metric).
- BS639 (1976) Covered electrodes, etc.
- BS4165 (1971) Electrode Wires and fluxes, etc.
- BS5400 Part 6 where this is not in conflict with BS153

B10 03 MATERIALS

1. **Structural Steel:** Structural steel shall comply with the requirements of BS 153 Part 1 (1972) and BS4360 (1972). In addition structural steel hot-rolled sections shall comply with the requirements of BS4 Part 1 (1972) and structural steel hot-rolled hollow sections with BS4 Part 2 (1969). The maximum carbon equivalents shall be in accordance with BS4360 (1972).

Structural Steelwork

Steel for headed stud shear connectors shall have a minimum yield stress of 400tf/cm² and a minimum tensile strength of 500tf/cm².

2. Substitution of Materials: If the Contractor is unable to obtain steel of the sections specified he shall submit alternative proposals, including all relevant calculations and drawings, to the Engineer for his approval. Fabrication shall not be put in hand until such approval has been given. Any approval shall in no way relieve the Contractor of his responsibilities under the Contract.

3. Cast Iron: Spheroidal or nodular graphite cast iron shall comply with the requirements of BS153 Part 1 (1972) and BS2789 (1973). It shall be Grade SNG 24/17.

4. Stainless Steel: Stainless steel shall comply with the requirements of BS970 Part 4 (1970) and the quality shall be either 302S25 or 321S20.

5. Screwed Rods, Bolts, Nuts and Washers and High Tensile Alloy Steel Bars: Black bolts and nuts shall comply with the requirements of BS153 Part 1 (1972) and either BS916 (1953), BS2708 (1956) or BS4190 (1967).

Special quality high tensile steel screwed rods, bolts and nuts shall comply with the requirements of BS 153 Part 1 (1972), BS970 Parts 1-6 (1970-1973) and either BS 1768 (1963) or BS1083 (1965).

High strength friction grip bolts, nuts and washers shall comply generally with the requirements of BS4395 Parts 1-3 (1969 & 1973) for dimensions and BS1083 (1965) or BS1768 (1963) for materials. Bolts shall be Grade V.

Plain tapered washers, other than for high strength friction grip bolts, shall comply with the requirements of BS153 Part 1 (1972) and BS3410 (1961) or BS4320 (1968).

The dimensions of close tolerance bolts, shall conform to those given for bolts faced under the head and turned on the shank in BS916 (1953) or BS2708 (1956). The numbers of bolts, nuts and washers supplied to site shall be in accordance with BS153 Part 2 (1972).

High tensile alloy steel bars shall be supplied by McCalls Macalloy Ltd., or equal approved. The bars shall be anchored by means of special nuts engaging on the threaded ends of the bars and bearing against mild steel plates. The special nuts, washers, and tapped end plates shall be formed from steel complying with BS970 Parts 1-6 (1970-1973) for wrought steels, and shall be as supplied by McCalls Macalloy Ltd., unless otherwise approved. High tensile alloy steel bars shall be of open hearth steel with sulphur and phosphorous contents each less than 0.05% when tested in accordance with BS18 Part 2 (1971). Methods for tensile testing of metals, the steel shall have a characteristic strength of not less than 1000 N force per mm² and 0.2% proof stress of not less than 85% nor more than 92% of the actual ultimate strength. The attention of the Contractor is directed to the need to order the bars to the correct lengths required for the Works in accordance with the instructions of the manufacturer. The bars shall be supplied perfectly straight and care shall be taken in their handling to ensure that they are undamaged when placed in the Works.

6. Electrodes for Welding: Welding electrodes for manual metal-arc welding of steel to BS4360 (1972) shall comply with the requirements of BS153 Part 1 (1972) and BS639 (1976).

Electrode wires and fluxes for submerged-arc welding shall comply with BS4165 (1971).

Weld metal deposited by an automatic or semi-automatic process except submerged-arc shall comply with the requirements of BS153 Part 1 (1972).

The electrodes used for procedure trials and fabrication shall all be supplied by one manufacturer. They shall be stored in accordance with his instructions and the coating shall be dry at the time of use.

B10 04 GENERAL REQUIREMENTS – WORKMANSHIP, FABRICATION AND ERECTION

1. Shop Drawings: The Engineer will supply the Contractor with all the information necessary for him to prepare and complete his working shop drawings except the calculated fabricated camber referred to in sub-clause 2 below and it shall be the Contractor's responsibility to prepare such drawings incorporating in them sufficient information for the proper fabrication of the steelwork.

In the event of any contradiction or ambiguity in the information or drawings supplied by the Engineer, the Contractor shall obtain from him other information and clarification.

Two copies of all working drawings prepared by or on behalf of the Contractor shall be submitted to the Engineer for approval. The Engineer will verify the correct interpretation of his requirements but will not verify the dimensions and the Contractor shall be entirely responsible for the accuracy of the drawings and the correctness of detail. The Contractor shall not commence fabrication of any item until the working drawing for it has been approved in writing by the Engineer.

The Contractor shall supply the Engineer's Representative with three copies of all approved drawings.

The dimensions of and approved procedures for all welds shall be clearly specified on the working drawings and the length of weld specified shall be the effective length excluding end craters.

2. Camber: Main girders shall be fabricated to a calculated camber which will ensure that the structure conforms to the vertical alignment shown on the drawings, under full dead load. The camber shall be calculated by the Contractor taking full account of his proposed deck concreting sequence.

3. Fabrication: All workmanship and fabrication shall be in accordance with BS153 Part 1 (1972).

The Contractor shall permit access at all reasonable times to all places where work is being carried out and shall provide all the necessary facilities for inspection of material and workmanship during fabrication.

Under no circumstances is any practice to be adopted which will result in injury to material.

No drifting of holes that would enlarge the holes or distort the metal will be allowed. All edges of sections and plates are to be smooth and free from broken, ragged, burred or notched edges.

All sharp corners and edges which are to receive paint treatment shall be rounded to approximately 6mm radius on completion of fabrication.

4. Interchangeability: All parts which have not been demonstrated to be fully interchangeable to the Engineer's satisfaction shall be distinctively marked during shop assembly.

Structural Steelwork

5. Steel Tapes: All steel tapes used both in the fabricating shop and on site shall be checked against an agreed standard tape which shall not be used for any other purpose.

6. Plate Edge Preparation: Edges of all plates and sections shall be accurately prepared and there shall be no gaps between the parts when assembled for welding.

Any Grade 50 steel parts which have been sheared shall have not less than 3mm of material removed from the sheared edge by machining.

Machine flame cutting of Grade 50 steel may be used as an alternative to machining provided.

(i) the flame cut edge is subsequently incorporated in a weld.

(ii) an approved flame cutting procedure is adopted.

7. Welding: All welding shall be by the electric arc process.

Unless specifically excluded the clauses shall apply equally to shop and site welding.

Unless otherwise described in the Contract, metal-arc welding shall comply with BS5135 (1974).

Wherever possible the welds shall be laid in the flat or horizontal-vertical position.

All parts to be welded shall be accurately prepared so that on assembly they fit closely together. After assembly and before general welding commences the parts shall be securely connected by tack welds in the line of the welded seams. The tack welds shall be strong enough to prevent relative movement of the parts but small enough to be covered by general welding.

Slag shall be removed from welds and spatter from surrounding surfaces after completion of welding and before grit blasting.

Welding procedures shall be designed to eliminate weld cracking and minimise distortion.

The welding procedure for making each joint shall be approved by the Engineer's Representative before work is commenced and recorded on the shop drawings.

Welding shall not be undertaken when the surfaces are wet from condensation or other causes.

Suitable allowance for weld contraction shall be made to ensure the finished dimensions are correct within the specified tolerances.

The temperature of steels welded in accordance with BS5135 (1974) shall be not less than 10°C when welding is commenced.

Electrodes and fluxes shall be used in accordance with the manufacturer's instructions. The use of welding processes other than those covered by BS5135 (1974) shall be subject to the approval of the Engineer.

The general welding programme for shop and site welds, including particulars of the preparation of fusion faces, the method of pre-heating where required, the methods of making the welds and the type of electrodes shall be submitted to the Engineer's Representative for his approval before the work is put in hand. No departure from the agreed welding programme or from the details shown on the drawings shall be made without the agreement of the Engineer's Representative. Electrodes and fluxes shall be so chosen that the properties of the deposited metal are not inferior to those of the parent metal.

The procedures for welding and flame cutting established by the procedure trials as Clause B10 04-11 shall be strictly followed.

Unless otherwise described in the Contract, all butt welds shall be complete penetration welds made between prepared fusion faces.

In the fabrication of built-up assemblies, all butt welds in each component part shall be completed, whenever possible, before the final assembly.

The position of welds required for temporary attachments shall be agreed by the Engineer before the work commences.

Where automatic or semi-automatic processes are used, back gouging of the deposited weld will not be required where the Engineer's Representative is satisfied that the root run is free from imperfection.

Where butt welds are to be ground flush there shall be no loss of parent metal. The final grinding shall be in the direction described in the Contract.

Stud shear connectors shall be welded in accordance with the manufacturer's instructions.

In butt joints the root edges or root faces shall not be out of alignment by more than one eighth of the thinner material for material up to 12mm thick or by more than 2mm for thicker material.

Requirements for 'run-on' plates and 'run-off' plates for butt welds shall be as follows:

- (i) One pair of run-on plates and one pair of run-off plates all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively of all butt welds. Unless otherwise required by the Engineer's Representative, approximately 1 in 5 pairs of run-off plates for butt welds in tension flanges and 1 in 10 pairs for other butt welds shall be production test plates. The combined size of each pair of production test plates shall be either 22.5cm, 30cm, or 37.5cm wide $\times$ 20cm long, as shown in Table B10/1 below, the length being measured in the rolling direction of the metal and at right angles to the weld.
- (ii) Butt welds shall run the full length of the joint and extend at full weld profile for a minimum distance of 2.5cm into the run-off plates, and for minimum distances of 20cm, 27.5cm and 35cm respectively into the 22.5cm $\times$ 20cm, 30cm $\times$ 20cm and 37.5cm $\times$ 20cm run-off production test plates.
- (iii) On completion of the welds the run-off production test plates shall not be removed until they have been marked in a manner agreed by the Engineer's Representative to identify them with the joints to which they are attached.
- (iv) When removing the run-on and run-off plates by flame cutting, the cuts shall not be nearer than 5mm to the sides of the parent metal and the remaining metal shall be removed by grinding or other method agreed by the Engineer's Representative.
- (v) Specimens for the following tests to be carried out shall be selected from the runoff production test plates by the Engineer's Representative as shown in Table B10/1.
 - (a) Transverse tensile test. (The number of test pieces shall be sufficient to cover the full thickness of plate).
 - (b) Transverse bend test.

Structural Steelwork

- (c) Three Charpy V-notch tests except for steel of Grades 43A and 50B to BS4360 (1972).

TABLE B10/1
SIZES OF RUN-OFF PRODUCTION TEST PLATES

Material	Combined size (per pair) of run-off production test plates	
	Plates up to 3cm thick	Plates from 3cm to 7.5cm thick
Steel of Grades 43A and 50B to BS4360 (1972)	22.5cm × 20cm	30cm × 20cm
Steel of Grades 40C, D and E, 43C, D and E and 50C to BS4360 (1972)	30cm × 20cm	37.5cm × 20cm

8. **Welding Plant:** The welding plant shall be capable of maintaining at the weld the voltage and current specified by the manufacturer of the electrodes. The Contractor shall supply instruments for verifying voltages and current as and when required by the Engineer's Representative.

9. **Supervision of Welding:** Welding shall be carried out only under the direction of an experienced and competent supervisor. Unless otherwise agreed by the Engineer's Representative, a record shall be kept to enable major butt welds to be identified with the welders responsible for the work but finished work shall not be marked by hard stamping for this purpose.

10. **Weld Repairs:** Any welding condemned by the Engineer's Representative shall be cut out and re-welded to his entire satisfaction.

11. **Welding and Flame Cutting Procedure Trials:** Before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of materials to be used in the work.

The samples of material shall be selected and marked by the Engineer's Representative when the materials for the work are inspected at the mills.

Trials on material 2cm thick shall be taken to include all material up to but not exceeding 2cm thick. Trials on material 3.8cm thick shall be taken to include material over 2cm and up to but not exceeding 3.8cm thick. Material over 3.8cm thick shall be tested for every thickness increment of 6mm.

The welding and flame cutting trials shall demonstrate to the satisfaction of the Engineer the procedures to be adopted in the fabrication of the work which shall include:

- (i) Welding procedure in accordance with BS5135 (1974) and Table B10/5.

- (ii) The heat control techniques required to ensure that the flame cut surfaces of steel are free from cracks, local hardness, and any other defects which would be detrimental to the finished work.

The trials shall include specimen weld details representative of the actual construction, which shall be welded in a manner simulating the most unfavourable conditions liable to occur in the particular fabrication. After welding the specimens shall be held at a temperature not less than 10°C for a period not less than 72 hours and shall then be sectioned and examined for cracks and other defects.

The following groups of tests to BS709 (1971) shall be carried out in accordance with the Testing Clauses of this Specification:

- (i) **Butt Welds:** Transverse tensile test.

Transverse and longitudinal bend tests.

Separate tests shall be performed in each case with the root of the weld in tension and compression respectively.

Charpy V-notch impact test except for Grades 43A and 50B steels to BS4360 (1972).

- (ii) **Fillet Welds:** Fillet weld fracture test.

12. Fabrication Tolerances: The fabricated steel members shall conform to the dimensions given on the Drawings within the tolerances specified in BS153 Parts 1 and 2 (1972) or the Special Specification of Particular Application.

13. Tightening High Strength Friction Grip Bolts: High strength friction grip bolts shall comply with BS4395 Part 1 (1969) and shall be used in accordance with BS4604 Part 1 (1970). The bolts shall be tightened by a part-torque part-turn method. The part-torque tightening for bedding down shall be in accordance with BS4604 Part 1 (1970), except that it shall be carried out by a calibrated tightening device such as a torque-controlled manual wrench or power operated wrench. The bedding torque to be applied to the bolts shall be as given in Table B10/2.

After bedding down of the joints, each nut and the protruding threads of the bolt shall be permanently marked to record their relative positions. The nuts shall then be tightened to the approval of the Engineer's Representative by the part-turn of the nut method in accordance with BS4604 Part 1 (1970).

Any friction grip bolts which are slackened after having been fully tensioned once shall be discarded.

TABLE B10/2
PRELIMINARY TIGHTENING OF NUTS

Nominal dia. of bolt	Bedding Torque ±10 per cent
mm	KNm
16	80
20	160
22	210
24	280
27	350
30	470

14. Drifting: No drifting shall be permitted in close tolerance bolt holes.

15. Shop Assembly: The main girders shall be fully shop assembled to prove the accuracy of dimensions and the workmanship, and in sufficient lengths to ensure that the correct unstressed camber is achieved.

Selected holes at the corners of any fabricated panels and the corresponding cover plates shall be drilled undersize initially and left unbolted until after the shop assembly has been approved by the Engineer's Representative. They shall then be reamed out for close tolerance bolts and carefully marked before the assembly is dismantled. These holes shall be used at site to ensure that the boxes are reassembled to the same shape as achieved in the shop assembly.

16. Marking: Each piece of steelwork shall be clearly marked in accordance with a marking diagram to be prepared by the Contractor. The form of marking shall be subject to the prior approval of the Engineer's Representative and shall be such that it is still clear after transport of the piece to site. Two copies of the drawings correctly showing the marks shall be supplied to the Engineer's Representative when the steelwork is despatched.

17. Machined Surfaces: All machined surfaces shall be carefully protected against corrosion or mechanical damage in handling, storage or service.

Before being brought into permanent contact they shall be coated with an approved wax or grease.

18. Transport and Storage of Painted Steelwork: The greatest care shall be taken in loading, unloading, transporting, stacking and erecting steelwork to avoid marking or damage to painted steelwork.

Painted fabricated steelwork which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surfaces. Suitable packings shall be laid between the layers of stacked materials. Where cover is provided it shall be ventilated.

Provisional inspection at the works of the fabricator shall not be a bar to rejection on delivery to site in the event of the piece not being received in good order and condition to the entire satisfaction of the Engineer. Any work so rejected shall be made good at the Contractor's expense to the satisfaction of the Engineer's Representative.

B10 05 SAMPLING AND TESTING

1. Submission of Samples and Test Certificates: The submission of the lists of suppliers, samples and test certificates shall be in accordance with Clause R1 05.

2. Testing of Steel for Structures: All tests on structural steel shall comply with BS4360 (1972). Steel test certificates shall include a ladle analysis of the chemical composition of the material.

3. Qualification and Testing of Welders: For the welding of any particular type of joint, welders shall show evidence to the satisfaction of the Engineer's Representative of having satisfactorily completed appropriate tests as specified by BS153 Part 1 (1972) and BS4872 Part 1 (1972).

B10 06 TESTING OF WELDING

The tests shall be carried out by the methods described in BS709 (1971). The following requirements shall be met:-

1. General: The test results of welded joints shall not be inferior, in any respect, to the British Standard test requirements for the parent metal.

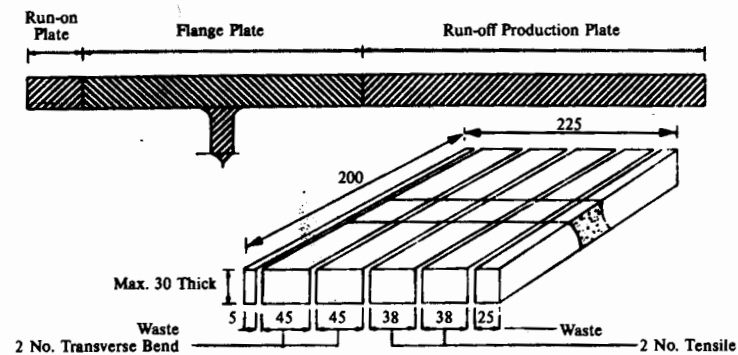
2. Procedure Trials

- (i) **Tensile and Bend Tests:** Should any one of the weld joint test pieces selected for transverse tensile and transverse and longitudinal bend tests fail to comply with the test requirements applicable to the parent metal of the joint represented by the test, 2 additional test pieces shall be taken from the joint material represented by the test. Both shall then comply with the test requirements in order to qualify for acceptance.
- (ii) **Charpy V-notch Tests:** Should the average impact value obtained from any set of 3 Charpy V-notch specimens fail to comply with the test requirements, 3 additional test pieces from the same sample shall be tested. The average of the 6 test results shall comply with the test requirements in order to qualify for acceptance.
- (iii) **Revised Procedures:** In the event of failure to meet the test requirements, the Contractor shall carry out further trials, using revised procedures, and further tests to the satisfaction of the Engineer's Representative.

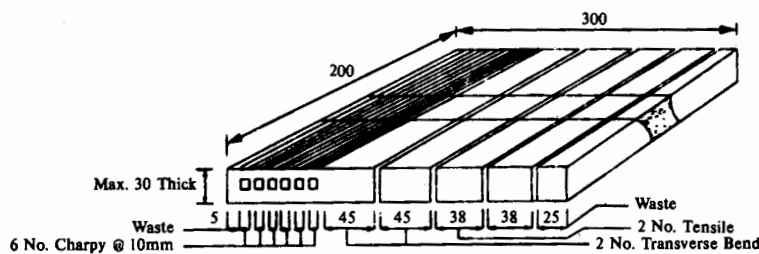
3. Production Tests

- (i) **Production Test Plates:** The run-off production test plate sizes specified shall be cut on the instructions of the Engineer's Representative as indicated in Figure B10/3 to enable up to 2 complete sets of test specimens to be obtained.
- (ii) **Tensile and Bend Tests:** Should any one of the weld joint test pieces selected for transverse tensile and transverse bend tests fail to comply with the test requirements applicable to the parent metal of the joint represented by the test, additional specimens shall be cut from the same production test plates and the tests repeated. Should either of the additional tests fail to comply with the requirements, the joint shall be rejected.
- (iii) **Charpy V-notch Tests:** Should the average impact value obtained from any set of 3 Charpy V-notch specimens selected fail to comply with the test requirements, 3 additional test pieces from the same production test plates shall be tested. Should

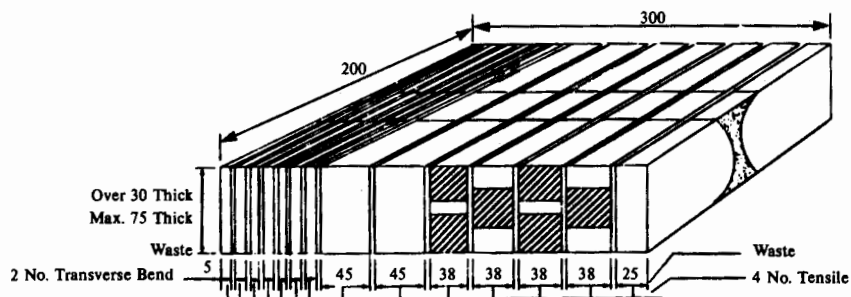
FIGURE B10/3
SIZES OF RUN-OFF PRODUCTION TEST PLATES



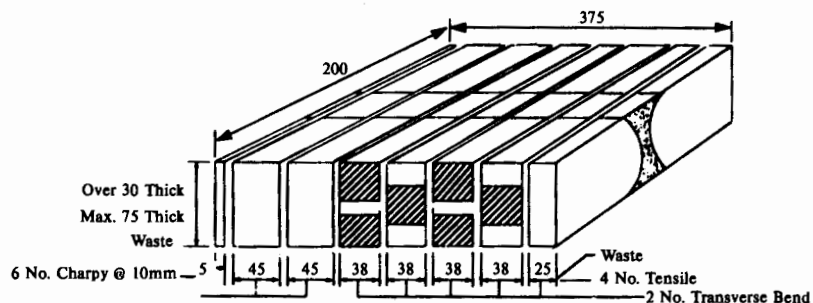
TEST PLATE 225 WIDE X 200 LG. FOR STEEL GRADES 43A AND 50B TO BS4360



TEST PLATE 300 WIDE X 200 LG. FOR STEEL GRADES 40C, D AND E, 43C, D AND E
AND 50C TO BS4360



TEST PLATE 300 WIDE X 200 LG. FOR STEEL GRADES 43A AND 50B TO BS4360



TEST PLATE 375 WIDE X 200 LG. FOR STEEL GRADES 40C, D AND E, 43C, D AND E,
AND 50C TO BS4360

Note: All dimensions are in millimetres

the average of the 6 test results fail to comply with the test requirements, the joint shall be rejected.

- (iv) **Re-welding and Re-testing:** In the event of failure to meet the test requirements, the welded joint represented by the tests shall be completely cut off. The joint shall then be re-welded and the tests repeated.

4. Non-destructive Testing: A method of non-destructive testing agreed with the Engineer's Representative shall be used for the examination of butt welds in tension members and where otherwise directed.

5. Testing of Shear Stud Connectors: All studs in the work shall be visually inspected to ensure that the weld is even and not undercut. Any stud with a base weld unsatisfactory to the Engineer's Representative shall be cut out and replaced. The height of each stud shall be measured and any stud larger than the specified dimension shall be rejected. A tolerance of 3mm will be allowed.

