

Specification

CONCRETE

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8.1 Scope of Section

This section covers concrete and mortar required in the Permanent Works other than the special concretes and mortars specified in other sections of the Specification.

8.2 Definitions

Structural concrete is any class of concrete which is used in reinforced, prestressed or unreinforced concrete construction, which is subject to stress and which is required to comply with Clause 8.4.

Non-structural concrete is composed of materials complying with the Specification but for which no strength requirements are specified and which is used only for filling voids and similar purposes where it is not subjected to significant stress.

A formed surface is a face which has been cast against formwork.

A free surface is a horizontal or nearly horizontal surface produced by screeding or trowelling to the level and finish required.

A pour refers to the operation of placing concrete into any mould, bay or formwork, etc., and also to the volume which has to be filled. Pours in vertical succession are also referred to as lifts.

Water/cement ratio is the ratio by weight of the free water in the mix divided by the weight of cement in the mix. Free water is the water in the mix excluding water absorbed by the aggregate.

8.3 Materials for Concrete

8.3.1 General

The Contractor shall submit to the Engineer full details of all materials which he proposes to use for making concrete. No concrete shall be placed in the Permanent Works until the Engineer has approved the materials of which it is composed. Approved materials shall not thereafter be altered or replaced by other materials without the consent of the Engineer.

8.3.2 Cement

Cement shall comply with the Standards indicated in the Schedule or on the Drawings. The Standards include the following:

BS 4027 for sulphate resisting Portland cement	(SRC)
ASTM C150 Type V	(Type V)
BS EN 197-1	(OPC)
BS 8500	

Cement shall be free flowing and free of lumps. It shall be supplied in the manufacturer's sealed unbroken bags or in bulk.

Bagged cement shall be transported in vehicles provided with effective means of ensuring that it is protected from the weather.

Bulk cement shall be transported in vehicles or in containers built and equipped for the purpose.

Cement in bags shall be stored in a suitable weatherproof structure of which the interior shall be dry and well ventilated at all times. The floor shall be raised above the surrounding ground level and shall be so constructed that no moisture rises through it.

Each delivery of cement in bags shall be stacked together in one place. The bags shall be closely stacked but shall not be stacked against an outside wall. If pallets are used, they shall be constructed so that bags are not damaged during handling and stacking. No stack of cement bags shall exceed 3m in height. Different types of cement in bags shall be clearly distinguished by visible markings and shall be stored in separate stacks.

Cement from broken bags shall not be used in the Permanent Works. Cement in bags shall be used in the order in which it is delivered.

Bulk cement shall be stored in weatherproof silos which shall bear a clear indication of the type of cement contained in them. Different types of cement shall not be mixed in the same silo.

The Contractor shall provide sufficient storage capacity on Site to ensure that his anticipated programme of work is not interrupted due to lack of cement having due regard to factors outside the Contractor's control such as transport, weather conditions, holidays and breakdowns.

Cement which has become hardened or lumpy or fails to comply with the Specification in any way shall be removed from the Site.

Samples of cement used in the Permanent Works shall be tested by the manufacturer or the Contractor in a laboratory acceptable to the Engineer. The tests shall be in accordance with the specified standard and the Contractor shall supply two copies of each test certificate to the Engineer.

Each set of tests carried out by the manufacturer or Contractor shall relate to not more than one day's output of each cement plant, and shall be made on samples taken from cement which is subsequently delivered to the Site. Alternatively, subject to the agreement of the Engineer, the frequency of testing shall be one set of tests for every 20 tonnes of cement delivered to Site from each cement plant.

Cement which is stored on Site for longer than one month shall be retested in a laboratory acceptable to the Engineer at the rate of one set of tests for every 20 tonnes, and at monthly intervals thereafter. Testing shall be in accordance with the specified standard for the cement supplied.

Cement which does not comply with the Specification shall not be used in the Permanent Works and shall be removed from site.

The Contractor shall keep full records of all data relevant to the manufacture, delivery, testing and use of all cement used in the Permanent Works and shall provide the Engineer with two copies thereof.

8.3.3 Aggregates for Concrete

Aggregates for concrete shall conform to the requirements for fine and coarse aggregates in BS EN 12620 . Fine and coarse aggregates shall separately conform to the requirements set out below:

(a) General Requirements

Aggregate shall be clean, hard, durable and frost resistant and shall not contain iron pyrites, iron oxides (other than magnetite), mica, shale, coal or other laminar, soft or porous materials.

(b) Gradings

Fine aggregate shall conform to BS EN 12620 - Table 2, Type CP or MP. In order to achieve an acceptable grading it may be necessary to blend materials from more than one source. Coarse aggregates shall be supplied in the nominal sizes specified & shall be graded in accordance with BS EN 12620 for single sized aggregates. A coarse aggregate shall be predominantly angular, rounded or irregular as defined in BS EN 933-4.

(c) Chlorides and Sulphates

The maximum permitted concentration of chlorides and sulphates expressed as a percentage by weight of fine aggregate is 0.06% (as NaCl) and 0.4% (as acid soluble SO_3) respectively whilst for coarse aggregate the limits as a percentage of the weight of coarse aggregate are 0.03% (as NaCl) and 0.4% (as acid soluble SO_3) respectively. These limits may be exceeded provided that the total chloride and sulphate content of the mix expressed as percentage of weight of cement in the mix does not exceed 0.2% (NaCl) and 4.0% (acid soluble SO_3) respectively.

(d) Not Used

(e) Not Used

(f) Soundness

When tested in accordance with ASTM C88 (5 cycles) shall not show a weight loss of more than 6 per cent using magnesium sulphate.

(g) Alkali Reactive Minerals

No part of the aggregates shall contain any mineral known to have a potential to cause alkali silica, alkali silicate, alkali carbonate or any other damaging chemical reaction between alkalis and aggregates. The minerals present should be determined in accordance with ASTM C294 on a range of samples selected to include every mineral type present in the aggregate as a whole irrespective of the proportion of the mineral.

If during the course of the test it is concluded that an unequivocal identification of a potentially reactive mineral is not possible, alternative tests shall be carried out such as to provide the required identification.

(h) Flakiness

Flakiness Index of coarse aggregates when tested in accordance with BS EN 933-3 shall be as set out hereunder.

For nominal 40mm aggregate and above, not more than 30. For nominal 20mm aggregate and below, not more than 30.

(i) The Impact Value of coarse aggregate, determined in accordance with BS EN 1097-2 shall be equal to or less than 32%.

(i) Shell Content

The Shell content of fine aggregate shall not exceed 3% when determined in accordance with BS EN 933-7. In addition the content of hollow and flat shells shall not be such as will reduce the 28 day strength below the minimum average strength required or reduce the average 28 day strength by more than 5 percent when tested in accordance with BS EN 12390 when 10 cubes made of concrete with shells are compared with 10 cubes made of concrete with shells removed.

(k) Water Absorption

The coarse aggregate shall not have a water absorption of more than 2.5 per cent when tested as set out in BS EN 1097-6.

(l) Organic Impurities

Fine and coarse aggregate shall be tested as set out in BS 1377 Part 3 and rejected if the percentage of organic matter exceeds 1 percent.

8.3.4 Aggregates for Mortar

Aggregates for mortar shall conform to BS EN 13139.

8.3.5 Aggregates for Pavement Concrete

Aggregates for pavement concrete shall comply with the requirements of this Section and also with any further requirements of Section 11 of this Specification.

8.3.6 Testing Aggregates

(a) Acceptance Testing

The Contractor shall deliver to the Engineer samples containing not less than 50 kg of any aggregate which he proposes to use in the Permanent Works and shall supply such further samples as the Engineer may require. Each sample shall be clearly labelled to show its origin and shall be accompanied by all the information called for in BS EN 12620.

Tests to determine compliance of the aggregates with all the requirements of Clauses 8.3.3 or 8.3.4 shall be carried out by the Contractor in a laboratory acceptable to the Engineer. If the tested materials fail to comply with the Specification, further tests shall

be made in the presence of the Contractor and the Engineer and acceptance of the material shall be based on such tests.

The acceptance tests carried out by the Contractor shall generally be on three representative samples of fine and coarse aggregates taken in the presence of the Engineer. Total numbers of tests required for acceptance are as follows:

Test	Fine Aggrega	Coarse Aggregat
Water	-	3*
Absorption	-	3*
Flakiness	-	3*
Index Impact	-	3*
Value	3*	1
Shell Content Determination		3 on each
Test for Shell Content (where	3*	nominal
required) Gradings	3*	size 3*
	-	3*
Chloride	As	3*
Content	required,	As
Sulphate	Minimum	required,
Content	3	Minimum
Soundness	3	3

* One test on each sample.

If at any time a significant physical or chemical change in the nature of the coarse or fine aggregate occurs, or a new source of aggregate is used, the Engineer may direct that some or all of the acceptance testing is repeated.

(b) Routine Testing

The Contractor shall carry out routine testing of aggregates for compliance with the Specification during the period in which concrete is being produced for the Permanent Works. The tests set out below shall be performed on aggregates from each separate source on the basis of one set of tests for each day on which aggregates are delivered to Site provided that no set of tests shall represent more than 250 tonnes of fine aggregate nor more than 500 tonnes of coarse aggregate, and provided also that the aggregates are of uniform quality. If the aggregate from any source is variable, the frequency of testing shall be as instructed by the Engineer.

Grading	BS EN 12620
Silt and clay content	BS EN 12620
Moisture content	BS EN 1017-5
Check on organic impurities	BS 1377, Part 3

In addition to the above routine tests, the Contractor shall carry out the following tests at the frequencies stated:

Moisture content: As frequently as may be required in order to control the water content of the concrete as required by the Specification.

Chloride content: As frequently as may be required to ensure that the proportion of chlorides in the aggregates does not exceed the limit stated in the Specification.

The Contractor shall take account of the fact that when the chloride content is variable it may be necessary to test every load in order to prevent excessive amounts of

chloride contaminating the concrete. For this purpose the Contractor shall use rapid field test results of the field test, the chloride content of the aggregate shall be determined in the laboratory as described in EN 1744.

8.3.7 Delivery and Storage of Aggregates

Aggregates shall be delivered to Site in clean and suitable vehicles. Different types or sizes of aggregate shall not be delivered in one vehicle.

Each type or size of aggregate shall be stored in a separate bin or compartment having a base such that contamination of the aggregate is prevented. Dividing walls between bins shall be substantial and continuous so that no mixing of types or sizes occurs.

The storage of aggregates shall be arranged so that as far as possible rapid drying out in hot weather is prevented in order to avoid sudden fluctuations in water content. Storage of fine aggregates shall be arranged so that they can drain sufficiently before use in order to prevent fluctuations in water content of the concrete.

8.3.8 Water for concrete and mortar

Water for mixing or curing concrete or mortar shall comply with the requirements of BS EN 1008 and shall not contain more than the following concentrations of impurities:

	Max mg/litre
The sum of sulphates, alkali carbonates and bicarbonates	1000
Chlorides	500
Suspended solids	2000
Other dissolved solids	2000

Seawater or brackish water shall not be used.

At the commencement of the Works the Contractor shall send a sample of the water proposed for concrete and mortar to an accredited laboratory capable of carrying out the full analysis of potable water. The results of the analysis shall be submitted to the Engineer. The sample of water sent for analysis shall be taken in the presence of the Engineer. If the water selected comes from a reliable potable water source the Contractor shall obtain a copy of a recent analysis from the chemist of the Water Authority. If the Engineer considers this satisfactory the tests required above need not be carried out.

Water to be used for mixing concrete or mortar shall be tested in accordance with BS EN 1008:2002 and shall comply with the recommendations for the Initial Setting Time test and the Compressive Strength test.

If the source of water is changed it shall be tested as above. If water contains 80 percent of the maximum concentration of impurities properties given above it shall be retested at two monthly intervals.

8.3.9 Admixtures

(a) General

The use of admixtures in concrete may be required under the Contract to promote special properties to the concrete or may be proposed by the Contractor to assist compliance with the Specification.

In all cases the Contractor shall submit to the Engineer full details of the admixture he proposes to use and the manner in which he proposes to add it to the mix. The information provided shall include:

- (i) The typical dosage and the detrimental effects of an excess or deficiency in the dosage
- (ii) The chemical names of the main active ingredients in the admixture
- (iii) Whether or not the admixture contains chlorides, and if so the chloride ion content expressed as a percentage by weight of admixture
- (iv) Whether the admixture leads to the entrainment of air when used at the manufacturer's recommended dosage, and if so, the extent to which it does so
- (v) Long and short term effects of the admixture on concrete including the effects on different types of cement and aggregates
- (vi) Storage life
- (vii) Safety precautions required in handling
- (viii) Compatibility with other additives
- (ix) Compliance with Standards.

The chloride ion content of any admixture shall not exceed 2 per cent by weight of the admixture nor 0.03 per cent by weight of the cement in the mix.

Admixtures shall not be mixed together without the consent of the Engineer.

(b) Super Plasticizing Admixtures

Super plasticizing admixtures shall comply with BS EN 934 – Part 2.

If Schedule 8.1 or the Drawings specify or the use of super plasticizing admixtures is subsequently authorised by the Engineer, the Flow Table test carried out in accordance with BS EN 12350 -5 shall be used to control and record workability.

