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## **GENERAL SPECIFICATION**

### **1.0            GENERAL REQUIREMENTS**

The requirements in this section of the Contract Specification shall, unless otherwise stated, apply to all the ensuing sections of the Contract Specification.

The whole of the Works and materials are to be in accordance with the Building Control Regulations and the relevant British Standard Code of Practice, unless otherwise stated.

The Contractor shall ensure that these requirements in the Specification be strictly adhered to when carrying out the Works, unless otherwise instructed.

### **1.1            Definition**

The term "Drawing" used in all sections of the Contract Specification shall mean "Working Drawings", unless otherwise stated.

### **1.2            Standards and Codes of Practice**

Wherever any standard or code of practice is referred to in the Contract Documents it shall be deemed to be the latest published edition of the relevant standard or code.

SS        Denotes Singapore Standard published by the Singapore Institute of Standards and Industrial Research.

EN        Denotes the Eurocodes which is otherwise known as the European Standards developed by the European Committee for Standardisation.

ASTM    Denotes American Society for Testing and Materials and refers to the Specifications published by the society.

ACI        Denotes American Concrete Institute and refers to the standards and codes published by that institute.

CP        Denotes Code of Practice published by either Singapore Institute of Standards and Industrial Research or British Standards Institution.

All materials and workmanship shall be in accordance with the edition of the referenced Codes and Standard contained in this Specification.

Where the year of issue or the date of amendment slips of the Codes and Standards referred to in this Specification is not stated, the published version current at the date of invitation of tender shall apply.

Where Codes or Standards are not defined specifically the appropriate European/British Standard shall be deemed to apply.

In the event of conflict between any referred Codes or Standards and this Specification, the most stringent requirement shall govern.

### **1.3            Coordination of Drawings**

The Contractor shall check all Drawings and schedules to ensure in good time that he has sufficient information to carry out the work and that all the instructions, Drawings and schedules he has, and provide compatible information on the work to be carried out.

### **1.4            Records and Certificates**

The Contractor shall maintain records of all inspections and tests performed to substantiate conformity with the Contract Specification, including those carried out by Subcontractors and/or third party testing agencies and manufacturers' or suppliers' certificates of test.

All records shall be retained on Site and be available for inspection at any time. On completion of the Works, all records shall be handed over to the Superintending Officer unless otherwise directed.

These records in a format approved by the Superintending Officer shall include, as appropriate, but not be limited to:

- a) a record of inspection and approval for concreting
- b) a record of repairs to defective structural works
- c) a record of tests on cement, sand and aggregates
- d) a record of concrete cube tests
- e) a record of tests on steel reinforcement

Any record, which indicates that the work or materials inspected or tested does not comply with the Contract Specification shall be submitted to the Superintending Officer without delay in order that, should the Superintending Officer allow, the Contractor's proposals for rectification may be assessed.

#### 1.5 Certificates of Materials

All materials shall be manufactured and tested in accordance with the appropriate European/British Standard or as specified. Where certificates of manufacture or tests are not available for materials proposed for use in the Works, the Superintending Officer may direct that independent testing is to be carried out to determine compliance with the European/British Standard or the Contract Specification.

Where appropriate all materials delivered to the Site shall bear the manufacturer's name, brand name or any other data they may be required to verify the exact nature of the material and relate it to the requirements of the Contract Specification.

Work test certificates shall include, whenever applicable, the location in the Works or the delivery or batch which the sample represents.

#### 1.6 Site Investigation Report

The Contractor should note that he has to satisfy himself as to the actual type of strata, geotechnical nature of the underlying stratum and ground conditions to be encountered during the works. It is to be at the risk of the Contractor if difficult ground conditions are actually encountered on the site.

If a Contractor wishes to perform investigation, which may involve excavation, sounding, or boring before submitting his tender he may do so at his own expense and arrangement could be made with the Superintending Officer.

#### 1.7 Levels

Site levels, either spot or contour, and all other levels shown on the Drawings are with respect to the datum +100.00 metres at mean sea level. The Contractor shall check and verify all existing and proposed levels as indicated on the Drawings prior to

the commencement of Works. Any discrepancy, which he discovers in respect of this information shall be brought to the attention of the Superintending Officer prior to the commencement of Works.

1.8

#### Safety Regulations and Temporary Works

The Contractor shall be responsible for the strict observance of all necessary safety requirements to comply with the provisions of the Factories Act 1995 and the Factories (Building Operations and Works of Engineering Construction) Regulations 1990.