The fixing of each stud after being welded in position shall be physically tested by striking the side of the head with a 2kg hammer to the satisfaction of and under the supervision of the Engineer's Representative.

During each day's welding by each machine, bend tests shall be carried out in addition to the visual inspection and measurement. Selected studs shall be struck with a 6kg hammer until their axis near the head is at an angle not greater than 45° with the plate on which they are welded. After this test, the weld must show no visible deterioration.

The results shall be interpreted as shown in Table B10/4.

TABLE B10/4
TESTING SHEAR STUD CONNECTORS

Number of Studs Tested	Number of Failures	Action
23	0	Stop testing
23	5	Reject all studs so far welded
23	1-4	Continue testing
34	1	Stop testing
34	5	Reject all studs so far welded
34	2-4	Continue testing
45	2	Stop testing

If after testing a total of 45 studs, 3 or more studs are found to be defective test procedure trials shall be carried out using representative samples of materials until consistent and satisfactory results are established.

B10 07 STRESSES IN WELDS

1. **Basic Permissible Stresses in Welds:** Butt welds, other than welds with incomplete penetration, shall be treated as parent metal with a thickness equal to the throat thickness, and the stresses shall not exceed those in the parent metal.

The basic permissible stress in fillet welds, based on a thickness equal to the throat thickness, shall be:

For steels of grades 40 and 43 to BS4360 using electrodes complying with BS639, 108N/mm².

For steel of grade 50 to BS4360 using electrodes complying with BS639, 130N/mm².

For steel of grade 55 to BS4360 using electrodes as agreed with the manufacturer, 161N/mm².

Where a fillet weld is subject to shear stress in two directions, the actual shear stress shall be taken as the vector sum of the separate shear stresses and shall not exceed the above values.

2. **Permissible Combined Stresses in Welds:** Where a weld is subjected to a combination of bending, shear and bearing stresses, the stresses shall be combined as required below, the value of the equivalent f_e being not greater than that permitted for the parent metal.

The equivalent stress f_e due to a combination of shear stress f_q and bending stress f_{bt} tensile, or f_{bc} compressive, is calculated from:

$$f_e = \sqrt{(f_{bt}^2 + 3f_q^2)} \text{ or } \sqrt{(f_{bc}^2 + 3f_q^2)}$$

The equivalent stress f_e due to a combination of shear stress f_q , bearing stress f_b and bending stress f_{bt} tensile, or f_{bc} compressive, is calculated from:

$$f_e = \sqrt{(f_{bt}^2 + f_b^2 + f_{bt}f_b + 3f_q^2)} \text{ or } \sqrt{(f_{bc}^2 + f_b^2 - f_{bc}f_b + 3f_q^2)}$$

The equivalent stress f_e shall not exceed the following values:

For steel of grade 43 to BS4360, 225, 215, 210N/mm² corresponding to yield stresses of 245, 230, 215N/mm² respectively.

For steel of grade 50 to BS4360, 325, 310, 295, 245N/mm² corresponding to yield stresses of 355, 340, 325, 280N/mm² respectively.

For steel of grade 55 to BS4360, 400, 385, 370 or 355N/mm² corresponding to yield stresses of 450, 430, 415 or 400N/mm² respectively.

For intermediate values of the yield stress, the permissible equivalent stress f_e shall be obtained by interpolation.

3. **Carbon Equivalent Scales:** The scale to be used in Figure B10/11 will depend principally on the weld deposit diffusible hydrogen content given by the consumables, appropriately dried to the manufacturer's recommendations, when sampled and analysed to BS639 (1976), using evolution over mercury. That standard deals with the testing of covered electrodes, but with slight modifications of specimen size it can be used to assess other consumables and welding processes. That standard permits only the use of mercury as a collecting fluid for diffusible hydrogen and the levels given below are based on measurements using mercury.

Scale A should be used under conditions of normal fit for consumables which give weld deposit hydrogen contents more than 15ml/100g after any appropriate drying treatment.

Scale B should be used under conditions of normal fit for consumables which give weld deposit hydrogen contents not more than 15ml/100g (but more than 10ml/100g) after any appropriate drying treatment.

Scale C should be used under conditions of normal fit for consumables which give weld deposit hydrogen contents not more than 10ml/100g (but more than 5ml/100g) after any appropriate drying treatment. Scale C should also be used under conditions of close fit for consumables otherwise defined for Scale B.

Scale D should be used under conditions of normal fit for consumables which give weld deposit hydrogen contents not more than 5ml/100g after any appropriate drying treatment.

Covered electrodes in Classes E1 – , E2 – , E3 – , E4 – , E5 – and E9 – should be used with Scale A unless otherwise assessed.

Covered electrodes in Classes E6 – (including E6 – H and E6 – HJ) unless otherwise assessed should be used with Scale B.

Solid electrode wire for gas-shielded arc welding should be used with Scale C unless otherwise assessed.

The scale should be used also with other suitably assessed consumables after appropriate drying treatments, as recommended by the manufacturer.

TIG welding should be used with Scale D; similarly with other suitably assessed consumables after drying or other treatments, e.g. *clean* solid electrode wires for gasshielded arc welding, and some E6 – covered electrodes after drying at temperatures recommended by the manufacturer. It should be noted that on occasions these temperatures could exceed 400°C.

Submerged arc welding, flux cored wire welding and continuous covered wire welding consumables can have hydrogen levels corresponding to any of the Scales A to D and therefore need assessing in the case of each named product.

TABLE B10/5

REFERENCES TO TABLES AND FIGURES TO BE USED FOR DIFFERENT
CARBON EQUIVALENT VALUES

Steel grade to BS4360	Carbon equivalent value	Manual metal-arc fillet weld: refer to table no. given below	Other processes or consumables, or joints other than fillet welds: refer to figure nos. given below	For higher or lower carbon equivalent values observed from mill sheets*
All 40 and 43 grades	0·40	B10/6	B10/11(a), (b) & (d)	Select graph from figures B10/11(a) to B10/11(n) according to carbon equivalent and Scale (see Clause B10 07-3)
50A, 50B and 50C	0·49	B10/7	B10/11(k), (j), (h) & (d)	
50D	0·43	B10/8	B10/11(g), (e) & (c)	
50D1	0·41	B10/9	B10/11(e), (c) & (b)	

*If the amount of residual elements is not known, a value of 0·03 should be added to the $C + \frac{Mn}{6}$ value to obtain the carbon equivalent, *except* in the case of steel from a known supply of low residual element content.

TABLE B10/6

**SIMPLIFIED CONDITIONS FOR FILLET WELDS IN STEEL TO BS4360 (1972)
GRADES 40 AND 43 USING MANUAL METAL-ARC WELDING
ELECTRODES, EXCEPT THOSE CLASSIFIED AS E--K AND E9--**

Suitable only for a maximum carbon equivalent of 0.40

1kJ = 101.972kgfm

Electrode classification and hydrogen potential scale	Specified minimum leg length	Minimum arc energy*	Minimum pre-heating temperature for welding plates of following combined thicknesses								
			20 mm	30 mm	40 mm	50 mm	60 mm	70 mm	80 mm	90 mm	Unlimited†
E2--, E3-- Scale A	mm	kJ/mm	°C	°C	°C	°C	°C	°C	°C	°C	°C
	4	1.0	0	0	0	50	100	125	125	125	125
	5	1.4	0	0	0	0	20	75	100	100	100
	6	2.0	0	0	0	0	0	0	20	50	50
	8	2.8	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale B	10	3.8	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	0	20	50	50	50
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale C	10	5.0	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	0	0	0	0	0
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale D	10	5.0	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	0	0	0	0	0
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale D	10	5.0	0	0	0	0	0	0	0	0	0

*For individual run.

†In situations of high restraint, a higher pre-heating temperature may nevertheless be necessary to avoid weld metal hydrogen cracking.

TABLE B10/7

**SIMPLIFIED CONDITIONS FOR FILLET WELDS IN STEEL TO BS4360 (1972)
GRADES 50A, 50B AND 50C USING MANUAL METAL-ARC WELDING
ELECTRODES, EXCEPT THOSE CLASSIFIED AS E--K AND E9--**

Suitable only for a maximum carbon equivalent of 0.49

1kJ = 101.972kgfm

Electrode classification and hydrogen potential scale	Specified minimum leg length	Minimum arc energy*	Minimum pre-heating temperature for welding plates of following combined thicknesses								
			20 mm	30 mm	40 mm	50 mm	60 mm	70 mm	80 mm	90 mm	Unlimited†
E2--, E3-- Scale A	mm	kJ/mm	°C	°C	°C	°C	°C	°C	°C	°C	°C
	4	1.0	50	125	150	150	175	175	200	200	200
	5	1.4	0	50	100	125	150	150	175	175	175
	6	2.0	0	0	20	100	125	125	150	150	175
	8	2.8	0	0	0	0	50	100	125	125	150
E6--, E6--J Scale B	10	3.8	0	0	0	0	0	0	50	75	125
	4	1.3	0	20	100	125	150	150	175	175	175
	5	1.7	0	0	20	100	125	125	150	150	175
	6	2.2	0	0	0	20	75	100	125	125	150
	8	3.4	0	0	0	0	0	0	20	75	100
E6--, E6--J Scale C	10	5.0	0	0	0	0	0	0	0	0	50
	4	1.3	0	0	75	125	125	150	150	150	150
	5	1.7	0	0	0	50	100	125	125	150	150
	6	2.2	0	0	0	0	50	75	100	125	125
	8	3.4	0	0	0	0	0	0	0	50	50
E6--, E6--J Scale D	10	5.0	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	50	75	100	125	125
	5	1.7	0	0	0	0	0	20	50	75	75
	6	2.2	0	0	0	0	0	0	0	20	20
	8	3.4	0	0	0	0	0	0	0	0	0
	10	5.0	0	0	0	0	0	0	0	0	0

*For individual run.

†In situations of high restraint, a higher pre-heating temperature may nevertheless be necessary to avoid weld metal hydrogen cracking.

TABLE B10/8

SIMPLIFIED CONDITIONS FOR FILLET WELDS IN STEEL TO BS4360 (1972)
 GRADES 50D USING MANUAL METAL-ARC WELDING ELECTRODES,
 EXCEPT THOSE CLASSIFIED AS E---K AND E9--

Suitable only for a maximum carbon equivalent of 0.43

1kJ = 101.972kgfm

Electrode classification and hydrogen potential scale	Specified minimum leg length	Minimum arc energy*	Minimum pre-heating temperature for welding plates of following combined thicknesses								
			20 mm	30 mm	40 mm	50 mm	60 mm	70 mm	80 mm	90 mm	Unlimited†
E2--, E3-- Scale A	mm	kJ/mm	°C	°C	°C	°C	°C	°C	°C	°C	°C
	4	1.0	0	20	100	125	125	150	150	150	150
	5	1.4	0	0	0	75	100	125	125	150	150
	6	2.0	0	0	0	0	20	75	100	100	125
	8	2.8	0	0	0	0	0	0	0	50	50
	10	3.8	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale B	4	1.3	0	0	0	20	75	100	125	125	125
	5	1.7	0	0	0	0	0	50	75	100	100
	6	2.2	0	0	0	0	0	0	0	50	75
	8	3.4	0	0	0	0	0	0	0	0	0
	10	5.0	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale C	4	1.3	0	0	0	0	20	50	75	100	100
	5	1.7	0	0	0	0	0	0	20	50	50
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
	10	5.0	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale D	4	1.3	0	0	0	0	0	0	0	0	0
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
	10	5.0	0	0	0	0	0	0	0	0	0

*For individual run.

†In situations of high restraint, a higher pre-heating temperature may nevertheless be necessary to avoid weld metal hydrogen cracking.

TABLE B10/9

SIMPLIFIED CONDITIONS FOR FILLET WELDS IN STEEL TO BS4360 (1972)
 GRADES 50D1 USING MANUAL METAL-ARC WELDING ELECTRODES,
 EXCEPT THOSE CLASSIFIED AS E--K AND E9--

Suitable only for a maximum carbon equivalent of 0.41

1kJ = 101.972kgfm

Electrode classification and hydrogen potential scale	Specified minimum leg length	Minimum arc energy*	Minimum pre-heating temperature for welding plates of following combined thicknesses								
			20 mm	30 mm	40 mm	50 mm	60 mm	70 mm	80 mm	90 mm	Unlimited†
E2--, E3-- Scale A	mm	kJ/mm	°C	°C	°C	°C	°C	°C	°C	°C	°C
	4	1.0	0	0	50	100	125	125	125	125	125
	5	1.4	0	0	0	0	50	100	100	125	125
	6	2.0	0	0	0	0	0	0	50	75	100
	8	2.8	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale B	10	3.8	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	20	50	75	100	100
	5	1.7	0	0	0	0	0	0	20	50	50
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale C	10	5.0	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	0	20	50	50	50
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
E6--, E6--J Scale D	10	5.0	0	0	0	0	0	0	0	0	0
	4	1.3	0	0	0	0	0	0	0	0	0
	5	1.7	0	0	0	0	0	0	0	0	0
	6	2.2	0	0	0	0	0	0	0	0	0
	8	3.4	0	0	0	0	0	0	0	0	0
	10	5.0	0	0	0	0	0	0	0	0	0

*For individual run.

†In situations of high restraint, a higher pre-heating temperature may nevertheless be necessary to avoid weld metal hydrogen cracking.

TABLE B10/10

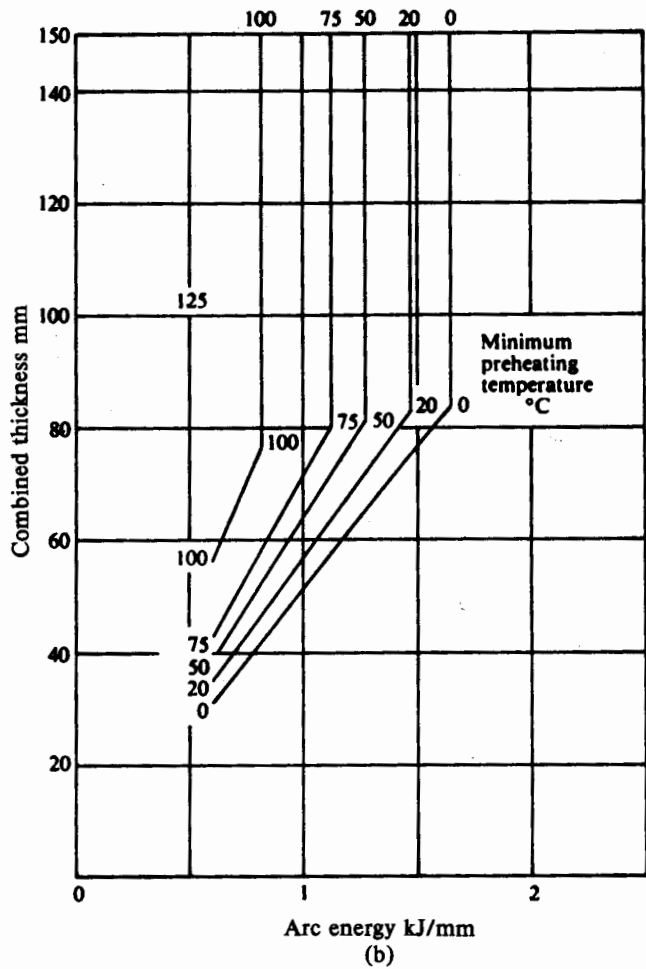
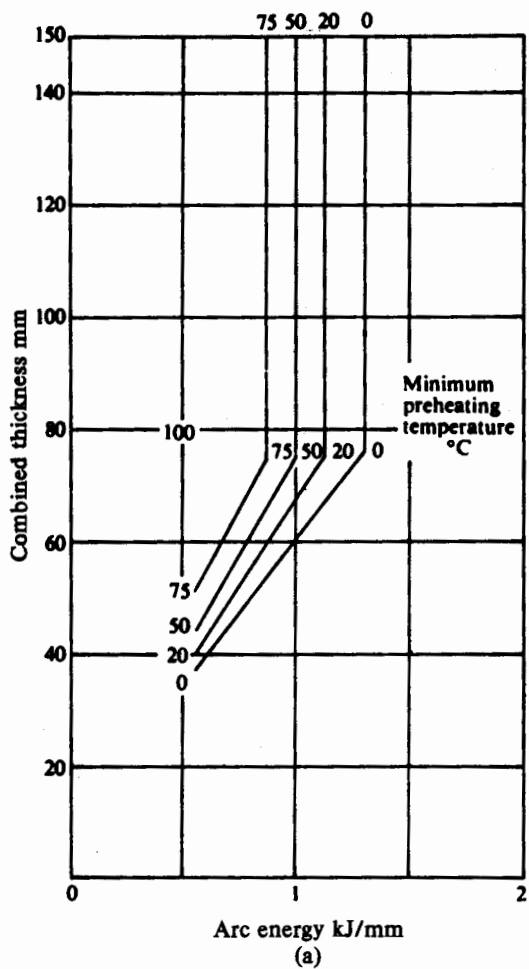
VALUES OF ARC ENERGY TO BE USED IN FIGURE B10/11 FOR SINGLE
RUN FILLET WELDS

These values are to be used only when the contractor is required to make fillet welds of the specified minimum leg length tabulated below. In other cases arc energy should be controlled by control of electrode run out.

$1\text{kJ} = 101.972\text{kgfm}$

Minimum leg length	Arc energy for following electrode classifications		
	E2-- E3--	E6-- E6--J	E2--K
mm	kJ/mm	kJ/mm	kJ/mm
4	1.0	1.3	—
5	1.4	1.7	0.8
6	2.0	2.2	1.1
8	2.8	3.4	1.6
10	3.8	5.0	2.3
12	5.5	6.5	3.1

FIGURE B10/11
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT

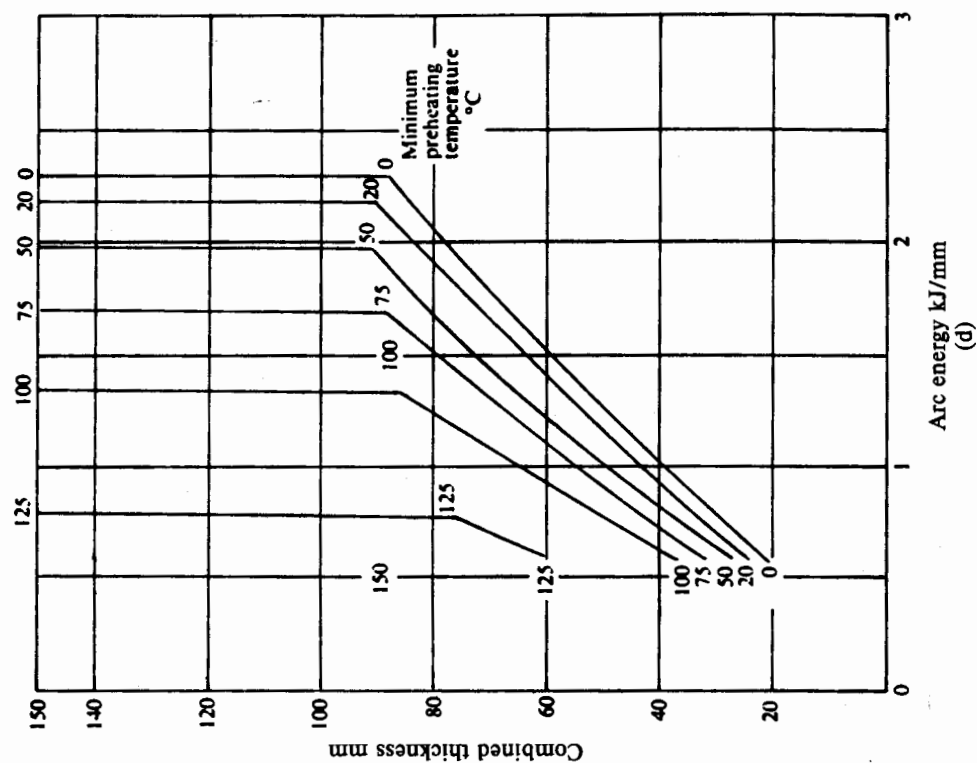


		Scale (see Clause B10 07-3)			
		A	B	C	D
To be used for carbon equivalent not exceeding	(a)	0·37	0·39	0·40	0·45
	(b)	0·38	0·40	0·41	0·46

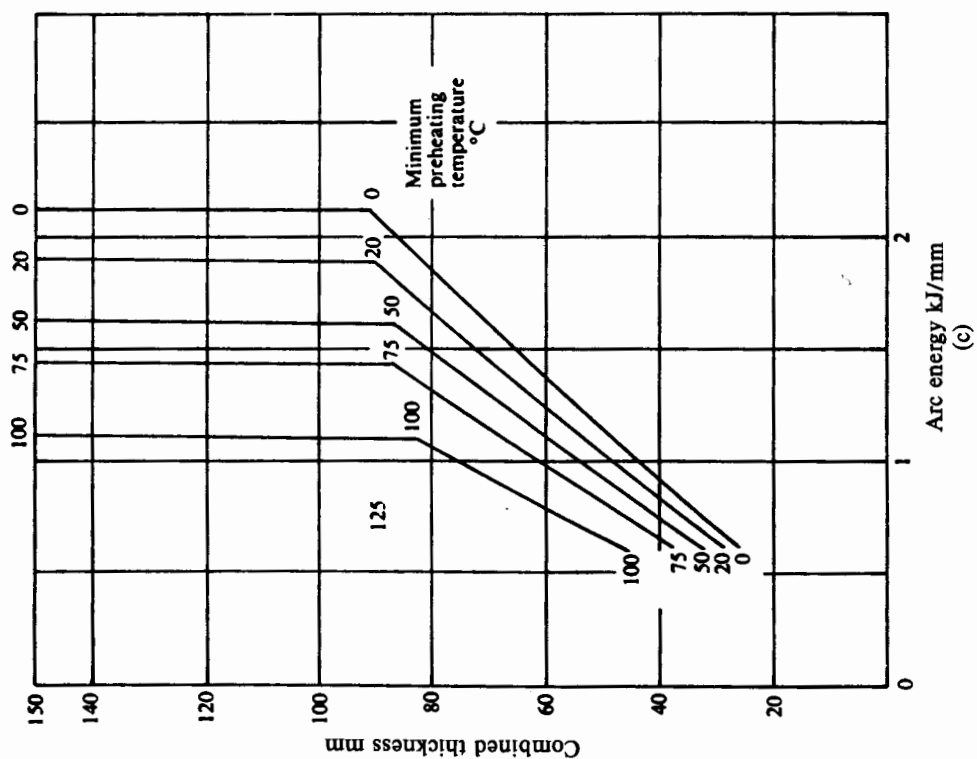
1kJ = 101·972kgfm

FIGURE B10/11 (cont.)

CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT



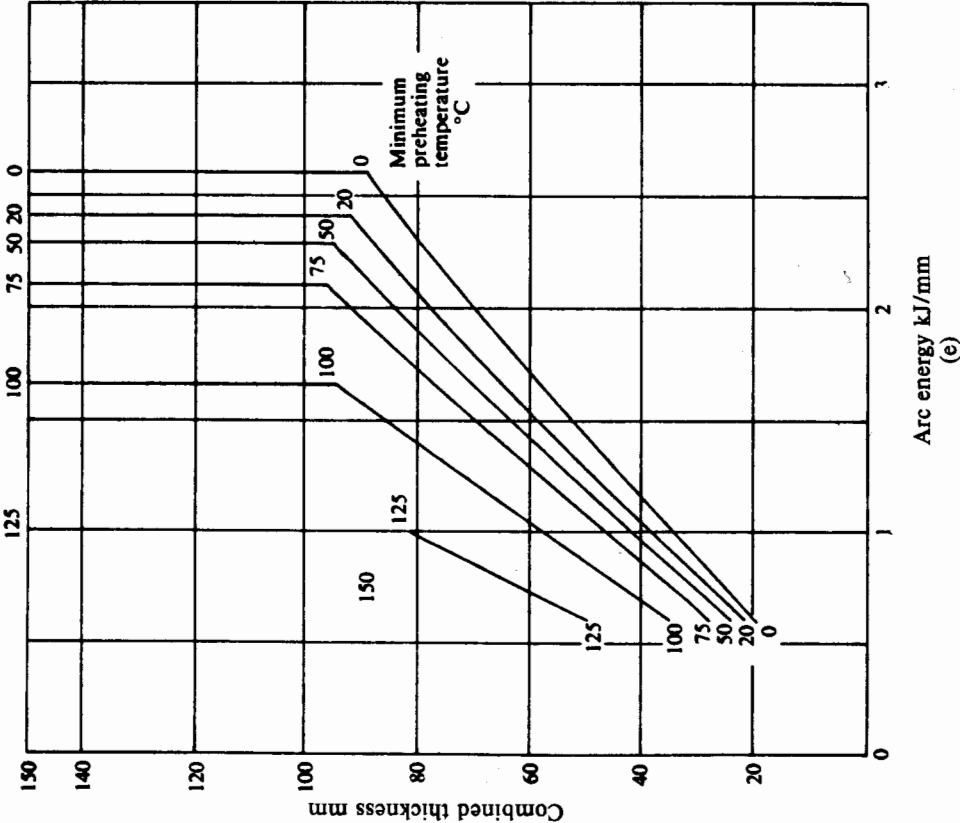
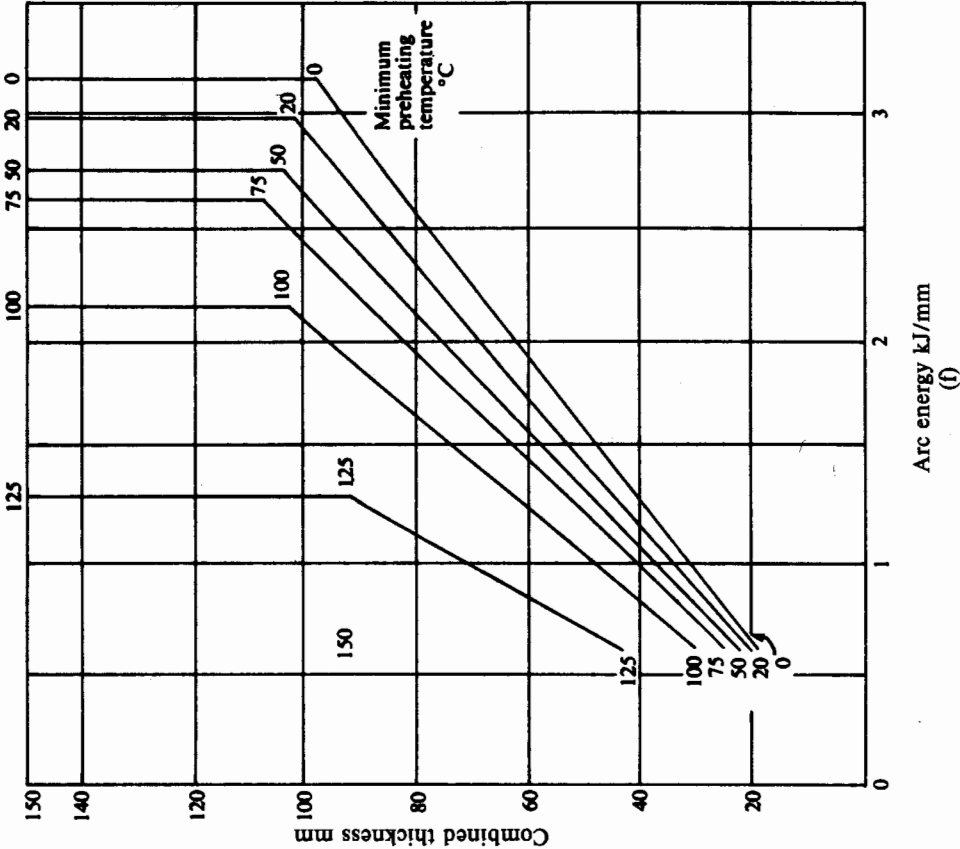
1kJ = 101.972kgfm



Scale (see Clause B1007-3)		A	B	C	D
		(c)	(c)	(c)	(c)
To be used for carbon equivalent not exceeding	(c)	0.39	0.41	0.43	0.48
	(d)	0.40	0.42	0.44	0.49

FIGURE B10/11 (cont.)

CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT

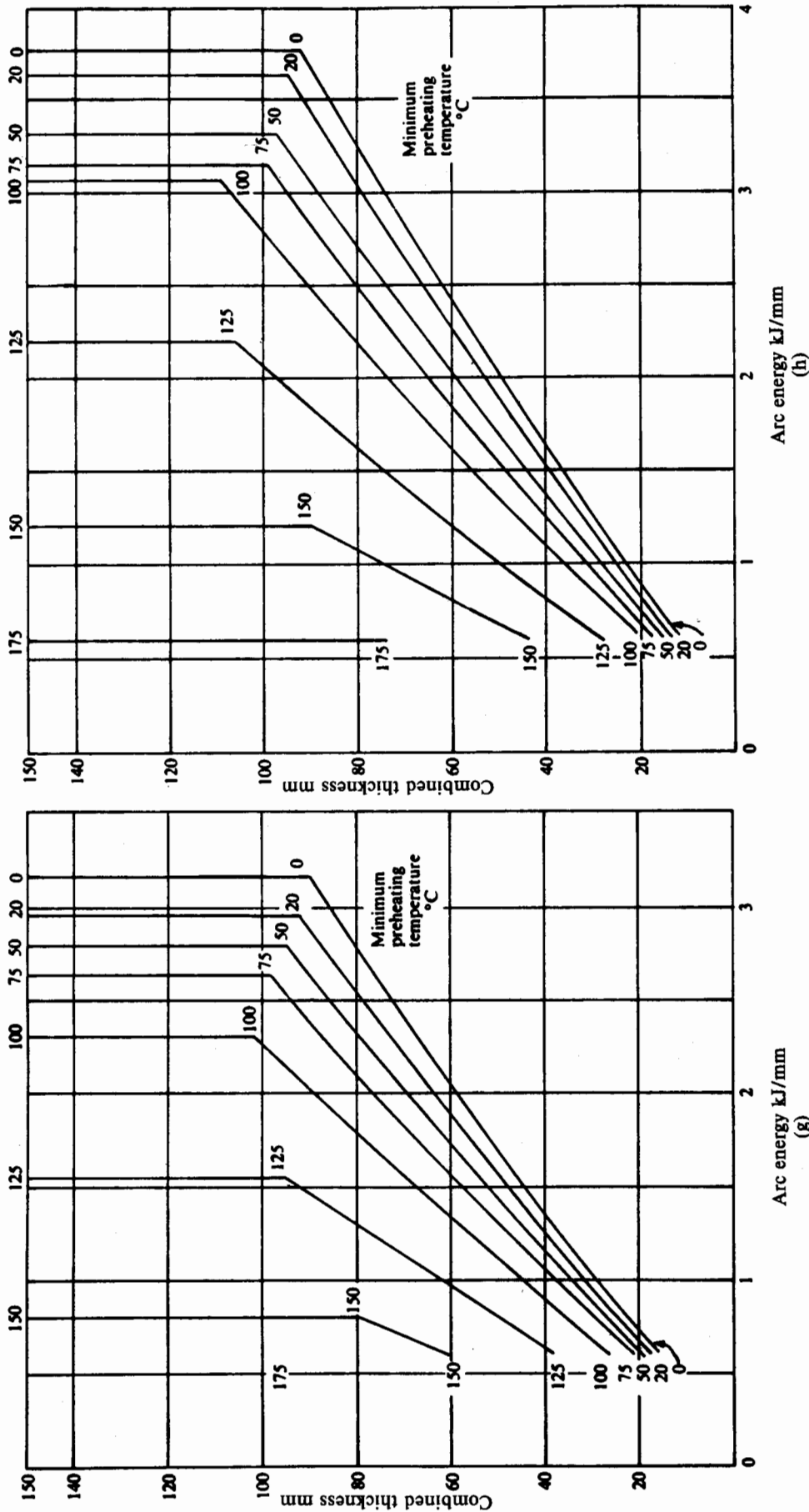


1kJ = 101.972kgfm

Scale (see Clause B1007-3)					
	A	B	C	D	
To be used for carbon equivalent not exceeding	(e)	0.41	0.43	0.45	0.50
	(f)	0.42	0.44	0.46	0.51

FIGURE B10/11 (cont.)

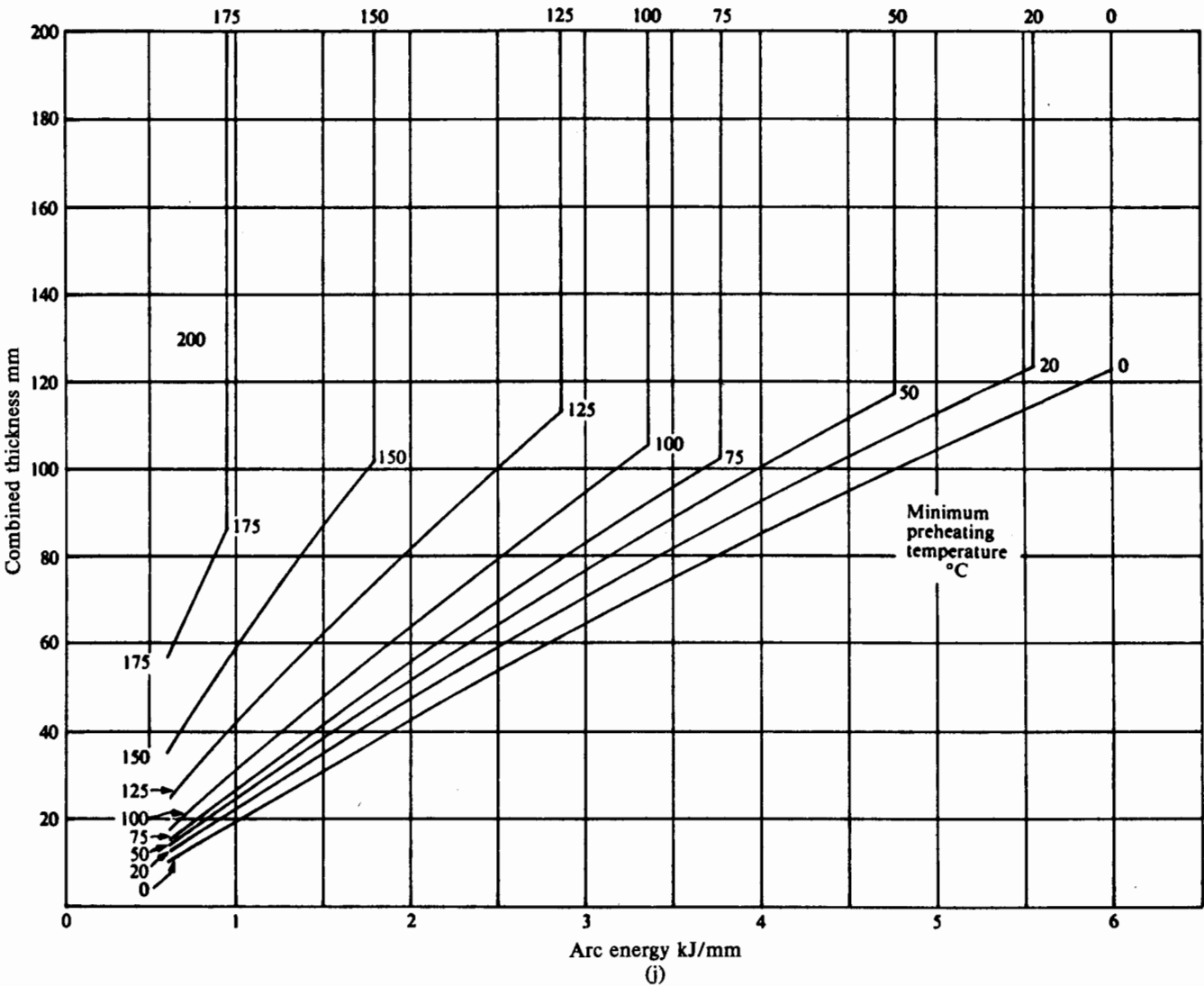
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT



1kJ = 101.972kgfm

Scale (see Clause B1007-3)					
To be used for carbon equivalent not exceeding		A	B	C	D
	(g)	0.43	0.45	0.47	0.52
	(h)	0.45	0.47	0.49	0.55

FIGURE B10/11 (cont.)
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT



1kJ = 101.972kgfm

	Scale (see Clause B10 07-3)			
	A	B	C	D
To be used for carbon equivalent not exceeding	0.47	0.49	0.51	0.57

FIGURE B10/11 (cont.)
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT

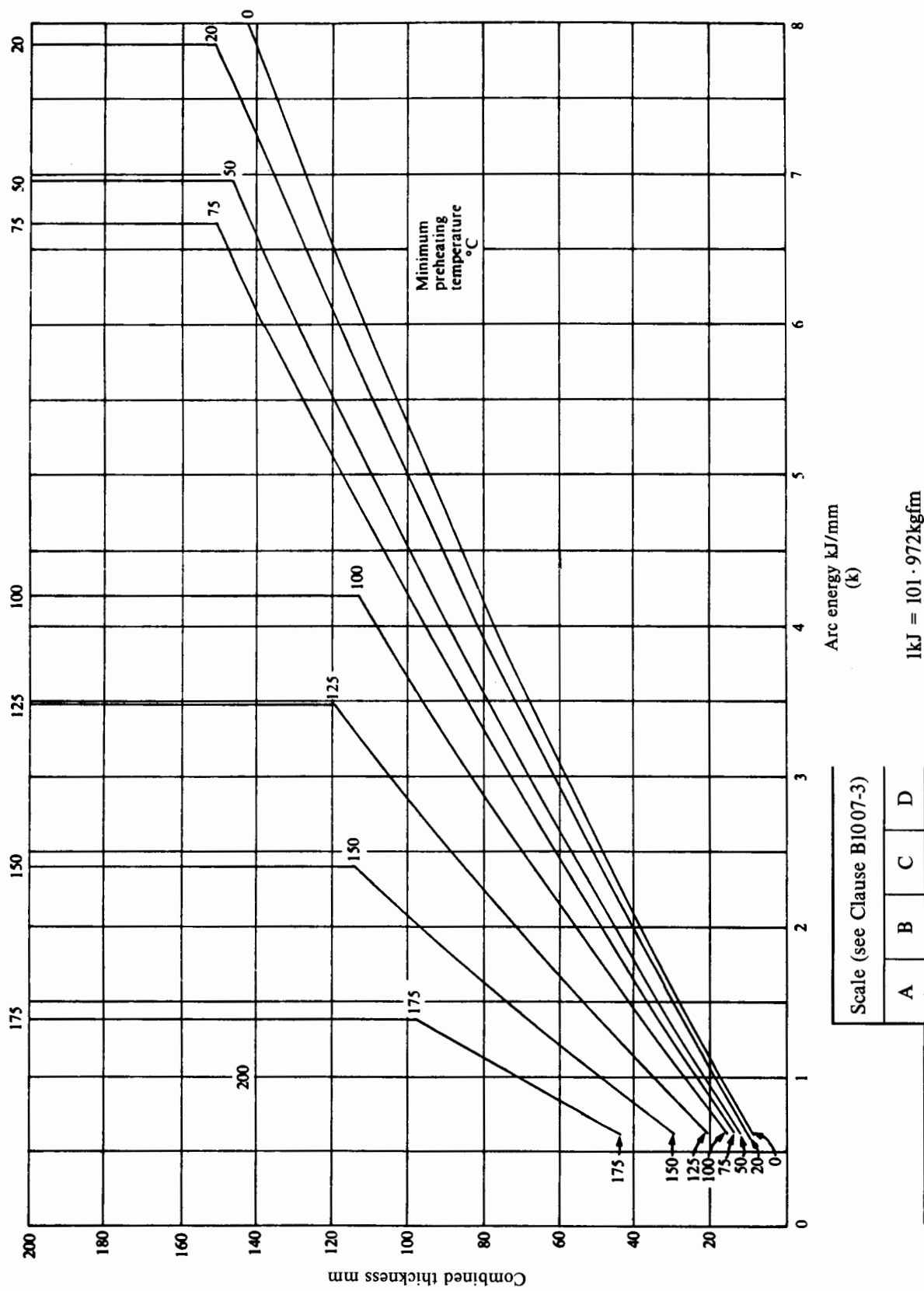


FIGURE B10/11 (cont.)
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT

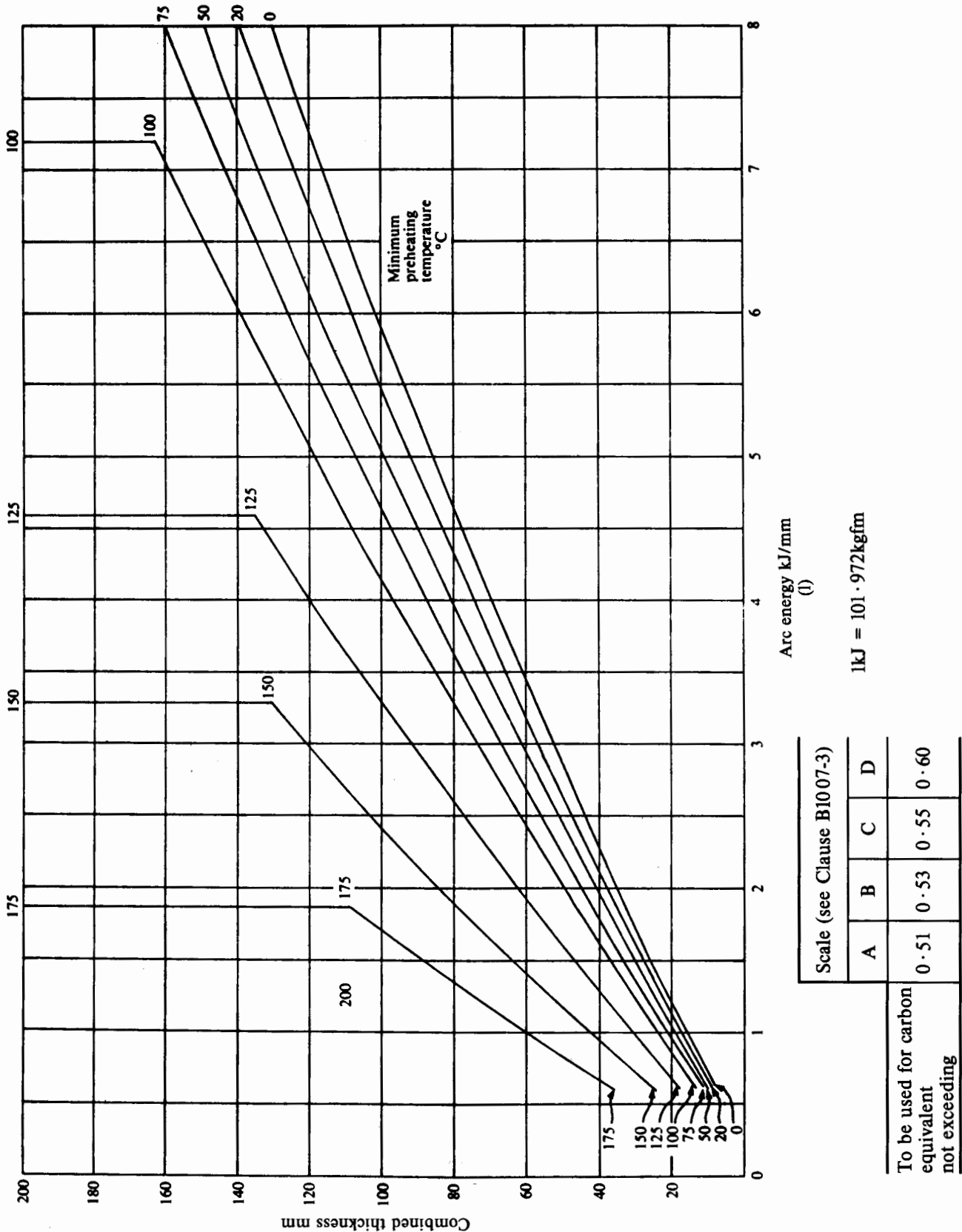


FIGURE B10/11 (cont.)

CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT

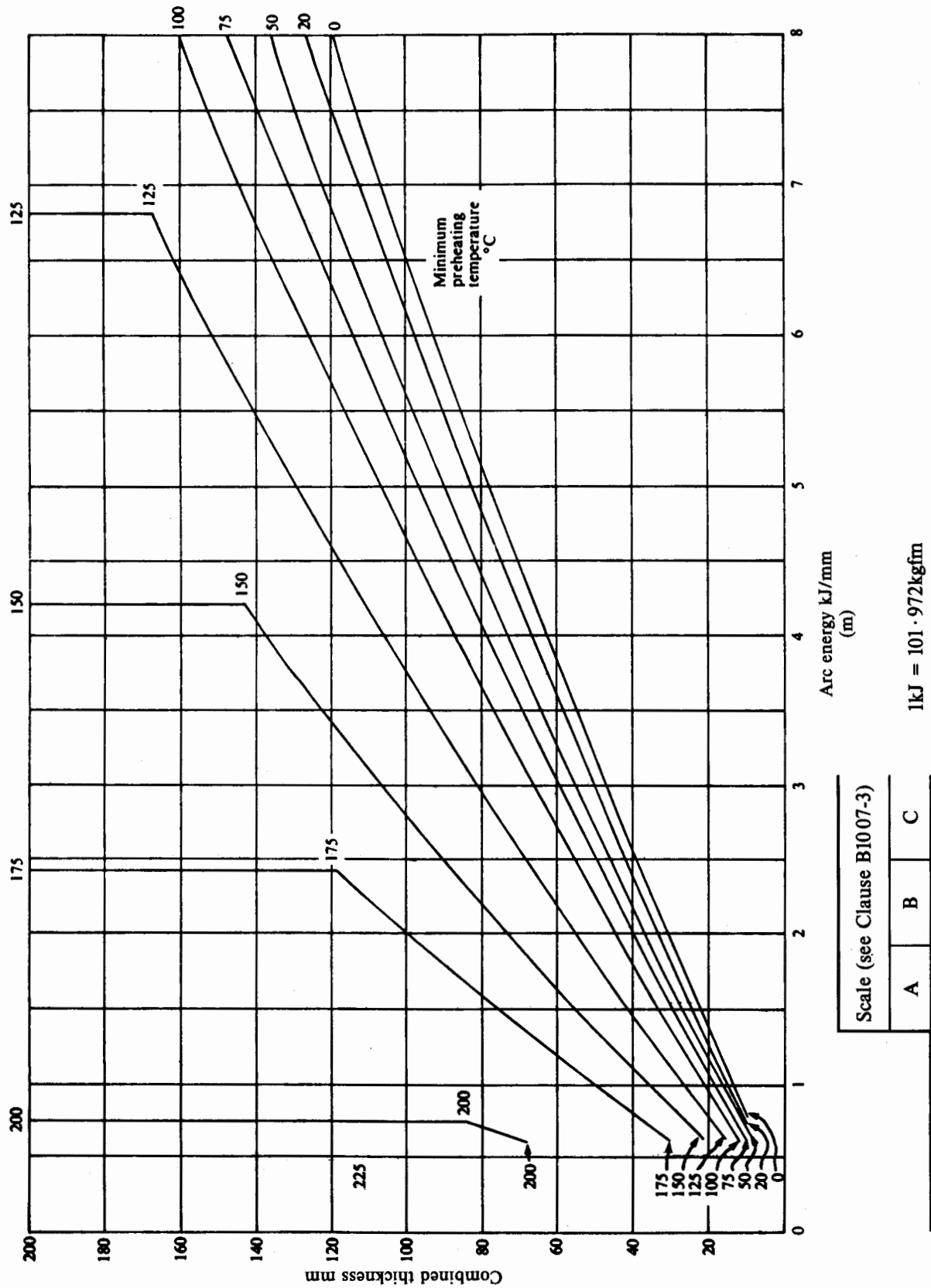
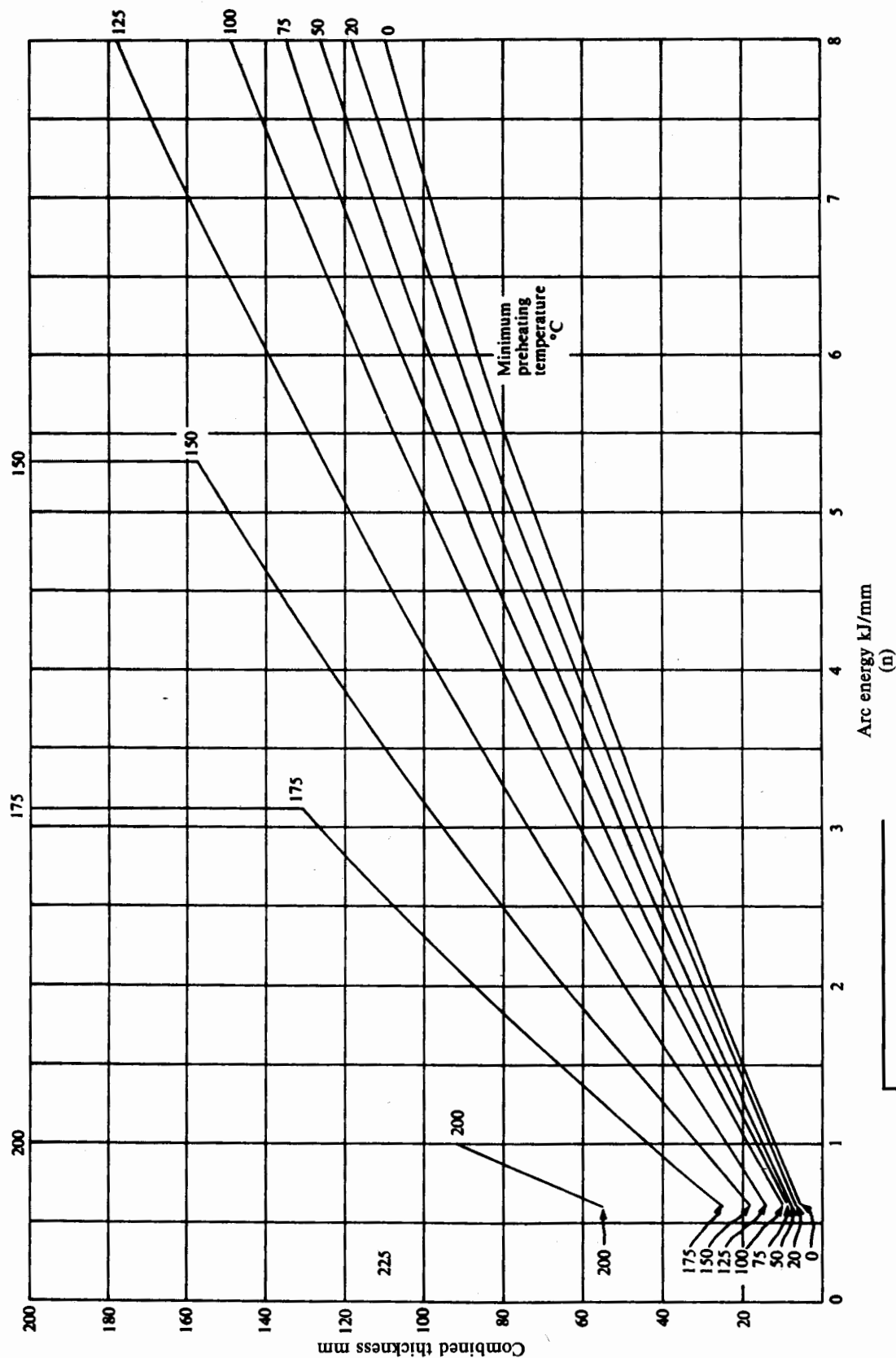


FIGURE B10/11 (cont.)
CONDITIONS FOR WELDING STEEL OF STATED CARBON EQUIVALENT



1kJ = 101.972kgfm

Scale (see Clause B1007-3)			
	A	B	C
To be used for carbon equivalent not exceeding	0.55	0.57	0.59

B10 08 MEASUREMENT AND PAYMENT

1. Structural steel work or steel shall be measured in metric tonnes and the weight of members will include the cost of the fabrication and erection of steelwork or alternatively where provided for in the Contract, paid for on a lump sum basis in accordance with the item in the Bill of Quantities. Such lump sum price shall be full compensation for all steel; other materials, labour, equipment and tools necessary for the manufacture, all fabrication, transportation erection and painting or protected as specified.

2. The measurement in tonnes shall be the total weight of the finished member comprising plates, rolled sections, shear connectors, stiffeners, cleats, packs, splice plates and all fittings computed in accordance with BS153 Part 2 (1972), without allowance for tolerance for rolling margin and other permissible deviations from standard weights, and excluding the weights of weld fillets, bolts, nuts, washers, rivet heads and protective coatings. No deductions shall be made for notches, cope holes, bolts holes and the like each less than 0.01m^2 . Concrete cast on preflexed beams at the place of fabrication shall not be measured either for the supply or the erection of the steelwork.

For the purpose of payment all minor items such as minor miscellaneous metals items as bearing plates, pedestals, forged steel pins, anchor bolts, field rivets, etc., unless otherwise provided for in the Bill of Quantities, shall be considered as structural Carbon Steel, even though made of other materials.

3. The weight of mild steel to BS4360 (1972) grades 43A1 and 43A shall be taken for measurement as 785kg/m^2 per 10cm thickness (7.85t/m^3). The weight of other metals shall be taken as stated in the Specification or, where not so stated, as stated in the supplier's catalogues.

SECTION B11

WATERPROOFING FOR STRUCTURES

B11 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour and in performing all operations in connection with the waterproofing of structures complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B11 02 STANDARD SPECIFICATIONS AND TEST METHODS

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the listed British Standard Institution's publications.

BS Code of Practice 144 Part 4 (1970), Roof Coverings-Mastic Asphalt.

BS988, 1076, 1097 & 1451 (1973), Mastic Asphalt for building, etc.

BS3690 (1970), Bitumens for Road Purposes.

B11 03 MATERIALS

1. **Primer:** Primer for sealing concrete surfaces prior to waterproofing shall be fully compatible with the bonding agent and waterproofing.
2. **Bonding Agent:** Unless otherwise specified in the Contract, the bonding agent shall be hot-applied oxidized bitumen having a softening point (Ring and Ball) within the range of 80-100°C and penetration at 25° C within the range of 20-30.
3. **Mastic Asphalt:** Unless otherwise described in the Contract, mastic asphalt for waterproofing shall comply with the requirements of BS988 (1973).
4. Where mastic asphalt for waterproofing is required in the Contract to comply with the requirements of BS1097 (1973), in addition its hardness number at the time of laying shall not exceed 90 at 25° C.
5. **Proprietary Waterproofing Systems:** Proprietary waterproofing systems shall comply with Clause R1 05 for the approval of the Engineer's Representative.
6. **Rubberized Filled Bitumen:** Rubberized filled bitumen for in-situ waterproofing shall be made from 85-100 pen. Straight-run bitumen, limestone filler with grading and qualities in accordance with the filler specification given in Clause R9 02, and unvulcanised natural rubber powder.
7. The final softening point (Ring and Ball) of the mixture shall be between 90° C and 100°C. The suggested method of manufacture to achieve this is as follows:
8. Approximately 3 parts by weight of filler are added to 1 part of bitumen and the mixture stirred for a minimum of 1 hour at 170-190° C. The softening point (Ring and Ball) of this mixture is to be between 75° C and 85° C; the exact filler/binder proportions being adjusted to obtain this result. To the filler/binder mixture is added 0.75-1 per cent by weight of rubber (allowance being made for non-rubber constituents of the powder) which is stirred in for a further period of 1 hour at 170 - 190° C. Should the final softening point

Waterproofing for Structures

be outside the limits specified, the softening point of the filler/binder mixture may be adjusted to obtain the correct result.

9. Sand Asphalt: Sand asphalt protection shall comply with the requirements of Section R9 Hot-mix Asphaltic Concrete Pavement.

B11 04 GENERAL

1. Immediately before waterproofing is laid, the surface to be waterproofed shall be clean, dry and free from membrane curing compounds and projecting tying wire. Waterproofing shall not be laid when the ambient temperature is below 4°C.

2. Only plant and equipment fitted with rubber tyres may travel on mastic asphalt waterproofing and, with the permission of the Engineer's Representative on other waterproofing systems for the purpose of laying hot sand asphalt or surfacing upon them.

3. The protective layer as Clause B11 03-9 shall be laid and compacted without damage to the waterproofing.

B11 05 WATERPROOFING WITH MASTIC ASPHALT

1. Mastic asphalt shall be laid in two courses to provide a total thickness not less than 2cm. The method of laying and workmanship shall conform with the principles contained in BS Code of Practice CP144 Part 4 (1970) Section 4 except that:

- (i) Sub-clauses 4.6.2., 4.6.3., 4.7.1., 4.7.2., 4.7.8., and 4.7.9. of the Code of Practice shall not apply and,
- (ii) Details shown in the Contract shall prevail over any conflicting requirement in the Code of Practice.

2. Joints shall be staggered at least 15cm between courses and their positions and the sequence of working shall be agreed with the Engineer's Representative before commencement of the work. The mating edges of all joints shall be intimately bonded. The surfaces of any gullies and other metal features with which the waterproofing will be in contact shall be clean and painted with bitumen as specified in Clause B11 08.

B11 06 WATERPROOFING WITH PREFABRICATED SHEETING

1. Concrete surfaces shall be thoroughly sealed with one coat of primer where specified. Primed surfaces shall not be covered until all solvent constituent has evaporated. When spirit-based primer is used, a minimum of 20 hours at a temperature between 10-16°C shall elapse before waterproofing is laid. When bituminous emulsion is used, all water shall be allowed to evaporate. The sheeting shall be installed in accordance with the manufacturer's instructions and shall be laid so that no air is trapped between it and the concrete surface or between successive layers of sheeting.

2. Unless otherwise specified in the Contract, joints between sheets shall be lapped with end laps of at least 15cm and side laps of at least 10cm. The joints shall be arranged so that at no point are there more than 3 thicknesses of sheeting and, as far as possible, so that water will drain away from the exposed edge.

B11 07 WATERPROOFING WITH RUBBERISED FILLED BITUMEN

1. Rubberised filled bitumen shall be laid at a temperature of about 180°C by means of squeegees. It shall not be heated to more than 200°C at any stage nor kept at a temperature above 170°C for more than 4 hours. Reheating of the material after setting will not be permitted. No traffic shall be allowed on rubberised filled bitumen until the surfacing has been laid.

B11 08 PAINTING WITH BITUMEN

1. Prior to the application of bitumen paint, surfaces to which it is to be applied shall be clean and dry. The first coat shall be allowed to dry before the second coat is applied.

2. Bitumen painting shall consist of two coats of cut-back bitumen complying with BS3690 (1970) and Clause R802-2 with a coverage of 1.8m²/litre.

B11 09 MEASUREMENT

The unit of measurement for waterproofing of structures shall be the square metres. The measurement shall be the number of square metres of structural surface covered by the system. No deduction shall be made for openings of 1 square metre or less. For each waterproofing system, the items in the Bill of Quantities shall be deemed to be inclusive.

B11 10 PAYMENT

Payment for the various items of waterproofing to structures will be made in accordance with the Specification at the price tendered in the Bill of Quantities for the several items involved according to the system and the waterproofing feature. Any item not included in the Bill of Quantities which is shown on the Drawings or called for in the Specification shall be understood to be included in the rates quoted for other items.

Payment shall include for the furnishing of all materials, labour, equipment and all items required for carrying out the waterproofing.

SECTION B12

PROTECTION OF STEELWORK AGAINST CORROSION

B12 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with the protection of steelwork against corrosion complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B12 02 STANDARD SPECIFICATIONS AND TEST METHODS

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the listed British Standard Institution's publications.

BS4232 (1967), Surface Finish of blast-cleaned steel for painting.

BS729 (1971), Hot dip galvanised coatings on iron and steel articles.

BS2569 (1964), Part 1 Sprayed metal coatings (zinc and aluminium).

BS3382 Parts 1 & 2 (1961), Electroplated coatings on threaded components.

B12 03 PREPARATION OF SURFACES TO RECEIVE PAINT

1. **Bare Metal Surfaces:** Surfaces of metal to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil, grease and other foreign substances. Unless blast cleaning is used, all weld areas, before cleaning is begun, shall be neutralised with a proper chemical, after which it shall be thoroughly rinsed with water. The first coat of paint shall be applied immediately after cleaning.

Unless otherwise specified, any of the following methods of cleaning as (i), (iii) and (iv) may be used.

- (i) **Blast Cleaning:** Blast Cleaning shall be carried out in accordance with BS4232 (1967) to first quality of surface finish unless otherwise described on the Drawings. The maximum grade of metallic abrasive permitted shall be as listed in Table 2 of the above British Standard. Non-metallic abrasives shall be permitted where agreed by the Engineer's Representative for use with portable equipment only. The abrasive used for blasting shall be free from harmful contamination and any recovered material shall be cleaned to the satisfaction of the Engineer's Representative before re-use. The maximum amplitude (peak to trough) of the blast cleaned surface shall not exceed 100 microns. A sample blast cleaned steel panel measuring not less than 15cm x 15cm x 6mm adequately protected by a sealed transparent wrapping shall be submitted to the Engineer's Representative for approval before any work is put in hand. The approved sample shall then be retained by the Engineer's Representative for comparison with the prepared steelwork.
- (ii) **Pickling:** Steel shall be pickled by the "Footner" process, a pickling process involving the successive immersions of steel in the following solutions:
 - (a) 5-15 per cent by weight sulphuric acid at 50 to 60°C.
 - (b) Hot rinsing water at 60 to 65°C.

Protection of Steelwork Against Corrosion

- (c) 2 per cent by weight phosphoric acid at not less than 85°C for 3 to 5 minutes.

It is an integral part of the process that the pickled steel should be primed or pretreated as soon as it has dried, while it is still warm.

- (iii) **Flame Cleaning:** All metal, except the exposure of the inside of boxed members and other surfaces which will be inaccessible to the flame cleaning operation after the member is assembled, shall be flame cleaned in accordance with the following operations:-

- (a) Oil, greases 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.
- (b) The surfaces to be painted shall be cleaned and dehydrated (freed 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 20cm and shall be not more than 4mm centre to centre. The oxyacetylene flames shall be traversed over the surface of the steel in such manner and at such speed that the surfaces are dehydrated; and dirt, rust, loose scale, scale in the form of blisters or scales, and similar foreign matter are freed by the rapid, intense heating of 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.
- (c) 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 material and foreign particles. Compressed air shall not be used for this operation.
- (d) The priming coat of paint shall be applied as soon as possible after the steel has been cleaned and is still warm 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. The heat input shall be controlled so that no harmful distortion of the steelwork occurs.

- (iv) **Mechanical Cleaning:** Mechanical cleaning shall be carried out by power driven tools such as carborundum grinding discs, chipping hammers and needle guns, followed by steel-wire brushing and dusting to remove all loosened material. Excessive burnishing of the metal through prolonged application of rotary wire brush shall be avoided.

2. Cleaning and Decontamination of all Surfaces

- (i) **General Cleaning:** Weld spatter shall be cleaned off all surfaces, and paint films shall be free of embedded foreign metallic particles. Deposits of concrete or other adherent matter shall be washed or cleaned off immediately they occur and if necessary the surface made good to the satisfaction of the Engineer. Areas contaminated by oil or grease shall be cleaned with white spirit. Unless otherwise instructed by the Engineer, the final works coating on external surfaces shall be cleaned at Site by washing with a solution of an approved liquid detergent followed by rinsing with clean fresh water and allowed to dry thoroughly before overcoating. Immediately prior to the application of paint all loose particles, dust and debris shall be removed.

- (ii) **Chemical Pollution:** A protective coating shall not be applied to surfaces bearing atmospheric corrosion products or other chemicals which may be harmful to the coating or succeeding coatings. These contaminants, which include any remaining after surface preparation as specified in Clause B12 03-1 and any produced by welding, shall be cleaned off to an extent agreed by the Engineer to be compatible with the specified protective system.

B12 04 METAL COATINGS

1. Unless otherwise specified by the Engineer, procedures for applying metal coatings shall be in accordance with the following:

- (i) BS729 (1971) Hot-dip Galvanised Coatings.
BS4921 (1973) Sherardised Coatings.

Metal coatings to BS729 shall only be applied to components of a tensile strength up to and including that of General Grade H.S.F.G. bolts unless specified by the Engineer.

- (ii) BS2569 Part 1 (1964) Sprayed Metal Coatings (Zinc and aluminium). The nominal thickness of coating to be 100 microns.
- (iii) BS3382 Parts 1 & 2 (1961) Electroplated Coatings on Threaded Components (Cadmium and zinc). This British Standard shall be deemed to cover the electroplating of components up to and including 36mm in diameter. The minimum thickness of coating to be 5 microns.

2. Where a metal coating is required only on part of an assembled section it shall be applied before the rest of the section receives its priming coat.

B12 05 PROTECTION OF JOINTS

1. High Strength Friction Grip (HSFG) Bolted Joints: In the case of zinc or aluminium sprayed steelwork where the metal spray is carried over the interfaces of the HSFG bolted joints, the etch primer on the parent metal shall be taken between 1cm and 2cm inside the perimeter of the joint area. The outer surfaces and edges of the joint material may also be given a coat of the same primer in order to reduce surface preparation required after the joint has been made.

In the case of painted steelwork where metal spray is specified only at the interfaces of HSFG bolted joints, the metal spray shall be carried between 1cm and 2cm outside the perimeter of the joint area and the blast primer taken between 1cm and 2cm inside the perimeter. If the outer surfaces and edges of the joint material are metal sprayed, these may be given a coat of etch primer in order to reduce subsequent surface preparation.

In the case of painted steelwork where the interfaces of HSFG bolted joints are bare steel, the blast primer shall be taken between 1cm and 2cm inside the perimeter of the joint area. The outer edges and surfaces of the joint material may also be given a coat of blast primer in order to reduce subsequent surface preparation.

2. Other Bolted Joints: Shop Joints. Metal spray plus etch primer, or blast primer alone shall be applied to parent and joint material. The joint shall be assembled immediately after the first undercoat of the parent system has been applied to the contact surfaces.

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Site Joints. Unless otherwise described in the Contract all surfaces, excepting those of fasteners, shall receive in the shop the painting system which is applied to the parent surfaces.

3. Riveted Joints: Shop and Site Joints. Metal spray plus etch primer or blast primer alone, shall be applied to parent and joint material. The joint shall be assembled immediately after the first undercoat of the parent system has been applied to the contact surfaces.

4. Welded Joints: Unless otherwise described in the Contract, welds and surfaces which have been affected by welding shall receive the protective system which is applied to the parent surfaces.

5. Treatment Adjacent to Joints: Metal spray shall be kept at least 15mm clear of areas to be welded and these areas shall be masked off during spraying.

Where paints other than blast primers are to be applied to the parent surfaces before the making of a joint, they shall be stepped back at 3cm intervals commencing at 8cm from welded joints and at 1cm from the perimeter of all other joints.

6. Painting of Joints: As soon as possible after joints have been made and passed by the Engineer's Representative the parent and joint material, exposed parts of bolts, nuts and washers, weld and weld affected areas shall be brought up to the same state of preparation and painting as the adjoining surfaces.

7. Other Treatment at Joints: All bolted joints shall be sealed against the ingress of water. Before painting commences and, subject to the approval of the Engineer's Representative, gaps at joints shall be plugged with an approved filler. The perimeter of all joints shall be sealed with subsequent coats of paint.

B12 06 STORAGE OF PAINT

1. Paint shall be stored in sealed containers in a lock-up store where it is not exposed to extreme temperature. The temperature of the store shall be kept between 4°C and 27°C. Any special storage conditions recommended by the manufacturer shall be observed.

2. Paint which has not been used within the 'shelf life' period specified on the containers or within 18 months of the date of manufacture, whichever is the lesser, shall be replaced.

3. At the end of each working period two pack primers, expodite, polyurethane and paints with a limited 'pot life' shall be discarded. Other types of paints from painters' kettles shall be returned to store and kept in sealed containers with not more than 10% ullage.

B12 07 APPLICATION OF PAINT

1. Where called for by the Engineer the Contractor shall carry out paint application procedure trials, either at the fabricator's works or at Site as appropriate, with the equipment and labour to be used in the Works. The Contractor shall supply suitable blast cleaned steel and sufficient paint for the trials and must demonstrate his ability to apply each coat of paint of a designated type and make as specified by the Engineer in the Special Specification of Particular Application in accordance with the specification and the paint manufacturer's performance guarantee certificate. No painting of the Contract steelwork will be permitted until the procedure trials have been completed to the satisfaction of the Engineer.