Test cubes shall be made in accordance with BS EN 12390-1 and -2 except that the concrete shall be placed in the cubes and compacted to the same degree as the concrete placed in the works.

In addition to the normal trial mix cubes required an additional set of cubes shall be made with 1.5 times the intended super plasticizing admixture addition to assess the effect of overdosage on the concrete.

If the super plasticizing additive is not specified but the Contractor requests permission to use it the Engineer shall not approve its use unless full particulars including chemical constituents of the admixture are submitted and the additional trial mixes mentioned above have been carried out and all are considered satisfactory.

The Engineer reserves the right to refuse the use of super plasticizing admixture for concrete required for particular structures.

(c) Air Entraining Agents

In addition to the general requirements, air entraining agents shall be capable of producing an air content in concrete mixes within the limits stated in Schedule 8.1 or on the Drawings without any tendency to produce excessive air content in the event of prolonged mixing times.

The effect of a proposed air entraining agent shall be tested by the Contractor in trial mixes produced in the plant which he proposes to use for the Permanent Works.

Air entraining agents shall comply with BS EN 934-2.

(d) Workability Agents

Subject to the agreement of the Engineer, admixtures may be used by the Contractor to assist in meeting the requirements of the Specification or to aid the placing of concrete.

Workability agents shall comply with BS EN 934-2 and shall not have any adverse effect on the properties of the concrete. If a reduction in strength of the concrete is caused, the Contractor shall counteract this by a reduction in water cement ratio or by an increase in cement content.

8.4 Design of Concrete Mixes for Structural Concrete

8.4.1 Classes of Concrete

The classes of structural concrete to be used in the Permanent Works shall be those shown in Schedule 8.1 or on the Drawings. The classes are designated in Table 8.1.

Concrete for water retaining, drainage and marine structures shall have maximum water/cement ratios as column B below or as shown in Schedule 8.1 or on the Drawings.

Concrete for other structures shall have maximum water/cement ratios as column A below or as shown in Schedule 8.1 or on the Drawings.

The coarse aggregate maximum size shall be 20mm unless 10mm or 40mm are shown in Schedule 8.1 or on the Drawings.

Table 8.1: Concrete Classes

Grade of Concrete	Minimum Cement Content kg/m ³	Maximum Water/Cement Ratios		150mm cub minimum average strength N/mm ²
		A	B	
15	230	0.42	0.30	
20	290	0.42	0.42	36
25	315	0.42	0.42	39
30	320	0.42	0.42	42
35	340	0.42	0.40	50
40	380	0.42	0.35	55
45	390	0.42	0.35	60
50	410	0.42	0.42	65

Note: MAS = Required Minimum Average 28 day strength

8.4.2 Design of Proposed Mixes

The Contractor shall design the mixes which he proposes to use in the Permanent Works to achieve acceptable workability and resistance to segregation during handling and placing. Mixes shall also comply with the following requirements:

- The aggregate portion shall be well graded from the nominal maximum size of stone down to the 150 micron size
- The cement contents shall be as designated in Table 8.1 unless a higher cement content is required to meet the strength requirement
- The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than that shown in Table 8.1 taking due account of any water contained in the aggregates. The Contractor shall take into account that this requirement may need the inclusion of a workability agent in the mix
- The workability shall be consistent with ease of placing and proper compaction having regard to the presence of reinforcement and embedded items
- The crushing strength at 28 days as determined in accordance with Sub-Clause 8.4.3 shall not be less than the minimum average strength given in Table 8.1 plus 2 N/mm²
- The drying shrinkage determined in accordance with BS EN 1367-4 shall not be greater than 0.05 per cent
- Blinding concrete shall be Grade 15 unless otherwise indicated on the drawings or in Schedule 8.1.

The Contractor shall submit full details of all the mixes he proposes to use to the Engineer.

8.4.3 Trial Mixes with 150mm test cubes

For each mix of concrete the Contractor shall in the presence of a representative of the Engineer prepare three separate batches of concrete using the materials which have been approved for use in the Permanent Works and the mixing plant which he proposed to use for the Permanent Works.

Six test cubes shall be cast from each batch.

The marking, curing and testing of all test cubes shall comply with the requirements of BS EN 12390. The slump of the concrete carried out in accordance with BS EN 12350-2 shall be recorded.

Three cubes from each batch shall be tested for compressive strength at seven days and the remaining three at 28 days.

The density of all the cubes shall be determined before the cubes are crushed.

The average value of the crushing strength of the nine cubes tested at 28 days shall be greater than the Minimum Average Strength given in Table 8.1 for the grade of concrete tested, plus 2 N/mm².

If the 28 day strength determined as above is less than the minimum average strength shown in Table 8.1 plus 2 N/mm² the mix shall be adjusted in order to comply.

If adjustment of aggregate proportions does not increase the strength the water cement ratio shall be reduced.

If it is then necessary to increase the workability the use of a plasticity additive will be accepted. An increase in cement content will not normally be acceptable.

The average strength of the final nine trial mix 28 day cubes accepted by the Engineer shall be referred to thereafter as the "Final Trial Mix Strength".

The Contractor shall carry out tests to determine the drying shrinkage of the concrete.

If the Engineer does not agree to a proposed concrete mix for any reason, the Contractor shall amend his proposals and carry out further trial mixes. No mix shall be used in the Permanent Works without the written consent of the Engineer.

Based on the results of the tests on the trial mixes, the Contractor shall submit full details of his proposals for mix design to the Engineer, including the type and source of each ingredient, the proposed proportions of each mix and the results of the tests on the trial mixes.

8.4.4 Quality Control of Concrete Production (150mm cubes)

For each grade of concrete in production at each plant for use in the Permanent Works, samples of concrete shall be taken at the point of mixing or of deposition as instructed by the Engineer and in the presence of a representative of the Engineer, all in accordance with the sampling procedures described in BS EN 12350-1.

The slump of each sample carried out in accordance with BS EN 12350-2 shall be determined at the time of sampling.

Samples shall be taken on the basis of one for each 20m³ of concrete placed but in any case not less than one sample per day or one sample for each pour of concrete placed, whichever is the more frequent.

Three 150mm test cubes shall be cast from each sample, cured and tested as set out in BS EN 12390.

One cube shall be tested at seven days and two at 28 days.

The average strength of the two cubes crushed at 28 days shall be referred to as one test result.

Concrete shall be deemed to comply with the strength specified if the average strength of any four consecutive test results (8 cubes) exceeds the Final Trial Mix Strength minus 2N/mm² for the grade of concrete with no single test result (2 cubes) being less than the Final Trial Mix Strength minus 6 N/mm².

8.4.5 Failure to Comply with Requirements

The Contractor shall take any action instructed by the Engineer to remedy concrete which fails to comply with the Specification. Such action may include but is not necessarily confined to the following:

- (a) Adjusting the mix proportions until the concrete again complies with the Specification
- (b) Cutting test cores from the failed concrete and testing in accordance with BS 1881
- (c) Carrying out additional works to overcome the effect of the failed concrete
- (d) Removing the failed concrete
- (e) Increasing the frequency of sampling until control is again established.

8.5 Mixing Concrete

Before any plant for batching, mixing, transporting, placing, compacting and finishing concrete is ordered or delivered to Site, the Contractor shall submit to the Engineer full details including drawings of all the plant which he proposes to use and the arrangements he proposes to make.

Concrete for the Permanent Works shall be batched and mixed in one or more central plants unless the Engineer agrees to some other arrangement.

Batching and mixing plants shall be modern efficient equipment complying with the requirements of BS 1305 and capable of producing a uniform distribution of the ingredients throughout the mass. Truck mixers shall not be used unless the Engineer agrees otherwise. If the plant proposed by the Contractor does not fall within the scope of BS 1305 it shall have been tested in accordance with BS 3963 and shall have a mixing performance within the limits of Table 5 of BS 1305

Unless the Engineer agrees otherwise, each mixing plant shall be tested for mix variability as set out in BS 1305 before it is used to mix concrete for the Permanent Works.

All mixing operations shall be under the control of an experienced supervisor.

The aggregate storage bins shall be provided with drainage facilities arranged so that drainage water is not discharged to the weigh hoppers. Each bin shall be drawn down at least once per week and any accumulations of mud or silt removed.

Cement and aggregates shall be batched by weight. Water may be measured by weight or volume.

The weighing and water dispensing mechanisms shall be maintained in good order. Their accuracy shall be maintained within the tolerances described in BS 1305 and checked against accurate weights and volumes when required by the Engineer.

The weights of cement and of each size of aggregate indicated by the mechanisms employed shall be within a tolerance of plus or minus two per cent of the respective weights per batch agreed by the Engineer.

The Contractor shall provide standard test weights at least equivalent to the maximum working load used on the most heavily loaded scale and other auxiliary equipment required for checking the satisfactory operation of each scale or other measuring device. Tests shall be made by the Contractor at intervals to be determined by the Engineer and shall be carried out in his presence. For the purpose of carrying out these tests, there shall be easy access for personnel to the weigh hoppers. The Contractor shall furnish the Engineer with copies of the complete results of all check tests and shall make any adjustments, repairs or replacements necessary to ensure satisfactory performance.

The nominal drum or pan capacity of the mixer shall not be exceeded. The turning speed and the mixing time shall be as recommended by the manufacturer, but in addition, when water is the last ingredient to be added, mixing shall continue for at least one minute after all the water has been added to the drum or pan.

If the Engineer has reason to doubt the adequacy of the mixing, he may order a variability test as set out in BS 1305 and the Contractor shall forthwith carry out such tests, the results of which shall comply with the requirements shown in BS 1305.

The 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.

The water to be added to the mix shall be reduced by the amount of free water contained in the coarse and fine aggregates. This amount shall be determined by the Contractor by a method agreed by the Engineer immediately before mixing begins each day and thereafter as the Engineer directs. When the correct quantity of water, determined as set out in the Specification, has been added to the mix, no further water shall be added, either during mixing or subsequently.

After mixing for the required time, each batch shall be discharged completely from the mixer before any materials for the succeeding batch are introduced.

Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed and thereafter the first batch of concrete through the mixer shall contain only half the normal quantity of coarse aggregate. This batch shall be mixed for one minute longer than the time applicable to a normal batch.

Mixers shall be cleaned out before changing to another type of cement.

8.6 Transport of Concrete

The concrete shall be discharged from the mixer and transported to the Works by means which shall prevent adulteration, segregation or loss of ingredients, and which shall ensure that the concrete is of the required workability at the point and time of placing. The loss of slump between discharge from the mixer and placing shall not exceed 25mm.

The time elapsing between mixing and placing a batch of concrete shall be as short as practicable and in any case no longer than will permit completion of placing and compaction before the onset of initial set. If the placing of any batch of concrete is delayed beyond this period, the concrete shall not be placed in the Permanent Works.

8.7 Placing of Concrete

8.7.1 Consent for Placing

Concrete shall not be placed in any part of the Permanent Works until the Engineer's consent has been given in writing, and the Contractor shall give the Engineer at least 18 hours notice of his intention to place concrete.

If concrete placing is not commenced within 24 hours of the Engineer's consent, the Contractor shall again request written consent as specified above.

8.7.2 Preparation of Surfaces to Receive Concrete

Excavated surfaces on which concrete is to be deposited shall be prepared as set out in Section 4 of the Specification.

Existing concrete surfaces shall be prepared as set out in Clause 8.13. Before deposition of further concrete they shall be clean, hard and sound and if required by the Engineer shall be wet but without any freestanding water.

Any flow of water into an excavation shall be diverted through proper side drains to a sump, or be removed by other suitable methods which will avoid washing away the freshly deposited concrete or any of its constituents. Any underdrains constructed for this purpose shall be completely grouted up when they are no longer required by a method agreed by the Engineer.

If so instructed by the Engineer rock surfaces against which concrete is to be placed shall receive a prior coating of mortar mixed in the proportions similar to those of the fines portion in the concrete to be placed. The mortar shall be kept ahead of the concrete. The mortar shall be well worked into all parts of the excavated surfaces and shall be not less than 5mm thick.

If any fissures have been cleaned out as described in Section 4, they shall be filled with the mortar or with concrete as instructed by the Engineer.

The amount of mortar placed at any one time shall be limited so that it does not dry out or set before being covered with concrete.

8.7.3 Placing Procedures

The concrete shall be deposited as nearly as possible in its final position. It shall be placed so as to avoid segregation of the concrete and displacement of the reinforcement, other embedded items, or formwork. It shall be brought up in layers approximately parallel to the construction joint planes and not exceeding 500mm in compacted thickness unless otherwise permitted or directed by the Engineer, but the layers shall not be less than four times the maximum nominal size of aggregate in thickness.

Layers shall not be placed so that they form feather edges nor shall they be placed on a previous layer which has taken its initial set.

In order to comply with this requirement, a layer may be started before completion of the preceding layer.

All the concrete in a single bay or pour shall be placed as a continuous operation. It shall be carefully worked round all obstructions, irregularities in the foundations and the like so that all parts are completely full of compacted concrete with no segregation or honeycombing. It shall also be carefully worked round and between waterstops, reinforcement, embedded steelwork and similar items which protrude above the surface of the completed pour.