The Contractor shall employ a Professional Engineer who shall be fully responsible for the design and supervision of all temporary works carried out in relation to the Works. The Contractor's professional Engineer shall endorse and submit all structural drawings and calculations pertaining to the temporary works in compliance with the Building Control Regulations 1990, to the Chief Inspector of Factories Ministry of Labour) and the other local Authorities. The name of the Professional Engineer employed by the Contractor shall be submitted with the tender.

If the Contractor executes the temporary works without complying with the abovementioned submission requirements, the Superintending Officer shall be empowered to instruct the Contractor to suspend all Works which are/shall be carried out within the said temporary works until such time that the Contractor can produce evidence showing that he had made the submission. Delays and costs to the Contractor caused by a suspension in such circumstances shall be the sole responsibility of the Contractor.

Delays and costs to the Contractor caused by a suspension in failure to observe the above requirements shall be the sole responsibility of the Contractor. No extension of time shall be granted to the Contractor and all the costs for delay or disruption shall be borne solely by the Contractor.

1.9

#### Site Information

The site is located at Singapore Sports School, 1 Champions Way, Singapore 737913.

The Contractor is to be aware that the neighbouring buildings are under operation during the construction stage and the institutional buildings are just next door. Care has to be taken that public safety is utmost importance. Proper hoardings, fencing and partitions are to be erected to prevent public from entering the site.

The Contractor has to survey and confirm the levels of the whole site before commencement of works and the survey plans duly endorsed by the registered surveyor are to be submitted to the Superintending Officer for approval.

The Contractor will be deemed to have visited and inspected the site and surrounding before preparing his tender and to have made himself thoroughly acquainted with all visible details of the site including those not specifically mentioned herein or shown on the drawings and which may affect his programme or methods of carrying out the Works. Any discrepancy between the drawings and site conditions is to be made known to the Superintending Officer and any additional cost is deemed to be included in the tender price.

1.10

#### Obstructions

An obstruction is defined as material the excavation of which requires additional effort. Upon encountering an obstruction, the Contractor shall immediately inform the Superintending Officer and shall agree with the Superintending Officer the method to be employed in removing the obstruction.

No claim for additional cost or time shall be allowed or excavation through obstructions and difficult ground conditions no matter how adverse or for the removal of boulders.

1.11 Discrepancies between Contract Drawings or Contract Documents

In the event of the discrepancy between the Contract Drawings or between Contract Documents and unless these were brought to the attention and resolved by the Superintending Officer before the submission of the tender, the more stringent of the requirements shall prevail and the Contractor is deemed to have priced his document accordingly. No claim whatsoever on this account will be entertained.

1.12 Regulations and Bye-Laws

It shall be the Contractor's responsibility to ensure full compliance with the relevant regulations and bye-laws of the local Authorities together with any future relevant regulations or bye-laws applicable in the Republic of Singapore.

The Contractor has to engage a Professional Engineer to design, prepare shop drawings and certify all the other structural items related to Architectural and M&E works that are not shown in the structural drawings, such as balustrade, trellis, precast elements, glass panel, window frames, services hangers, services manholes and ducts, etc. Any deficiency in the details is to be strengthened to comply with the Authorities' requirements and is deemed to be included in the tender price. No claim of time and cost will be entertained.

The Contractor shall also be held responsible for any delays due to the stoppage of work on Site by the Authorities for non-compliance with the above. He shall pay all charges levied by the Authorities, which have jurisdiction on the areas of his non-compliance.

2.0 WORKMANSHIP

2.1 Breaking Up of the Existing Works

Before the breaking up of existing Works, the Contractor shall seek the permission of the Authority concerned and the Superintending Officer to carry out such Works. All costs and expenses incurred including the reinstatement if required shall be borne by the Contractor.

2.2 Existing Services

Before commencement of the Works, the Contractor shall obtain from the relevant Authorities as much information as possible regarding drains, cables and other utilities below the Site. The Contractor will be responsible for any claims arising from damage to these services. The Contractor shall carry out the works so that adjacent buildings and building foundations are not disturbed or damaged.

The Contractor must take due care to safeguard all services and culverts that will be affected by his works and the Contractor will be responsible for any damage done to these services and culverts as a results of his works. The Contractor has to carry out trial trenches to expose the existing services, within one metre region, before commencing on timber piling works of the culvert construction near any electrical substation.