2. All requirements of the paint manufacturer's data sheets shall be complied with. Paint shall be supplied from the Contractor's paint store to the painters ready for application,

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the only adjustment of formulation being as provided for in the Special Specification of Particular Application. Any addition of thinners must be made in the store under the supervision of the Engineer's Representative and only as allowed under the manufacturer's data sheet.

3. All painting shall be carried out by skilled and experienced painters under constant supervision by competent qualified staff.

4. Paint shall be applied only to surfaces which have been prepared and cleaned in accordance with Clause B1203.

5. Paint shall not be applied under the following conditions:

- (i) When the ambient temperature falls below 4°C or the relative humidity rises above 90 per cent.
- (ii) During rain, snow, fog or mist.
- (iii) Where the amount of moisture on the surface or that likely to be caused by subsequent condensation may have a harmful effect.

6. Two pack paints of the epoxide resin type shall not be applied when the temperature is below 5°C or as required by the paint manufacturer, nor shall such paints be applied when the temperature is likely to fall below the specified minimum during the curing period.

7. As soon as the first undercoat has dried, an extra stripe coat of paint shall be applied by brush to edges, corners, crevices, exposed parts of bolts, rivet heads and welds, using a similar undercoat but in contrasting shade. Successive coats shall have different shades for identification.

8. The Contractor shall ensure that the proposed coverage rates will enable the specified average dry film thickness of each coat to be attained.

9. Wet film thickness gauges shall be used to check the rate of paint application.

10. All shop painting shall be carried out in a fully enclosed workshop unless otherwise agreed by the Engineer's Representative.

11. Two pack or any similar chemically cured type paint shall not be used after the expiration of the "pot life" stipulated by the manufacturer and such paints shall not be mixed with fresh paint.

12. Unless otherwise described in the Contract, a coat of paint in a system shall be applied by one of the following methods:

- (i) Brush
- (ii) Roller, supplemented by brush where necessary
- (iii) Air pressure spraying
- (iv) Airless spraying

13. Galvanised surfaces which are required to be painted shall be treated as follows:

In five litres of soft water dissolve 62g each of copper chloride, copper nitrate, and sal ammoniac, then add 62g of commercial nitric acid. This should be done in an earthen or glass vessel, never in tin or other metal receptacle. Apply the solution with a wide, flat brush to the galvanised surface, when it will assume a dark, almost black colour which

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on drying becomes a greyish film. Approved alternative treatments may be used as permitted by the Engineer's Representative in writing.

14. Surfaces of iron and steel castings, either milled or finished, shall be given one coat of paint.

15. With the exception of abutting joints and base plates, machine-finished surfaces shall be coated as soon as practicable after being accepted with a hot mixture of white lead and tallow or other approved coating complying with this Clause before removal from the shop.

16. Erection marks for the field identification of members and weight marks shall be painted upon the surface area 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.

17. Each coat of paint of a specified paint system shall be generally free from surface defects, particularly cratering, pinholing, rivelling, sagging, bittiness, dry spray and cissing. The finished system shall have an even and uniform appearance.

18. Where applicable, the degree of gloss of a finishing coat shall be agreed with the Engineer's Representative before it is applied. A reference panel 15cm x 10cm, shall be provided by the Contractor for this purpose.

19. Each coat of paint of a specified system shall have satisfactory adhesion as demonstrated by one of the currently accepted adhesion tests specified by the Engineer's Representative.

B 12 08 STORAGE OF STEEL AND FABRICATED STEELWORK

1. The Contractor shall take precautions to minimise exposure to chemical pollution of steel awaiting fabrication.

2. Fabricated steelwork which is stored, awaiting delivery to site or erection, shall be kept clear of the ground and shall be laid out or stacked so as to reduce to a minimum the amount of water or dirt that can accumulate on or against any of the surfaces. Suitable packings shall be placed between layers of stacked steelwork. Where cover is provided it shall be ventilated sufficiently to keep condensation to a minimum.

3. Unless otherwise described in the Contract, exposure times for blast cleaned or coated surfaces other than at joint shall not be longer than those in Table B12/1 below. 'Outside' refers to any area outside a fully enclosed workshop.

TABLE B12/1

Surface	Enclosed Workshop	Outside
a. Blast cleaned	4 hours	Nil
b. Metal sprayed	4 hours	Nil
c. Mechanically cleaned	48 hours	Nil
d. Blast primer on 'a'	Maximum exposure of 8 weeks, with up to 2 weeks of this time outside.	
e. Etch primer on 'b'	24 hours	Nil
f. Primer on 'c'	48 hours	Nil
g. 1st undercoat on 'd', 'e', or 'f'	48 hours	Nil
h. Subsequent undercoats	As agreed by the Engineer	

The exposure times tabulated in Table B12/1 refer to any part of the surface being blast or mechanically cleaned, metal sprayed or painted.

4. For surface condition 'd' where blast primed steelwork is exposed outside, the minimum dry paint film thickness over the peaks of the blast cleaned steel shall not be less than 13 microns.

5. Zinc rich coated steelwork may only be exposed outside for the minimum period to allow movement at the fabricator's works. Such movement shall be under the supervision of the Engineer's Representative and unless the weather conditions are favourable the sections shall be covered.

6. Where it is necessary to overcoat two pack paints of the epoxide or polyurethane type, they shall be recoated within 48 hours of application. Where it is not possible to overcoat within this time, the paint film shall be abraded to produce a roughened surface and given a flash coat of suitable primer which shall be allowed to dry for at least 4 hours before application of the next coat of the system.

7. No steelwork shall be loaded for transport until the paint system has been passed by the Engineer's Representative as being sufficiently dry for handling.

B12 09 REPAIRS TO DAMAGED SURFACES

1. Areas of paint which have been damaged shall be cleaned to bare metal, or to metal coating where this has been applied, and the edges of the undamaged paint bevelled with sandpaper.

2. Where a metal coating has been damaged the affected area shall be rubbed down to remove excessive roughness, cleaned and made good by the application of a coat of an approved zinc-rich primer.

3. The full specified painting system shall then be applied in such a manner that the new paint overlaps the existing paint by at least 5cm all round the affected part.

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B12 10 ETCH PRIMERS AND BLAST PRIMERS

Etch primers and blast primers shall be suitable for continuous spray application. They shall not be used on phosphated steel nor shall they be overcoated with zinc-rich primers.

B12 11 UNCOATED SURFACES

Unless otherwise specified, surfaces which will have concrete cast against them (or may be brought into contact by means of friction grip bolts) shall be left uncoated and shall be clean and free from loose rust and scale at the time of concreting. The shop applied paint system on adjoining surfaces shall be extended 2.5cm as marginal stripes within the contact surface.

B12 12 PROTECTIVE COATINGS FOR STEEL PILES

1. The provisions of Section B12 shall apply generally to protective coatings to steel piles.
2. Before paint is applied to any pile, the surface shall be prepared as described in the Contract. Where blast-cleaning is specified, this shall be to Class 2 quality as defined in BS4232(1967).
3. The painting system for piles where non-abrasive conditions of driving are expected to occur, shall consist of a compound of coal tar pitch, creosote oil and bitumen blended to the approval of the Engineer.
4. The painting system for piles where abrasive conditions of driving are expected to occur, shall consist of a pitch extended epoxy resin compound.
5. Where described in the Contract, cathodic protection of steel piles shall be provided.

B12 13 SAMPLING AND TESTING

1. **Submission of Samples and Test Certificates:** The submission of the lists of suppliers, samples and test certificates shall be in accordance with Clause R1 05 Approval of sources and types of material and plant.
2. **Testing of Paints:** Immediately after selection by the Engineer's Representative of paint in accordance with the paint application procedure trials as Clause B12 07, samples of each type of paint to be used for the Works shall be despatched by the Contractor to the testing authority in accordance with the Engineer's Representative's instructions. The samples shall be supplied in 5 litre unopened containers as received from the paint manufacturer.
3. The first sample shall always be taken from the first batch of each type of paint to be supplied and painting shall not commence until the Engineer's Representative confirms that these first samples are satisfactory. Paint must be supplied in sufficient time to allow for the initial testing.
4. Immediately after selection by the Engineer's Representative of control samples of paints being used for the Works, the Contractor shall fill 500ml containers with the selected materials and hermetically seal and despatch these to the testing authority. The containers shall be provided by the Contractor and be of such material as not to affect the contents.
5. **Testing of Metal Coatings:** Unless otherwise specified by the Engineer's Representative, the Contractor shall apply the appropriate test or tests described in the British Standards referred to in Clause B12 04. The Contractor shall make arrangements for the

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Engineer's Representative to witness such test records as the Engineer's Representative may require.

B12 14 MEASUREMENT AND PAYMENT

The cost of preparation of the metal surfaces, the application, protection and drying of the paint coatings, and the supply of all tools, tackle, scaffolding, labour and materials shall be included in the price tendered for Structural Steelwork in Place and no additional payment for painting will be allowed.

SECTION B13

BRIDGE BEARINGS

B13 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with bridge bearings, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the directions of the Engineer's Representative.

B13 02 STANDARD SPECIFICATIONS AND TEST METHODS

This Specification for Bridge Bearings should be read in conjunction with Sections B7 to B12 and with the other parts of British Standards which cover the design, materials and workmanship of concrete, steel and composite bridges.

Except as modified by this Specification, the following standard specifications and test methods shall govern in all cases and reference must be made accordingly to the listed British Standards Institution's publications.

Steels

- BS970 Parts 1, 2 & 4 (1970 & 72) Wrought Steels in the form of blooms, etc.
- BS1449 Part 1 (1972) Carbon steel plate, sheet and strip
- BS1449 Part 2 (1975) Stainless and heat resisting steel plate, sheet and strip
- BS3100 (1976) Specification for steel castings for general engineering purposes
- BS4360 (1972) Weldable structural steels
- BS4670 (1971) Alloy steel forgings

Cast Iron

- BS2789 (1973) Iron Castings with spheroidal or nodular graphite

Aluminium

- BS1470 (1972) Wrought aluminium and aluminium alloys for general engineering purposes – plate, sheet and strip
- BS 1472 (1972) Wrought aluminium and aluminium alloys for general engineering purposes – forging stock and forgings
- BS1474 (1972) Wrought aluminium and aluminium alloys for general engineering purposes – bars, extruded round tubes and sections
- BS1490 (1970) Aluminium and aluminium alloy ingots and castings, etc.

Copper Alloy

- BS1400 (1973) Copper alloy ingots and copper alloy castings
- BS2870 (1968) Rolled copper and copper alloys. Sheet, strip and foil
- BS2872 (1969) Copper and copper alloys. Forging stock and forgings
- BS2874 (1969) Copper and copper alloys, Rods and sections, etc.
- BS2875 (1969) Copper and copper alloys. Plate

- PTFE** BS3784 (1973) Polytetrafluoroethylene (PTFE) sheets

Rubber

- BS903 Part A2 (1971) Determination of tensile stresses strain properties
- BS903 Part A6 (1969) Determination of compression set after constant strain

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BS903 Part A 19 (1975) Heat resistance and accelerated air ageing tests

BS903 Part A23 (1963) Determination of resistance to ozone cracking under static conditions

BS903 Part A26 (1969) Determination of hardness

BS1154 (1970) Vulcanised natural rubber (high quality)

BS2752 (1975) Vulcanised chloroprene rubber

Finishes

BS729 (1971) Hot dipped galvanised coatings on iron and steel articles

BS1615 (1972) Anodic oxidation coatings on aluminium

BS1706 (1960) Electroplated coatings of cadmium and zinc on iron and steel

BS4232 (1967) Surface finish of blast-cleaned steel for painting

Adhesives

BS5350 Part C5 (1976) Determination of bond strength in longitudinal shear.

B13 03 MATERIALS

1. **General:** Materials used in the manufacture of bridge bearings shall be from the selected grades of steel, cast iron and aluminium as determined by the Engineer or from those in use by selected and approved specialist manufacturers of bearings, all in accordance with the British Standards listed in Clause B13 02 and the Special Specification for Particular Application.

2. **Adhesives:** Adhesives for bonding PTFE or stainless steel to backing plates shall have a minimum tensile shear strength of 60kgf/cm² at 24°C when tested in accordance with the recommendations of BS5350 Part C5 (1976). They shall be fully resistant to the action of lubricants, atmospheric and biological agents and the range of temperature to which the bearings may be subject. The adhesives proposed shall be submitted for approval to the Engineer. Such approval shall be obtained before manufacture is commenced.

3. Polytetrafluoroethylene (PTFE)

Unfilled PTFE shall be pure virgin PTFE without any addition of regenerated material or fillers. It shall be free sintered and not pressure cooled. The mechanical properties of the PTFE shall comply with the requirements of BS3784 (1973) for Grade A.

Filled PTFE containing 25% glass fibres by weight, or PTFE with other fillers of similar characteristics may be used for side restraints where improved resistance against deformation and wear is required.

PTFE is a linear chain polymer of great molecular strength known for its chemical inertness and low coefficient of friction. PTFE is not oxidised easily, it is resistant to all common solvents and it remains stable at extremes of atmospheric temperatures. The PTFE material for use as the main load bearing surface in bridge bearings should be adequately backed and supported to prevent flow, elongation or creep under load.

4. **Lubricants:** Lubricants for use in PTFE based bridge bearings shall retain their properties within the expected temperature range, shall not attack the sliding surfaces nor change their consistency with time. A silicone grease with a metallic soap thickening agent can give a satisfactory performance. They shall have the following properties when tested in accordance with the appropriate standard:

(i) Static Penetration 240-280 (DIN 51804)

(ii) Worked Penetration 265-295 (DIN 51804)

- (iii) Solidification Point not exceeding 40°C (DIN 51556)
- (iv) Bleed Test – separation after 24 hours at 150°C not exceeding 3% (BS5297 (1976))
- (v) Oxidation stability – pressure drop after 100 hours at 160°C not exceeding 0.7kgf/cm² (DIN 51808)

The Specification, etc. of lubricants to meet the above requirements for use in PTFE based bridge bearings shall be submitted to the Engineer for approval with relevant test reports, before manufacture is commenced.

5. Other Materials: Should a manufacturer wish to market a bearing in which the materials used do not comply with the requirements of the above, full details of the bearing including specification and drawings together with relevant test reports shall be submitted to the Engineer for approval which shall be obtained before manufacture is commenced.

B13 04 METAL BEARINGS

1. Metal bearings comprise the following types: –

- (i) Roller bearings with single roller, double roller, triple roller and two level sets of rollers.
- (ii) Rocker, knuckle and pin, pot and spherical bearings.

2. Special requirement descriptions

- (i) Pot Bearings. These bearings comprise of a vertical metal cylinder in which is located a metal piston supported by an elastomeric plug. As the elastomeric plug is fully confined within the cylinder, it provides a load carrying medium at the same time providing the bearing with a multi-directional rotational capacity. Horizontal translation may be accommodated by the provision of sliding plates located above the piston.
- (ii) Spherical Bearings. These bearings are provided with spherical (or cylindrical) load carrying surfaces, which permit multi-directional rotation by the sliding of the spherical (or cylindrical) bearings.

3. Bearings with cylindrical load carrying surfaces will permit rotation about a single axis only. Rotation about two axes can be accommodated by the use of two cylindrical load carrying surfaces placed at right angles to each other.

4. For the types of bearings listed in paragraph 1(ii) above horizontal translation may be accommodated by the provision of sliding plates located above the load carrying surfaces.

5. All roller bearings shall have a device to maintain correct alignment.

B13 05 ELASTOMERIC BEARINGS

1. An elastomer is either a natural rubber or a synthetic material with rubber-like characteristics and is used in the following elastomeric bearings.

- (i) A laminated bearing is an elastomeric bearing consisting of one or more elastomer slabs bonded to metal plates to form a sandwich arrangement.
- (ii) A bearing pad is a single unreinforced elastomer slab (i.e. without metal plates).

Bridge Bearings

- (iii) A bearing strip is a continuous bearing pad for which the effective width (B) divided by the effective length (L) of the bearing (measured parallel to and at right angles respectively to the axis of rotation) is greater than 5.

2. Elastomeric bearings shall be designed to the requirements of the Engineer as set out in the Special Specification for Particular Application and the Method of Attachment and Location may be as follows.

- (i) Location may be effected by means of dowels or by suitable recesses in the concrete structure. The use of welding for bonding metal-to-metal surfaces will not be permitted as there is a risk either of burning the elastomer or of affecting adversely the bonding in the bearing.
- (ii) The design requirements for permitted reliance upon the effects of friction for both location and attachment shall be as specified by the Engineer in the Special Specifications as above. The design shall provide for easy inspection and replacement as far as this is practicable and meet such special requirements as limited space, extreme exposure and high ozone concentration, since it must be accepted that all elastomeric bearings may need replacement during the lifetime of a bridge.
- (iii) Where appropriate bearings may be attached to the structure by an approved adhesive, or by means of an approved bedding mortar, subject to the provisions of paragraph (ii) above.

B13 06 SLIDING BEARINGS

General

1. Bearings shall meet all the design requirements for movement of the bridge superstructure with the minimum of restraint.

2. Bearings which are designed to allow translation movement in one direction only shall be provided with side restraints. The side restraints shall consist of structural members with a minimum factor of safety of 2 against shearing or tearing away from the bearing components under the action of the appropriate horizontal basic load.

3. Sliding Interfaces. All sliding bearings shall have the larger of the sliding surfaces positioned above the smaller to ensure that the bearing is loaded concentrically at all times. Sliding bearings shall generally be screened to prevent the ingress of foreign matter.

4. All PTFE sliding surfaces shall be lubricated to reduce the initial coefficient of friction and dimples or grooves will be permitted subject to the approval by the Engineer, since tests have shown that they prolong the effectiveness of the lubricant.

5. PTFE containing glass fibres may be used on the side restraint surfaces.

6. PTFE shall be located either by bonding or confinement or both. Confined PTFE should be recessed into a metal support plate and shall be within 3mm of the size of the recess.

7. Surfaces Mating with PTFE.

- (i) The surfaces mating with PTFE shall be polished stainless steel except for spherical interfaces which may be of polished cast aluminium.
- (ii) The stainless steel mating surface shall normally form the upper component of the bearing and be larger than the lower PTFE component. The design shall be such

that the interface is always in compression to prevent the ingress of abrasive particles, etc.

- (iii) The stainless steel plate shall be attached to the backing plate by epoxy or phenolic resin bonding. The strength of the bonding shall be as specified for the PTFE bonding. In addition to bonding, the corners and edges of the stainless steel shall be secured to the plate with positive mechanical means, such as studs, rivets or metal screws, capable of resisting, in shear, 0.06 times the vertical load capacity without interfering with the sliding surface, at maximum spacings of 15cm, 30cm and 60cm for plates 1.5mm, 2mm and 3mm thick respectively. The interface between the stainless steel and backing plate shall be sealed to prevent the ingress of moisture. Alternatively the stainless steel plate may be welded to the backing plate by means of a continuous fillet weld all round the edge. In the case of stainless steel plate attached to side restraints, the mechanical attachment shall be capable of resisting, in shear, 0.08 times the maximum horizontal load capacity of the bearing.
- (iv) Wiper seals shall be incorporated to sweep the stainless steel surface clean at the interface in advance of the moving part of the bearing.

8. Flat sliding surfaces must not be used to accommodate rotation. Other provision must be made and such provision shall be designed to limit the edge pressure to the following values.

- (i) The maximum Contact Pressures for PTFE in bearings shall not exceed:—

	For bonded PTFE	For confined PTFE
Dead load + Superimposed		
dead load + Shrinkage & creep		
+ Temperature effects	200kgf/cm ²	305kgf/cm ²
All loads	305kgf/cm ²	460kgf/cm ²

- (ii) In the case of circular PTFE surfaces the following maximum edge pressure are permitted provided the average contact pressures do not exceed the values given in sub-paragraph (i) above.

Dead load + Superimposed		
dead load + Shrinkage & creep		
+ Temperature effects	255kgf/cm ²	380kgf/cm ²
All loads	380kgf/cm ²	560kgf/cm ²

- (iii) For calculation of pressures the contact surface shall be taken as the gross area of the PTFE without deduction for recesses provided for lubrication (dimples or grooves), provided these do not exceed 20% of the gross area.
- (iv) When working to pressures given in sub-paragraphs (i) and (ii) above it is important to ensure that the permissible stresses in other components and in concrete underneath the bearings are not exceeded.

B13 07 WORKMANSHIP

1. All screwed rods, bolts, nuts, washers, steel bars and plates shall comply with the Specification requirements of Clause B10 03-5.

Where specified by the Engineer bolts or screws shall be of a vibration resistant type or installed with a locking liquid.

2. Welding

(i) Welding procedures shall be so organized to minimize distortion of the bearing components and to avoid damage to finished work or bonded materials. In PTFE based bridge bearings as far as practicable all welding shall be completed prior to the bonding or installation of the PTFE or stainless steel sheets into the bearing assembly.

(ii) All fabrication, weld preparations, processes and procedures shall comply with Clause B10 04-7 Welding.

3. Machining:

As far as practicable machining shall be carried out in the principal direction of sliding and shall not be carried out until all welding on the component has been completed.

All machined surfaces in contact shall bear accurately over the full area of contact within ± 0.1 mm. All machined steel keys shall be a drive fit.

4. Contact Surfaces:

Where male and female parts are designed to be in contact, the manufacturing process shall ensure that they are accurately paired together.

All mating parts shall be paired together before despatch.

Machined and polished surfaces shall be protected from contamination and/or mechanical damage before assembly.

The clearance between the side restraints of a bearing and the moving component shall not exceed 1 mm.

5. PTFE Sliding Surfaces

(i) For a bonded only application, the PTFE shall have a minimum thickness of 1.5 mm.

(ii) The minimum thickness of PTFE shall conform to the following;—

For a confined application the minimum thickness of PTFE including its projection from the recess shall be as follows:

Maximum Dimension of PTFE (Diameter or Diagonal)	Minimum Thickness	Projection
Up to 60cm	4-5mm	2-0 $\pm$ 0-2mm
60-120cm	5-0mm	2-5 $\pm$ 0-2mm
120-150cm	6-0mm	3-0 $\pm$ 0-2mm

The minimum thickness of bonded PTFE shall be as follows:

Maximum Dimension of PTFE (Diameter or Diagonal)	Minimum Thickness
up to 60cm	1.0 mm
60-120cm	1.5 mm

(iii) PTFE may be dimpled or grooved, in order to prolong the effectiveness of the lubricant, provided that they conform with the following;—

(a) The plan area of the dimples or grooves shall be between 10% and 20% of the total PTFE bearing surface including the area of the dimples or grooves in any 10cm x 10cm portion of the surface.

- (b) The volume of the dimples or grooves shall not exceed 7% of the total PTFE volume including the volume of the dimples or grooves. In the case of confined PTFE, the volume shall be that which projects above the backing plate.
- (c) The depth of dimples or grooves shall not exceed either half the thickness of the PTFE or the height of its projection above the backing plate. For the confined application they shall not exceed 1 mm or the height of the projection from the recess, whichever is the lesser.
- (iv) Epoxy or phenolic resin adhesives may be used for bonding of PTFE sheet to backing plates. In a 90° peel test the bond strength between PTFE and its backing plate shall be at least 4kgf/cm width when tested in accordance with the requirements of BS5350 Part C5 (1976).
- (v) When the PTFE is bonded in position, it shall be bonded over its entire area of contact.

