

***TECHNICAL SPECIFICATION FOR CONSTRUCTION OF ARTIFICIAL
REEFS
MONTSERRAT***

Table of Contents

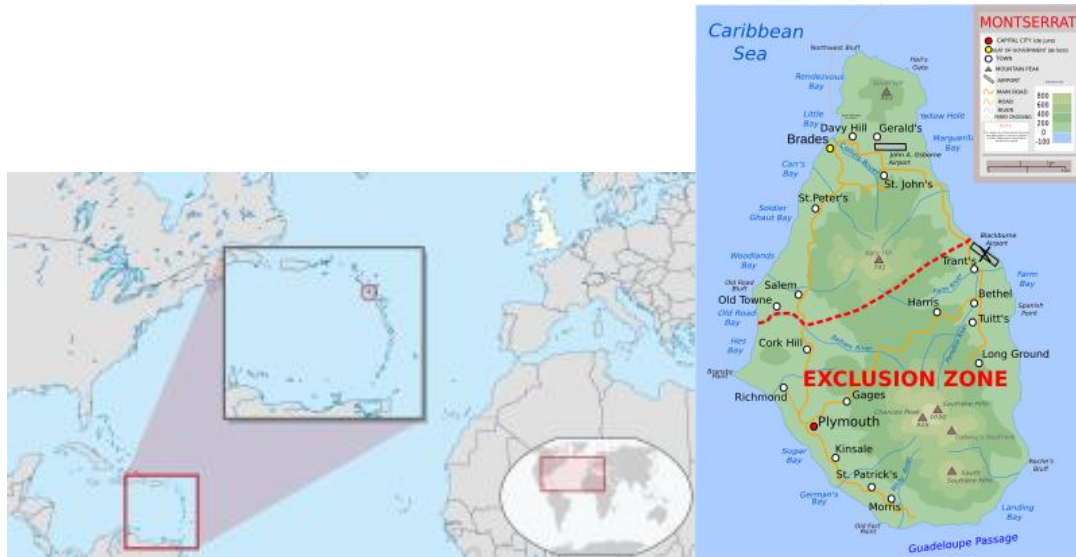
Contents

100	GENERAL AND PRELIMINARY ITEMS	4
101.0	LOCATION OF WORKS, ACCESS TO WORKS, WORKING AND STORAGE AREAS	4
102.0	SCOPE OF CONTRACT	5
103.0	DRAWINGS	5
104.0	CONSTRUCTION SEQUENCING	5
105.0	PROGRAMME AND METHOD STATEMENTS	5
106.0	PARTICULAR MATTERS TO BE BROUGHT TO THE ATTENTION OF THE CONTRACTOR	6
107.0	SURVEY OF EXISTING PROPERTIES. ROADS. LANDS. CROPS ETC	6
108.0	STANDARDS AND ALTERNATIVE STANDARDS	7
109.0	SAFETY POLICIES ETC.	7
110.0	SAFETY OF WORKS AND ADJACENT STRUCTURES	8
111.0	TEMPORARY FENCES	8
112.0	EXISTING SERVICES	8
113.0	SERVICES FOR SITE USE	9
114.0	SANITARY CONVENIENCES	9
116.0	BOUNDARIES CUT THROUGH	9
117.0	DRAINS. STREAMS. WATERCOURSES ETC.	10
120.0	PROTECTION OF COMPLETED WORK	10
121.0	TRAFFIC	10
122.0	DAMAGE TO ACCESS ROADS	11
123.0	DATUM, CO-ORDINATES, SURFACE LEVELS	11
124.0	TESTING	12
125.0	PHOTOGRAPHS	12
126.0	NOTICE BOARDS	12
127.0	"DIRECTED" AND "APPROVED"	12
128.0	ABATEMENT OF NUISANCE	13
129.0	CONTRACTORS SITE ESTABLISHMENT	13
130.0	CONTRACTOR'S TRANSPORT	14
200	MATERIALS AND EQUIPMENT	14
201.0	ALTERNATIVE MATERIALS AND EQUIPMENT	14
202.0	MANUFACTURER'S INSTRUCTIONS	14
203.0	SUPPLY OF MATERIALS	15
204.0	COPIES OF ORDERS	15
205.0	TEST CERTIFICATES	15
400	CONCRETE	15
401.0	CONCRETE	15
402.0	CHLORIDES IN CONCRETE	15
403.0	CEMENT	16
404.0	CEMENT TESTING	16
405.0	STORAGE OF CEMENT	17
406.0	FINE AGGREGATES	17
407.0	COARSE AGGREGATES	18
408.0	STORAGE OF AGGREGATES	19
409.0	WATER FOR CONCRETE	19
410.0	ADMIXTURES	19
412.0	CONCRETE CLASSES	20
413.0	CONCRETE MIX DESIGNS: CLASS 15/20	21
414.0	TRIAL MIXES	22
415.0	WORKS TEST	22

416.0	ADDITIONAL CUBE TESTS -----	23
417.0	TEST FAILURE -----	23
418.0	WORKABILITY -----	24
419.0	CONSISTENCY -----	25
420.0	CONCRETE RETURN AND RECORDS -----	25
421.0	BATCHING -----	25
422.0	MIXING CONCRETE BY MACHINE -----	26
423.0	MIXING CONCRETE BY HAND -----	26
424.0	TRANSPORT OF CONCRETE -----	26
425.0	PLACING OF CONCRETE -----	26
426.0	NO PARTIALLY SET MATERIAL TO BE USED -----	27
427.0	COMPACTION OF CONCRETE -----	27
428.0	VIBRATION OF CONCRETE -----	28
429.0	CONCRETING IN ADVERSE WEATHER -----	28
430.0	CONCRETING AT NIGHT OR IN THE DARK -----	28
431.0	CONCRETING IN HIGH AMBIENT TEMPERATURE -----	28
432.0	CURING AND PROTECTION -----	29
433.0	CONSTRUCTION JOINTS -----	29
437.0	CONCRETE FORMWORK -----	30
438.0	FORMWORK FOR EXPOSED CONCRETE SURFACES -----	31
439.0	FORMWORK FOR NON-EXPOSED CONCRETE SURFACES -----	31
440.0	PREPARATION OF FORMWORK FOR CONCRETING -----	31
441.0	REMOVAL OF FORMWORK -----	31
443.0	CONCRETE SURFACE FINISH -----	32
444.0	TOLERANCES -----	33
446.0	CEMENT MORTARS -----	33
447.0	BUILDING WORK -----	33
500.0	MATERIALS STANDARD -----	33

100 GENERAL AND PRELIMINARY ITEMS

101.0 Location of Works, Access to Works, Working and Storage Areas



101.1 The works are to be executed off the coast of isles Bay, Montserrat. The works are to be undertaken at the location shown on the location plan and set out in accordance with the site plans.

101.2 The Works are described in the Tender Documents – Special Conditions of Contract & Preamble to the Bill of Quantities. The precise extent of the Works is shown on the Drawings.

101.3 The Working Areas, i.e. “The Site” will be made available by the Contracting Authority.

101.4 Location and provision of areas for offices, plant & equipment, materials will be the responsibility of the contractor.