The Contractor shall comply with all the requirements of the various Statutory Authorities and Government Departments in respect of the existing services at and around the vicinity of the site. The Contractor shall also inform and liaise with the Authority/Department for all the necessary assistance in ensuring timely diversion,

disconnection, termination, or capping off of all utility services. All costs in connection therewith shall be deemed to have been included in the Contract Sum.

### 2.3 Reinstatement of Roads and Street Furniture

The Contractor shall make allowance for the reinstatement of roads, all the street furniture, the foundation and surfaces of any roads, kerbs, walkways, footways and grass areas etc disturbed by the construction works both within and outside the actual piling area.

The Contractor shall allow for the complete reinstatement of all surfaces damaged in side-tables, and all other Private or Government Lands to the satisfaction of the Superintending Officer and the respective Authorities.

Permanent reinstatement must be carried out completed as soon as possible. The Superintending Officer may instruct the Contractor to reinstate the roads in sections as the work proceeds. No claim on time and cost will be entertained. The reinstatement must comply with all requirements of the Authorities.

Should the Contractor fail to carry out all the required reinstatement works within 7 days of his being directed to do so, the Superintending Officer may arrange for the execution of the work by another party at the expense of the Contractor.

### 2.4 Flow of Water Through Drains, Culverts, etc

The Contractor shall ensure that the execution of his Works will not disrupt, fill, block or disturb all the existing drains, culverts, temporary diversion drains and other side drains, etc. The Contractor shall not place or store any construction materials in close vicinity to the existing surface water drainage system such that they can be discharged or washed into the drains, culverts, temporary diversion drains and other side drains etc.

Where the proposed positions of the permanent roadside drains are in conflict with the existing temporary drainage system, the Contractor shall submit temporary diversion drainage proposals to the Authorities for the affected areas. The Contractor shall not commence work on the construction of the permanent roadside drains until such temporary diversion drainage proposals are approved by the Authorities and the construction of the temporary diversion drains is completed.

### 2.5 Safeguarding Properties Adjacent to Site

The Contractor's site procedures and method of working shall at all times be such as to limit to a practical minimum any settlement and lateral movement of the ground and buildings around the Site.

The Contractor shall be responsible for any damage or movement in adjacent properties including roads, paved areas, drains, services, buildings, street furniture, underground structures of any type etc.

Allowance shall be made for any ancillary treatment and all works necessary to ensure the stability of roadways, adjacent structures, services and underground constructions and for all remedial works needed to make good any damage to the satisfaction of the Authorities or the Superintending Officer.

### 2.6 Checking and Monitoring

The Contractor shall provide all necessary instrumentation, complying with the

Authorities requirements, for the close and continuous checking of the movements of adjacent structures, services, and underground constructions.

The Contractor is required to :

- i) conduct a pre-construction survey of the neighbouring properties before work commences, extend relevant portion of the survey to owners of neighbouring properties and keep a copy of the whole survey at site.
- ii) give an undertaking (as in Annex A) at permit application stage that the pre-construction survey shall be given to the owners of the neighbouring properties before work commences.

The Contractor is to engage a specialist firm to :

- i) submit to the Superintending Officer vibration monitoring plan showing the locations of the vibration monitoring devices before the work commences.
- ii) state the vibration limit, taking into account the vulnerability of the neighbouring properties to damage, with the necessary certification and endorsement by the specialist. The limit shall not be any less stringent than the lowest vibration velocity as in the prevailing Standard DIN 4150 Part 3.
- iii) submit the plans to BCA for record before work commences.
- iv) assess the vibration readings and once the vibration limit is exceeded on site or any damage occurs in neighbouring properties, the Contractor has to carry out corrective actions or suspend works and notify the Superintending Officer on these situations.

The Contractor has to implement vibration monitoring and to take readings in the presence of the site supervisor appointed for the project and submit the readings to the Superintending Officer.

Before work commences, the Contractor has to put in place sufficient precautionary and contingency measures to safeguard the integrity of the neighbouring properties. It is advisable that the Contractor has a dialogue with the owners of the neighbouring properties to inform them about the construction activities.

Annexe B is attached for further clarifications.

## 2.7

### Defective Work

Where in the opinion of the Superintending Officer, any of the finished work or materials or workmanship in any part of the Works fails to comply with the Contract Specification, that part of the Works will not be accepted and may be classed as defective.

All work classified as defective shall be cut out and removed from the Works and replaced or otherwise dealt with in accordance with the Conditions of Contract.

The extent and nature of any measures required as a result of defective work shall be delivered by the Contractor to the Superintending Officer. All costs for such defective works including consultant costs and expenses shall be borne by the Contractor.