6. Stainless Steel Sliding Surfaces

- (i) Stainless steel sheet when used as a sliding surface in contact with PTFE shall have a minimum thickness of 1.5mm.
- (ii) The maximum surface roughness of stainless steel and hard chrome, Ra as defined in BS1134 Part 1 (1972), shall not exceed the following values:

Plane surfaces – 0.15 micron

Curved surfaces – 0.5 micron

For surfaces mating with PTFE the deviation from the intended profile over the length L of the bearing surface shall not exceed the value of $0.0002Lh$, where h is the protrusion of confined PTFE, or the thickness of bonded PTFE. For metal to metal sliding surfaces the departure from flatness measured with a straight edge and feeler gauge shall not exceed 0.0005 of the length of plate measured in any direction.

- (iii) Bonded stainless steel sliding plates shall also be attached mechanically.
- (iv) Stainless steel sliding plates shall be prepared for bonding in accordance with BS CP3012 (1972) Cleaning and preparation of metal surfaces.
- (v) The stainless steel plate shall be bonded over its entire area of contact.

B13 08 PROTECTIVE TREATMENT OF BEARINGS

1. Iron and Steel Components: Exposed parts of iron and steel components other than those of stainless steel, shall be prepared and painted as follows:—

- (i) steel parts shall be blasted clean in accordance with BS4232 (1967) to a first quality finish.
- (ii) spheroidal graphite iron castings shall be blast cleaned in accordance with BS4232 (1967) to a third quality finish.
- (iii) painting shall be in accordance with Clause B12 07 giving a minimum total film thickness of 150 microns.

2. Aluminium Alloy Components: Permanently exposed surfaces of aluminium alloy components shall be hard anodised to a standard not inferior to grade AA25 of BS1615 (1972) or degreased etch primed and painted in accordance with Section B12.

Bridge Bearings

3. **Exposed edges:** Sharp exposed edges and corners of components shall be rounded off to approximately 5mm radius or half the thickness of the plate whichever is the lesser.

4. **Exposed Bolts:** Exposed bolts, nuts, washers and shear keys shall be sherardised to Class 1 of BS4921 (1973) or electroplated with zinc to Class A of BS 1706 (1960). Alternatively the items may be made of stainless steel.

5. **Steel/Aluminium Insulation:** Steel bolts etc. shall be insulated from aluminium components by fibre washers.

6. **Limits of Protective Treatment:** The protective system shall be returned round edges for a distance of at least 10mm.

B13 09 INSPECTION OF BEARINGS

1. **General:** Such facilities as are necessary for the inspection during manufacture and on completion of bearings shall be provided at all reasonable times.

2. **Test Certificates:** Test certificates shall be provided for all materials incorporated in the bearings.

B13 10 TESTING OF BEARINGS

1. **General:** The properties and performance of proprietary and other special type bearings should be supported by test verification by an independent testing house or by properly documented previous experience. The verification document should give a full description of the bearings tested, setting out material properties, tolerances, conditions of fit up, assembly and installation and all other such data which, if departed from, could affect the performance of the bearing.

Careful consideration should be given to conditions likely to affect the bearing in service and reduce its efficiency and these should where practicable be simulated in the tests; examples of possible causes of adverse effects are: extremes of temperature, variations in rate of loading compared to that used in the tests, corrosion and fouling with foreign material, exposure of rubber to sunlight, deterioration of lubricants used to reduce the coefficient of friction in sliding bearings until these are 'run in', or high initial resistance to movement while the bearing is in service but not 'run in'. Test verification should state that these and other possible adverse effects have been considered and, where necessary, investigated and appraised. Full information on these matters should be supplied with the Testing House report.

2. **Proof Load Testing of Bearings:** Proof Loading tests shall be carried out on all prototype bearings to verify the design principles and load carrying capacity.

(i) **Vertical Proof Load.** Except in the case of roller bearings the vertical proof load shall be the greater of the following:

(a) 1.5 times the design dead load, superimposed dead load and Standard Live Loading.

(b) 1.25 times the design dead load, superimposed dead load and Military Loading.

The vertical proof load shall not however exceed 1500 tonnes. For roller bearings the vertical proof load shall be equal to the design load.

- (ii) **Horizontal Proof Load.** The horizontal proof load shall be 1.5 x the design horizontal load capacity with a maximum value of 250 tonnes.

Where appropriate to the bearing design, the proof load shall be applied eccentrically.

Proof loads shall be measured to an accuracy of 5% and be applied in ten equal increments. The maximum load shall be maintained for a minimum period of 30 minutes and then released incrementally. The deflection shall be measured for each increment of loading released. The relationship between load and deflection shall be linear and the recovery on removal of load shall not be less than 95%.

Immediately after proof load testing the bearings shall be dismantled and examined visually to ensure that no damage has occurred.

The test machine shall have a compression capacity of not less than 100 tonnes and shall have the facility to permit the simultaneous application of vertical load and horizontal force.

3. Friction Testing of Bearings: Tests to establish the coefficient of static friction shall follow the procedures specified in the following clauses. Except in the case of roller bearings, the imposed vertical loading shall be 1.3 times the design dead load and superimposed dead load. For roller bearings it shall be equal to the design dead load and superimposed dead load. The coefficient of friction shall be calculated from the greatest force required to move the bearing.

Sufficient tests shall be carried out to establish a value for the coefficient of static friction such that there is a probability of not more than 1 in 100 of its being exceeded.

For friction testing of PTFE based Sliding Bearings, the following test procedure shall be adopted.

- (i) An imposed vertical load, as specified in Clause B13 10-2 shall be applied to a pair of bearings mounted back to back between the press platens, such that the PTFE is subjected to the design bearing pressure.
- (ii) The load shall be applied for one hour. After one hour a horizontal force shall be applied to a pair of sliders at a rate of 1.0 tonne/minute, sufficient to cause movement of not less than 25mm between the stainless steel and PTFE surface at a rate of not more than 50mm per minute. The maximum force required to cause this movement shall be recorded. The load shall then be removed from the bearings which shall then be removed from the rig and inspected.
- (iii) The test shall be carried out at room temperature using prototype bearings and shall be repeated if the materials or workshop processes and quality controls used by the manufacturer are changed.
- (iv) After testing, the stainless steel shall be checked for flatness which must still be within the specified limits. The bond to the backing plate shall be unaffected. The PTFE shall be free from mechanical damage.
- (v) The coefficient of friction shall be calculated as:

$$\frac{\text{maximum horizontal force}}{2 \times \text{vertical load}}$$

and shall not be greater than 0.02.

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4. Testing of Elastomeric Bridge Bearings

- (i) Elastomeric bearings selected by the Engineer shall be subjected to tests as required in the Contract.

Number and nature of tests

- (a) Bond test. Test pieces for this purpose shall be prepared from one of the selected bearings, which may previously have been used for tests specified in sub-paragraph (iii).
- (b) Tests for physical properties and weathering test. Test pieces shall be taken from the inside and outside regions of the bearing and they shall be prepared as for the bond test. Alternatively, they may be prepared from a test sheet formed from the elastomer used in the manufacture of the bearing and being in a similar state of cure. A test piece cut from a bearing should produce not less than 75 per cent of specified performance results required from a prepared test sheet.
- (c) At least one full scale test for each bearing type and one test for every twenty bearings of the same type shall be carried out in respect of stiffness in compression and where applicable in shear. The rate of loading shall be agreed with the Engineer.

Subject to the approval of the Engineer, any or all of the tests may be waived where evidence can be produced that satisfactory test results are already available for materials and bearings identical with those to be used.

- (ii) Stiffness in compression. The bearing shall be loaded to 1.5 times the design load and this load shall be maintained for a period of two minutes. The loading shall then be reduced to 10 per cent of the design load and maintained at this value for ten minutes when gauge readings shall be taken. The bearings shall then be reloaded to 1.5 times the design load and maintained at this value for ten minutes.

Gauge readings shall be taken and used in conjunction with the earlier readings to evaluate the stiffness. The compressive stiffness shall be within ± 20 per cent of the value quoted by the manufacturer and approved by the Engineer. In addition, for any one structure the compressive stiffness for bearings of the same type shall not deviate from the value quoted by more than ± 15 per cent.

- (iii) Stiffness in shear. The bearing shall be loaded to produce 1.5 times the design movement and this load maintained for a period of two minutes. The loading shall then be reduced to produce 10 per cent of the design movement and maintained at this value for ten minutes when gauge readings shall be taken. The bearing shall then be re-loaded to produce 1.5 times the design movement and maintained at this value for ten minutes. Gauge readings shall be taken and used in conjunction with the earlier readings to evaluate the stiffness. The shear stiffness shall be within ± 20 per cent of the value quoted by the manufacturer and approved by the Engineer.
- (iv) No surface flaws shall become apparent during the stiffness tests and laminated bearings shall show no irregularities in deflected shape.
- (v) Bond of elastomer to metal. Tests shall be performed in accordance with Method B of BS903 Part A21 (1974). The average of the peak values of load during separation shall be not less than 7kgf/cm width of the test piece.

- (vi) Physical properties. The physical properties of the elastomer in respect of hardness, tensile strength, elongation at break, and compression set, shall comply with the requirements of BS1154 (1970) or BS2752 (1975) both as received and after ageing.

The respective tests shall be as described in the following:

Determination of Hardness BS903 Part A26 (1969) Determination of Tensile Strength and Elongation at Break BS903 Part A2 (1971). Determination of Compression Set BS903 Part A6 (1969). Accelerated Ageing Tests BS903 Part A19 (1975).

- (vii) Weathering. Tests shall be performed in accordance with BS903 Part A23 (1963). The ozone concentration shall be 25 ± 5 parts per hundred million at $30 \pm 1^\circ\text{C}$ and the elongation not less than 20 per cent. Each of the test pieces shall, at the end of the test period of 48 hours in the exposure chamber, be free from visible cracks when examined with a lens of $\times 7$ magnification.

6. Where a prototype bearing has been satisfactorily tested and the Engineer is satisfied that the materials and workmanship in the bearings supplied to a contract comply with this standard, no further acceptance testing of whole bearings will be required.

B13 11 INSTALLATION OF BEARINGS

1. General

- (i) After the final inspection and acceptance of the bearing at the manufacturer's works, the upper and lower parts shall be assembled and clamped together truly parallel. The overall dimensions of the assembled bearing shall be within $\pm 3\text{mm}$ of the dimensions on the drawings. When set to be parallel the upper and lower surfaces of the assembled bearing shall be parallel within a tolerance of $\pm 0.1^\circ$. Unless otherwise specified, all measurements shall be made with a steel rule or other device calibrated at a temperature of 20°C .
- (ii) Bearings with sliding surfaces shall be preset with the upper part offset in relation to the lower part by an amount specified by the Engineer, at the time of fixing the clamping straps.
- (iii) The clamping straps shall be sufficiently rigid to ensure that foreign matter cannot contaminate the contact or sliding surfaces and that the upper and lower parts of the bearings are retained in position during transport and handling.
- (iv) The clamping straps shall permit any vertical compression or rotation of the bearing that may occur under erection loading.
- (v) Depending upon the type of bridge structure and its method of erection the bearings may be set on packings or temporarily hung from the underside of the structure. In either case the clamping straps shall be kept in position until the bearings are finally set in position. At no time after despatch from the manufacturer's works shall any parts of the bearing be separated.
- (vi) Suitable lifting attachments shall be provided.
- (vii) Where necessary, provision shall be made for uplift at the bearing caused by a temporary erection condition.
- (viii) Prior to the installation of bearings employing shear keys/holding down bolts, the shear keys/holding down bolts shall have been accurately installed in the substructure using a steel template supplied by the bearing manufacturer. The shear key/

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holding down bolt recesses in the substructure shall be filled with mortar or cement grout. The grout used shall be approved by the Engineer's Representative.

- (ix) After the mortar/grout in the recesses has matured and the bearings set to the correct line and level as specified below, the gap between the underside of the bearing and the substructure shall be filled with well rammed Dry Pack mortar.
- (x) Dry Pack mortar shall consist of 1 part Portland cement to 1½ parts of fine granite or other equivalent hard aggregate as Table 2 of BS1201 (1973), unless otherwise approved by the Engineer's Representative. The minimum compressive strength at 28 days shall be 550kgf/cm². Sufficient water shall be added to produce a mortar which will adhere together on being moulded into a ball by slight pressure of the hands and will not exude free water, but will leave the hands damp. The mix shall be well rammed into place using caulking tools of not more than 2.5cm square section. The procedure to be adopted when using this mix shall be to the Engineer's Representative's approval.
- (xi) No additional load shall be placed on the bearings until at least 72 hours after Dry Packing.

2. Installation of bearings supporting in-situ concrete structures.

- (i) If the bearing is to be installed on the substructure in advance of the construction of the superstructure, it shall be installed in accordance with the following sequence of operations:
 - (a) Bearings which do not employ shear keys/holding down bolts shall not be installed in advance of the construction of the bridge superstructure.
 - (b) The bearing shall be set in position to within ± 5 mm of the specified level, on steel folding wedges or similar.
 - (c) The bearing shall be mechanically attached to the shear keys/holding down bolts, in order to avoid tilting or disturbing the bearing during the placing of the Dry Pack mortar bedding.
 - (d) The gap between the underside of the bearing and the substructure shall be filled with well-rammed Dry Pack mortar.
 - (e) The thickness of the Dry Pack mortar shall not be less than 2.5cm nor greater than 5cm.
 - (f) When the Dry Pack mortar has attained a cube strength of 300kgf/cm² the steel wedges shall be removed and the resulting voids filled with Dry Pack mortar. The construction of the bridge superstructure may then proceed, as required. The clamping straps referred to in Clause B13 11-1 (ii) to (v) shall remain in position until the superstructure above the bearing has been completed. Where necessary suitable arrangements shall be made to accommodate thermal movements of the incomplete superstructure.
- (ii) If the bearing is to be installed at the time of the construction of the bridge superstructure, it shall be installed in accordance with the following sequence of operations:
 - (a) The bearing shall be set in position, to within ± 10 mm of the specified level, on steel folding wedges or similar.

- (b) The formwork to the in-situ concrete superstructure shall be placed around the bearing and the superstructure concrete placed in position. Particular care must be taken to avoid tilting or disturbing the bearing during the concreting process.
- (c) When the concreting of the superstructure in the vicinity of the bearing has been completed the gap between the underside of the bearing and the substructure shall be filled with well rammed Dry Pack mortar.
- (d) The thickness of the Dry Pack mortar shall not be less than 2.5cm nor greater than 5cm.
- (e) When the Dry Pack mortar has attained a cube strength 300kgf/cm² the steel wedges shall be removed and the resulting voids filled with Dry Pack mortar.
- (f) The supporting falsework and formwork to the bridge superstructure shall not be removed nor permit a transfer of load to the bearing prior to the removal of the temporary supporting wedges as described in subparagraph (e) above and the release of the clamping straps.

3. Installation of bearings supporting precast concrete structures

- (i) The bearings shall be installed in accordance with the following sequence of operations.
 - (a) The bearing shall be bolted to an anchor plate, previously cast into the precast concrete diaphragm or pier unit of the superstructure prior to the erection of the precast concrete unit.
 - (b) Prior to the erection of the precast concrete diaphragm or pier unit, the shear keys/holding down bolts shall have been set in the substructure.
 - (c) The precast concrete unit and bearing shall be erected to the correct level $\pm 10\text{mm}$, such that there is no load transferred to the bearing.
 - (d) The gap between the underside of the bearing and the substructure shall be filled with Dry Pack Mortar.
 - (e) The thickness of Dry Pack Mortar shall not be less than 2.5cm nor greater than 5cm.
 - (f) When the Dry Pack mortar has attained a cube strength of 300kgf/cm² the construction of the superstructure may continue and load may be transferred to the bearing.

4. Installation of bearings beneath steel structures

- (i) The bearings shall be fixed to machined sole plates attached to the underside of the superstructure and positioned to ensure that the bearing loads are correctly transmitted to the stiffeners.
- (ii) The bearings shall be so positioned that the following conditions are met:
 - (a) The main levels of bearings on any support to multi-span continuous girders shall be as shown on the Drawings ± 0.0001 times the sum of adjacent spans.

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- (b) Where a box structure is supported on pairs of bearings at each support the difference in level between the bearings shall not exceed:

$$\frac{\text{span} \times c}{3000 B_b}$$

where c = the distance between centres of bearings at the support and B_b = the width of the bottom of the box.

Where necessary the levels shall be adjusted by machined packings or other means to ensure parallel adjustment. Alternatively, the structure may be temporarily supported on balance jacks or other approved compressible supports centred about the shear centre and the bearing offered up to contact the box uniformly at the time of completing the bedding beneath the bearing.

- (c) All bearings shall be set to within $\pm 0.1^\circ$ of their intended inclination.
- (d) Bearings shall be positively located to ensure correct alignment beneath diaphragms or load-bearing stiffeners. Fixed bearings shall be aligned to within $\pm 5\text{mm}$ of the centre lines shown on the Drawings and shall be checked in relation to the internal stiffening. Expansion bearings shall be located in relation to the internal stiffening so that the same tolerance will be obtained at the setting out reference temperature.
- (iii) When the bearings are installed on the substructure in advance of the construction of the superstructure, the sequence of operations shall be as described for bearings supporting in-situ concrete structures in Clause B13 11-2 (i)(c) to (f).
- (iv) When the bearings are offered up to the superstructure before completing the bedding the sequence of operations shall be as described for bearings supporting precast concrete structures in Clause B13 11-3 (i)(d) to (f).

B13 12 MEASUREMENT AND PAYMENT

Payment for Bridge Bearings will be made at the price tendered for each type of bridge bearings complete, by number in place, which price shall be full compensation for all materials, labour, tools and equipment necessary to fabricate, erect, give protective treatment, set as directed and for installing, maintaining and removing temporary ramps or other safeguards during construction.

SECTION B14

BRIDGE RAILINGS

B14 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, material and labour and in performing all operations in connection with Bridge Railings and Safety Fencing on structures, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and the direction of the Engineer's Representative.

In addition to parapets, Safety Fencing (collision railings) used for the protection of vehicular traffic and posts, web members and horizontal members of sidewalk and roadway hand railings is included.

Safety Fencing is specified in Section R14, Guard Rails and Safety Fencing for use in normal highway locations other than structures. This Section includes for the fixing of Safety Fencing on structures where specified or shown on the Drawings.

B14 02 MATERIALS

All materials shall conform to the Specification for the various classes of materials from which the parapets and railings are constructed.

B14 03 PARAPETS, HAND RAILINGS AND SAFETY FENCING

Hand railings shall be erected and fastened true to line and grade. Parapets on steel spans may be erected at the same time the trusses or girders and floor system are erected, but shall not be completely fastened until after the roadway slab is in place. On spans having concrete sidewalks, the parapets and hand railings shall be aligned and fastened in place and strutted and tied to the trusses or girders before placing concrete in sidewalk slabs. Struts and ties shall remain in place for at least five days after the slab is placed.

The horizontal rails, of parapets, and all horizontal elements of Safety Fencing shall be aligned and fastened after all dead load has been applied to the span.

Bolts in hand railings and Safety Fencing shall be placed with heads of bolts facing the roadway and all bolt heads shall have top and bottom edges parallel to the grade.

On multiple span bridges the parapet railings and Safety Fence heights at the end of each span shall be varied a sufficient amount to produce a uniform profile or grade from the end of the bridge. All construction methods not mentioned here shall be in accordance with Section B2 Concrete Structures General, Section B3 Steel Structures General, Section B7 Steel Reinforcement for Structures, Section B8 Structural Concrete and Section B 10 Structural Steelwork.

B14 04 METAL PARAPETS

1. **General:** The requirements of Clauses B1004-1, B1004-8 and B1004-9 shall apply generally to all parapet fabrication. Proprietary vehicle parapets shall be of a design which has been registered with or approved by the Employer. Metal parapets shall be furnished with the name, trade mark or other means of identification of the proprietary parapet system, group designation and type or mark number.

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2. **Welding:** In the case of steel parapets, welding shall comply with the requirements of Clause B1004-7 and the qualification and testing of welders for steel parapets shall be as described in Clause B1004-9.

In the case of aluminium and aluminium alloy parapets, welding shall comply with the requirements of either BS3019 Part 1 (1958) or BS3571 Part 1 (1962).

3. **Inspection and Testing of Welding:** When directed by the Engineer's Representative and before fabrication is commenced, welding procedure trials shall be carried out using representative samples of materials to be used in the work.

A penetrant dye or other non-destructive method of testing agreed with the Engineer's Representative shall be used to examine the welds selected by the Engineer's Representative.

4. **Erection of Parapets:** When parapets are erected they shall be securely held in their correct position until all connections and fastenings are complete and the post fixings have gained sufficient strength to withstand the design holding-down moment. The assessment of the strength of the post fixing shall be subject to the Engineer's Representative's agreement.

The finished parapets shall be true to line throughout their length.

5. **Protection against Corrosion:** The provisions of Section B12 Protection of Steelwork against Corrosion shall apply.

6. **Expansion Joints:** Expansion joints shall be at positions detailed on the drawings and to be in accordance with the drawings or to be of an approved Proprietary design. Care must be taken to ensure that site painting does not impair the efficiency of the expansion joint.

B14 05 CONCRETE HAND RAILINGS

1. **General:** Concrete hand railings shall be constructed in so far as possible after the roadway and footpath slabs for the entire structure are completed.

2. **Forms for Concrete Hand Railing:** Timber or metal forms for concrete hand railing shall be as specified in Section B6.

All joints and corners shall be carefully fitted. All exposed corners, except in rail web openings, shall be chamfered one centimetre. Expansion and construction joints except the top surface of rail caps, shall have one centimetre chamfers on each side of the joint.

Sides of web openings and ends of posts shall be placed plumb. Tops and bottoms of web openings, and tops of posts shall be parallel to the grade of the rail.

Re-use of forms shall be subject to approval of the Engineer's Representative and when the forms are no longer fit for use, the Contractor shall construct forms of new material.

Forms shall be so constructed that the alignment and grade of the railings and kerbs shall be of pleasing appearance. On structures having horizontal and/or vertical curves, the heights of railings and/or kerbs shall be varied at points of change in grade if, in the opinion of the Engineer, such variations are necessary to produce the desired appearance. Pronounced sags or humps in rail and kerb tops will not be permitted.

3. **Removal of Forms:** Forms for concrete railings shall not be removed for at least three days after the placing of the concrete. Kerb forms may be removed as soon as practicable.

Forms shall be removed without injury to the concrete. After removal, all forms intended for re-use shall be cleaned and freshly coated with form oil.

4. Finishing and Curing: The top surfaces of caps and posts shall be finished true to line and grade. Strike rods, floats and metal trowels shall be used only to the extent necessary to perfect line and shape. An unduly large amount of trowelling and working, for the purpose of securing an excessively smooth finish, will not be permitted. Edges having radii of one centimetre shall be used at the edges of caps. Tops of posts shall have one centimetre chamfered edges. At expansion and construction joints in rail caps, an edger tool having a radius of $\frac{1}{2}$ cm shall be used on each side of the joint on the top surface of the cap. Particular care shall be taken at these joints to maintain the true lines of the cap and avoid a short, unsightly incline on each side of the joint.