101.5 Location of disposal areas for excess excavated material, which the Project manager may instruct to be removed from site, is the responsibility of the contractor.

101.6 Before exercising any right negotiated, by him in connection with wayleave or accommodation outside the Site, the Contractor shall notify the Contracting Authority and the Project manager in writing of the arrangements he has made.

101.7 All necessary facilities will be given by the Contracting Authority for the access of the Contractor's employees to the Works and the Contractor shall be responsible for seeing that such employees obey all regulations made by the Contracting Authority regarding the conditions of access to and over his property.

101.8 The Contractor shall take all reasonable steps to maintain the free movement of traffic on any permanent roads used by him to gain access to the Works. All permanent and site access roads are to be maintained free of any spillage from the Contractor's vehicles.

101.9 The Contractor shall provide and maintain to the Project manager's approval all temporary roads he may require and shall permit the free use by the Contracting Authority, or any person employed by the Contracting Authority, subject to such use not causing undue damage or interference with the Contractor.

102.0 Scope of Contract

The Works to be executed under the Contract are those identified in the Contract Document

103.0 Drawings

103.1 The Works are shown on the Tender Drawings listed in Appendix A.

104.0 Construction Sequencing

Upon award of the Contract, the Contractor shall without delay proceed with the construction of works as indicated in the Special Conditions Article 31.1

105.0 Programme and Method Statements

105.1 In amplification of Article 15 of the Conditions of Contract the Contractor shall submit a programme and a method statement showing how he proposes to carry out the Works. The statement shall describe the methods to be employed in carrying out the Works, the Construction Plant and Temporary Works which the Contractor intends to supply or use and the programme shall show the estimated dates on which the various sections of the Works will commence together with the estimated rate of construction so that the whole of the Works may be completed within the Contract period.

105.2 The Contractor's Programme is to be supported by a list of plant and support facilities by which the Contractor will achieve the progress set out in above.

105.3 The Contractor's plant facilities and outputs quoted are to make due allowance for sufficient plant being on the site to ensure the maintenance of his programme and sufficient spare items of plant are to be available to allow for unserviceability or ineffective working.

105.4 The Contractor is to progress the Works thoroughly in order to ensure that the program submitted is strictly adhered to at all times. The Contractor shall submit detailed programmes of the various sections of the Works and monitor progress on a regular and routine basis as required by the Project manager.

105.5 The Contractor's programme should specify in detail when possession is required of land so that adequate arrangements for this can be made in good time.

106.0 Particular Matters to be brought to the Attention of the Contractor

106.1 The Contractor's hours of working shall be limited to normal working hours, except in that night working and weekend working may be allowed if the Contractor can demonstrate that local residents will not be disturbed by construction activities.

106.2 Noise levels at properties adjacent to the Works shall be limited to L_{eq} 70 dB(A) and L_{max} 85dB(A) (maximum noise level in any hour).

106.3 The Contractor shall ensure that any nuisance caused by dust is kept to a minimum by appropriate measures including the use of water sprayed on the road surface and the road condition is maintained in condition acceptable to other users. If in the opinion of the Project manager the Contractor is not maintaining roads to acceptable standard the Project manager may issue a written warning under the provision of Article 5 of the conditions of Contract and in the event of failure of contractor to make instructed improvements the Contractor will be liable to liquidated damages in accordance with Article 34 of the Conditions of Contract.

107.0 Survey of Existing Properties. Roads. Lands. Crops etc

Where required, the Contractor, in conjunction with the Project manager and any relevant authority, owners or occupiers, shall carry out surveys of the condition of existing properties, roads, lands, crops etc, which may be affected by the Works. The results shall be

recorded in appropriate documents and submitted to the Project manager for approval so that the approved copies constitute a record of the condition prior to commencement.

108.0 Standards and Alternative Standards

Materials, equipment and methods shall comply with the standards (current 30 days prior to the latest date for submission of tenders) indicated or the relevant British Standards and Codes of Practice.

The Contractor may propose, for the Project manager's approval, the adoption of alternative standards, in which case he shall provide comprehensive details and explanations, including translation of foreign language standards, with his proposal. The Contractor shall allow for the time necessary for review and approval of such alternative standards by the Project manager.

109.0 Safety Policies etc.

109.1 When required the Contractor shall provide the Contracting Authority & Project manager with a copy of the written safety policy and any revisions thereof which he has prepared as an Employer, and which relate to the execution of the Works. Prior to commencement of work on the Site the Contractor shall provide the Contracting Authority & Project manager with a copy of the relevant notices submitted to the Government of Montserrat if required, to satisfy Health and Safety Requirements and shall inform the Project manager of the name and location of his appointed safety Project manager(s).

109.2 The Contractor shall also provide the Project manager with written details of any control measures he proposes to institute in compliance with the control of substances hazardous to health.

109.3 The Contractor shall be responsible for health and safety on the Site. He shall coordinate his own activities and those of his sub-contractors and suppliers to achieve safe and healthy working environments. The contractors work practices shall comply with all legislation currently in force in Montserrat.

109.4 Neither the Contracting Authority, the Project manager or the Project managers Representative shall be liable in any form whatsoever for the Contractors failure to comply with current legislation.

109.5 Notwithstanding his general duties under health and safety legislation and regulations, the Contractor shall advise the Project manager in writing of any substances which he proposes to bring onto the Site or incorporate into or use about the Works, or which he discovers existing on the Site, which fall within the Control of the Substances Hazardous to Health Regulations or otherwise require special precautions to be taken.

110.0 Safety of Works and Adjacent Structures

110.1 The Contractor shall at his own expense provide and erect to the approval of the Project manager all supports required to protect efficiently all structures or works requiring support as a result of the Works and shall remove the same on completion.

111.0 Temporary Fences

111.1 The Contractor shall erect and maintain at his own expense suitable and approved temporary fencing as may be necessary to meet his obligations under Articles 9 and 20 of the Contract. Access shall be provided in the temporary fencing as necessary for the use of the occupiers of adjacent land(s).

112.0 Existing Services

112.1 No warranty is given as to the accuracy or completeness of the information on existing services included in the Contract. The Contractor shall consult all relevant authorities and services owners before commencing any excavations and shall satisfy himself as to the exact position of existing services which affect or may be affected by the Works. If any service is found to exist but is not as indicated in the Contract, then the Contractor shall at once give written notification to the Project manager. The Contractor shall record the position of all located existing services on the horizontal alignment drawings a copy of which shall be made available by the Contractor to the Project manager.

112.2 The Contractor shall execute the Works in such a manner that he does not damage or interfere with existing services on or near the Site. If damage or interference is so caused the Contractor shall make his own arrangements, to the approval of the Project manager and the relevant authority, to execute the repairs at his own cost. If the service authority concerned elects to make good the damage, the Contractor shall give all facilities and shall pay all charges.

112.3 The Contractor shall make his own arrangements for any diversion or removal of services, which he may require for his own convenience or method of working and shall obtain the prior approval of the Project manager to such arrangements.

112.4 Permanent diversions of public utility services are not required.

112.5 Where public utility services are to be diverted the works shall be carried out in such a way that the service is maintained while the diversion is installed. The existing service shall not be broken into until the diversion is in place. Should temporary diversions of services be required, the Contractor shall be responsible for arranging such temporary diversions with the relevant Authority who will carry out the work of diverting the pipe or cable.