## 2.8

### Testing Authority

"Testing Authority" shall mean an organisation or laboratory accredited under the Singapore Laboratory Accreditation Scheme (SINGLAS) approved by the

Superintending Officer, fully equipped to carry out special tests and checks required by this Specification.

If for any reason, the Superintending Officer is not satisfied with the performance of the Testing Authority he may direct the Contractor to use a different testing laboratory at the cost of the contractor.

2.9 Licence, Permits and Liaisons with Government Departments, etc

The Contractor shall be responsible to initiate action and to apply for all necessary licences, permits, etc and to carry out all necessary liaison with the Government Departments and Statutory Boards, etc whenever necessary, for the satisfactory completion of the Works. The Contractor shall be responsible for any delay in obtaining these licences, permits liaisons etc for the satisfactory completion of the Works.

Though submissions to the various authorities are made through the Consultants, the Contractor shall be responsible to ensure that the information are given in good time and adequate to obtain approval from the authorities. The Consultants shall not be responsible for any delay caused by the Contractor for insufficient information submitted.

All costs and expenses arising out of the necessity to apply for the licenses, permits, permissions, etc shall be borne by the Contractor.

2.10 Tests to Establish Acceptability of Works

Any tests that are proposed by the Contractor as a result of failure to comply with the requirements of the Specification shall be at the Contractor's expense.

The Contractor shall be responsible for any consequential costs and delays.

The results of such tests will not necessarily be accepted as proof of compliance with the Specification.

2.11 Survey and As-Built Drawings

The Contractor shall allow for carrying out the as-built survey as soon as the piling, structural, minor sewerage, drainage, external works, etc are completed.

All the as-built and survey plans shall be endorsed by the Registered Surveyor. These plans shall be in A1 size and shall be submitted in the form of:-

- i) 4 paper print sets (NOT USED)
- ii) 3 compact disc of CAD and PDF files
- iii) A digital copy encrypted by the Register Surveyor

2.12 Site Supervision

The Contractor shall provide experienced personnel including full-time site engineers with a Degree from an approved University, reference to IES recognized list of qualification to supervise the Works. The Contractor shall provide with the tender, details of the supervisory staff who will be assigned on a full-time basis to the Works, including the capacity in which employed, experience and length of employment with the Contractor.

2.13 Cutting of Pile Heads

The Contractor is to note that the Piling Contractor will only commence cutting of pile head to the cutting-off-level after receiving notice from the Contractor. The Contractor should give the Piling Contractor at least 3 days notice to mobilise. The Contractor shall

ensure the continuity of the pile head cutting activity by having excavated and getting ready sufficient number of piles for the Piling Contractor to carry on with his work.

2.14

#### Watertightness

The following structural elements including all construction joints shall be completely watertight in their finished state :-

1. All Basement Walls and Slabs
2. 1<sup>st</sup> Storey slabs over Basement area
3. All Sumps, Inspection Chambers and Grease Traps
4. Non-shrink pressure grout infill sealing around the service penetrations through basement walls
5. All the roof slabs

If there is any leakage, dampness and presence of seepage water resulting from hydrostatic pressure or capillary action on the surfaces of the said structural elements that are visible to the Employer, the Contractor shall submit to the Superintending Officer for approval, his proposals for rectification, and he shall carry out the rectification so approved at his own expense and at the direction of the Superintending Officer.

2.15

#### Trial Panels

The Contractor shall provide all materials or components and erect or assemble, to the satisfaction of the Superintending Officer, all trial panels required by the Contract Specification or directed by the Superintending Officer. Such panels shall be adequately protected and maintained and upon completion of the Works demolished and removed from the Site.

2.16

#### Quality Assurance

##### 2.16.1 Quality System

The Contractor shall describe in his Tender and implement during the Contract a quality system to verify that the whole of the Works comply with the requirements of the Contract.

The quality system shall be based on EN 29000, unless required otherwise by this Specification.

The Contractor shall provide a quality plan prior to commencement Works. The quality plan shall fully describe the specific practices, resources and activities for the implementation of the quality system on the Contract. The quality plan shall include provisions and procedures under the following headings :

- (a) Organisation
- (b) Documentation
- (c) Control of Subcontractors
- (d) Materials and prefabricated items
- (e) Inspection and testing
- (f) Inspection equipment

##### 2.16.2 Organisation

The Contractor shall allocate to a senior member of his staff the responsibility and resources necessary for ensuring that the quality system is effective.