After the trowelling and edging are completed, the top surface may be lightly brushed with a fine bristle brush. The top surface shall then be covered with cotton blankets or other heavy quilted material, after which water shall be sprayed on the blankets and forms at intervals short enough to keep them thoroughly wet for three days.

After the removal of the forms, all lips and edgings shall be removed with sharp tools or chisels, holes filled with mortar and corners of openings trued up. Stoning or grading of surfaces shall be done only where necessary to remove concrete projecting beyond the true surface. After removal of forms, the railing shall be covered with cotton blankets, which shall be kept continuously wet for a period of at least seven days, making a total wet-curing time of ten days. Hessian will not be considered as a satisfactory covering for use in curing concrete railings.

The finished work mentioned above may be done during the curing period by keeping all of the railing covered and wet except the immediate area in which the work is being done. If this procedure is not followed, it will be necessary to prohibit any finishing for ten days after the concrete has been poured.

At the end of the curing period, the surfaces shall be washed with water and all form oil, mud, dust and other substances removed. A one to one mortar, composed of one part of Portland cement, of the same brand as used in the railing concrete, and one part clean, fine plaster sand, shall then be applied with brushes and well rubbed into the air holes and small crevices in the concrete. As soon as the mortar has taken its initial set, it shall be rubbed off, using a piece of sacking or carpet for that purpose. The railing shall then be covered with wet blankets for at least 48 hours.

The completed surface of the concrete shall be of uniform colour and texture. The tops of rail caps and posts are included in above method of finishing as the brushed surface is the finish desired.

In the construction of road kerbs, where there is no adjoining footpath, the above provisions shall also apply, except that the kerb forms may be removed as soon as practicable after the concrete has been placed. The total curing time for such kerbs, during which time concrete shall be kept continuously wet shall be ten days.

B14 06 SAFETY FENCING

1. General: Insofar as it is applicable, Safety Fencing, including Tensioned Corrugated Beam, Tensioned Rectangular Hollow Section and Open Box Beam Safety Fencing shall comply with Clauses R14 08 to R14 11.

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2. Where the fence is mounted on a structure the posts shall be furnished with a base plate for bolting down with four approved bolts which shall be contained within the supporting concrete and after fixing each bolt shall resist a tensile load of not less than 8,500kgf.

3. Where shown on the Drawings, adjustable length posts shall be used to accommodate excessive variation in the surface level beneath the fence.

4. **Expansion Joints:** Where shown on the drawings the safety fencing shall incorporate expansion joints to designs shown on the drawings or as approved by the Engineer's Representative.

B14 07 MEASUREMENT AND PAYMENT

Payment for bridge railings including metal parapets, hand railings and safety fencing will be made at the price tendered per linear metre in place, which price shall be full compensation for all materials, labour, tools and equipment necessary to fabricate, erect and paint as shown on the Drawings and specified above.

SECTION B15

BRIDGE MOVEMENT JOINTS

B15 01 SCOPE

The work covered by the Section of the Specification consists in furnishing all plant, equipment, materials and labour, and performing all operations, including setting joints as directed by the Engineer's Representative, in connection with Movement Joints for Structures, complete, subject to the terms and Conditions of Contract, in strict accordance with this Section of the Specification and the applicable Drawings.

B15 02 MATERIALS

1. All materials shall conform to the Specification for the various classes of materials from which the bridge movement joints are constructed.

2. **Epoxy Resin Mortar:** Epoxy resin mortar for nosings shall be one of the formulations described in the Contract and may be constructed on both concrete and steel bridges.

3. **Joint Sealants and Seals:** Joint Sealants shall consist of hot or cold poured compounds or preformed compression seals as described in the Contract and which comply with the following Clauses:

- (i) *Hot poured Sealants:* Hot-poured sealants shall comply with the requirements of BS2499 (1973) for Type A2 Sealant.

Hot-poured sealants shall not be poured into joints when the temperature of the joints is below 10°C. The pouring temperature of the sealant shall not exceed the manufacturer's recommended safe heating temperature. When a primer is required or recommended by the sealant manufacturer it shall be applied strictly in accordance with the manufacturer's instructions.

- (ii) *Cold-poured Sealants:* Cold-poured sealants for joints in pavements and footways shall comply with the performance requirements for the Normal type of sealant given in BS5212 (1975).

The sealant shall be composed of a curing agent and a base resin, which shall be in such proportions as recommended by the manufacturer to provide a fast cure if the material is mixed and applied by special machines, or a retarded cure if mixed by hand. When a primer is recommended by the manufacturer, it shall be applied within the temperature range of 10°C to 40°C. It shall cure within one hour and remain active for not less than 4 hours. The sealant shall be applied after the curing period of the primer and within the period that the primer remains active.

Materials mixed and applied by hand shall be supplied in separate containers in the correct proportions and shall be mixed using a powered stirrer or mixer or any other method approved by the Engineer's Representative.

The work life for machine mixed material shall be adjusted to suit the appliance.

- (iii) *Testing Poured Sealants:* Unless a manufacturer's certificate is produced to state that the material has satisfactorily passed the BS tests within 6 months prior to use, the Engineer's Representative may require samples to be taken and tests to be carried out in accordance with the relevant BS. The Engineer's Representative may at any

Bridge Movement Joints

time also require a sample to be taken and tested in accordance with the BS to determine the quality of the material as poured into the joint.

B15 03 TYPES OF JOINTS

The type of joint will be as shown on the Drawings or as otherwise directed by the Engineer. In the event of the Contractor wishing to submit any particular manufacturer's proposal for a joint, it shall be designed to withstand the combinations of both vertical and horizontal loading as directed by the Engineer or as specified in the Special Specification for Particular Application. Joints shall also comply with the requirements given in Table B15/1 for total longitudinal movement and maximum acceptable vertical movement between two sides of joint, and shall also satisfy the following expansion joint functional requirements.

- (i) It shall withstand traffic loads and accommodate movements of the bridge due to temperature, creep, shrinkage and loading and shall not give rise to unacceptable stresses in the joint or other parts of the structure.
- (ii) It shall have good riding quality and shall not cause inconvenience to any class of road user. (Including cyclists, pedestrians and animals where they have access).
- (iii) When a joint would present a large smooth metal area at the road surface it shall not cause a skidding hazard.
- (iv) The joint shall not generate excessive noise or vibration during the passage of traffic.
- (v) Parts liable to wear shall be easily replaceable.
- (vi) It shall either be sealed, or have provision for carrying away water, silt, grit and salt.
- (vii) It shall be easy to inspect and maintain.

B15 04 CONSTRUCTION REQUIREMENTS

1. General:

- (i) 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.
- (ii) The position of all bolts cast into concrete and holes drilled in plates shall be accurately determined from templates.
- (iii) The mixing application and curing of all proprietary materials shall comply with the manufacturer's requirements.

TABLE B15/1
MOVEMENT JOINT REQUIREMENTS

Joint Type	Total Longitudinal Movement (see Note (iv) below)		Maximum Acceptable Vertical Movement Between Two Sides of Joint mm
	Min. mm	Max. mm	
1. Buried joint under continuous surfacing	5	20	0.5
2. Gap joint with poured sealant	5	12	3
3. Gap joint with preformed expanded plastic sealer fixed by adhesion	5	20	3
4. Gap joint with preformed foamed plastic sealer in compression	5	40	3
5. Gap joint with hollow extruded sealer in compression	5	45	3
6. Gap joint with flexible membrane sealer	5	50	3
7. Open gap joint	5	60	3
8. Fully cantilevered toothed plates	50	—	3
9. Toothed plate supported by and sliding on synthetic rubber	50	—	3
10. Fully cantilevered comb blocks or other specially designed joints	100	—	3

NOTES

- (i) The minimum of the range is given to indicate when the type of joint will not be economical.
- (ii) When the total horizontal movement is less than 5mm it is not considered that any special expansion provision is necessary.
- (iii) Movements above 25cm require special consideration and are not covered by this clause although the basic principles still apply.
- (iv) The table above gives the total range of movement and not for instance the variation, plus or minus, from a hypothetical mean deck temperature.
- (v) Open gap joints should have a minimum gap of 6mm at maximum temperature.

Bridge Movement Joints

2. Prevention of Damage

- (i) 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.
- (ii) 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.
- (iii) 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's Representative permits their removal.

3. Epoxy Mortar Nosings

- (i) 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 warm dry weather. The air temperature around the joint shall be not less than 10°C which shall be achieved artificially if necessary.
- (ii) 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.
- (iii) Unless otherwise described in the Contract, 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.
- (iv) 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 300g/m². The mortar shall then be applied as quickly as possible while the priming coat is still tacky.
- (v) 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. Aggregate shall be clean and completely dry.
- (vi) 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 Compounder's instructions.
- (vii) The mortar shall be placed in position within the time recommended by the Compounder, 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 Contract.
- (viii) Epoxy mortar shall generally be compacted in courses of thickness not exceeding 5cm. Where an underlying course is more than 1 hour old it shall, unless otherwise agreed by the Engineer's Representative be primed with an unfilled epoxy resin priming coat before placing the next course.

Bridge Movement Joints

- (ix) Traffic shall not be permitted to run on the mortar until agreement has been obtained from the Engineer's Representative.

4. Sealing

- (i) A poured sealant shall only be placed when the mean bridge temperature is between 10°C and 16°C, unless otherwise agreed in writing by the Engineer's Representative.
- (ii) Joints shall be clean and dry before sealing.

B15 05 MEASUREMENT AND PAYMENT

Payment for Bridge Movement Joints will be made at the price tendered for each type of movement joint complete, by number in place, which price shall be full compensation for all materials, labour, tools and equipment necessary to fabricate, erect, give protective treatment, set as directed and for installing, maintaining and removing temporary ramps or other safeguards during construction.

SECTION B16

BRICKWORK FOR STRUCTURES

B16 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour and in performing all operations in connection with Brickwork for Structures, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification the Drawings and directions of the Engineer's Representative.

B16 02 MATERIALS

1. All bricks shall be of best quality and as described on the Drawings, made from well tempered clay and free from lime and shall be hard, well burnt, square and of uniform size, shape and texture. Samples of all bricks intended for use in the Works shall be submitted to the Engineer's Representative for his approval.

2. Bricks will be of three varieties and designated as follows:

- (i) *Common*: Bricks of ordinary quality suitable for general building work but having no special claim to give an attractive appearance.
- (ii) *Facing*: Bricks of ordinary quality, specially made or selected to give an attractive finish without rendering or other surface treatment and not as made for internal use only.
- (iii) *Engineering*: Bricks of ordinary quality having a dense and strong vitreous body conforming to limits of absorption and strength acceptable by the Employer as the best local product available including special quality of a standard of durability suitable for use in situations of extreme exposures, all as specified in the Special Specification of Particular Application.

3. **Shaped Bricks**: Brickwork in quoins, copings, string courses, arch rings, etc. shall be constructed with purpose made bricks as shown on the Drawings.

4. Mortar

- (i) Mortar for brickwork, blockwork and masonry shall be mixed in the proportions given in Table B16/1 according to the mortar class described on the Drawings.
- (ii) For work in which a Class 3 mortar is required, the Contractor shall select the appropriate mortar from one of the mixes for this Class given in Table B16/1. If this work is to be carried out in frosty weather and the bricks are wet when laid, then a 1:5 - 6 cement : sand mortar with an air-entraining plasticiser shall be used.

The plasticiser shall be free from calcium chloride or similar salts.

TABLE B16/1
PROPORTIONS BY VOLUME

Class	Cement: lime: sand	Masonry cement: sand	Cement: sand with plasticiser
1	1:0-0.25:3	—	—
2	1:0.5:4-4.5	—	—
3	1:1:5-6	1:4.5	1:5-6

- (iii) The inclusion of lime in Class 1 mortar is optional. The proportions of lime given in Table B16/1 are for lime putty. If the lime is measured as the dry hydrate, the amount may be increased up to 1.5 volumes for each volume of lime putty. Where a range of sand contents is given in Table B16/1, the higher shall be used for sand that is well graded and the lower for coarse or uniformly fine sand.
- (iv) Sand shall be a natural sand or crushed natural stone or a combination of both as specified in BS1200 (1976). Mortar shall be mixed thoroughly either by hand or mechanically until its colour and consistency are uniform. The constituent materials shall be accurately gauged, allowance being made for bulking of sand. Mortar shall be made in small quantities only as and when required. Mortar which has begun to set or which has been mixed for a period of more than 1 hour in the case of a Class 1 mortar or more than 2 hours in the case of other classes shall be discarded.
- (v) Mortar for bedding shall comply with the strength requirements described in the Contract.

B16 03 CONSTRUCTION REQUIREMENTS

1. General: Bricks shall be laid to the specified bond on a full bed of the mortar described on the Drawings and single frogged bricks shall be laid with the frog uppermost. Perpend between bricks shall be filled with mortar before the next mortar bed is laid. Whole bricks shall be used except where necessary for closers or where expressly authorised. Exposed joints shall be treated as specified in Clause B16 03-5.

Brickwork shall be built uniformly, corners and other advanced work shall be racked back and not raised above the general level more than 90cm. Courses shall be kept horizontal and matching perpend shall be in vertical alignment.

Unless agreed by the Engineer's Representative overhand work shall not be permitted.

2. Cold Weather Working: No bricks shall be laid when the air temperature in the shade is below 3°C unless special precautions are taken which have been approved by the Engineer's Representative.

3. Protection of New Work: Immediately after laying and for 3 days thereafter, brickwork shall be protected against harmful effects of weather. The upper surface of newly laid brickwork shall continue to be protected against rain as the work proceeds by covering with approved waterproof sheets until such time as the brickwork is completed and the upper damp-course, coping or other finishing feature is laid.

All visible brickwork and any surface below the brickwork which is visible at the completion of the Works shall be clean and free from damage: all purpose made open joints shall be free from debris of any description.

4. Reinforced Brickwork: Fabric reinforcement shall be completely embedded in the mortar joint.

5. Treatment of Exposed Joints

- (i) *Pointed Joints:* The joints shall be raked out to a depth of 12mm and after the completion of the entire facework, pointed in cement mortar as described on the Drawings.
- (ii) *Unpointed Joints:* The mortar for joints which are not to be pointed shall extend slightly beyond the full width of the beds and shall then be struck off flush as the work proceeds.

6. Brick Facework Fixed to Concrete: Any loose material shall be removed from the concrete, and its surface washed with clean water before any bricks are laid.

The portion of the fixing projecting from the concrete shall be completely embedded in the mortar of the facework and shall be kept back a minimum of 4cm from the face of the brickwork.

The cavity between brick facework and concrete shall be completely filled as the work proceeds with mortar of the same mix as that specified for the facework.

B16 04 MEASUREMENT AND PAYMENT

Payment for brickwork to structures will be made at the price per square metre of the thickness described, which price shall be full compensation for all pointing, cutting and fitting to arches, spandrels, skewbacks, masonry and concrete, etc., and all templates, centering, scaffolding, materials, labour, tools, and other equipment necessary to construct, as shown on the Drawings and specified above.

SECTION B17

MASONRY FOR STRUCTURES

B17 01 SCOPE

The work covered by this Section of the Specification consists in furnishing all plant, equipment, materials and labour in performing all operations in connection with Masonry for Structures, complete, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the Drawings and directions of the Engineer's Representative.

B17 02 MATERIALS

1. Building stone shall be as described on the Drawings, of good hard durable quality, uniform in texture and free from iron bands, spots, sand holes, flaws, shakes and other imperfections. Samples of stone intended for use in the Works shall be submitted for the prior approval of the Engineer's Representative.

2. Mortar for masonry and cast stone facework shall be as for brickwork as specified in Clause B16 02-4.

3. Testing of masonry for structures shall be in accordance with ASTM C586 for limestone and C616 for Sand stone.

B17 03 CONSTRUCTION REQUIREMENTS

1. General

- (i) Except where otherwise described in the Contract, the length of any stone shall not exceed three times its height. The breadth on the bed shall be not less than 15cm nor greater than three-quarters of the thickness of the wall.
- (ii) All stratified stone possessing bedding planes shall be laid with its natural bed as nearly as possible at right angles to the direction of load. In the case of arch rings, the natural bed shall be radial.
- (iii) Facework quoins shall be built to a height not exceeding 90cm in advance of the main body of the work and adjacent walling stepped down on either side.
- (iv) Masonry facework between the quoins shall then be built to a height not exceeding 45cm above the backing which shall then be brought up level with the completed facework. At no time shall the backing be built up higher than the facework.

2. **Joints:** Except for dry rubble walling, all joints shall be sufficiently thick to prevent stone-to-stone contact and shall be completely filled with mortar. Mortar shall be of the type described in the Contract and shall comply with the relevant requirements of Clause B1602-4.

3. **Cold Weather Working:** Masonry shall not be laid when the air temperature in the shade is below 3°C unless special precautions are taken which have been agreed by the Engineer.

4. **Protection of New Work:** Newly laid masonry shall be protected against the harmful effects of weather. All visible masonry and any surface below the masonry which will be visible at the completion of the Works shall be clean and free from damage.

Masonry for Structures

5. **Ashlar:** All stones shall be dressed to accurate planes on the beds and joints, and they shall be fair and neatly or fine tooled on the face unless otherwise described in the Contract.

6. **Block-in-course:** Beds and joint shall be squared and dressed for a distance of at least 22cm from the exposed face. Bond stones shall form not less than one sixth of the area of the exposed face and shall extend at least 90cm into the wall or for the full thickness of the wall if the latter is less than 90cm. Unless described in the Contract as tooled or drafted, the exposed face of all stones shall be blocked and left rough. Arrises shall be dressed square at all beds and joints.

7. **Squared Rubble-Coursed or Broken Coursed:** All stones shall be truly squared and dressed on the beds and joints for a distance of at least 12cm from the exposed face. Bond stones shall be provided at the rate of one to every 0.85m² of exposed face, and shall measure not less than 15cm x 15cm on the face, and not less than 45cm in length or the full thickness of the wall if the latter is less than 45cm. Sneck stones shall be not less than 7.5cm in any dimension. Vertical joints shall not include more than three stones, and the horizontal lapping of the stones shall be not less than 10cm.

8. **Random Rubble-Coursed or Uncoursed:** All stones shall be carefully set with a bond stone providing at the rate of one to every 0.85m² of exposed face. Bond stones shall measure not less than 15cm x 15cm on the exposed face, and not less than 45cm length or the full thickness of the wall if the latter is less than 45cm unless otherwise described in the Contract. For coursed work the joints shall be levelled as described in the Contract and the backing flushed up in cement grout.

9. **Backing to Masonry Facework:** Backing to masonry facework shall be as described in the Contract. The facework shall not be displaced by the placing of the backing.

10. **Masonry Facework Fixed to Concrete:** Any loose material shall be removed from the concrete, and its surface washed clean before any masonry is laid.

The variation in depth, front to back of stones for masonry facework, shall not exceed that described in the Contract and the space between the facework and the backing shall be completely filled as the work proceeds with fine concrete.

The portion of the fixing projecting from the concrete shall be completely embedded in the mortar of the facework and shall be kept back a minimum of 5cm from the face of the masonry.

11. **Dry Rubble Walling:** Dry rubble masonry shall be constructed generally to the requirements of uncoursed random rubble masonry, as specified in Clause B17 03-8 but with the omission of mortar. All stones shall be carefully shaped to obtain a close fit at all beds and joints, any interstices between the stones being filled with selected stone chippings or spalls. The exposed tops or copings of dry rubble walls shall be formed as described in the Contract.

12. **Special Stonework including Quoins, Copings, Plinths, Voussoirs, etc:** Special stonework shall consist of selected and approved stones dressed to the shapes and dimensions and where required, their faces worked, all as described in the Contract.

13. **Cast Stonework:** Cast stone facework shall be fixed to concrete in accordance with the requirements of Clause B17 03-10. The stones shall be bedded and jointed as described in the Contract.

B17 04 MEASUREMENT AND PAYMENT

Payment for masonry to structures will be made at the price per square metre of the thickness described, which price shall be full compensation for all pointing, cutting and fitting to arches, spandrils, skewbacks, and concrete, etc., and all templates, centering, scaffolding, materials, labour, tools, and other equipment necessary to construct, as shown on the Drawings and specified above.

SECTION B18

CASTINGS, STEEL FORGINGS AND MISCELLANEOUS METALS

B18 01 SCOPE

This Section covers all castings, steel forgings and miscellaneous metals required in completed structures as shown on the Drawings.

B18 02 MATERIALS

1. **Steel Castings:** Steel castings shall conform to the requirements of the Standard Specifications for Alloy-Steel Castings for Structural Purposes, ASTM A148-73. Unless otherwise designated on the Drawings or in the Special Specification of Particular Application, they shall be Class A, Grade I.

2. **Gray-Iron Castings:** Gray-iron castings shall conform to the requirements of the Standard Specification for Gray-iron Castings, ASTM A48-76. The class of castings to be furnished shall be that designated on the Drawings or in the Special Specification of Particular Application.

3. **Malleable Iron Castings:** Malleable iron castings shall conform to the requirements of the Standard Specifications for Malleable Iron Castings, ASTM A47-77.

4. **Steel Forgings:** Steel forgings shall conform to the requirements of the Standard Specifications for Carbon-Steel Forgings for General Industrial Use, ASTM A668-77. The classes for forgings to be furnished shall be those shown on the Drawings or called for in the Special Specification of Particular Application.

5. **Bronze Castings:** Bronze castings shall conform to the requirements of the Standard Specifications for Bronze Castings for Turntables and Movable Bridges, and for Bearing and Expansion Plates of Fixed Bridges, ASTM B22-76.

6. **Copper Seals:** Copper sheets for seals shall be uniform in quality and temper, clean, sound, smooth and commercially flat. The sheets shall be rolled from virgin metals or from virgin metals and scraps of known quality and approved composition and shall contain not less than 99.88 per cent copper, silver being counted as copper. Unless otherwise specified on the Drawings, copper sheets shall be of a gauge or thickness weighing not less than 0.5gm. per square cm.

B18 03 CONSTRUCTION REQUIREMENTS

1. **General:** The provisions outlined in Section B10, Structural Steelwork, and Section B12, Protection of Steelwork which are applicable, including painting, shall also apply to castings, steel forgings and miscellaneous metals.

2. **Steel Castings:** All steel castings shall be thoroughly annealed unless otherwise provided and shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

Blow holes appearing upon finished castings shall be so located that a straight line in any direction will not cut a total length of cavity greater than 2.5cm in any 30cm, nor shall any single blow hole exceed 2.5cm in any dimension or have an area greater than 3cm.

Castings, Steel Forgings and Miscellaneous Metals

Blow holes shall not have a depth injuriously affecting the strength of the casting. Minor defects which do not impair the strength may, with the approval of the Engineer, be welded by an approved process. The defects shall be removed to solid metal by chipping, drilling or other satisfactory methods and, after welding, the castings shall be annealed, if required by the Engineer. Castings which have been welded without the Engineer's permission shall be rejected.