All work shall be completed on each batch of concrete before its initial set commences and thereafter the concrete shall not be disturbed before it has set hard. No concrete that has partially hardened during transit shall be used in the Permanent Works and the transport of concrete from the mixer to the point of placing shall be such that this requirement can be complied with.

Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete. Means shall be provided to remove any water accumulating on the surface of the placed concrete. Concrete shall not be deposited into such accumulations of water.

In drying weather, covers shall be provided for all fresh concrete surfaces which are not being worked on. Water shall not be added to concrete for any reason.

When concrete is discharged above its place of final deposition, segregation shall be prevented by the use of chutes, downpipes, trunking, baffles or other appropriate devices.

Forms for walls, columns and other thin sections of significant height shall be provided with openings or other devices that will permit the concrete to be placed in a manner that will prevent segregation and accumulations of hardened concrete on the formwork or reinforcement above the level of the placed concrete.

When it is necessary to place concrete under water the Contractor shall submit to the Engineer his proposals for the method and equipment to be employed which shall generally be in accordance with the Technical Report No 35 of the Concrete Society of Great Britain a copy of which shall be kept on site. The concrete shall be deposited either by bottom-discharging watertight containers or through funnel-shaped tremies which are kept continuously full with concrete up to a level above the water and which

shall have the discharging bottom fitted with a trapdoor and immersed in the concrete in order to reduce to a minimum the contact of the concrete with the water. Special care shall be taken to avoid segregation.

If the concrete in a tremie pipe is allowed to fall to such an extent that water enters the pipe, the latter shall be removed from the pour and filled with concrete before being again lowered into the placing position. During and after concreting under water, pumping or de-watering in the immediate vicinity shall be suspended if there is any danger that such work will disturb the freshly placed concrete.

8.7.4 Formwork

Formwork is defined as the casing into which concrete is poured, and its supporting falsework.

It shall be designed and constructed so that the concrete can be efficiently placed and compacted without displacing or deforming the reinforcement. It shall be firmly supported, braced, guyed or tied back so that it is stable against vertical and horizontal forces. It shall be capable of adjustment and sufficiently strong not to distort significantly by the pressure of the concrete or by other loads and influences. Internal spacers and ties shall be of types that do not produce holes completely through the concrete and any permanently embedded parts shall not be nearer the finished surface than the cover to the reinforcement. Joints in the formwork shall be close fitting to prevent leakage. Temporary openings shall be provided, if necessary, for cleaning and inspection. The arrangement shall allow for removal of formwork from the sides of members without disturbing soffit formwork.

Rough-faced formwork may be used only for surfaces which are normally never exposed to view. Where such surfaces are to be tanked, by covering with paint or sheeting, the formwork shall be capable of achieving a finish suitable for the proposed tanking.

Exposed formwork shall be used for surfaces of concrete which will be exposed to view or to liquids. It shall be constructed from material of sufficiently high quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grain or steppings or ridges. Where lined, the same type of lining shall be used throughout any one structure.

All formwork shall have joints close enough to prevent leakage of liquid from the concrete and formwork shall be jacked or wedged and clamped or bolted to permit adjustments before concreting and to permit easing and removal of formwork without jarring the concrete. Formwork shall be securely braced and strutted against lateral deflections and vertical movements. Where formwork is supported on previously constructed portions of the reinforced concrete structural frame, the Contractor shall by consultation with the Engineer ensure that the supporting concrete structure is capable of carrying the load and / or is sufficiently propped from lower floors or portions of the frame to permit the load to be temporarily carried during construction.

Formwork shall be cambered by the Contractor to the amount approved by the Engineer to compensate for anticipated deflections prior to hardening of the concrete.

Separate specification clauses cover the requirements for formwork for special surface finishes.

Formwork, or an approved alternative, shall be used for upper inclined surfaces of concrete where the slope is greater than 30° to the horizontal.

Formwork shall be designed so that splays, fillets, chamfers and projections are cast as the work proceeds. Unless specifically deleted all external angles on exposed concrete shall have

a 25mm by 25mm chamfer.

Before placing the concrete, all extraneous matter shall be removed from the interior of formwork and the faces to be in contact with the concrete shall be wetted or treated with a non-staining composition to prevent adhesion. The composition shall be applied in such a manner as not to reduce the bond between reinforcement and concrete.

Facilities for examination of the formwork after its erection and before concrete is placed shall be provided and 24 hours' notice shall be given to enable the Engineer to examine the formwork if he so wishes. Approval of formwork must be obtained before any concrete is placed.

8.7.5 Interruptions to Placing

If concrete placing is interrupted for any reason and the duration of the interruption cannot be forecast or is likely to be prolonged, the Contractor shall immediately take the necessary action to form a construction joint so as to eliminate as far as possible feather edges and sloping top surfaces and shall thoroughly compact the concrete already in place in accordance with Clause 8.8. All work on the concrete shall be completed while it is still plastic and it shall not thereafter be disturbed until it is hard enough to resist damage. Plant and materials to comply with this requirement shall be readily available at all times during concrete placing.

Before concreting is resumed after such an interruption the Contractor shall cut out and remove all damaged or uncompacted concrete, feather edges or any other undesirable features and shall leave a clean sound surface against which the fresh concrete may be placed.

If it becomes possible to resume concrete placing without contravening the Specification and the Engineer consents to resumption, the new concrete shall be thoroughly worked in and compacted against the existing concrete so as to eliminate any cold joints.

8.7.6 Dimensions of Pours

Unless otherwise agreed by the Engineer, pours shall not be more than two metres high and shall as far as possible have a uniform thickness over the plan area of the pour. Concrete shall be placed to the full planned height of all pours except in the circumstances described in Sub-Clause 8.7.4.

The Contractor shall plan the dimensions of pours in such a way that thermal or shrinkage stresses are minimised.

8.7.7 Placing Sequence

The Contractor shall arrange that as far as possible the intervals between placing successive lifts of concrete in one section of the Permanent Works are of equal duration. This duration shall normally be not less than three nor more than seven days under temperate weather conditions unless otherwise agreed or instructed by the Engineer.

Where required by the Engineer to limit the opening of construction joints due to shrinkage, concrete shall not be placed against adjacent concrete which is less than 21 days old.

When the Drawings call for contraction gaps in concrete, these shall be of the widths and in the locations shown on the Drawings and they shall not be filled until the full time interval shown on the Drawings has elapsed.

8.8 Compaction of Concrete

The concrete shall be fully compacted throughout the full extent of the placed layer. It shall be thoroughly worked against the formwork and around any reinforcement and other embedded items, without displacing them. Particular care shall be taken at arrisses and other confined spaces. Successive layers of the same pour shall be thoroughly worked together.

Concrete shall be compacted with the assistance of mechanical immersion vibrators, unless the Engineer agrees another method.

Immersion vibrators shall operate at a frequency of between 7000 and 10000 cycles per minute. The Contractor shall ensure that vibrators are operated at pressures and voltages not less than those recommended by the manufacturer in order that the compactive effort is not reduced.

A sufficient number of vibrators shall be operated to enable the entire quantity of concrete being placed to be vibrated for the necessary period and, in addition, stand-by vibrators shall be available for instant use at each place where concrete is being placed.

Where the concrete contains aggregate with a nominal size of 75mm or more, vibrators with a diameter of 100mm or more shall be used.

Vibration shall be continued at each point until the concrete ceases to contract, a thin layer of mortar has appeared on the surface and air bubbles have ceased to appear. Vibrators shall not be used to move concrete laterally and shall be withdrawn slowly to prevent the formation of voids.

Vibration shall not be applied by way of reinforcement nor shall vibrators be allowed to touch reinforcement or other embedded items. The vibrators shall be inserted vertically into the concrete to penetrate the layer underneath at regular spacing which shall not exceed the distance from the vibrator over which vibration is visibly effective.

8.9 Curing of Concrete

8.9.1 General

Concrete shall be protected during the first stage of hardening from loss of moisture and from the development of temperature differentials within the concrete sufficient to cause cracking. The methods used for curing shall not cause damage of any kind to the concrete.

Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least fourteen days or until the concrete is covered by later construction whichever is the shorter period.

The curing process shall commence as soon as the concrete is hard enough to resist damage from the process, and in the case of large areas or continuous pours shall commence on the completed section of the pour before the rest of the pour is finished.

Details of the Contractor's proposals for curing concrete shall be submitted to the Engineer before the placing of concrete commences in the Permanent Works.

8.9.2 Loss of Moisture

All exposed horizontal concrete surfaces shall be closely covered with polythene sheeting immediately after the concrete has been finished. Joints in the polythene sheeting shall be lapped by at least 300mm and sealed with tape. This sheeting shall be properly secured to prevent its removal by wind and the development of air spaces beneath it. This shall be carried out, wherever possible by placing a layer of dry sand 80mm thick on the polythene.

Care shall be taken at all stages to prevent damage to the polythene sheeting which shall be left in position for at least 7 days.

If sand cannot be used heavy insulation blankets may be used.

8.10 Protection of Fresh Concrete

Freshly placed concrete shall be protected from rainfall and from water running over the surface until it is sufficiently hard to resist damage from this cause.

No traffic shall be allowed on any concrete surface until such time as it is hard enough to resist damage by such traffic.

Concrete placed in the Permanent Works shall not be subjected to any structural loading until it has attained at least its minimum average strength as defined in Clause 8.4.

If the Contractor desires to impose structural loads on newly-placed concrete, he shall make at least three test cubes and cure them in the same conditions as the concrete they represent. These cubes shall be tested singly at suitable intervals in order to estimate the time at which the minimum average strength is reached.

8.11 Concreting in Hot or Cold Weather

8.11.1 General

The Contractor shall prevent damage to concrete arising from exposure to extreme temperatures, and shall maintain in good working order all plant and equipment required for this purpose.

In the event that conditions become such that even with the use of the equipment the requirements cannot be met, concrete placing shall immediately cease until such time as the requirements can again be met.

8.11.2 Concrete Placing in Hot Weather

During hot weather the Contractor shall take all measures necessary to ensure that the temperature of concrete at the time of placing in the Permanent Works shall not exceed 30°C or such other temperature specified elsewhere in the Contract, and that the concrete shall not lose any moisture during transporting and placing.

Such measures may include but are not necessarily limited to the following:

- (i) Shielding aggregates from direct sunshine
- (ii) Use of a mist water spray on aggregates
- (iii) Sun shields on mixing plants and transporting equipment
- (iv) Painting all equipment and sun shields white.
- (v) Cooling the mixing water. If ice is used for this purpose it should preferably be in flake form. Lump ice shall not be allowed to enter the tank supplying the mixer drum.
- (vi) Covering skips closely with polythene sheet so that the latter is in contact with the concrete.

Areas in which concrete is to be placed shall be shielded from direct sunshine and rock or concrete surfaces shall be thoroughly wetted if instructed by the Engineer to reduce absorption of water from the concrete placed on or against them.

After concrete in any part of an area has been placed, the selected curing process shall be commenced as soon as possible. If any interval occurs between completion of placing and start of curing, the concrete shall be closely covered during the interval with polythene sheet to prevent loss of moisture.

8.12 Finishes on Free Surfaces

Horizontal or nearly horizontal surfaces which are not cast against formwork shall be finished to the class shown on the Drawings and defined hereunder.

8.12.1 U1 Finish

All surfaces on which no higher class of finish is called for on the Drawings or instructed by the Engineer shall be given a U1 finish.

The concrete shall be levelled and screeded to produce a uniform plain or ridged surface, surplus concrete being struck off by a straightedge immediately after compaction.

8.12.2 U2 Finish

The surface shall first be treated as a Class U1 finish and after the concrete has hardened sufficiently, it shall be floated by hand or machine sufficient only to produce a uniform surface free from screed marks.

8.12.3 U3 Finish

The surface shall be floated as for a U2 finish but to the tolerance stated below. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

8.12.4 U4 Finish

The requirement is similar to a U3 finish but the permissible tolerances are smaller.

8.12.5 U5 Finish - Brushed Finish

The concrete surface shall firstly be prepared as a U2 finish and then lightly brushed with a stiff brush to produce a textured finish. The brush used, once approved, shall be kept for the brushed finish only and not used for any other purpose.

8.12.6 Tolerances

The permissible tolerances on free surfaces shall not exceed the values given in Table 8.4.

Table 8.4 - Surface Tolerances

Class of Finish	Tolerance in mm. See Notes		
	A	B	C
U1	Not applicable	10	+ 20 or - 10
U2	Nil	10	+ 20 or - 10
U3	Nil	5	+ 12.5 or - 7.5
U4	Nil	2	+ 6 or - 4

NOTES: 1. Column A is the maximum allowable value of any sudden change of level in the surface.
2. Column B is the maximum allowable value of any gradual irregularity of the surface, as indicated by the gap between the surface and a three metre long straightedge or correctly shaped template placed on the surface.
3. Column C is the maximum allowable value of the difference in level or position between a straightedge or correctly shaped template placed on the surface and the specified level or position of that surface.

Where dimensional tolerances are given on the Drawings or elsewhere in the Specification they shall take precedence over those given in Table 8.4.

8.13 Records of Concrete Placing

Records, in a form agreed by the Engineer, shall be kept by the Contractor of the details of every pour of concrete placed in the Permanent Works. These records shall include class of concrete, location of pour, date of pour, ambient temperature and concrete temperature at time of placing, moisture contents of aggregates, details of mixes, batch numbers, cement batch number, results of all tests undertaken, location of test cube sample points and details of any cores taken.