The Contractor shall provide details and duties of the personnel to be involved

both on and off site, and of all independent inspecting authorities, which he proposes to employ.

The Contractor shall ensure that all personnel have appropriate qualifications, experience or training for the tasks allocated to them.

#### 2.16.3 Documentation

The Contractor shall maintain records to substantiate conformance to specified requirements, including work carried out by Subcontractors, manufacturers, suppliers, and independent inspecting authorities. The records shall include :

- (a) Identification of the element, item, batch or lot
- (b) The nature and number of observations and tests
- (c) The number and type of deficiencies found
- (d) Details of any corrective action taken or proposed

Any record, which indicates that material or workmanship in any part of the Works does not comply with the specified requirements, shall be submitted without delay together with the Contractor's proposals for rectification.

All records shall be retained on site and made available for examination. On completion of the Works a copy of all records shall be provided to the Superintending Officer unless direction otherwise.

#### 2.16.5 Materials and Prefabricated Items

All materials and prefabricated items shall be manufactured and tested in conformance with the specified requirements. When evidence of conformance depends solely on inspections and tests performed by a Subcontractor, manufacturer, supplier, or independent inspecting authority, the Contractor shall ensure that such evidence is satisfactory and the appropriate records are maintained.

No materials or prefabricated items shall be used in the Works until it has been verified that they comply with the specified requirements.

Where appropriate, all materials and prefabricated items delivered to the site shall bear the manufacturer's name, brand name, or any other data that may be required to verify the exact nature of the material or item that relate it to the specified requirements.

Where applicable materials and prefabricated items shall be obtained from suppliers and manufacturers who have been assessed by an independent certification authority accredited by the SINGLAS for Certification Bodies.

Where applicable, materials and prefabricated items shall bear the British Standards Institution certification mark, the British Board of Agreement certification mark or other appropriate certification mark.

Transportation, handling and storage of materials and prefabricated items shall be controlled to prevent misuse, damage or deterioration.

The Contractor shall operate procedures for the identification and isolation of materials and prefabricated items that do not comply with the specified requirements.

Works test certificates shall include, whenever applicable, the location in the

works or the delivery or batch which the sample represents.

#### 2.16.6 Inspection and Testing

The Contractor shall be responsible for carrying out or arranging to be carried out all inspections and tests required by his quality plan to verify that the Works comply with the specified requirements.

The Contractor shall operate a system for identifying the inspection status of the Works at all stages.

The Contractor shall provide agreed notice to enable the Superintending Officer to be present, if so desired, at whatever inspections or tests are performed by the Contractor, Subcontractors, manufacturers and suppliers, and others.

#### 2.16.7 Inspection Equipment

The Contractor shall be responsible for providing, controlling, calibration and maintaining inspection, measuring and test equipment suitable to demonstrate that the Works comply with the specified requirements. This or similar equipment shall be made available to the Superintending Officer or his representative whenever required for examination of the Works.

#### 2.16.8 Non-Conforming Work

Where in the opinion of the Superintending Officer, any of the finished work or materials or workmanship in any part of the Works fails to comply with the Specification that part of the Works will not be accepted.

Any work which the Superintending Officer judges to be inferior in respect to an approved sample or trial panel or to be unacceptably different from parts of the Works already constructed or which is subsequently stained or damaged will not be accepted.

All such work shall be cut out and removed from the site and replaced or otherwise dealt with in an approved manner.

#### 2.16.9 Protection of the Works

The Contractor shall be responsible for ensuring where appropriate that new work is adequately protected at the completion of each day and during periods of inclement weather.

All works exposed to view in the finished Works shall be protected from spillage, stains and other damage.

The Contractor shall take all necessary actions to maintain the Works free from water where it may be deleterious to the Works. He shall obtain all necessary approvals from the Local Authority, Water Authority and any other interested parties to his proposals for disposal of water from the Works.

## **GENERAL CONCRETE SPECIFICATION**

### **1.0 GENERAL**

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## GENERAL CONCRETE SPECIFICATION

### 1.0 GENERAL

#### 1.1 Standards

Unless modified by this section of the Contract Specification all concrete sampling, testing and compliance shall comply with SS EN 206-1 'Specification, performance, production and conformity' In cases of conflict, this section of the Contract Specification takes precedence over SS EN 206-1.

References in brackets in clause headings in this section of the Contract Specification are to clauses or sub-clauses of SS EN1992 'Design of concrete structures'. Unless modified by this section of the Contract Specification, concrete work shall comply with the requirements and Recommendations of these clauses or sub-clauses. In cases of conflict, this section of the Contract Specification takes precedence over SS EN1992.