112.6 The planning and co-ordination of the work with and of the services authorities shall be the Contractor's responsibility and due allowance for such shall be made in the Contractor's programme.

113.0 Services for Site Use

113.1 The Contractor shall arrange at his own cost the supply of electricity, fresh water, telephone, compressed air and other services as necessary to his Site establishment, and shall provide, maintain and remove on completion all pipes, cables and fittings which carry such services to his operations. The Contractor shall provide an adequate supply of safe drinking water on the Site. All electrical installations forming part of the Temporary Works shall comply with the relevant provisions of the current regulations for electrical installations applicable in Grenada.

114.0 Sanitary Conveniences

Sanitary conveniences for the use of persons employed on the Works shall be provided and maintained by the Contractor in accordance with the appropriate regulations. All persons engaged upon the Works shall be required to use them. The Contractor shall provide and maintain temporary arrangements for the proper discharge of sewage, waste and drainage from or in connection with the Works.

116.0 Boundaries Cut Through

116.1 Fences, walls, etc, crossed by the Works and forming boundaries of plots outside the area occupied by the Works shall not be cut through or destroyed for more than the distance necessary to permit the erection of new fencing etc. and the Contractor shall

make the ends of the cut fences reasonably secure. Where fences or walls are damaged or destroyed, the whole shall be restored and reinstated with like materials to the satisfaction of the owners, occupiers and the Project manager.

117.0 Drains. Streams. Watercourses etc.

117.1 Drains, pipes, canals, channels, water courses or streams affected by the Contractor's operations not forming part of the permanent works are to be maintained by temporary channels or pumping if necessary and on completion restored to their original condition as soon as possible after the relevant operations have ceased. The Contractor shall notify the Project manager in writing 14 days in advance of his intention to start any part of the Works affecting watercourses, canals, streams, drains, pipes, channels etc. The Contractor shall be responsible for maintaining the watercourses within the Site in effective working condition.

117.2 The contractor shall execute the works in a manner that will avoid the pollution or siltation of rivers, streams or the sea.

117.3 The Contractor shall take steps to ensure that existing vegetation and wildlife is disturbed as little as possible in the execution of the Works. Flagrant breaches of this Article will be treated as damage to property and compensation at recognized local rates shall be sought from the Contractor.

120.0 Protection of Completed Work

120.1 The Contractor shall protect completed work from damage during subsequent operations, from the weather or any other cause, including the naturally aggressive nature of the environment in which the Works are to be constructed and make good any damage arising from his failure to do so in accordance with Article 20.

121.0 Traffic

121.1 Prior to commencing any work in or which may affect the use of any highway, the Contractor shall obtain the written approval of his proposed methods of working from the Project manager and the Highway and the Police Authorities. Throughout the duration of the Contract, the Contractor shall cooperate with the Highway and Police Authorities concerning works in, or access to, the highway. Any requirements of such Authorities shall be notified in writing by the Contractor to the Project manager.

121.2 Where required, the Contractor shall provide and maintain all necessary temporary diversions, which shall be operational before interference with existing carriageways, foot paths or public right of way.

121.3 Reasonable access shall be maintained to properties adjacent to the Works.

121.4 The Contractor shall provide traffic lights, flagmen and signaling equipment as may be necessary to control the traffic to the satisfaction of the Project manager. Roadways closed to traffic shall be protected by effective barricades on which shall be placed acceptable warning and directional signs. All temporary detour routes shall be indicated clearly throughout their entire length. All barricades and obstructions shall be illuminated at night and all lights shall be lit from sunset to sunrise.

122.0 Damage to Access Roads

122.1 The Contractor shall ensure that damage to any public or private roads, footpaths, beaches or bays used by any vehicles or plant proceeding to or from the Site is kept to a minimum and he shall be responsible for the cost of all repairs necessary to restore such to the satisfaction of the Project manager and/or controlling authorities.

123.0 Datum, Co-ordinates, Surface Levels

Levels shown on the drawings are given in metres above Ordnance Survey Datum. Local control points for construction use will be indicated by the Project manager.

All co-ordinates are grid co-ordinates. Actual ground distances may be computed by dividing grid distances by a scale factor in the range 0.999627 to 0.999645. The appropriate value for a given location is available from Lands and Surveys Department.

Before commencing work on any section of the Works, the Contractor shall survey [and level] the original ground surface and shall prepare and submit to the Project manager plans, and sections for agreement.

124.0 Testing

The Contractor shall provide all staff, labour and equipment necessary for the performance of all tests required, or he may employ an independent testing laboratory approved by the Project manager to carry out all or part of the testing.

If the Contractor provides his own testing facilities, the equipment staff and method of operation shall be to the approval of the Project manager, and up to 25% of all tests conducted by the Contractor shall simultaneously be carried out, on samples of the same material, by an approved independent testing laboratory. The cost of supplying samples shall be included in the Contractor's rates, but the cost of independent testing shall be under a provisional sum. In either case, the Project manager shall have access to the laboratory(ies) at all reasonable times. The Contractor shall obtain the approval of the Project manager for his proposed testing arrangements and shall submit all results without delay.

125.0 Photographs

The Contractor shall provide the Project manager with sets of colour photographs as per the Schedule of Prices, taken at the following stages:

- a. Commencement
- b. Twice during construction, or as otherwise instructed by the Project manager
- c. Substantial completion

Photographs shall be taken from locations directed by the Project manager. The photos, approximately 150 x 90mm, of each photograph shall be supplied. Each print shall be neatly mounted on plain backing and titled. A set will consist of 10 photographs, and each set shall be handed to the Project manager within 14 days of the photographs being taken.

The negatives and all prints shall be the property of the Contracting Authority.

126.0 Notice Boards

126.1 The Contractor shall provide, and erect notice boards as detailed in Appendix E. No other notice boards or signs of any description shall be erected unless directed or approved.

127.0 “Directed” and “Approved”

127.1 The terms "directed" and "approved" in the Specification mean "directed by the Project manager and "approved by the Project manager" except where the context clearly implies another meaning.

128.0 Abatement of Nuisance

128.1 The Contractor shall adopt such measures as the Project manager may consider reasonable and necessary to minimize nuisance from dust, noise, or other cause.

128.2 The Contractor shall observe all agreements entered into by the Contracting Authority with any person or persons relating to occupation of the properties by the Contracting Authority and to the execution of the Works thereon. The Contractor will be given on request copies of any agreement or part thereof relating to such matters.

128.3 The Contractor shall prohibit the committing of nuisance on the site of the Works or upon the land of the Contracting Authority or adjacent landowners and any employee found violating this provision shall be liable to immediate dismissal and shall not again be re-employed on the Works.

129.0 Contractors Site Establishment

129.1 The Contractor shall provide, erect, service and maintain all necessary temporary buildings such as offices and plant yard/stores for himself, his staff and his employees.

129.2 The Contractor shall make all necessary arrangements for and pay all costs in connection with the supply of electricity and water and waste disposal.

129.3 All buildings shall comply with the appropriate local regulations and the Contractor shall provide the appropriate Authority with sufficient details of the establishment so that approval of the appropriate authority can be obtained prior to construction. The Contractor shall also construct and maintain adequate roads or paths to all buildings.