The Contractor shall supply to the Engineer four copies of these records each week covering work carried out the preceding week. In addition he shall supply to the Engineer monthly histograms of all 28 day cube strengths together with accumulative and monthly standard deviations and any other information which the Engineer may require concerning the concrete placed in the Permanent Works.

8.14 Mortar

This clause covers mortar for use ahead of concrete placing, and other uses not covered elsewhere in the Specification.

Mortar shall be composed of fine aggregate complying with Clause 8.3.3 and the type of cement specified in Schedule 8.1 or on the Drawings. The mix proportions shall be as stated on the Drawings or if not stated shall be one part of cement to two parts of fine aggregate by weight.

Small quantities of mortar may be hand mixed but for amounts over 0.5m³ a mechanical mixer shall be used.

The water content of the mortar shall be as low as possible consistent with the use for which it is required but in any case the water/cement ratio shall not be more than 0.5.

Mortar which is specified as "dry pack" shall be mixed with sufficient water for the mix to become cohesive but not plastic when squeezed in the hand. Dry pack mortar shall be rammed into the cavity it is required to fill, using a hand rammer with sufficient force to ensure full compaction.

8.15 Grouting of Pockets and Holes and Underpinning of Baseplates

Pockets and holding-down bolt holes shall be thoroughly cleaned out using compressed air and water jet. Holes drilled by a diamond bit shall be roughened. The pockets and holes shall be filled with grout consisting of cement and clean fresh water mixed in proportion of two parts by weight of cement to one part by weight of water. The pouring of liquid grout shall cease as soon as each hole is filled and any excess grout on the surface dried off before the next operation proceeds.

The space between the top surface of foundation concrete and the underside of baseplates shall be filled with a special mortar made up in the following proportions:

Portland cement	50 kg
Fine aggregate	50 kg

An additive acceptable to the Engineer to counteract shrinkage in proportions recommended by the manufacturer.

The special mortar shall be mixed with the lowest water-cement ratio which will result in a consistency of mix of sufficient workability to enable maximum compaction to be achieved.

The special mortar shall then be well rammed in horizontally below the baseplate and from one edge only until it is extruded from the other three sides. The mortar which has extruded shall then be rammed back to ensure complete support without voids.

8.20 Embedded Metal Surfaces

All areas of metal to be cast into concrete members shall be thoroughly cleaned to the Engineer's satisfaction using a combination of washing with cold water complying with sub-clause 8.3.8 and brushing prior to the placing of the concrete.

8.21 Ready Mixed Concrete

Ready Mixed Concrete for use in the Permanent Works shall only be obtained from a ready mix concrete supplier approved by the Engineer.

Ready mix concrete shall comply with the requirements of this section. The concrete shall be carried in truck mixers operating continuously. The concrete shall be compacted and in its final position within two hours of the introduction of cement to the aggregates. Water shall be added to the mix at the central batching plant and in no circumstances shall any further water be added. The delivery note shall record the weights of the constituents of the mix, the time of introduction of cement to the aggregates and the time water was added to the mix.

8.22 Porous No Fines Concrete

No Fines concrete shall consist of Ordinary Portland Cement as specified and 20/40mm single size aggregate complying with BS EN 12620.

The ratio of aggregate to cement shall be 8:1 by volume or 10:1 by mass. 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. The concrete shall be compacted by hand only.

SECTION 8 - CONCRETE

SCHEDULE 8.1 : CONCRETE CLASSES AND LOCATIONS

1. CONCRETE CLASSES

Grade	Type of Ceme	Type of Aggrega te	Admixture s	Minimu m Cement Content	Maximum Water/ Cement Ratio
15	OPC	As	NWR	230	0.57
20	OPC	As	NWR	290	0.42
25	OPC	As	NWR	315	0.42
30	OPC	As	NWR	320	0.40
35	OPC	As	NWR	340	0.35
40	OPC	As	NWR	380	0.35
45	OPC	As	NWR	390	0.35
50	OPC	As	NWR	410	0.35

2. LOCATIONS

Locati on	Severit y	Grad e of	Cov er	Meth od of	Type of Reinforcem	Coatin g or
All works unles s	Severe	30/35/40	As per Drawi ngs	As specif ied	T	As specifi ed
Blindi ng Mass	Corrosiv e	15	/	As specif ied	/	/

OPC = Ordinary portland cement to BS EN197-1
R = Hot rolled mild steel to BS 4449
NWR = Normal water reducing admixture to BS EN 934-2 AIR
 = Air entrained as specified.
SRC = Sulphate resisting cement to BS 4027 or ASTM C150 Type V
T = Type 2 deformed reinforcement to BS 4449
RHC = Rapid Hardening
Information on Drawings which differ from that above shall take precedence

Specification

SECTION 4

EXCAVATION, EARTHWORKS AND FILL

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4.1 Excavation and Earthworks

4.1.1 Scope of Section

This Section covers all excavation and filling operations forming part of the Permanent Works.

4.1.2 Definitions

The following definitions apply to this Section.

"Required excavation" is the excavation required solely for the Permanent Works and does not include excavation for Temporary Works, working spaces, access and the like.

"A foundation" is that part of the ground which will support Permanent Works.

"A formation" is a surface on which earthworks operations, or stages of operations, have been completed.

"Topsoil" is material from the surface layers of the ground which is capable of supporting plant life.

"Spoil" is excavated material which is unsuitable for use in the Permanent Works or is material which is surplus to the requirements of the Permanent Works.

"Suitable filling" is material which is not unsuitable as defined hereunder and which is approved by the Engineer for use in the Permanent Works.

"Unsuitable material" is material which in the opinion of the Engineer falls into one or more of the following classifications:-

1. material from swamps, marshes and bogs;
2. peat, timber, tree roots and stumps, refuse and material containing degradable matter; material susceptible to spontaneous combustion;
3. material with an organic content exceeding two per cent as determined by Test Method 3 of BS 1377: Part 3: 1990 - Determination of organic matter content; material which is too wet for compaction in accordance with the Specification; material containing chlorides, sulphates or other chemicals in quantities which will be injurious to the Permanent Works;
4. any other material which is not approved by the Engineer.

4.1.3 Demolition of existing bases

Demolish existing bases and cart away debris from AML compound.

Where underground structures, manholes, wells, services and similar items are discovered, their presence shall be reported immediately to the Engineer and they shall not be further disturbed until the Engineer has given his instructions for their disposal, re-routing or protection.

Where such underground structures, manholes, wells and similar items are demolished and removed from areas which are to be occupied by buildings, roads, hard standings and other Permanent Works, any holes or depressions resulting from such removal shall be filled with material similar to that in the surrounding ground and compacted to a density equal to that of the surrounding ground unless other treatment is shown on the Drawings or instructed by the Engineer.

No material arising from site clearance shall be burnt on Site, all material shall be disposed of as spoil.

All removable items, which are to be preserved in accordance with the Drawings, the Specification or the instructions of the Engineer, shall be stored on Site in a place of safety and in a manner appropriate to their nature. All such items shall remain the property of the Employer.

4.1.4 Control of Water in Excavations and Earthworks

Unless otherwise required or permitted by the Contract, excavation and earthworks shall be carried out in the dry. The Contractor shall at all times maintain control of water entering excavations from any source.

Water shall not be allowed to flow across or down any excavated surface which is liable to erode. Water emerging on to excavated surfaces shall be trapped and led away by suitable means before any Permanent Works are placed on or against such surfaces.

The Contractor shall provide enough sumps to deal with all flows encountered and shall by pumping or otherwise keep the water level in such sumps at least 0.5 metres below the lowest excavated surface for as long as may be required for the purposes of constructing the Permanent Works.

The Contractor shall repair to the approval of the Engineer any foundations damaged by water.

No water shall be allowed to flow on to earthfill and the surface of such fill shall at all times be maintained at a gradient adequate to shed rainwater.

Formations or soil structures which deteriorate under rainfall shall either be covered to prevent damage by rainfall or left high and trimmed immediately before being concreted.

4.1.5 General Requirements for Excavation and Earthworks

The Contractor shall adhere to all appropriate recommendations detailed in BS 5975 – Code of Practice Earthworks

(a) Constructional Plant

N/A

(b) Ground Levels

Following site clearance and before any excavation or earthworks is commenced the site of the excavation or earthworks shall be surveyed by the Contractor in a manner and to the extent required by the Engineer. Drawings recording the survey shall be signed by the Contractor and the Engineer as a true record and the Contractor shall then supply to the Engineer two prints and an electronic copy of the drawings in AutoCAD 2008 format or such other format as may be agreed.

Such records shall not be altered in any way unless such alterations are agreed and signed by both the Contractor and the Engineer.

(c) Excavated Surfaces

All excavated surfaces shall be finished neatly to the lines and levels shown on the Drawings unless such lines and levels are shown as nominal.

When such lines and levels are stated to be nominal, the final lines and levels will be instructed by the Engineer to take into account the conditions of the ground exposed as the excavation nears the nominal lines and levels shown on the Drawings and the Contractor may be required to carry out the excavation in more than one stage in order to arrive at the final lines and levels. The surface shall be left not less than 150 mm above its final level until immediately before commencing Permanent Works construction.

Excavated surfaces which will remain permanently exposed on completion of the Permanent Works shall be cleared of all loose material, pieces of rock, debris rubbish and the like and left neat and tidy.

The Contractor shall leave no excavation open within the Apron areas without the approval of the Engineer, DCA and AML.

Consideration will be limited to an obstacle which does not exceed 9 m², narrow trenches may exceptionally be allowed up to 28 m². Any obstacle permitted should be limited in height to provide propeller or pod clearance for the type of aircraft using the aerodrome, and in no case should the height exceed 1 m above the ground. Any piles of earth or debris which could damage aircraft or engines must be removed. Trenches and other excavation should be backfilled and compacted as soon as possible. Excavations which cause degradation in the services of the ILS, PAPI and Approach Lights will not be permitted.

(d) Supports to Excavation

The responsibility of the Contractor for the safety and care of the Works under the Contract shall include taking the following measures:-

- (i) The Contractor shall excavate the sides of excavations which are not positively supported to slopes which will remain stable.
- (ii) The sides of excavations which are not cut to a stable slope shall be properly and adequately supported to the extent necessary to ensure stability during the period of construction of the Permanent Works, and the excavation shall then be backfilled unless otherwise indicated on the Drawings.
- (iii) No materials, plant or other load shall be placed so close to any excavation that the stability of the sides of the excavation is endangered.
- (iv) The Contractor shall remove or otherwise secure by barriers, nets or other means any material which might fall and thereby cause damage to the Permanent Works or injury to any person.

The Contractor shall be responsible for the installation and subsequent removal of all necessary sheeting, timbering, strutting, shoring and the like to secure the excavations, to prevent any movement of adjacent ground and to ensure the safety of workmen and freedom from damage to structures, buildings, sewers, drains, walls, services or any other thing.

(e) Slips and Over-excavation

The Contractor shall avoid excavating beyond the lines and levels shown on the Drawings, disturbing ground adjacent to excavations, or damaging material beyond the limits of the required excavation except to provide the minimum adequate working space.

Slippages, excavation for working space, over-excavation and damaged areas shall be made good to the satisfaction of the Engineer. In the case of surfaces on which or against which Permanent Works are to be constructed, this remedial work shall comprise replacing the slipped, over-excavated or damaged material with suitable filling material or with concrete, as instructed by the Engineer.

Slips, falls, subsidences and other damage which have the effect of removing or reducing support to existing or proposed structures, services and the like shall be made good in concrete or otherwise in a manner acceptable to the Engineer.

In the case of permanently exposed surfaces, remedial work shall comprise replacing and compacting material similar to that which has been removed in order to provide a surface not less satisfactory than adjacent correctly excavated surfaces. If this is not possible, remedial works shall be as instructed by the Engineer.

4.1.6 Regrading of Embankment

1. Material Requirements:

Fill material must meet the specified properties (e.g., granular soil with specific gradation and compaction characteristics). Topsoil and vegetation (if required) must comply with environmental guidelines.

2. Construction Methods:

Earthmoving and grading equipment must be appropriate for the scale of the project. Sequential excavation and filling to minimize instability during construction. Grassing shall be carried out to prevent erosion control. Restoration of disturbed areas with native vegetation or approved landscaping. Regular compaction tests during filling to achieve the required density in layers of 500mm. Work must be completed within a specified duration

3. Safety Standards:

Use of barricades, signage, and personal protective equipment (PPE) for worker safety and monitoring of slope stability during construction with visual inspections and instrumentation (e.g., inclinometers).

Measures to protect nearby water bodies from sediment runoff (e.g., silt fences or sediment basins).

4.1.7 Preparation and Inspection of Foundations

(a) Foundations on Rock

Rock surfaces shall be free of all dust, mud, loose or fractured material and other debris. Fissures shall be cleaned out to the extent instructed by the Engineer and filled with concrete, mortar or grout of the class instructed by the Engineer. If instructed by the Engineer, the Contractor shall clean part of the foundation in advance of the remainder for the purpose of inspection.