Large castings, if required by the Engineer, shall be suspended and hammered all over. No cracks, flaws, or other defects shall appear after such treatment.

No sharp unfilleted angles or corners will be allowed.

Surfaces of cast pedestals and shoes which are to come in contact with metal surfaces shall be planed and those which are to bear on concrete shall be rough finished.

All steel castings shall be cleaned of scale and sand so as to present a smooth, clean and uniform surface.

3. Gray-Iron Castings: Iron castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow and other defects in positions affecting their strength and value for the service intended.

Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect.

All gray-iron castings shall be cleaned of scale and sand so as to present a smooth, clean and uniform surface.

4. Malleable Iron Castings: All malleable iron castings shall be thoroughly annealed unless otherwise provided and shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

The castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. The surfaces shall have a workmanlike finish.

All malleable iron castings shall be cleaned of scale and sand so as to present a smooth, clean and uniform surface.

5. Steel Forgings: All forgings shall be thoroughly annealed prior to being machined to form finished parts.

6. Bronze Castings: A coupon shall be cast with every melt as an integral part of the casting and shall be fed and cooled under the same conditions as the castings. This coupon shall be cylindrical in shape with a diameter of 3cm and a height of not less than 10cm. The coupon shall be broken at the gate connecting with the casting and this fracture shall be left unaltered so that coupons may be identified with castings by the Engineer.

Surfaces of bronze bearing plates intended for sliding contact shall be carefully milled and polished.

7. Copper Seals: Copper seals shall be constructed and installed in accordance with the details shown on the Drawings.

All splices or joints shall be carefully brazed or soldered to produce a continuous water tight seal for the full length of each unit.

B18 04 MEASUREMENT

1. **Steel, Gray-Iron and Malleable Castings:** The weight of steel, gray-iron and malleable iron castings for which payment will be made shall be the shop-scale weights of the castings providing such weights do not exceed the weights computed from the dimensions shown on the approved Drawings with an addition of 10 per cent for fillets and overrun.

2. **Steel Forgings:** The weight of steel forgings for which payment will be made shall be shop-scale weight.

3. **Bronze Castings:** The weight of bronze castings for which payment will be made shall be the shop-scale weights of the finished castings.

4. **Copper Seals:** The weights of copper seals for which payment will be made shall be the weight computed from the dimensions shown on the design Drawings.

B18 05 PAYMENT

Payment will be made for such of the following prices tendered as are included and shown in the Bill of Quantities.

1. "Cast Steel in Place", per kilogram.
2. "Cast Iron in Place", per kilogram.
3. "Malleable Iron in Place", per kilogram.
4. "Cast Bronze in Place", per kilogram.
5. "Forged Steel in Place", per kilogram.
6. "Copper Seals in Place", per kilogram.

SECTION B19

RIPRAP OR STONE PITCHING

B19 01 SCOPE

This Section covers all riprap classified under the heads "Loose Riprap" and "Hand Placed Riprap".

B19 02 MATERIALS

1. **General:** The stones for this work shall be durable, angular field or quarry stones of approved quality, sound, hard, free from seams and other structural defects, and shall have a specific gravity of not less than 2.20. For hand placed riprap the stones shall be approximately rectangular in shape.

2. **Loose Riprap:** At least 50 per cent of the stones shall have a weight of 200kg or more each, and no stone shall have a perimeter of less than 45cm when measured on the smallest section.

3. **Hand Placed Riprap:** At least 50 per cent of the riprap shall consist of stone having a weight of 60kg or more each, and of the remaining 50 per cent no stone shall have a weight not less than 20kg nor a thickness less than 8cm when measured at the thinnest section.

B19 03 CONSTRUCTION REQUIREMENTS

1. **General:** Riprap or stone pitching shall consist of broken stone placed on shoulders, slopes or such other places as may be indicated in the Drawings or as directed by the Engineer. The riprap shall be constructed to the shape and dimensions shown on the Drawings in accordance with the provisions of this Specification.

2. **Loose Riprap:** The slopes upon which the riprap is to be placed shall be shaped to the required lines and grades. Unless otherwise ordered, a trench 60cm in depth shall be excavated along the toe of the embankment to receive the base stone. Foundation trenches shall be excavated and approved before the placing of riprap is begun.

The stone shall be handled or dumped on the approved slopes to form the cross-section shown on the Drawings. The rock shall be manipulated sufficiently to secure a regular surface and mass stability. When the thickness of the riprap is not on the Drawings it shall be at least 45cm, measured perpendicular to the slope.

3. **Hand Placed Riprap:** The stone shall be laid by hand, on slopes shaped to the required lines and grades, and to the thickness shown on the Drawings. Unless otherwise ordered, a trench 60cm in depth shall be excavated along the toe of the embankment to receive the base stone. Each stone shall be so placed that it will rest primarily on the slope of the embankment and not on the stone below it and it shall be thoroughly tamped or driven into place. The space between the larger stones shall be filled with spalls of suitable size driven to face. The finished surface of the riprap shall be made as smooth as the shape and size of the stones will permit, varying not more than 6cm from the required contour. When the thickness of the riprap is not indicated on the Drawings, it shall be at least 30cm measured perpendicular to the slope. Thickness of gravel bedding, if any, and details of cement or bituminous mortar grouting, if any, shall be as shown on the Drawings.

Riprap or Stone Pitching

4. **Sedimentary Rock:** Where sedimentary rock is used stones are to be placed so that the bedding planes are not parallel to the flow of water.

B19 04 MEASUREMENT

“Loose Riprap, in Place” and “Hand Placed Riprap, in Place” will be measured by the square metre in its final position and shall equal the thickness shown on the Drawings. The limiting paid dimensions shall not exceed those shown on the Drawings or established by the Engineer.

B19 05 PAYMENT

The accepted quantities of riprap will be paid for at the price tendered per square metre for “Loose Riprap, in Place” or “Hand Placed Riprap, in Place” to the minimum thickness shown on the Drawings.

Excavation for foundation for riprap will be measured and paid for as provided in Section R5 Earthworks.

SECTION B20

SUNDRY MATERIALS

B20 01 SCOPE

All materials required for the construction of any works in Parts I and II of this Standard Specification for Roads and Bridges are specified under the various Sections and references made to other Standard Specifications when applicable.

This Section includes for sundry, mainly basic, materials not already specified separately as above.

The proposed use of any material not included in this Specification, neither in this section nor in the Special Specification of Particular Application shall be referred to the Engineer's Representative for Specification requirements and direction regarding its use and testing.

B20 02 MATERIALS

1. **Clay Puddle:** Clay puddle shall be impervious to water and free from stones, roots, or any matter likely to detract from its function. Clay for puddling shall be obtained from a source approved by the Engineer's Representative and shall be of tenacious quality.

2. **Displacers for Concrete:** Displacers for concrete, to be used in mass concrete work only, shall consist of clean, hard, non-porous natural stone or other equivalent material approved by the Engineer's Representative, of roughly cubical shape and not exceeding the maximum dimensions shown on the Drawings.

3. **Hardcore for Filling:** Hardcore for filling shall consist of broken stone, brick, concrete or other hard material graded from 22cm to 8cm and of a quality approved by the Engineer's Representative.

4. **Timber for General Purposes:** Timber, whether sawn or round, shall be sound and entirely free from worm, beetle, splits, all forms of rot and deadwood, decayed knots or other defects.

Timber for joinery shall be sound, well seasoned, free from warps and twists, saps, shakes, large or loose knots, waney edges or other defects.

Timber for heavy carpentry as in fenders either in the round or sawn shall generally be pressure impregnated with creosote or other approved preservative, after the timber is cut or worked. Where further working is necessary after preservative treatment, the exposed part shall be brushed over with two coats of preservative before being fitted into position.

B20 03 MEASUREMENT AND PAYMENT

The unit of measurement for clay puddle shall be the square metre. The measurement shall be the number of square metres of each thickness in place as shown on the Drawings or required in writing by the Engineer. Payment will be made in accordance with the Specification at the price tendered in the Bill of Quantities and shall include for all materials, labour and placing.

Sundry Materials

No measurement of payment will be made for displacers for concrete. The cost thereof will be deemed to be covered by the appropriate items for mass concrete in the Bill of Quantities.

The unit of measurement for hardcore for filling will be the cubic metre. The measurement shall be the number of cubic metres as shown on the Drawings or required by the Engineer. Payment will be made in accordance with the Specification at the price tendered in the Bill of Quantities and shall include for all materials, labour and placing.

Loose Riprap and Hand Placed Riprap will be measured in place by the square metre in its final position at the thickness shown on the Drawings. The paid dimensions shall not exceed those shown on the Drawings or established by the Engineer. The accepted quantities of riprap will be paid for at the price tendered for square metre for Loose Riprap or Hand Placed Riprap to the minimum thickness shown on the Drawings. Excavation for foundation for Riprap will be measured and paid for as provided in Section R5 Earthworks.

The measurement and payment for timber for general purposes that will be incorporated in the Works, as in fencing, will be as shown in the appropriate Section or the Special Specification of Particular Application. No measurement or payment will be made for timber for general purposes that is part of the temporary works as in formwork, except in so far as payment is specifically allowed for under the appropriate Section.

PART III
ILLUMINATION

PART III

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SECTION I1

ILLUMINATION

I1 01 SCOPE

The work covered by this Section of Specification consists in the furnishing of all labour, equipment, supplies and materials and in performing all operation in connection with street lighting, subject to the terms and conditions of the Contract and in strict accordance with this Section of the Specification, the applicable drawings and the directions of the Engineer's Representative.

The work shall consist of, but not be limited to the following main components and works:

- Distribution boards with enclosures
- Main and branch cables, incl. joints
- Lighting columns incl. fuses
- Street lighting luminaires, incl. lamps, ballasts, power factor correction
- Earthing system

I1 02 DESIGN CRITERIAS

The quality of the street lighting shall comply with the CIE Recommendation No.12, especially concerning:

- luminence level
- overall uniformity ratio
- lengthwise uniformity ratio
- glare control mark (tunnels only)
- threshold increment (tunnels only)

Class of pavement according to the CIE Recommendation: R3

Maintainance factor: 0.75

Voltage drop for the last pole of the circuit: max. 3%

Supply system: 3 x 380/220V: 50Hz

Preliminary drawings: shall show the street lighting system which will be used, approximately the location of poles, masts and distribution boards, the power of luminaires, the height of poles and masts.

Final contract drawings: The location of poles and masts, the height of poles and masts, the power and number of luminaires and floodlights, the location and number of distribution boards incl. on wire diagram of all distribution boards, cable lines, cable crossections the location and duct number and masts. The columns position has only advisory character. The streetlighting plan shall be provided in the scale 1:1000 or 1:2000.

Working drawings: shall show the exact location of the poles, mast with the distances in metres, exact location of cable ducts, cable lines and distribution boards in the scale 1:500, installation details of distribution boards, the detailed drawings of distribution board

Illumination

with exact description of each circuit, cable crossection, size of fuses, contactors, circuit breakers. The exact location of cable trenches and cable ducts in the scale 1:500. The lighting plan with poles and masts location in the scale 1:500.

The contractor shall submit the exact calculation of illuminance distribution, luminance distribution on the road surface, uniformity ratio and voltage drop for the last two poles.

11 03 STANDARDS

Unless specified otherwise in the particular specifications, design, materials, manufacture and testing of all works concerning street lighting shall comply with an approved Standard.

Standard publications issued by the following Organizations of Standardization are approved Standards.

- ISO International Organization for Standardization
- IEC International Electrical Commission
- DIN Deutsches Institut fuer Norm
- VDE Verein Deutscher Elektriker
- CIE Commission Internationale de l'Eclairage
- CSN Czechoslovak Standard
- B.S. British Standard
- NBN Norme Belge (Belgian Standards)

11 04 DISTRIBUTION BOARDS

The distribution boards shall be suitable for Operation on the 3phase, 4wire 380/220V 50Hz supply system. Protection against electric shock will be by earthing.

The distribution boards shall be mounted in a weatherproof encloser complying with class IP55 of IEC publication 144. All construction shall be hot dipped galvanised or die cast injected Aluminium, the door shall be lockable and filled with neopren gaskets, the door shall have provisions for padlocking.

The distribution board shall be constructed to operate in an ambient temperature of 50°C in the shade and with 90% humidity.

For distribution board a sun-blind is required.

The distribution board shall be installed on the concrete foundation with proper cable entry facilities. All incoming and outgoing cables shall be fixed by suitable cable glands which provide a good grounding connection of the cable armouring.

For the protection of the outgoing cables fuses shall be installed in order to cut off a fault circuit. A metallated distribution board shall be protected durable against corrosion.

The distribution board shall be equipped with main and auxiliary busbar systems for a minimum peak short circuit of 50kA.

The photocell shall be used to switch on/off the street Lighting System. It will be installed near the Distribution Board, or on it. The relay for switch on will be used in the second Distribution Boards or in the next if necessary as well. The control cable shall connect the all Distribution Boards for the whole interchange and approaches. The dis-

tribution boards shall have facilities and space for mounting kWh meters. The dimensions of the kWh meters shall be obtained from State Organization of Electricity (SOE). The SOE also shall be notified of the electrical load required for each distribution board.

11 05 POLES

Lighting poles shall be steel, hot dip galvanised in accordance with ISO publications No. 1495, 1460, 1461. The poles shall be provided with a flange which is to be bolted to a reinforced concrete foundation. The poles shall have a base compartment with a lockable door of sufficient dimensions to facilitate easy connections of the cables and access to electrical gear. The minimum dimension of the access door shall be in the range of 600 x 140mm. Earthing screws shall be provided.

The poles shall be suitable for top mounted lantern, or having a bracket.

The mounting plate installed in the base part shall comprise:

- suitable clamps or glands, to secure incoming cables
- terminal block capable to connect the incoming cables and the rising cables to the lanterns
- fuse holders with fuses for each lantern on the lighting pole
- earth terminal, electrically connected with the column, to receive the armouring of the underground cable

Lighting poles shall have an earth terminal.

Lighting poles with brackets and lanterns incl. the anchorage shall withstand the windspeed 160km/h.

The pole shall either be made of one piece folded in an octagonal conical section or consist of stepped tubular sections. Octagonal cross-section being preferred.

Dimensions of base plates:

Poles 1m-12m: 400mm x 400mm, center distance 300mm x 300mm, plate thickness not less than 10mm, anchor bolts length 500mm, diameter 24mm.

Poles 15m: 400mm x 400mm, center distance 300mm x 300mm, plate thickness not less than 25mm, anchor bolts length 700mm, diameter 27mm. All bolts shall be j-shaped.

11 06 HIGH MASTS

Lighting fittings mounted at a height exceeding the above ground level shall be installed on high masts as described hereafter.

The masts shall be made of steel folded in octagonal conical Section, automatically welded in one longitudinal seam.

The sections shall be telescopic jointed.

The steel parts of the mast shall be hot dip galvanised in accordance with ISO publications No. 1459, 1460, 1461.

After installation of the mast, all exposed anchor bolts and nuts on the foundation shall be given one coat of bituminous paint, or covered by suitable heavy duty plastic caps which must be able to withstand durably the prevailing high temperatures.

High masts incl. all fittings shall withstand the windspeed of 160km/h.

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The masts shall be equipped with raising and lowering floodlight carrier to facilitate maintainance of the fittings.

The lamp accessories such as fuses, ballasts, ignitors and capacitor shall be mounted on suitable frame of extruded aluminium for avoiding corrosion and preferable installed inside the mast on the ground level.

The steel wire rope supporting the fitting carriage shall be in tension at all time. The top pulleys shall be of large diameter appropriate to the multicore cable used.

All cables (steel wires and electrical cables) shall be incorporated in the mast. Winches shall be completely self-sustaining with the gear ratio at least 50:1. Winch and gear must be incorporated into the mast.

Near the accessories frame inside the mast an earth terminal of at least M10 diameter shall be provided, directly welded to the mast.

11 07 LANTERNS

The lanterns shall be of the top or bracket mounted. They shall have protection degree min. IP 55 according to IEC 144.

The lanterns shall comprise mainly the following parts:

- noncorrosive housing with an optical system for cut-off or semicut-off light distribution according to the CIE recommendations; however cut-off luminaires are preferred;
- die cast aluminium body piece containing all electrical gear and facilities for easy top mast or bracket mounting;
- highly transparent bowl for maximum lantern efficiency.

The lantern shall be designed for easy maintainance with removable optical and electrical units. The bowl shall hinge from the housing to facilitate re-lamping and maintainance.

The power factor of the lantern shall be at least 0.85.

The ballast shall be tropicalized. Power factor capacitors shall be metal or moulded resin clad. Lampholders shall be porcelain and E40 for all lamps above and including 250watt rating, while porcelain E27 holders shall be for 125watt lamps.

Side entry luminaires shall have a bore diameter of 60mm. The covers (bowls) shall not be polycarbonate as this material deteriorates in comparatively short time. Very High Resistive clear glass (VHR) bowls are preferred.

The reflectors: electro brightened and anodized and firmly fixed in their positions in such a way as to prevent loosening due to vibrations.

11 08 CABLES AND CABLE INSTALLATION

All cables for LV distribution and control shall be the armoured, multicore, underground cables of the 600/1000V type complying with IEC or VDE regulations. The cables shall have PVC insulated copper conductors, steel wire or double steel tape armouring and PVC sheated overall. The multicore cables installed inside the poles between the lantern and fuse shall be of the same type at the lantern underground cables, but the armouring may be omitted.

The distribution cables shall be run in the longest possible lengths without joints. Sharp bends shall be avoided, the bending radius of any cable shall be not less than 15 times the outside cable diameter.

The minimum clearance at the crossing between distribution cable and watermain shall be 40cm, between distribution cable and gasmain shall be 20cm and between distribution cable and telephone cable shall be 30cm.

Moreover, in any case the designed crossing clearance will be approved by a Representative PTT, BWSA a.s.o.

Where more than one cable is to be laid in a trench they are to be placed 5cm apart from each other and cable crossings are not permitted.

Cables crossing over each other shall have a minimum of 5cm vertical displacement.

Where cables are laid in the ground, the trenches shall be of such a depth that the top of the cables are not less than 0.8m from the finished surface.

The dimension of cables shall be calculated for voltage drop max. 3% for the last two poles.

II 09 LIGHTING SOURCES

The high pressure sodium clear tubular lamps for their efficiency are preferred for the street lighting installations. For service roads, local roads and for some interchange branches the high pressure mercury vapour or metal-halide lamps can be used.

The high pressure sodium lamps shall have the lighting output after 200 burning hours at least:

14500 lm	for 150W lamps
25500 lm	for 250W lamps
48000 lm	for 400W lamps

The lighting position shall be universal.

The high pressure mercury vapour lamps shall have the universal lighting position and the lighting output after 100 burning hours shall be at least:

6300 lm	for 125W lamps
13500 lm	for 250W lamps
23000 lm	for 400W lamps

Metal halide lamps:

19000 lm	for 250 watt
25000 lm	for 400 watt.

II 10 DUCTS

Where cable cross under the paved areas they shall be installed in PVC ducts. The inner diameter of ducts shall be at least 90mm.

Ducts shall be laid in a depth of not less than 70cm below the kerb grade in the sidewalk areas and median areas and 100cm below roadway pavement grade under road areas.

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The ducts shall be of a rigid type.

The number of ducts shall be sufficient for all cables indicated in the drawings with addition of at least 30% for the future cables.

All ducts shall be capped until the cables will be installed. Ducts for future cables remain capped. A pull wire shall be installed in all ducts. All ducts and changes of their directions shall be located and identified by permanent markers.

The ducts under roadway pavement shall be protected against damage by 15cm layer of plain concrete.

II 11 EARTHING

All metal components of the street lighting installation i.e. poles, masts, lanterns, distribution boards, cable armouring shall be mechanically and electrically secured to form a continuous system which shall be effectively earthed.

In the lighting poles the cable armouring shall be secured to the earth terminal and from there the lantern shall be earthed via one of the conductors of the multicore rising.

The earthing shall be effected by means of earthing rods which shall be installed at each distribution board and at lighting pole which is the furthest pole of the circuit of corresponding distribution board.

The earth rods shall be of copper or copper-clad steel bars and the diameter shall not be less than 12.5mm. The rods shall be installed to such a depth that the total earth resistance will comply with local regulations, but shall not be more than 50ohms.

The independent wire for earthing shall be used for the unarmouring cables.

II 12 CABLE TRENCHES

The depth of the excavation for cable trenches shall be minimum 90cm with the width according to the number of cables (under sidewalk 70cm, under median 90cm).

Before laying the cables the trenches shall be filled with a layer of earth free of stones, or clean sand having a thickness of 15cm. The cables shall be covered by another layer of the same material and thickness.

The polyethylene sheet shall be laid over this second layer to protect the cable against damaging. The sheet shall be marked continuously with the word "DANGER" in the Arabic and the English language.

The recommended widths for laying of cables:

one or two cables	35cm
three	50cm
four or five	65cm
six or seven	80cm

11 13 CALCULATIONS

For each designed streetlighting installation shall be provided the computer calculations showing the illuminance distribution, luminance distribution, longitudinal and overall uniformity on the surface.

All photometrical and glare calculations shall be made according to the CIE Recommendations.

For the calculations the surface RIII according to the CIE Recommendation shall be taken into consideration.

The minimum average maintained value of the luminance on the motorway surface shall be:

standard interchanges	.....	2.5cd/sqm	.....	approx. 40 lx for concrete surface
Expressway inter.	.....	3.5cd/sqm	.....	approx. 55 lx for concrete surface
uniformity ratio	.....	longitudinal	.....	> 0.7
	.....	transversal	.....	> 0.35

Resthouse areas:

illuminance shall be	.....	15 lx
uniformity ratio	.....	0.25

11 14 TESTING

The whole street lighting installation shall be subject to inspection and testing.

All tests shall be carried out in accordance with the relevant standards.

The whole electrical system shall be tested in accordance with the following schedule:

- all circuits shall be continuous and free of short-circuits;
- insulation between cores or between cores and earth shall be at least 20 MOhm when measured earth 1000V Megger;
- the maximum earth resistance of each earth electrode shall not exceed 10 Ohms;
- the continuity of the earthing – the resistance between any point of the installation and the MDB doesn't exceed 0.5 Ω ;
- the voltage drop in the furthest pole of each circuit doesn't exceed 3% of the rate value;
- actual measured values of the street lighting shall be in accordance with calculations of the Street lighting;
- the coloured symbols of wires will be kept by connecting of all terminals and distribution boards.

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I1 15 MEASUREMENT

Measurement of the various items involved in the construction of "Illumination" shall be made in accordance with the Specifications for the several items involved.

I1 16 PAYMENT

Payment for the various items involved in the construction of "Illumination", will be made in accordance with the Specification, at the price tendered in the Bill of Quantities for the several items involved. Any item not included in the Bill of Quantities which is shown on the Drawings or called for by the Specification shall be understood to be included in the rates quoted for other items.

Payment shall include the furnishing of all materials, labour, equipment and all items required to complete the work.