129.4 The Contractor shall provide and maintain adequate first-aid facilities and shall provide transport facilities for the removal of injured or sick personnel to hospital or home.

129.5 All hutments, buildings, fixtures and fittings provided under this Article shall be removed and the site reinstated at the end of the Contract.

130.0 Contractor's Transport

The Contractor shall make his own arrangements for the transport, where necessary, of his staff and workmen to and from the site of the Works.

200 MATERIALS AND EQUIPMENT

201.0 Alternative Materials and Equipment

The Contractor may propose, for the Project manager's approval, alternative materials or equipment to those specified, provided either: -

They are of at least equal quality and performance, or

They are of like quality and performance and comply with approved alternative standards.

If alternative materials or equipment are proposed, the Contractor shall submit comprehensive details including technical descriptions, drawings and specifications to demonstrate that the alternative complies with either requirement of this Article. The Contractor shall allow for the time necessary for review and approval of such alternative by the Project manager.

202.0 Manufacturer's Instructions

202.1 Materials and equipment shall be used or installed where relevant in accordance with the instructions of the manufacturer unless otherwise required.

203.0 Supply of Materials

203.1 As soon as possible after the Contract has been awarded, the Contractor shall submit a list of suppliers from whom he proposes to purchase the materials and equipment required for the Works.

203.2 Samples shall be taken and tested in accordance with the relevant British Standards where applicable. Materials and equipment sources and suppliers shall not be changed without prior written approval.

204.0 Copies of Orders

The Contractor shall, if required, by the Project manager, submit to him copies of orders for materials and equipment to be incorporated in the Works.

205.0 Test Certificates

Unless required otherwise in this Specification, the Contractor shall supply works test certificates, analyses, mill sheets etc as relevant to the particular materials and as required by relevant Standards etc.

400 CONCRETE

401.0 Concrete

Concrete shall consist of cement, graded aggregate and water thoroughly mixed, placed and compacted as specified in the following Articles.

402.0 Chlorides in Concrete

The total combined content of calcium chloride and sodium chloride in any batch of concrete is not to exceed 0.33% by weight of the amount of cement.

403.0 Cement

403.1 The cement used throughout the Works shall be obtained from manufacturers approved in writing by the Project manager and shall as appropriately comply with the following specification: -

High Sulphate Resisting Portland Cement (SRPC) to BS 4027

Except where otherwise specified the cement shall be **Sulphate Resisting Cement**.

404.0 Cement Testing

404.1 All cements shall be certified by the manufacturers as complying with the requirements of the appropriate Specification. Before orders are placed the Contractor shall submit details of the proposed supplier(s) together with such information on the proposed methods of transport, storage and certification so that the Project manager may satisfy himself that the quantity and quality required can be supplied and maintained throughout the construction period. Where necessary the Project manager may require further representative samples of the proposed cement to be taken and forwarded to a nominated laboratory for analysis and testing before the source is approved.

404.2 Having obtained the Project manager's approval of the source(s) of supply, transport, storage and certification of the cement, the Contractor shall not modify or change the agreed arrangements without first having obtained the Project manager's permission.

404.3 In addition to routine test certificates which are to be supplied by the manufacturer to show the average results of Sample tests made on batches of cement produced at the works, the Project manager may also make any further tests which he shall consider necessary or advisable to satisfy himself that the cement on Site complies with the deterioration in any manner during transit or storage.

404.4 The Contractor shall ensure that the arrangements for the storage of the cement on the Site as hereinafter specified are sufficient for the segregation and identification of each consignment until the results of the sampling and testing referred to in sub-Article (3) above are available.

404.5 No cement shall be used in the Works until it has been passed as satisfactory by the Project manager.

405.0 Storage of Cement

The cement shall be delivered to the site of the Works in bulk or in sound and properly sealed bags and while being loaded or unloaded and during transit to the concrete mixers whether conveyed in vehicles or by mechanical means, must be protected from the weather by effective coverings. Where directed by the Project manager the Contractor shall supply and erect efficient screens at his own expense to prevent wastage of cement during strong winds.

If the cement is delivered in bulk, the Contractor shall provide at his own cost approved silos of adequate size and numbers to store sufficient cement to ensure continuity of work and the cement shall be placed in these silos immediately it has been delivered on the Site. Approved precautions must be taken during unloading to ensure that the resulting dust does not constitute a nuisance.

If the cement is delivered in bags, the Contractor shall provide at his own cost perfectly weatherproof and well-ventilated sheds having a floor of wood or concrete raised at least 500 mm above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of work and each consignment must be stacked separately therein to permit easy access for inspection, testing and approval. On delivery at the Site the cement is at once to be placed in these sheds and shall be used in the order in which it has been delivered.

Cement which has been damaged in transit to the Site or has become stale or otherwise unsuitable, and hardened lumps or cakes of cement which cannot be crumbled into fine powder in the hand shall not be used in the Permanent Works except with the specific approval of the Project manager.

406.0 Fine Aggregates

Fine aggregate for concrete shall be clean sand complying with B.S. 882 "Aggregates from natural sources for concrete". The sand shall be from approved sources and sand which in the opinion of the Project manager is not clean shall be washed before use.

Crushed sand up to a maximum of 50% may be added to natural sand in order to achieve the required grading. Crushed sand alone may only be used with approval of the Project manager. Sand for use in mortar and rendering shall conform in all respects with B.S. 1198-1200. "Building sands from natural sources".

407.0 Coarse Aggregates

- 407.1 Coarse aggregate for concrete and other purposes shall comply with B.S. 882 "Aggregates from natural sources for concrete". Subject to sub-Article (6) hereof it may be either natural gravel or stone broken to the desired size and shall be obtained from quarries, pits or other sources approved by the Project manager.
- 407.2 Gravel or ballast shall be free from clay, earth, loam or other organic or similar material and shall be approved by the Project manager. Any sand that may be amongst it shall, unless otherwise directed, be removed by screening if required and kept apart. Should the sand thus obtained be suitable in the opinion of the Project manager for use in concrete, it may be used for the purpose provided that it complies with the conditions specified for sand in the preceding Article. Gravel or ballast which in the opinion of the Project manager is not clean shall be thoroughly washed before use.
- 407.3 Broken stone shall be of hard durable rock. Notwithstanding approval by the Project manager of its source, the stone as delivered to the Works will be subject to rejection if for any reason the Project manager considers it unsatisfactory. It must be perfectly clean and no soft, clayey, shaley, decomposed or weathered stone will be approved. The stone must be broken in a stone crusher of approved type to the sizes hereinafter specified and any dust or fine material below 5mm in size made in the stone crusher is to be removed by screening if so required and if the Project manager so orders the stone shall be thoroughly washed by an approved method.
- 407.4 When so required and before the Work is commenced, laboratory tests shall be made of the aggregates to be used on the Works to establish their suitability for concrete. In addition to these laboratory tests the Project manager may require check tests of actual deliveries to be made at the Site from time to time.
- 407.5 The grading of coarse aggregate by analysis shall be within the limits laid down in B.S. 882-1201, Table 1, Coarse Aggregates. Should an analysis of the grain size of the material show a deficiency in any particular size such as to affect the density of the concrete, the Project manager may require the Contractor to add such quantity of aggregate of any particular size that he may deem advisable. In every case the material shall when mixed with sand produce a well graded mixture from the largest to the smallest size specified to ensure that concrete of high density shall be produced.
- 407.6 The "flakiness index" for coarse aggregate as determined by the sieve method described in B.S. 812 "Methods for sampling and testing of mineral aggregates, sands and fillers", shall not exceed 40 for 40 mm aggregate nor 35 for 20 mm and 10 mm aggregate.