(b) Foundations on Materials other than Rock

Surfaces other than rock shall be trimmed to the correct line and level immediately before commencing Permanent Works construction and any loose or disturbed material shall be removed down to a nominal stripping depth of 0.2m.

If the natural ground exposed by stripping or excavation does not meet the density requirements specified for the depth, the material shall be compacted to a depth where the subgrade does satisfy the density requirements shown in Schedule 4.2 Tables B and C.

Excavated surfaces shall be compacted by a minimum of four passes of a vibrating drum roller with a static weight of at least 4500kg per metre of width. Excavated or

natural slopes which are too steep for such compaction shall be benched and each bench shall be compacted when the fill reaches the level of each bench.

(c) Inspection of Foundations

When the Contractor considers that a foundation is ready for Permanent Works construction to commence, he shall inform the Engineer in writing, who will either approve the foundation in writing or instruct any further work which he may consider to be necessary.

4.1.8 Disposal of Excavated Material

Unless areas within the Site have been designated in the Contract or agreed by the Engineer as spoil areas, all spoil shall be disposed of in areas to be found by the Contractor outside the Site, approved by the relevant Government Agencies and the Engineer.

Temporary stockpiles of material for later use in the Works shall be formed with side slopes which will remain stable under all conditions to which they will be subject and the tops shall be graded to prevent the ponding of water. They shall not interfere with Airport operations.

Different materials shall be placed in separate spoil tips or stockpiles unless otherwise agreed by the Engineer.

Spoil tips and stockpiles shall be placed so that there is no risk of material obstructing or polluting watercourses.

4.1.9 Backfilling

Excavations which are to be backfilled around structures shall be filled with suitable material from the excavations unless the Contract requires otherwise. If insufficient material is available from this source, the Contractor shall supply suitable material from another source.

All vegetation, topsoil, rubbish and unsuitable material shall be removed from any area on which fill is to be placed unless the Engineer agrees otherwise.

Except where special placing and compaction requirements are required by the Specification, the material shall be placed in layers not exceeding 300mm after compaction, and compacted to not less than 95% of its maximum dry density measured as in BS 1377, Part 4, Test 3 - Determination of the dry density/moisture content relationship (2.5kg rammer).

When placing backfill the Contractor shall make due allowance for settlement and shall ensure that the final lines and levels are as shown on the Drawings.

Any areas which subside shall be made good without delay, up to the end of the Defects Notification Period.

4.1.10 Formation for Pavements

N/A

4.2 Fill

4.2.1 General Requirements for Fill

The Contractor shall be responsible for identifying and testing suitable sources of fill and select fill.

Fill shall be any granular or cohesive material that can be compacted to the degree specified. The fill after compaction shall comply with the requirements given in Schedule 4.2 with the grading given in Table A and with the compaction requirements given in Tables A and B. The Contractor may submit alternative material types or gradings to the Engineer for approval.

Four possible fill types have been identified:

- Clean Rockfill (Type 1A) – Rock boulders passed through primary crusher
- Clean Gravel (Type 1B) – As above but passed through secondary crusher
- Quarry Run Rockfill (Type 1C) – Wide graded mixture of rockfill, gravel and sand sizes
- Bulk Fill (Type 1D) – Predominantly well graded sandy silt or gravely silty sand derived from decomposed or weathered basalt and free of any organic matter

4.2.2 Selected Fill

Where fill is shown on the Drawings as selected fill, it shall comply with the requirements set out in Schedule 4.2 for selected fill.

Not less than two weeks before selected fill is used in the Permanent Works, the Contractor shall submit details to the Engineer of the material he proposes to use including at least three sets of test results from a laboratory acceptable to the Engineer showing that the material complies with the Specification.

4.2.3 Placing Fill

All areas to be covered shall be prepared in accordance with Clause 4.1.9, including removal of vegetation, topsoil and other unsuitable overburden, prior to placing of fill.

Fill shall be placed so that the surface is sufficiently even and has sufficient camber to shed surface water and to avoid ponding.

Where it is necessary to place fill around Permanent Works structures, it shall be placed and compacted evenly on all sides to minimise unbalanced loads on the structures. Such fill shall not contain boulders or any other hard material of a size which is the opinion of the Engineer may result in damage to the structures or incomplete compaction of the fill.

Where fill is to be placed in trenches, pits and other places the sides of which are supported, those supports which are to be removed shall as far as practicable be withdrawn ahead of the layer of fill to be compacted and all voids left by the supports shall be filled with fully compacted material.

If fill material which has been deposited but not fully compacted reaches a moisture content by wetting or by drying at which it cannot be compacted in accordance with the Specification, the Contractor shall take action, subject to the agreement of the Engineer, to render the material suitable. Such action may include:

- (a) Removing the material and replacing it with suitable material.
- (b) Adjusting the moisture content by appropriate mechanical or chemical methods including the addition of water in the case of material which is too dry.
- (c) Ceasing work on the material until it again becomes suitable.

4.2.4 Compaction of Fill

(a) Definitions

The specified thickness of a layer of fill is the thickness after compaction has been completed.

The standard against which the degree of compaction will be compared is the maximum dry density and the optimum moisture content obtained by BS 1377, Part 4, Test 3 - Determination of the dry density/moisture content relationship (4.5 kg rammer method).

For granular materials which fail to produce a usable result curve from the above test, Maximum and Minimum Density testing ASTM Designation: D4253-83 and D4254-83 shall be used as an alternative unless otherwise instructed by the Engineer.

Care shall be taken in determining the moisture content of cohesive soils. The mineralogy of these soils may affect their moisture contents at higher temperatures. Therefore, at the start of the works, a suitable method of determining moisture contents shall be determined by comparing moisture contents as obtained by oven drying at 105-110°C with those obtained by drying samples at 60°C. Samples for compaction tests shall be air dried.

The field density tests called for in the Specification are those described under BS 1377, Part 9, Test 2- In-situ density of soil on the Site, or, for Coarse-grained materials, the Orovill Ring Tests (Australian Standard 1289.E3.5-1977) shown in Appendix A20 to this Specification.

(b) General Requirements

Fill shall be compacted in layers of optimum thickness for the compaction plant in use but in any case not thicker than the thickness permitted in Table 4.2.

The Contractor shall carry out tests on the material used for filling and determine the maximum dry density and optimum moisture content. The results of these tests shall be reported to the Engineer. Before and during compaction of a layer the moisture content of the material shall be adjusted to within plus or minus 2% of the optimum moisture content.

Fill shall be compacted to a dry density not less than that shown in Schedule 4.2 expressed as a fraction of the maximum dry density, and measured by field density tests.

If fill has moisture content too low to permit the specified dry density to be achieved, the Contractor shall incorporate sufficient water, by a method acceptable to the Engineer, to permit compliance with the Specification. For quarry run rockfill material 1C the layer shall be freely sluiced with water during compaction to prevent any build up of fine material on the surface of the layer.

If fill becomes sufficiently wet to cause severe rutting by construction traffic or heaving under compaction plant and to an extent that the required dry density cannot be obtained, placing and compaction shall forthwith cease, and shall not be resumed until the Contractor has taken whatever action may be necessary in accordance with Clause 4.2.3 to restore the fill to a proper condition for compaction.

(c) Compactive Effort

Fill shall be compacted using the type of equipment, the depth of layer and the number of passes determined in accordance with Table 4.2 and the notes appended thereto to achieve the dry density specified in Schedule 4.2. If the dry density is not obtained, the depth of layer shall be decreased or the number of passes shall be increased, or the type of equipment shall be changed until the required dry density is achieved.

Compaction trials with the main types of material likely to be encountered and type of equipment to be used shall be completed before Permanent Works with the corresponding materials will be allowed to commence. Compaction work shall be continued until a state of compaction is reached in the layer being compacted such that 9 out of every 10 consecutive samples taken of the compacted material have a dry density at least equal to that specified.

If the Contractor proposes to use compaction equipment which is not covered by Table 4.2, he shall place fill in a trial area to a total depth of at least 600mm using the plant, layer thickness and number of passes which he proposes, in order to demonstrate the adequacy of his proposals. The trial area may form part of the Permanent Works provided it complies with the Specification.

(d) Field Control of Compaction

The Contractor shall regularly check the dry density which is being achieved in fill compacted in accordance with Table 4.2 or agreed modifications thereof by testing as set out in BS 1377, Part 9, Test 2, or agreed alternative standard for fill containing large particles, using the method appropriate to the soil being compacted. Tests shall be made in each layer compacted on the basis of one test for every 1000m³ with a minimum of three tests per layer. For layers greater than 300mm the tests shall be carried out in vertical pairs to test the full layer thickness.

Tests for the maximum dry density and optimum moisture content, the Atterberg limits and particle size analysis shall be made when the placing of fill commences and subsequently on the basis of one set of tests for every 10m³ of fill placed until such time as 25% of the fill type has been placed and the Engineer agrees that the frequency of testing may be reduced. In addition, such tests shall be made on samples taken adjacent to the site of any in situ density determination which fails to reach the specified compaction requirement or which indicates more than 100 per cent compaction.

In addition, the Engineer will require end-product testing and proof-rolling to be undertaken in the areas and frequency of his choosing. End-product testing shall consist of further dry density testing undertaken at an increased frequency selected by the Engineer but not exceeding the rate required at the commencement of placing of fill. Proof-rolling shall be undertaken by the construction traffic or a 6 tonne steel wheeled roller at the Engineer's discretion. It shall be used to identify areas where compaction is not up to the general standard.

SCHEDULE 4.2 - SPECIAL REQUIREMENTS FOR FILL

FILL

Fill material shall satisfy the following criteria:

- (i) The maximum particle size shall not exceed the lesser of 500mm or two thirds of the compacted thickness of the layer being placed. The grading shall lie within one of the envelopes shown in the table below, and shall generally conform to the shape of the envelope:

SCHEDULE 4.2 TABLE A

Grading Requirements after Compaction for Acceptable Fill Material

Percentage by mass passing the size shown											
Type		Size (mm)	BS Sieve Size (mm)						Size (µm) BS Sieve		
		500	125	37.5	10	6.3	3.35	2	600	300	63
Clean Rockfill	1A	100	0-100	0-30		0-14		0-4			
Clean Gravel	1B		100	0-100		0-100	0-35	0-10	0-2		
Quarry Run Rockfill	1C	100			0-50			0-35	0-25		0-5
Bulk Fill	1D		100	80-100	50-100			35-80	25-65	20-60	15-50

- (ii) The 4 day soaked CBR at 95% of BS Heavy Compaction Maximum Dry Density at Optimum Moisture Content $\pm 2\%$ shall not be less than 6%.
- (iii) The Liquid Limit shall not exceed 80% and the Plasticity Index shall not exceed 40%.
- (iv) Compaction shall be in accordance with Table B or C as appropriate.

SELECTED FILL

Selected fill material shall be well graded and satisfy the following criteria:

- (i) The maximum particle size shall not exceed the lesser of 125mm or two thirds of the compacted thickness of the layer being placed and the grading shall lie evenly graded and within the envelope shown above for Type 1B or Type 1D Materials.
- (ii) The 4 day soaked CBR at 95% of BS Heavy Compaction Maximum Dry Density at Optimum Moisture Content $\pm 2\%$ shall not be less than 15%.
- (iii) The Liquid Limit shall not exceed 35% and the Plasticity Index shall not exceed 10%.

Characteristics to be Measured Test Method

Particle size distribution	BS 1377-2:1990, Test 9
Liquid Limit	BS 1377-2:1990, Test 4
Plasticity Index	BS 1377-2:1990, Test 5
California Bearing Ratio	BS 1377-4:1990, Test 7

SCHEDULE 4.2 - TABLE B

Compaction of Fill Material

The compaction that is required to be achieved for different fill material shall be:

Type/Area	Minimum Percent of Maximum Dry Density	
	Non Cohesive Material	Cohesive Material
Structural Backfill	90	90
Selected Fill	100	95
Embankment Fill		
1. Under Aircraft Pavements, Strip and Roadways	See Schedule 4.2 Table C	See Schedule 4.2 Table C
2. General Fill	90	85
Drainage Fill Under Slabs	85	-
Drainage Fill at Other Locations	85	-
Bedding Material and Initial Backfill	90	-
Trench Backfill	95 or as shown	90

NOTE

1. Non cohesive soils, for the purposes of determining compaction control are those with a plasticity index of less than 6.
2. Maximum Dry Density shall be determined from BS 1377, Part 4, Test 3 (4.5kg rammer).

SCHEDULE 4.2 - TABLE C
Soil Compaction

Location	Depth below Formation level	Minimum Per Cent of Maximum Dry Density Non Cohesive Material		Depth below Formation level	Minimum Per Cent of Maximum Dry Density Cohesive Material	
		Fill	Cut		Fill	Cut
(a) Beneath all flexible pavements	Top of Sub grade to 600mm	100	100	Top of sub grade to 250mm	95	95
	600mm to 1050mm	95	95	250mm to 500mm	90	90
	1050mm to 1500mm	95	90	500mm to 700mm	90	85
	1500mm to 2000mm	95	85	700mm to 950mm	90	80
(b) Beneath all rigid pavements	Top of Sub grade to 150mm	100	100	Top of sub grade to 150mm	90	90
	150mm to 600mm	95	95	Greater than 150mm	90	-
	Greater than 600mm	95	-			
(c) Beneath unpaved areas within 150m of the Centreline of runway.	Finished level to 1000mm	95	95	Finished level to 150mm	90	90
	Greater than 1000mm	90	-	Greater than 150mm	90	
(d) Beneath roadways	Top of Sub grade to 500mm	98	98	Top of sub grade to 250mm	93	93
	Greater than 500mm	95	-	Greater than 250mm	90	-

NOTE:

1. Compaction requirements below shoulders to aircraft pavements are as for the adjoining pavement.
2. Non cohesive soils, for the purpose of determining compaction control, are those with a plasticity index of less than 6.
3. If for non cohesive materials the relative density criteria are used employing maximum and minimum density control tests, then the following equivalence shall be assumed.