407.7 The "ten per cent fines" value of the coarse aggregate determined in accordance with BS 812 shall not be less than 8 tonnes, and not less than 5 tonnes on a soaked specimen. Alternatively, the aggregate crushing value determined in accordance with BS 812 shall not exceed 35%, and shall not exceed 40% on a soaked specimen.

407.8 The material shall be subjected to 5 alternations of AASHTO Sodium Sulphate Soundness test T104. The weighted loss shall be not more than 12 per cent mass. Where the presence of weathering rock is suspected, petrography tests shall be carried out to determine the proportion of secondary minerals present.

408.0 Storage of Aggregates

All sand and aggregate for concrete shall be stored on close fitting timber, steel or concrete stages of approved design with drainage slopes or in bins of substantial construction in such a manner as to prevent segregation of sizes and to avoid the inclusion of dirt and other foreign materials in the concrete. All such bins shall be emptied and cleaned at intervals as instructed by the Project manager. Each size of aggregate shall be stored separately unless otherwise approved by the Project manager.

409.0 Water for Concrete

Clean fresh water is to be used for the mixing of all concrete and mortar and is to be from a source approved by the Project manager. If required by the Project manager, samples shall be taken from the proposed source of supply and submitted to a nominated laboratory for testing in accordance with B.S. 3148 -"Tests for water for making concrete" and on the results of these tests the Project manager will decide whether the source is acceptable.

410.0 Admixtures

410.1 The use of non-corrosive additives or admixtures in concrete may be ordered or approved by the Project manager according to circumstances. Such approval will only be given when the Contractor has demonstrated to the satisfaction of the Project manager that the resulting concrete is no less strong, dense and durable than that obtainable without the use of additives.

410.2 Samples of any additive or admixture proposed by the Contractor shall be submitted for testing at least 60 days in advance of use, which shall require the written approval of the Project manager.

410.3 When additives or admixtures are used in the Works very strict control is to be maintained to ensure that the correct quantity is used at all times.

412.0 Concrete Classes

The classes of concrete to be used in the Works shall be as shown on the Drawings, Bills of Quantities or as directed by the Project manager. For each class of concrete the characteristic 28-day crushing strengths, when tested in accordance with the following Articles, shall be as set out in the table below, the 7-day strengths shall be used only as a guide

Class of Concrete	Max. size of Aggregate	Characteristic 28day Strength	Characteristic 7day Strength	Minimum Cement Content
	<i>mm</i>	<i>N/mm2</i>	<i>N/mm2</i>	<i>Kg/m3</i>
In Situ R.C.				
15/20	20	15	11	200
20/20	20	20	18	250
30/20	20	30	22	350
35/20	20	35	25	450
Mass Conc.				
10/40	40	--	--	150
15/40	40	15	11	200

The term characteristic strength means the value of the strength of concrete below which not more than 5 per cent of the test results fall.

The characteristic strengths specified are for concrete cured at a mean temperature between 75 and 80-degree F. Should the curing temperature be in excess of the higher values of these ranges, the acceptable cube strength shall be Increased by an amount to be determined by the Project manager.

The actual cement contents, aggregate/cement ratios and water/cement ratios will depend on the closeness of control which the Contractor is prepared to exercise in production and upon the quality of materials used. Where necessary the Project manager may impose an upper or lower aggregate/cement ratio and/or water/cement ratio which shall not be exceeded for any class of concrete.

Before any concrete of Class is placed in the Works the Contractor shall submit to the Project manager for his approval full details of the mixes he proposes to use for each class of concrete together with their expected average strengths. These mixes shall be based on the results of trial mixes as specified hereafter.

The contractor shall employ an experienced concrete specialist who will be responsible for all of the contractor's concrete works. If the contractor does not employ said specialist or the person employed is not sufficiently specialized in the opinion of the Project manager, then the Project manager may instruct the contractor to obtain all further concrete from a reputable ready-mix concrete plant. Additional costs as a result of this shall be borne by the Contractor.

413.0 Concrete Mix Designs: Class 15/20

Preliminary tests are to be carried out jointly by the Contractor and the Project manager to determine the mixes which will satisfy the Specification with the available materials. These mixes shall be designed with due regard for the workability necessary to allow the Contractor to place and compact the concrete with the equipment he proposes to use in any particular situation.

In default of satisfaction trial mixes for Class 15/20 being undertaken, Class 20/20 shall be substituted wherever class 15/20 is specified in the design or the drawings.

The mixes shall be designed to have mean strengths that are greater than the specified characteristic cube strengths by a margin of 1.64 times the standard deviation expected from the concreting plant. The standard deviation shall be calculated from at least 40 individual cube results each representing separate batches of similar concrete produced by the same plant and under the same supervision except that no standard deviation less than 3.5 N/sq.mm shall be used as a basis for designing a mix. In the absence of such previous information a standard deviation of 7 N/sq.mm shall be used for initial mix design purposes. It is assumed that the same standard deviation applies to both the 7 day and 28-day strengths.

414.0 Trial Mixes

Where there is not existing data showing that the proposed mix proportions will produce the grade of concrete required with adequate workability for full compaction by the method to be used in production, trial mixes shall be prepared under full scale conditions and tested in accordance with B.S. 1881 "Methods of testing concrete". Trial mixes shall also be made subsequently whenever a change is intended in materials or in the proportions of the materials to be used. Representative samples of the materials to be used shall be taken and three trial mixes using the proposed proportions shall be made on different days. The workability of each of these three mixes shall be determined and a batch of six cubes from each mix shall be made three for tests at 7 days and three for tests at 28 days. The Project manager will normally approve the proposed mix proportions provided the average strength of the three trial mixes is not less than the designed mean strength minus the designed standard deviation and subject to the conditions noted below. Further trial mixes shall be made if the range of strength, that is the maximum minus the minimum, of the three cube results in any batch exceeds 15% of the average of that batch, or if the range of the three batch averages exceeds 20% of the overall average of the batches.