Relative Density		Per Cent of Maximum Dry Density
Sand	Gravel	(BS 1377, Part 4, Test 3 (4.5 kg rammer))
85	80	90
75	70	85

TABLE 4.2: Indicative Compaction Requirements

Type of Plant	Size of Plant	Cohesive Materials				ly Graded terials	
		Depth of Layer	Min Number of Passes	Depth of Layer	Min number of passes	Depth of Layer	Min number of passes
Vibratory Roller ♦	Static load per metre width of roll	-	Unsuitable	75	16	150	16
	0.3-0.45 tonne	-	Unsuitable	75	12	150	12
	0.45-0.7 tonne	100	12	130	12	150	6
	0.7-1.25 tonne	130	8	150	8	200	10*
	1.25-1.8 tonne	150	4	150	4	225	12*
	1.8-2.3 tonne	180	4	180	4	250	10*
	2.3-2.9 tonne	200	4	200	4	275	8*
	2.9-3.6 tonne	225	4	225	4	300	8*
	3.6-4.3 tonne	250	4	250	4	300	6*
	4.3-5.0 tonne	-	-	300	4	450	6
	over 5+ tonne	-	-	450	4	-	-
	over 5+ tonne over 5+ tonne	-	-	600	6	-	-
Vibrating Plate Compactor ♦	Static pressure under baseplate per m ²	-	Unsuitable	-	Unsuitable	75	6
	0.8-1.0 tonne	-	Unsuitable	75	10	100	6
	1.0-1.2 tonne	-	Unsuitable	75	6	150	6
	1.2-1.4 tonne	100	6	130	6	150	4
	1.4-1.8 tonne	150	6	150	5	200	4
	1.8-2.1 tonne over 2.1 tonne	200	6	200	5	250	4
Vibro-Tamper ♦	Wt in Kgs						
	50-65	100	3	100	3	150	3
	65-75	130	3	130	3	200	3
	over 75	200	3	150	3	225	3
Power Rammer ♦	Wt in Kgs						
	100	150	4	150	6	-	Unsuitable
	Over 500	275	8	275	12	-	Unsuitable

*see note 2 ♦ see note 2

TABLE 4.2: Indicative Compaction Requirements (continued)

Type of Plant	Size of Plant	Cohesive Materials		Well Graded Granular and Dry Cohesive Materials		Uniformly Graded Materials	
		Depth of Layer	Min Number of Passes	Depth of Layer	Min number of passes	Depth of Layer	Min number of passes
Smooth Wheeled Roller ♦	Load per metre width of roll						
	2.2-2.7 tonne	130	8	130	10	130	10*
	2.7-5.5 tonne	130	6	130	8	130	8*
	Over 5.5 tonne	150	4	150	8	-	Unsuitable
Grid Roller	Load per metre width						
	2.7-5.5 tonne	150	10	-	Unsuitable	150	10
	5.5-8.0 tonne	150	8	130	12	-	Unsuitable
	Over 8.0 tonne	150	4	150	12	-	Unsuitable
Pneumatic Tyred Roller ♦	Load per wheel						
	1.0-1.5 tonne	130	6	-	Unsuitable	150	10*
	1.5-2.0 tonne	150	5	-	Unsuitable	-	Unsuitable
	2.0-2.5 tonne	180	4	130	12	-	Unsuitable
	2.5-4.0 tonne	225	4	130	10	-	Unsuitable
	4.0-6.0 tonne	300	4	130	10	-	Unsuitable
	6.0-8.0 tonne	350	4	150	8	-	Unsuitable
	8.0-12.0 tonne	400	4	150	8	-	Unsuitable
	over 12.0 tonne	450	4	180	6	-	Unsuitable
Tamping Roller	Load per roll						
	Over 4.0 tonne	225	4	150	12	250	4

*see note 2 ♦ see note 2

Notes on Table 4.2

1. Definitions

The depth of a layer is the amount by which an area of fill is raised by each successive compacted layer.

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.

Where the layer of fill being compacted is within 600mm of formation to receive pavement the number of passes is doubled.

The load per metre width of roll is the total load on the roll divided by the width in metres.

Cohesive soils include clays and marls containing up to 20% gravel or rock and having a moisture content not less than the value of the plastic limit less 4. They also include chalk with a saturation moisture content of 20% or more.

Well graded granular and dry cohesive soils include clays and marls with more than 20% of gravel or rock and with a moisture content less than the value of the plastic limit less 4. They also include well graded sands and gravels.

Uniformly graded materials include sands and gravels with a uniformity coefficient of 10 or less and all silts and pulverised fuel ashes.

2. An asterisk (*) indicates that a roller towed by a tracked laying vehicle is necessary. A self propelled roller would be unsuitable.

A diamond (♦) indicates that the type of compaction plant is unsuitable for materials with a liquid limit greater than 50.

3. Where combinations of different types or sizes of plant are used, the compaction requirements shall be determined in accordance with the following rules:-

- (a) The depth of layer shall be that for the type of plant requiring the least depth of layer.
- (b) 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.

4. Vibratory Rollers

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

The requirements for vibratory rollers are based on the use of the lowest gear on a self-propelled machine and a towing speed of 1.5 - 2.5 km/hr 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.

Vibratory rollers operating without their vibration mechanism in use will be classified as smooth-wheeled rollers.

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.

5. Vibrating-Plate Compactors

Vibrating-plate compactors are machines having a base-plate to which is attached a source of vibration consisting of one or two eccentrically-weighted rotating shafts.

The static pressure under the plate of a vibrating-plate compactor is calculated by dividing the total weight of the machine in working order by the area in square metres in contact with the fill.

Vibrating-plate compactors shall be operated at the frequency of vibration recommended by the manufacturer. They shall normally be operated at travelling speeds of less than 15 metres/min. but, if higher speeds are necessary, the number of passes shall be increased in proportion to the increase in speed of travel.

6. Vibro-tampers

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.

7. Power Rammers

Power rammers are machines, which are actuated by explosive combustion in an internal combustion cylinder, each explosion being controlled manually by the operator.

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.

8. Smooth Wheeled Rollers

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 metre width.

9. Grid Rollers

Grid rollers, whether self-propelled or towed, will be assessed on the same basis as smooth-wheeled rollers.

10. Pneumatic Tyred Rollers

For pneumatic tyred rollers, wheel load is the total weight of the roller divided by the number of wheels.

In assessing the compactive effect of pneumatic tyred rollers to meet the requirements of the Table 4.2, the effective width shall be the sum of the widths of the individual wheel tracks together with the sum of the spacings between the wheel tracks provided each spacing does not exceed 225 mm. Where the spacings exceed 225 mm, the effective width shall be the sum of the widths of the individual wheel tracks.

11. Tamping Rollers

Tamping rollers are machines which have rolls from which 'feet' project. The requirements shown in Table 4.2 are for machines which have two rolls in tandem. If the machine has only one roll, the number of passes shown must be doubled.

Specification

REINFORCEMENT FOR CONCRETE

Contents

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7.1 Scope of Section

This section covers plain and deformed bar reinforcement and steel fabric to be cast into concrete in any part of the Works but does not include pre-stressing tendons or any other embedded steel.

7.2 Materials

Reinforcement shall comply with the British Standards indicated on the Drawings. The Standards include the following:

BS 4449	for hot rolled plain bar and high yield deformed bar
BS 4482	for hard drawn mild steel wire
BS 4461	for cold worked steel bar
BS 4483	for steel mesh fabric

All reinforcement for use in the Permanent Works shall be tested for compliance with the appropriate British Standard in a laboratory acceptable to the Engineer and two copies of each test certificate shall be supplied to the Engineer. The frequency of testing shall be as set out in the British Standard.

In addition to the testing requirements described above, the Contractor shall carry out additional tests as instructed by the Engineer.

Steel reinforcement bars with 'seams' will not be permitted to be used within the works.

Any reinforcement which does comply with the Specification shall be removed from Site.

7.3 Storage of Reinforcement

Reinforcement shall be stored on Site either in racks or on a hard impermeable base so that it remains straight and free from contamination.

Any reinforcement which is likely to remain in storage for a long period shall be protected from the weather so as to avoid corrosion and pitting. All reinforcement which has become corroded or pitted to an extent which, in the opinion of the Engineer, will affect its properties shall be removed from Site.

7.4 Bending Reinforcement

7.4.1 Bar Schedules

The Contractor shall prepare and submit in duplicate to the Engineer bar schedules showing cutting and bending details of the reinforcement shown on the Drawings.

The schedules shall be prepared in accordance with BS 8666 - Specification for scheduling dimensions, bending and cutting of steel reinforcement for concrete.

7.4.2 Cutting and Bending Reinforcement

The Contractor shall cut reinforcement to length and bend it to the shape shown on the schedules within the dimensional tolerances given in BS 8666. Bars shall be bent cold by the application of slow steady pressure. Hooks or right angle bends shall be formed where called for by the schedules and to the dimensions and tolerances specified in BS 8666.

After bending, bars shall be securely tied together in bundles or groups and legibly labelled as set out in BS 8666.

Reinforcement shall be thoroughly cleaned and all dirt, scale, loose rust, oil and other contaminants removed before it is placed in the Permanent Works.

7.5 Fixing Reinforcement

Reinforcement shall be securely fixed in position within a dimensional tolerance of 20mm in any direction parallel to a concrete face and within a tolerance of 5mm at right angles to a face, provided that the cover is not thereby decreased below the minimum shown on the Drawings.

Unless otherwise agreed by the Engineer, all intersecting bars shall either be tied together with a 1.6mm diameter soft annealed iron wire and the ends of the wire turned into the body of the concrete, or shall be secured with a wire clip of a type agreed by the Engineer.

Proprietary spacers shall be used for ensuring that the correct cover is maintained on the reinforcement. Spacers shall be as small as practicable and of a shape agreed by the Engineer and designed so that they will not overturn or be displaced when the concrete is placed. Spacer blocks of mortar shall not be permitted in the Permanent Works.

Reinforcement shall be rigidly fixed so that no movement can occur during concrete placing. Any fixings made to the formwork shall not be within the space to be occupied by the concrete being currently placed.

No splices shall be made in the reinforcement except where shown on the Drawings or agreed by the Engineer. Splice lengths shall be as shown on the Drawings.

Reinforcement shall not be welded except where required by the Contract or agreed by the Engineer. If welding is employed, the procedures shall be as set out in BS 2640 for gas welding or BS EN 1011 for metal arc welding. Full strength butt welds shall only be used for steel complying with BS 4449, and if used on high yield deformed bars complying with BS 4449 the permissible stresses in the vicinity of the weld shall be reduced to those applicable to plain bars complying with that specification.

Mechanical splices shall not be used unless the Engineer agrees otherwise.

The Contractor shall ensure that reinforcement left exposed in the Permanent Works shall not suffer distortion, displacement or other damage. When it is necessary to bend protruding mild steel reinforcement aside temporarily, the radius of the bend shall not be less than four times the bar diameter for plain bars or six times the bar diameter for high yield bars. Such bends shall be carefully straightened before concrete placing continues, without leaving residual kinks or damaging the concrete round them.

Bars complying with BS 4461 or other high tensile bars shall not be bent after placing in the Works.

Before concrete is placed in any section of the Permanent Works which includes reinforcement, the reinforcement shall be completely clean and free from all contamination including concrete which may have been deposited on it from previous operations.

7.6 Cover to Reinforcement

The concrete cover to reinforcement shall not be less than the cover shown on the Drawings.

7.7 Approval before Concreting

The Contractor shall in all cases request the approval of the steel work by the Engineer in sufficient time to allow an inspection to be made and shall not commence concreting until such approval and his intention to commence concreting shall not be less than one clear normal working day and the Engineer may require a longer period if, in his opinion, the reinforcement is of such complexity as to require it.

Such approval shall not relieve the Contractor of his responsibilities under the contract.

Scaffolding

All erected scaffolding should comply to the Occupational safety and health act regulations made by the Ministry under the section 100(1) of the occupational safety and Health Act. Safety of Scaffolds

30. Approved metal scaffolds

Every employer shall ensure that no metal scaffold is constructed, erected or installed unless the scaffold complies with the manufacturer's specifications or a registered professional engineer's certification.

31. Design of metal scaffolds by registered professional engineer

(1) Every employer shall ensure that any metal scaffold -

- (a) exceeding 15 metres in height in any workplace, including a shipyard; or
- (b) erected on cantilever or jib support,

is constructed, erected or installed in accordance with the design and drawings of a registered professional engineer and meets the requirements of regulation 10(1).

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(2) Every employer shall ensure that no metal scaffold referred to in paragraph (1) is put to use unless the scaffold has been examined by a registered professional engineer after its construction, erection or installation, and a certificate is issued by the registered professional engineer, in the form set out in the Third Schedule, certifying that the scaffold is safe for use.

(3) Every employer shall ensure that the metal scaffold is inspected by a registered professional engineer at least once every 3 months.

(4) (a) Where any defect in the metal scaffold is discovered in the course of the examination or inspection referred to in paragraphs (2) and (3) respectively, the registered professional engineer shall, as soon as possible, notify the employer of the defect.

(b) Where an employer is notified of a defect under paragraph (a), the employer shall immediately take action to rectify the defect before the scaffold is put to use.

(5) Notwithstanding paragraph (1), where the Permanent Secretary has reasonable grounds to believe that the safety of employees may be adversely affected by the nature of any scaffold work, he may direct an employer to construct, erect or install a metal scaffold of height less than 15 metres in accordance with the design and drawings of a registered professional engineer and the requirements of regulation 10(1).

Specification and Scope of works:

Waterproofing works on roof slab:

- Remove and cart away of existing waterproofing membrane on the slab
- Making good to the edges of slab.
- Brushing and cleaning of surface.
- Applying bituminous primer.
- Applying a coat of hot bituminous layer.
- Supply and lay 2 layers waterproofing membrane, each layer of 3 to 4mm thickness (Top layer Grey colour), apply with blow torch.
- Clear site work after work on daily basis
- To overlap new waterproofing membrane onto existing waterproofing membrane
- Necessary precautions to be taken during waterproofing works are carried out to prevent any leakage into building, by fixing first waterproofing layer just after removal of existing membrane, surface cleaning, primer/bituminous layer, on the same day.

Waterproofing works around openings:

- Existing sealant to be removed and free from any other materials.
- Surfaces to be clean and dust free.
- Apply waterproofing sealant around existing openings.
- Waterproofing sealant to be:
 - Moisture and oxidation resistance
 - Have good adhesion properties on concrete and aluminium surface
 - Resist to ageing and weathering

Waterproofing works to walls:

- Wall surface to be clean and dust free.

- Application of cold liquid waterproofing with two plies of polyester reinforced membrane (0.4-1.2mm)

Notes:

- I. Works will be carried out in a restricted zone.
- II. Working hours: 07h 30 to 17h 30 but some work may be required to carry out after office hours, Monday to Saturday
- III. To provide specifications/samples of materials with bidding document.
- IV. 10 years warranty should be given by contractor

STRUCTURAL STEEL WORK SPECIFICATION

1.0.0 Quality of Materials and Workmanship

- 1.1.0 The quality of all materials and workmanship used in the execution of this contract shall comply with the requirements of most recent issues of the following British Standards and Codes of Practice, including all amendments to date of calling for tenders:

BS 4360	Weldable Structural Steels
BS 5950	Structural Use of Steelwork in Building
BS 4848 and BS 4 (Part 1)	Hot Rolled Structural Steel Sections
BS 4848 (Part 2)	Hollow Sections
BS 4848 (Part 4)	Equal and Unequal Angles
BS 5135	Arc Welding of Carbon and Carbon Manganese Steels
BS 639	Covered Carbon and Carbon Manganese Steel Electrodes for the Manual Metal Arc Welding
BS EN 288 (Part 3)	Welding Procedure Tests for the Arc Welding of Steel
BS 2600 (Part 1)	Radiographic Examination of Fusion Welded Butt Joints in Steel
BS 4190	ISO Metric Black Hexagon Bolts, Screws and Nuts
BS 3692	ISO Metric Precision Hexagon Bolts, Screws and Nuts
BS 4320	Metal Washers for General Engineering Purposes Metric Series
BS 5493	Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion
BS 729	Hot Dip Galvanized Coatings on Iron & Steel Articles
BS 2569 (Part 1)	Sprayed Metal Coatings. Protection of Iron and Steel by Aluminium and Zinc against Atmospheric Corrosion
BS 5531	Code of Practice for Safety in Erecting Structural Frames

The Contractor is required to submit a certificate of compliance from his supplier stating that the material to be supplied to him for the project shall meet the requirements of the relevant specifications mentioned above, similarly, certificate for the manufacture/ fabrication / galvanizing, etc. should be submitted; all before ordering.

Contractor is required to obtain test certificates for chemical analysis and mechanical test, including Chapter V notch impact test from steel maker for each batch of the steel supplied to his fabricator and to submit the same to the Engineer for his written approval.

The Engineer may at any time require any materials to be tested in accordance with the requirements of the Standards listed above. The cost of all successful tests shall be borne by the Client, but the Contractor shall, when required, promptly supply to the laboratory for testing at his own expense test pieces as required by the Engineer. The costs of tests on materials failing to comply with this standard shall be borne by the Contractor. If in the opinion of the Engineer, faulty material and/or workmanship have been used in the Works, the Contractor may be directed to dismantle and cut out the parts concerned and remove them for examination and testing. The cost of dismantling, cutting out and making good to the approval of the Engineer shall be borne by the Contractor, in addition to the costs due to delays, etc., all in accordance with the Conditions of Contract.

The test certificates of chemical analysis will give all necessary information including percentage of alloying elements to assist the fabricator of the Contractor to decide on precautions to be taken during welding.

- 1.2.0 Materials, fabrication and erection in hot rolled sections of structural steel work shall comply with BS 5950: Part 2: 1985 and additionally unless where specified otherwise in this specification, the information given under Article 10.0.0 of this specification for each particular project is supplied to the Contractor for him to comply with, and for use by the Steelwork Contractor's design as required in Appendix A.3 of this British Standard.

2.0.0 Fixing to Concrete

- 2.1.0 Contractor is to check and ensure that provision for tolerances shown on the drawings for connection to concrete are adequate for erection. Contractor may propose to use at his cost appropriate diameter tubes in expanded metal covered with nylon mesh or removable appropriate diameter tubes for casting of the holding down bolts before grouting with cement sand mortar as per Clause 2.6 of Section 2 of British Standard BS 5950: Part 2. The tolerance gap up to 25 mm between the base plate and the concrete top will be in approved thick fluid epoxy mortar instead of Portland cement grout so that the space is completely filled. Gap greater than 25 mm will be filled as per the above-mentioned Clause of the British Standard. Holding down bolts should not be grouted until steelwork has been corrected for all defective work, lined, plumbed and levelled. All holding down bolts will have an additional lock nut.

3.0.0 Fabrication

3.1.0 Cutting and Bending

All members, plates, brackets, etc., shall be neatly and accurately sheared, sawn, or profiled to the required shape as shown on the drawings. It will be free from burrs and distortion. Cutting of sheet material up to 15mm thickness shall be by guillotine shear and/or by heavy duty shears.

Thicker plates shall be cut by cold saw or abrasive wheel. Manual oxyacetylene flame cutting will not be permitted. Laser cutting for the hollow sections will be preferred. Ends of sections (CHS) are required to be prepared by saddling machine, Muller or similar before welding.

If members or plates are bent or set, the bends or sets shall be correctly made to the radii or angles specified without leaving marks. The material may be heated to permit this. Material that has been heated shall be annealed to approval.

3.2.0 Punching & Drilling

Holes for black and high precision bolts shall be drilled or punched 2 mm larger in diameter than the bolt used. Holes for high tensile friction grip bolts shall be drilled or sub-punched and reamed to 3 mm larger in diameter than the specified bolts sizes.

All drilled holes shall be parallel sided and shall be drilled with the axis of the holes perpendicular to the surface. Badly drilled holes shall either be reamed out if approved and/or larger bolts fitted or otherwise as directed by the Engineer. All rough arises shall be ground off. Holes for bolts in material thicker than 8mm must be drilled. When holes are drilled in one operation through two or more thicknesses of material, the parts shall be separated after drilling and all burrs removed before assembly. Holes for bolts shall not be formed by a gas cutting process.

- 3.3.0 Holes of not less than 12 mm dia must be drilled at places to be agreed with the firm galvanising the finished product to allow for access to molten zinc, venting of hot gasses and subsequent draining of zinc.

4.0.0 Assembly

4.1.0 General

4.1.1 Girders, Trusses and Portal Frames

Girders, trusses and portal frames shall be carefully set out to the dimensions shown on the drawings.

Where it is required that girders, trusses and portal frames be cambered, such camber shall be provided by bending the bottom chord to the arc of a circle.

Notwithstanding any dimensioned spacing of purlin cleats, the Contractor shall ensure that purlin cleat spacing is satisfactory for the available stock lengths of roof sheeting. However, the Engineer's approval must first be obtained before any alteration is made in purlin spacing or sheeting sizes.

4.1.2 Boxed Members

Abutting edges of boxed members shall be connected and sealed with a continuous weld to exclude the entrance of moisture. Where specified such welds shall be ground flush if it is directed by the Engineer and finished to the approval of the Engineer.

4.1.3 Shop Assembly

Such assembly of unit in the shop as is specified or necessary before transporting to the site will be inspected by the Engineer before and after galvanising. The work will be laid out in the shop or yard so that all parts are accessible for inspection and testing of the work.

The Contractor shall furnish all facilities for inspection and testing of the work and he must notify with reasonable notice the Engineer on each occasion when material is ready for inspection.

4.1.4 Storage & Handling

Fabricated steelwork must be stored clear of the ground and be kept clean. Handle and store to avoid damage to steelwork and its protective coating.

4.2.0 Welding

All welding shall be carried out in strict accordance with the specified British Standard with electrodes also to specified British Standard.

Unless where shown otherwise all welds shall be of size not less than 8mm. Welding on site is not permitted unless where shown specified as site welding on the drawings.

Fusion faces shall be free from irregularities such as tears, fins, etc., which would interfere with the deposition of weld metal.

Fusion faces shall be smooth and uniform and shall be free from loose scale, slag, rust, grease, paint and/or other deleterious material.

All welds shall be of acceptable types, shall be of the finished sizes specified, and shall be carried out in such sequence that minimum distortion of the parts welded results. No welds less than four times the nominal fillet size shall be deemed capable of carrying load.

Preparation of edges for welding shall be carried out by planning or machine flame cutting.

Parts to be welded shall be maintained in their correct relative positions during welding by jigs.

Multiple run welds shall be carried out with each run closely following the previous run but allowing sufficient time for the proper removal of slag.

The Contractor shall ensure that each run is inspected and any unsatisfactory weld cut out and remade to approval.

Welds in material 25 mm or greater in thickness shall be made by the Argon arc or similar approved process, and special precautions shall be taken to prevent weld cracking.

Unless otherwise shown, the minimum size of fillet/butt weld shall be 8mm.

On completion, welds shall present a smooth and regular finish. Weld metal shall be solid throughout with complete fusion between weld metal and parent metal and between successive runs throughout the joint.

Defects shall be cut out and made good to approval in sound weld metal.

For butt welds to ensure full throat thickness at ends run on and run off plates are used. Butt welds in CHS or RHS shall be with backing plates of the thickness shown or of the thickness of the thicker member. Materials of the plates should be same as that of materials welded.

No additional welds or tack welds other than shown on the drawings will be permitted without the written approval of the Engineer.

Contractor is required to submit and to arrange for testing at the workshop all at his cost, the evidence of competence of welders in accordance with the specified British Standard for the type of works of the project.

Contractor will be deemed to have allowed in his rate for fabrication costs for welding for radiographic tests in accordance with the specified British Standard Weld defect criteria C generally in accordance with Tables 18 and 19 of BS 5135 will be applicable.

4.3.0 Bolting

All bolts used shall be of such length that at least two full threads is exposed beyond the nut after the nut has been tightened on washer/washers between bolt head/nut and the structural member. Where a nut or bolthead would bear on an inclined surface, a bevelled washer of the correct shape shall be interposed between the two surfaces. Bevelled washers shall not be allowed to get out of position during fabrication and erection and for this purpose may be spot welded to the steel surface. Such spot weld will be treated as welding on site. Washers for oversize/shaped holes shall be of thickness shown or that of the connecting plates. No bolts used shall be less than 12 mm diameter.

Bolts, nuts and washers used shall be spun galvanised to have minimum coating of 85 microns and they shall be tapped lightly oiled after galvanising.

Seal bolt holes by an approved method (this will be deemed to have been included in the rate of fixing) to prevent access of moisture in hollow sections. Contractor will submit the method for Engineer's approval.

4.4.0 Marking

All members of the structure to be site assembled shall be match marked in accordance with the shop details and marking plans submitted for approval. Members should not be marked with hard stamping indentation.

4.5.0 Protective Treatment

After manufacturing the lengths of the columns, girders, trusses, bracings, etc. between the bolted connections shown on the drawings are required to be hot dipped galvanised to BS 729 with minimum coating thickness of 85 microns.

The steel is cleaned of foreign material, scale and roughen surface. It may be necessary to use an approved blast cleaning to Engineer's approval before acid pickling by immersing in a bath of suitably inhibited acids which dissolve or remove mill scale and rust to achieve galvanising to BS 729.

Double bath dipping can be used when the length or width as shown on the drawing exceeds the size of the bath.

Inside of hollow section shall be dry and clear of all debris before sealing holes left for ventilation, etc. as per section 4.6 of the British Standard. Contractor is deemed to have included the cost of such works in the tendered price.