415.0 Works Test

- 415.1 Test cubes shall be made, cured, stored, transported and tested in compression in accordance with B.S. 1881 "Methods of testing concrete". The method of compacting cubes by vibration shall be subject to the approval of the Project manager.
- 415.2 A sample of concrete shall be taken at random on eight separate occasions during each of the first five days of using a mix. Thereafter a sample shall be taken from at least 4% of the batches made, and in any case at least one sample shall be taken each day of concrete of each grade made. The number of samples per day and the times which they shall be taken shall be varied at random or as directed by the Project manager.
- 415.3 From each sample two cubes shall be made for testing at 28 days and one for testing at 7 days for control purposes.
- 415.4 To ensure that the mix proportions are suitable for a particular grade of concrete 28-day test cube results shall satisfy the four conditions given below.
- 415.5 The works test 28-day cube results shall be examined both individually and in consecutive (but not overlapping) sets of four, for which the average and the range of each set shall be calculated. The mix proportions shall be modified to increase the

strength if, in the first ten consecutive (but not overlapping) sets, any of the following conditions are not satisfied;

415.6 Not more than two individual results of the 40 cube tests shall fall below the specified characteristic cube strength,

415.7 No value of the range in any set shall exceed 3.2 times the designed standard deviation,

415.8 No value of the average of any set shall be less than the specified characteristic strength plus the designed standard deviation, and

415.9 Not more than one set shall have an average which is less than the specified characteristic strength plus 1.3 times the standard deviation.

415.10 After ten consecutive sets of results have been obtained the overall average and the standard deviation of the 40 results shall be calculated and any appropriate modifications made to the mix proportions. Subsequently, any of the foregoing conditions do not apply to the individual results or the sets of four, the overall average and the standard deviation of the previous consecutive 40 results, including the non-complying set shall be calculated. If the overall

415.11 average strength minus 1.8 times the standard deviation is less than the specified characteristic works cube strength, then the mix proportions shall be modified.

416.0 Additional Cube Tests

In addition to the works test cube described above the Project manager may order additional cubes to be made for the following purposes:- to determine the strength of concrete at the time of stripping moulds; to determine the duration of curing or to check testing errors.

417.0 Test Failure

Should any works test cube fail to attain the specified strength, an immediate examination shall be made to find the cause of the failure and a report sent to the Project manager's Representative who will take suitable action which may be one of the following: -

He may order the concrete corresponding to the cubes to be cut out and replaced in accordance with Article 39 of the Conditions of Contract.

When the failure relates to concrete used as artificial reef members which lend themselves to being load tested, the Project manager may order the affected member to be so tested in accordance with his instructions. If cracking or any other sign of failure appears, the concrete shall be cut out to the extent ordered by the Project manager and replaced with sound material. Otherwise the member may be accepted as satisfactory.

When the failure, in the opinion of the Project manager's Representative, is slight and occurs in a continuing concreting operation for a large mass of concrete, the next works test result may be awaited and, if the failure then persists, the Project manager's Representative may order that concreting shall cease forthwith and not be resumed until further preliminary tests indicate that the mix has been corrected. Otherwise the concreting may be allowed to continue with the same mix

When the failure is serious and relates to a concrete mass which lends itself to it, the Project manager's Representative may order one or more test cylinders to be drilled out and tested in accordance with B.S. 1881. According to the result of these tests the Project manager may order the suspected concrete to be cut out and replaced in accordance with Article 42 of the Conditions of Contract.

The cost of these tests including the provisions and placing of jacks, kentledge, deflectometers, etc., and the cutting out and replacing of concrete of inferior quality shall be borne by the Contractor if the test results shows the concrete not to be in accordance with the Specification.

418.0 Workability

418.1 The concrete shall be of such consistency that it can be readily transported and placed in the Works without segregation of the materials. The resulting concrete shall be uniform and free from honey-combing.

418.2 Where necessary and before the mixes are approved the Contractor shall supply a section of formwork complete with reinforcement fixed in position and generally representative of the sections comprising the Works. This formwork shall be filled with concrete produced for the trial mixes and compacted in the same manner and with the same equipment to be used on the Works. The appearance of the concrete after striking the formwork shall be to the satisfaction of the Project manager who may otherwise require the mix to be modified, and further batches of concrete made and tested as before.

418.3 A simple and convenient system of varying the water released into each batch must be installed with graduated gauges fixed to the supply tanks which can be set by the Project manager. The method of releasing the water into the mixer shall be such that the full measured quantity is discharged in one operation and the Row is stopped by an automatic valve or siphon arrangement only when the full quantity of water has been released. No arrangement which permits the discharge of partial quantities of water at the discretion of the mixer driver shall be allowed.

418.4 The Contractor shall be required to have an accurate knowledge of the moisture content of all sand and coarse aggregate as they reach the mixer and he shall make such adjustments to the mix as are necessitated by change in the moisture content of all aggregates.

419.0 Consistency

419.1 The Contractor shall carry out slump, compaction factor or other workability tests as required during concreting of permanent works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes.

420.0 Concrete Return and Records

The Contractor shall send weekly to the Project manager a return showing the quantities of cement and the number of mixings of each class of concrete used in each section of the Works.

Records shall be kept by the Contractor of the positions in the Works of all batches of concrete, of their class and of all test cubes or other specimens taken from them. Copies of these records shall be supplied to the Project manager.

421.0 Batching

421.1 The aggregates and cement shall be proportioned by means of efficient weigh batching machines except when the Project manager has approved the use of volume batching. The machines shall be carefully maintained and cleaned and they shall be provided with simple and convenient means of checking the accuracy of the weighing mechanism, and they shall be checked when required by the Project manager.

421.2 For volume batching suitable gauge boxes shall be used. Cement shall be taken as weighing 1440 kg/cu.m or such other amount as may be determined by the Project manager as a result of tests.

422.0 Mixing Concrete by Machine

422.1 The concrete is to be mixed in machines of the batch mixing or other approved type. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposition in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their contents while running.

423.0 Mixing Concrete by Hand

Where it is not possible to employ machine mixing and approval has been obtained from the Project manager, concrete shall be mixed by hand as near as practicable to the site where it is to be deposited. Clean mixing bankers or platforms of sufficient area for the proper execution of the work shall be provided. These platforms if constructed of timber shall consist of planks closely jointed so as to avoid the loss of any grout or liquid from the wet concrete. The whole of the aggregate and cement shall be turned over on the banker in a dry state at least twice. The water shall then be added gradually through a rose head, after which the materials shall again be entirely turned over in a wet state at least three times.

424.0 Transport of Concrete

The concrete shall be discharged from the mixers and transported to the Works by means which shall be approved by the Project manager and which shall prevent contamination, (by dust, rain or other causes) segregation or loss of ingredients. The means of transportation shall ensure that the concrete is of the required workability at the point and time of placing.

425.0 Placing of Concrete

425.1 The concrete shall be placed in the positions and sequences indicated on the Drawings, in the Specification or as directed by the Project manager. Except where otherwise directed, concrete shall not be placed unless the Project manager or his Representative is present and has previously examined and approved the positioning, fixing and condition of reinforcement and any other items to be embedded and the cleanliness, alignment and suitability of the containing surfaces or formwork.