Where the protective surface is damaged by handling tack welding for temporary members, cutting, drilling, welding, etc., it shall be cleaned with an approved blasting before treating the surface with zinc metal spray coating to BS 2569: Part 1. Such coating will be of 170 microns thickness.

All architectural/structural steel section, wire rope not shown as structural members on structural drawings, etc., shall have protected hot dipped galvanised coating and finished as structural members. Steel windows forming part adjacent to the roof light or wall structure shall be hot dipped galvanised as structural members including its fixings.

Painting to structural members shown on drawings is not required unless specified after galvanising. But cleaning of them without damaging protective treatment should be carried out at no costs.

5.0.0 Erection

5.1.0 Delivery Storing and Handling

Steel shall be stored and handled and erected in such a manner that no member is subject to excessive stresses which could have an adverse effect on the properties of the steel. If

in the opinion of the Engineer, the steelwork has been subject to such treatment, the Contractor shall remove this steel from the site and replace it at his own expense.

5.2.0 Erection of Structural Steel Works, Equipment etc

Contractor shall give a fortnight's notice to the Engineer before start of work. All erection shall be carried out by competent and experienced men and the Contractor shall take every care to safeguard the public, workmen, and adjoining property. Contractor shall comply with the requirements of Occupational Safety, Health and Welfare Act of Mauritius 1989. Recommendations of BS 5531 Code of Practice for Safety in Erecting Structural Frames shall apply.

All gear used shall be of adequate strength and shall comply with all Regulations current at the time. Approval of the Factory Inspectorate will be obtained in writing where it is required to comply with Government Regulations. Remove from site any defective equipment and label it out of order in bold visible letter for such time until it is removed from site.

During erection the work shall at all times be adequately bolted, guyed and/or braced to make the structure secure.

The Contractor shall be held responsible for all damage caused to the structure, workmen, or buildings during erection.

5.3.0 General

5.3.1 Alignment Site Dimension etc

No erection shall commence before accurate Site Dimensions have been taken by the Contractor, and no claim will be considered should final dimensions differ from those on the drawings. Any modifications to the structural steel required in order to comply with Site dimensions shall be made in an approved workshop to the Engineer's approval before erection is commenced.

5.3.2 Erection Details

No member or part of a member which has been bent or distorted shall be erected in that condition. All straightening shall be done in the workshop.

Columns shall be wedged to line and level on steel wedges and checked by the Engineer. After acceptance, column bases shall be grouted to approval before wedges are removed. Unless shown on the drawing, all columns shall be left truly vertical and correct to line and level. Beams, girders, trusses, etc., shall be erected level unless otherwise shown, and correctly positioned.

Trusses and open web joints shall be carefully handled at all times and when being erected shall be lifted at such points and in such a manner as will preclude any possibility of damage from erection stresses.

Immediately after erection, each girder/truss shall be made secure by purlins, bracing or guys to approval.

Bracing shall be placed in position as soon as dependent work will permit.

5.3.3 Field Connections

In making connections, drifting of unfair holes will not be permitted and holes not matching properly shall either be reamed or drilled out and a larger bolt inserted or otherwise as directed by the Engineer.

Members having holes formed or enlarged by oxy cutting will be condemned

Supports and Foundation

6.0.0 **Supports and Foundation**

6.1.0 Positioning and Setting Out of Foundation Bolts

Subcontractor for fabrication/erection will check the discrepancies with Main Contractor who will immediately inform the Engineer with his proposal for rectification for Engineer's approval.

Where foundation bolts are not shown they will be not less than 16 mm diameter and all bolts will be of grade 8.8 as of specified British Standard.

6.2.0 Packings

Packing shall not be larger than 25 mm under the base plate.

6.3.0 Bedding and Grouting Up of Structure

Space up to 25 mm and under below base plate shall be grouted by epoxy mortar instead of neat cement.

Contractor is deemed to have included in his rate encasing by concrete as specified in Clause 6.3.3 of BS 5950: Part 2 of steel work in foundations up to ground floor into his rate for fixing bolts of structure.

7.0.0 **Tolerances**

7.1.0 For tolerances allowed for in Clause 3.24(1) in specification for concrete shall apply for reinforced concrete bases, reinforced concrete columns and reinforced concrete beams supporting the steel structure.

- 7.2.0 Deviation for camber at mid span to be not more than $L/1000$ or 6 mm whichever is greater.
- 7.3.0 Flatness for contact bearing shall be such that when measured with 1 m straight edge the gap does not exceed 0.75 mm.
- 7.4.0 Fitting and components whose location is critical, i.e. main columns, girders and trusses for supporting the forces due to loads, deviation from the intended position shall not exceed 3 mm and isolated bolt holes or group of holes the deviation shall not exceed 2 mm.
- 7.5.0 Punched hole deviation due to distortion shall not be more than 1 mm.
- 7.6.0 The Engineer at his own discretion can increase the tolerances by 25% to 50% to line up with other approved international standards upon request to by reputed and experienced firm of steel fabrication/erection Contractor.

8.00 Roofing, Cladding, Flashings and Gutters

8.1.0 General

The Contractor shall supply all materials viz, purlins, roof and side claddings, gutters, flashings etc., and install them to the lines and levels as shown in the drawings and described in the specification. The roof and wall cladding are designed to resist cyclonic winds and to remain watertight during cyclones. However, responsibility of the watertightness of the roof and wall cladding will remain that of the Contractor. The test of roof and wall cladding will be carried out with water pressure at an appropriate pressure with 32 mm diameter hosepipes and minimum 3 No. pumps for minimum 3 hours for each 15.0 bay.

8.2.0 Design Life and Durability

The roof and wall cladding including its fixing is to perform satisfactorily for the following periods:

Twenty years without any maintenance for structural members and ten years for roof sheeting.

Fifty years with appropriate regular maintenance.

The Contractor has to provide the guarantee for the above requirements.

8.3.0 Purlins

The purlins shall be rolled sections formed from zinc coated high strength steel strip having a minimum thickness of 2.5 mm. The steel strip should conform to Australian Standard 1397 "Hot Dipped Zinc Coated 610 gms/m² or Aluminium/Zinc Coated Steel

Sheet” in the grade of 2.5 mm base thickness – Australian Standard 1397 grade 450 Z 275 (450 MPa minimum yield stress, 275 gms/m² minimum coating mass).

8.4.0 Roof and Wall Sheets

The sheeting shall be of steel of high yield strength 550 N/mm². It shall be spandek hiten or multidek of profile as shown on the drawing. It shall comply with Australian Standard AS 1562, design and installation of metal roofing. Base thickness should be 0.48 mm (minimum). They shall be treated with zinc/aluminium for 150 gm/mm² to AS 1397. The exterior surface shall be of selected color and colorbond or colorcote – oven baked polyester finish to AS 2728. The total thickness to be min 0.54 mm coating to have a guaranteed life without maintenance for 10 years after completion of the project. Fixing of sheeting to be as shown and stated on the drawing. Suppliers such as SpandekHiten from Lysaght or Multidek Hiten from KH Industries (SEA) Pte Ltd or Profilage Ocean Indien Ltee or similar should allow for all the fittings, fixings weather strips, plastic supports, etc., all as shown on the drawings and also normally required for roof sheeting in cyclonic region with 10 years maintenance free guarantee.

They shall be in one length except at change of angle where it will be bent to shape/angle before over baked polyester finish to AS 2728 is applied and will be lapped 300 mm on either side of the change of angle such that it is bolted to both the purling provided at the change of angle.

8.5.0 The purlings shall be of section x 2.5 mm thick exclusive of coating as shown on the drawing and shall be of steel of high yield strength of 450 N/mm² to Australian Standard AS 1397.

8.6.0 Painting to structural steel shall be as specified for galvanised steel where so required by the Architect.

8.7.0 Contractor shall submit shop drawings with full details of roof sheeting purlins, fixing, etc., for written approval by this office before ordering and/or commencing.

8.8.0 Fasteners

All Fasteners for fixing of wall and roof cladding shall be in stainless steel 8 mm diameter J bolts yield strength 350 N/mm² at purlins and rails as shown on drawing. No tapping self driven screws will be used for fixing the sheeting to purlins and rails. @ 300 c/c are fixed with self drilled stainless steel fasteners of 6 mm diameter. All fasteners should be suitable for cyclonic areas and should have a design life of 50 years with no maintenance. The sheeting will have plastic support at all J bolts with necessary nuts, washers for the Engineer’s approval.

8.9.0 Sealers

All joints shall have waterproof strip/sealant. The sealants shall be approved by the Engineer and should be appropriate for the type and manufacture of sheeting.

8.10.0 Translucent Sheets

Translucent Sheets shall be made of polyester resin reinforced with glass fibre incorporating UV light stabilizers and shall meet the architectural specifications and shall be strong to resist cyclonic wind speed and watertightness. Contractor will submit strength and design calculations for Architect and Engineer's approval. The translucent sheet shall match with the approved roof sheeting profile. Fixing shall be carried out strictly as recommended by the Manufacturers. The translucent sheets shall be laid according to Architect and Engineer's instructions.

8.11.0 Flashing

They shall be as specified for sheeting and/or of shape as shown on Architect's drawing. Flashings shall be manufactured from the same base material as specified herein above for roofing and cladding and shall cover the claddings by a minimum of 300 mm. Attachments and joints shall be made with fasteners and sealants as indicated herein above.

8.12.0 Laying of Claddings

The method of laying shall be as per the recommendation of the Manufacturer and as approved by the Engineer.

Roofing, Cladding, Flashings and Gutters – cont'd

9.0.0 **Care of Works**

All roofing and claddings and other material shall be properly packed and secured at the Manufacturer's premises before shipment.

Packs of sheets shall be kept dry in transit and on site to prevent water and/or condensation being trapped between adjacent surfaces. Packs of sheets standing on site shall be stored clear of ground. Sheets shall be handled using clear dry gloves. The roof and gutters shall be swept clean of all debris at the end of each day's and particularly on completion of fixing. The job shall be left in a clean and watertight condition.

9.1.0 Paints

All paints are to be supplied to meet the requirements of the appropriate British or other specified Standard by a supplier approved in writing by the Engineer.

Paints are to be delivered to the site or the Structural Contractor's works in the original containers as supplied by the manufacturer with seals unbroken and are to be used in strict accordance with the manufacturer's instructions. Manufacturer's representatives are to be free to visit the site and inspect materials and workmanship, and if necessary take samples of materials for laboratory analysis.

Paints are not to be thinned unless instructed by the Engineer.

No external painting is to be carried out during rain or when rain is likely to occur before the paint has had time to dry.

All surfaces are to be dry and free from moisture at the time of painting.

9.2.0 Preparation for Painting

All structural steel shall be thoroughly scraped and wire brushed to remove mill scale and rust. Dirt and grease or oil shall be washed off with white spirit and the steel allowed to dry.

9.3.0 Painting to Ungalvanised Surfaces

A first coat of Red Lead type C Primer shall be applied in the works immediately the steel preparation has been completed, in accordance with the requirements specified in MS 13. A minimum of 24 hours shall elapse before the steel is moved from its position whilst painting.

After delivery to site, the steel shall be carefully examined and all areas where the priming coat has been damaged and/or where rust has developed shall be washed with white spirit and wire brushed as necessary and a further priming coat as for the first coat applied to completely cover the damaged areas.

A minimum of 48 hours after any patching work has been completed, the whole of the steel shall be cleaned off with white spirit and 2nd coat of Red Lead Type C Primer of a different approved colour or shade from the first coat shall be applied and the painted steelwork left undisturbed for a further 48 hours.

During erection, surface of steel which is to be in contact shall be painted with 1 further coat of primer as previously described and the surfaces brought together whilst the paint is still wet.

After erection a third and finishing high gloss alkvd enamel (white) or other approved shade of colour to BS 4800 “Schedule of Paint Colours for Building Purposes”, meeting the requirements of SABS 630 “Decorative high gloss enamel paint for interior and exterior use” or a coat of Micaceous Iron Oxide is applied if noted on the drawing.

Bolts, nuts and washers, etc, shall, after erection is completed to approval, be carefully degreased with white spirit and painted as for steelwork.

Steel purlins and sheeting rails shall generally be painted as for steelwork except for purlins and rails supporting aluminium sheeting, when the following specification shall be used:

- 1st coat - Red Oxide Zinc Chromate Primer
- 2nd coat - Red Oxide Zinc Chromate Primer
- 3rd coat - Approved Aluminium Paint

The interior of mild steel gutters shall be prepared as previously described and painted with 2 coats of Epilac Coal Tar Epoxy Paint.

9.4.0 Painting to Galvanised Surface

9.4.1 Surface Treatment

- (a) Surfaces shall be thoroughly cleaned wire brushed to remove scales. Dirt and grease or oil shall be washed with hot water.
- (b) Apply 1 coat of etching primer (with min 15% phosphoric acid) to enable sufficient adhesion of the subsequent paint.
- (c) Apply 1 coat of calcium plumbate primer in accordance with “SABS 912”
- (d) Apply 2 coats of white high gloss enamel in accordance with SABS 630 “Decorative High Gloss Enamel Paint for Interior and Exterior Use” of an approved shade of colour to BS 4800.

Allow 24 hours intervals between each coat.