- 425.2 The concrete shall be deposited as nearly as possible in its final position without rehandling or segregation and in such a manner as to avoid displacement of the reinforcement, other embedded items or formwork. Wherever possible bottom opening skips shall be used. Where chutes are used to convey the concrete, their slopes shall not be such as to cause segregation and suitable spouts or baffles shall be provided where necessary. Concrete shall not be dropped through a greater height than 1200 mm except with the approval of the Project manager who may order the use of bankers and the turning over of the deposited concrete by hand before being placed.
- 425.3 Where pneumatic placers are used the velocity of discharge shall be regulated by suitable baffles or hoppers where necessary to prevent segregation or damage and distortion of the reinforcement, embedded items and formwork, caused by impact.
- 425.4 All concreting shall be carried out in sections previously ordered or approved by the Project manager and shall proceed continuously in each section until completed and no interval shall be allowed to elapse while the work is in hand.
- 425.5 The concreting shall be carried out in such a way that the exposed faces of concrete shall be sound and solid, in accordance with drawings. No plastering of imperfect concrete faces will be allowed, any concrete that is defective in any way will, if so ordered by the Project manager, be cut out and replaced to such depth or be made good in such manner as the Project manager may direct.
- 425.6 The placing of concrete under water will be permitted with the prior approval of the Project manager. Where it is allowed, 25 per cent additional cement must be added. Concrete shall be deposited continuously in each section by the use of termite pipes or other approved means and no horizontal construction joints will be permitted to be made under water and approved and adequate protection against possible damage or movement due to scour must be provided.

426.0 No Partially Set Material to be Used

All concrete must be placed and compacted in its final position within 30 minutes of discharge from the mixer unless otherwise approved. No partially set material shall be used in this work.

427.0 Compaction of Concrete

The concrete shall be fully compacted throughout the full depth of the layer and shall be brought up in level layers of such depth that each layer is readily and properly incorporated

with the layer below with the use of internal vibrators or by spading, slicing or ramming. It shall be thoroughly worked against formwork and around any reinforcement or embedded items without displacing them.

428.0 Vibration of Concrete

Except where otherwise permitted by the Project manager, concrete shall, during placing, be compacted by hand held vibrators of a type to be approved by the Project manager. The vibrators shall be suitable for continuous operation. The vibrators shall be disposed in such a manner that the whole of the mass under treatment shall be adequately compacted at a speed commensurate with the supply of concrete from the mixers. Vibration is to continue until the concrete being placed is fully compacted and all air bubbles have been expelled. Care must be taken that segregation of mortar and aggregate by excessive vibration is avoided.

Vibration is not to be applied directly, or through the reinforcement, to sections or masses of concrete which have hardened or after the initial set has taken place. Vibration must not be used to make the concrete flow in the formwork so as to cause segregation.

429.0 Concreting in Adverse Weather

No concreting will be allowed to take place in the open during storms or heavy rains. Where strong winds are likely to be experienced additional precautions to ensure protection from driving rain and dust shall also be taken. The Project manager may withhold approval of commencement of concreting until he is satisfied that full and adequate arrangements have been made.

430.0 Concreting at Night or in the Dark

430.1 Where approval has been given to carry out concreting operations at night or in places where day- light is excluded, the Contractor is to provide adequate lighting at all points where mixing transportation and placing of concrete are in progress.

431.0 Concreting in High Ambient Temperature

431.1 Where the ambient shade temperature exceeds 32 deg C the Contractor shall take special measures in the mixing, placing and curing of concrete. The temperature of the concrete when deposited shall not exceed 30 deg C. The Contractor shall carry out all necessary special measures to ensure that the maximum concrete

temperature after placing shall not exceed 50 deg C or 30 deg C above the concrete temperature at the time of placing whichever is the lower.

431.2 During placing suitable means shall be provided to prevent premature stiffening of the concrete placed in contact with hot surfaces.

432.0 Curing and Protection

Concrete shall be protected during the first stage of hardening from the harmful effects of sunshine, drying winds, cold, rain or running water. The Contractor shall pay particular attention to the need to protect concrete immediately after the finishing operation and prior to its final set and shall submit his proposals to achieve this protection for the Project manager's approval.

Protection of concrete which has achieved its final set shall consist of one or more of the following

A layer of sacking, canvas, hessian, straw mats or similar absorbent material or a layer of sand, kept constantly moist by spraying with water as necessary for 7 days or such periods as may be directed by the Project manager.

Except in the cases of surfaces to which concrete has subsequently to be bonded, an approved liquid curing membrane at a rate specified by the manufacturer. On horizontal surfaces the curing membrane shall be applied immediately after placing the concrete and on vertical surfaces immediately after removing the formwork.

The use of saline water for curing purposes will not be permitted.

433.0 Construction Joints

433.1 Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be as indicated on the Drawings or as previously approved by the Project manager. The Contractor is to allow for working beyond the ordinary working hours where necessary in order that each section of concrete may be completed without any lapse while the work is in hand. All construction joints are to be formed square to the work. Keyways are to be formed in all horizontal and vertical construction joints except where ordered to be omitted by the Project manager.

433.2 Surfaces against which further concrete is to be placed shall be prepared as early as possible after casting. This preparation shall be carried out preferably when the concrete has set but not hardened by jetting with a fine spray of water or brushing with a stiff brush, just sufficient to remove the outer mortar skin and to expose the larger aggregate without it being disturbed. Where this treatment is impracticable and work is resumed on a surface which has set, the whole surface shall be thoroughly roughened or scabbled with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible. These roughened surfaces shall be thoroughly cleaned by compressed air and water jets or other approved means and brushed and watered immediately before depositing concrete. If so ordered surface shall be covered with cement mortar prior to placing the new concrete.

437.0 Concrete Formwork

437.1 The Contractor shall submit for the approval of the Project manager details of the methods and materials proposed for formwork to each section of the work. Details of all proposed wrought formwork and formwork to produce special finishes are to be submitted for approval in writing, by the Project manager before any materials are brought on to the Site. If the Project manager so requires, samples of formwork shall be constructed and concrete placed so that the proposed methods and finish effect can be demonstrated.

437.2 Formwork shall be constructed from sound materials of sufficient strength, properly braced, strutted and shored as to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. Formwork shall be so constructed that it can be removed without shock or vibration to the concrete. No part of any metal tie or spacer remaining permanently embedded in the concrete shall be nearer than 50 mm to the finished surface and the cavity shall be so formed as to permit satisfactory filling with cement mortar.

437.3 All joints shall be close fitting to prevent leakage of grout and at construction joints the formwork shall be tightly secured against previously cast or hardened concrete to prevent stepping or ridges to exposed surfaces.

437.4 Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete shown on the Drawings. Due allowance shall be made for any deflection which will occur during the placing of concrete within the formwork. Panels shall have true edges to permit accurate alignment and provide a neat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints either vertical or horizontal, unless otherwise specified or approved. Unless otherwise detailed, arises of all concrete shall be finished to a 20 mm x 20 mm chamfer. When chamfers are to be formed, the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

438.0 Formwork for Exposed Concrete Surfaces

438.1 Unless otherwise stated on the Drawings, wrought formwork shall be used for all permanently visible concrete surfaces. Wrought formwork shall be such as to produce a smooth and even surface free from perceptible irregularities. Tongued and grooved planed boards, plywood or steel forms shall have their joints flush with the surface.

438.2 The finished surface shall be within the tolerances specified.

439.0 Formwork for Non-Exposed Concrete Surfaces

439.1 Unless otherwise stated on the drawings, rough formwork may be used for all surfaces which are not permanently exposed. Rough formwork may be constructed of plain butt-joined sawn timber but the Contractor shall ensure that all joints between boards shall be grout-tight. The finished surface shall be within the tolerances specified and full cover to reinforcement steel shall be maintained.

440.0 Preparation of Formwork for Concreting

440.1 Before concrete is placed, the formwork shall be thoroughly cleaned and freed from sawdust, shavings, dust or other debris. Temporary openings shall be provided to assist in removal of the rubbish.

440.2 After cleaning the formwork shall be coated with an approved release agent, which shall not be allowed to run on to reinforcement, other embedded steelwork or concrete at any construction joint.

440.3 All formwork shall be inspected and approved by the Project manager before concrete is placed in it though this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of the concrete specified elsewhere.

441.0 Removal of Formwork

441.1 Formwork shall be removed in such a manner as will not damage the concrete. No formwork shall be removed until the concrete has gained sufficient strength to support itself. Centres and props may be removed when the member being supported has gained sufficient strength to carry itself and the load to be supported on it with a reasonable factor of safety. The following table is a guide to the minimum periods which must elapse between the completion of the concreting operations and the removal of formwork. No formwork shall be removed without the permission of the Project manager and such permission shall not relieve the Contractor of his responsibilities for the safety of the structure.

441.2 Minimum stripping and striking times shall be as follows unless otherwise approved by the Project manager.

Concrete Element	Ordinary or Sulphate Resistant Portland Cement Concrete	Rapid Hardening Portland Cement Concrete
	<i>Normal Weather</i>	<i>Normal Weather</i>
	<i>hours</i>	<i>hours</i>
Vertical surfaces	10	8
Vertical wall surfaces (less than 300mm thick)	30	20

443.0 Concrete Surface Finish

The concrete surface finish on upward facing horizontal or sloping faces shall be, except for blinding concrete or otherwise stated on the drawings, a "fair" surface. A "fair" surface shall be obtained by screeding and trowelling with a wood float.

Screeding shall be carried out, following compaction of the concrete, by the slicing and tamping action of a screed board running on the top edges of the formwork or screeding guides to give a dense concrete skin true to line and level.

Wood float trowelling shall be carried out after the concrete has stiffened and the film moisture has disappeared. Working should be kept to a minimum compatible with a good finish and the surface shall be true to the required profile to fine tolerance. Whenever necessary the Contractor shall provide and erect overhead covers to prevent the finished surface from being marred by raindrops or dripping water.

The surface of blinding concrete shall be that obtained by screeding as described above.

Where a "fine" surface is indicated upon the drawings this shall be obtained in a similar manner to "fair" surface save that a steel float shall be used in lieu of the wood float.

444.0 Tolerances

444.1 Concrete work shall be executed to the tolerances specified below.

Maximum departure from horizontal position	25mm
Maximum departure from vertical position	25mm
Maximum surface tolerance - gradual	12mm in 2m
Maximum surface tolerance – abrupt	6mm
Maximum departure in dimension	-3mm to +6mm

446.0 Cement Mortars

446.1 Cement mortar shall, unless otherwise specified, consist of three parts of sand to one part of High Sulphate Resistant Portland cement mixed and thoroughly incorporated together. Cement lime mortar shall, unless otherwise specified, consist of three parts of sand to one part of a mixture comprising one part of cement to one part of hydrated lime. In each mortar just enough water will be added to give a workability appropriate to its use. The above proportions are by volume. Mortar shall be used whilst freshly mixed and no softening or re-tempering will be allowed.

447.0 Building work

- Concrete to be 1:2:4 mix by weight.
- Minimum cement content 550lb/cubic yard or 325Kg/m³
- All nails/screws used to be galvanized or otherwise plated

500.0 MATERIALS STANDARD

Artificial reef materials must consist of multi-sided, prefabricated artificial reef modules, or similar, as follows:

Type 1

Large Tetrahedron Reefs, 10ft. (minimum) to 12ft. tall (maximum, 8 ton (approximate) hollow concrete walled structure with three or more sides, average number of interconnecting holes to be 25, quantity approved by the Project Manager. The interior of each tetrahedron must contain habitat structure providing a complex and diverse shelter for small/juvenile fishes and invertebrates

Type 2

Large Concrete Ball Reefs, 6ft. diameter, 5ft. tall and 6ft. wide (maximum), 8 ton (maximum) aggregated exposed external surface texture with average number of holes to be 25, quantity to be approved by the Project Manager. The interior of each Concrete Ball must contain habitat structure providing a complex and diverse shelter for small/juvenile fishes and invertebrates

Type 3

Medium Concrete Ball Reefs, 4ft to 5ft. diameter, 3.5ft tall and 4ft. wide (maximum), 1.5 ton (maximum) aggregated exposed external surface texture with average number of holes to be 17, quantity to be approved by the Project Manager. The interior of each Concrete Ball must contain habitat structure providing a complex and diverse shelter for small/juvenile fishes and invertebrates

All artificial reef materials shall be clean and free from excess dirt, asphalt, petroleum, or other hydrocarbons and toxic residues, loose free-floating material and other deleterious substances. Prefabricated modules must be composed of Marine Grade Concrete with a minimum strength of 4,000 pounds per square inch (psi) with micro-silica strengthening agent. Prefabricated modules shall consist of concrete with no exposed metal framework. Prefabricated modules will be designed with multiple openings of various sizes all the way through the outer surface to allow for water circulation and access by aquatic life. All modules must have a solid bottom, or the top of the structure must have an opening greater than 36 inches in diameter to allow for sea turtle escapement. Units must be capable of being lowered to an upright position on the seafloor within 50 feet of designated coordinates for each unit; greater accuracy is desired where possible. Any lifting lines or straps used during deployment must be temporary and removed by the Contractor prior to payment.

Derelict Vehicle Artificial Reef

Derelict Vehicles utilized for Artificial Reef shall have the electrical, glass, rubber, plastic, metal and other loose or transferable materials removed so as only the vehicle frame is engaged. Vehicle frame must be adequately cleaned from all tint, oils and other hazardous or toxic substances before it is transported to the site.

LOADING AND TRANSPORTATION

Artificial reef materials will be loaded using a suitable means of conveyance for transportation to a staging area site and loading onto a barge or other suitable vessel for offshore transportation to the designated artificial reef site. Offshore transportation shall be

provided by a sufficiently powered transport or towing vessel and shall include the necessary personnel and equipment to safely transport and deploy the reef material. Reef material loaded on to the transporting vessel must be properly secured in compliance with the Montserrat Coast Guard standards to allow for its safe transport to the reef construction site.

DEPLOYMENT PATTERN STANDARD

Materials proposed must be deployed within the specified permitted area shown in the Site Plan. During the deployment of the artificial reef material, the transport vessel must be effectively moored through double anchoring, be spudded down, or otherwise be held securely in place with minimal movement (+/-50 feet) to ensure accurate placement of the concrete modules for patch reef on the bottom; greater accuracy is desired where possible. Material must be arranged to provide habitat complexity as well as provide sand bottom forage area opportunities. Individual reef materials should not be widely scattered. Any machinery used to move and deploy the reef materials should be sufficiently powered/manoeuvrable and capably operated to ensure timely, effective and safe off-loading of materials. The tug or transport vessel shall meet all U.S Coast Guard certification and safety requirements, be equipped with a working, accurate Global Positioning System (GPS) unit and other marine electronics including a working VHF radio. Materials proposed must be deployed within one specified permitted area.