The Contractor shall keep copies of these Standards on Site.

A bracketed asterisk (\*) indicates that this clause of this section of the Contract Specification modifies the provisions of SS EN1992 or SS EN 206-1. This indication is included for convenience only; its absence does not mean that the provisions of SS EN1992 or SS EN 206-1 have not been modified by this section of the Contract Specification.

#### 1.2 Definitions

##### 1.2.1 Characteristic Strength (\*)

'Characteristic strength' of concrete shall mean that value of strength below which no more than 5% of the works test results for each concrete grade will fail. 'Concrete Strength' is usually taken as the fifth percentile values derived directly from laboratory test results in cases where it is unlikely that more than 5% of results will fail.

##### 1.2.2 Concrete Strength Classes

The "Concrete Strengths" are based on the characteristic cylinder strength,  $f_{ck}$  at 28-days.

### 2.0 MATERIALS

#### 2.1 General

Before any concrete is supplied to the Works, the Contractor shall provide the following, which shall confirm compliance with specified requirements:

- (a) Information listed in Clause 7.2 of SS EN206-1.
- (b) Information on aggregates in accordance with EN12620.
- (c) Evidence of suitability of concrete mix.
- (d) Workability of concrete mix.
- (e) All other information regarding constituent materials required by this section of the Contract Specification.

#### 2.2 Cement

### 2.2.1 General

Super-sulphated and high alumina cements shall not be used.

All cement shall be delivered to the Site in sealed containers or bulk cement lorries of suitable design.

Manufacturers' certificates shall be submitted to the Superintending Officer.

### 2.2.2 Cement Type

Cement shall be Ordinary Portland Cement to SS EN197-1.

## 2.3 Aggregates

### 2.3.1 General

Materials used as aggregates shall be chemically inert, strong, hard, durable, of limited porosity, and free from deleterious substances and impurities that may cause corrosion of the reinforcement or impair the strength and durability of the concrete. Aggregates shall comply with EN12620.

The aggregates shall be taken from a source approved by the Superintending Officer and shall consist of naturally occurring sand and crushed granite.

### 2.3.2 Uniformity

The Contractor shall ensure that sufficient supplies of fine and coarse aggregates of the quality of type specified are available to complete the Contract.

### 2.3.3 Coarse Aggregate Size

Unless specified otherwise, the maximum coarse aggregate size for the concrete shall be 20mm.

### 2.3.4 Type And Shape

aggregates Coarse aggregates shall be crushed granite rock. The grading of the coarse shall comply with EN 12620.

In construction specified on the Drawings as watertight, the coarse aggregates shall not have combined indices for flakiness and elongation exceeding 35 percent, nor shall the flakiness index exceed 15 percent.

Fine aggregates shall be natural sand and shall be free from coagulated lumps. The fine aggregates shall comply with EN 12620.

## 2.4 Water

The water shall be clean and fresh and free from organic or inorganic matter in solution or suspension in such amounts that may lessen the strength or durability of the concrete.

Only water of approved quality shall be used for concreting, and flushing and wetting of formwork, and for curing. The contractor shall make adequate arrangements to deliver and store sufficient water at the Works for use in mixing and curing the concrete, and for flushing and wetting the forms.

When so directed, the Contractor shall arrange for tests of the water to be carried out in accordance with BS EN 1008.

## 2.5 Admixtures

Admixture may be permitted in designed mixes provided the details of the admixture and the associated mix design and trial results are approved.

Calcium chloride and admixtures containing calcium chloride will not be permitted.

All admixtures should be used in accordance with the manufacturer's written instruction.

## 2.6 Concrete

### 2.6.1 Concrete Mixes

Concrete mix requirements are scheduled in Table 1 and trial mixes and tests shall be carried out on concrete of all strength classes.

### 2.6.2 Chloride

The maximum chloride content of the concrete mix is limited to 0.2-0.4% in the case of reinforced concrete and 0.1-0.2% in the case of prestressed concrete. The total chloride content shall be calculated from the mix proportions and measured content of each of the constituents. The Contractor shall provide confirmation of compliance at intervals of one month or less during the supply of concrete to the Works.

### 2.6.3 Sulphates

The total water soluble sulphate content of the concrete mix, expressed as SO<sub>3</sub>, shall not exceed 4% SO<sub>3</sub>, by mass of the cement in the mix. The sulphate content shall be calculated as the total from the various constituents of the mix. The Contractor shall provide confirmation of compliance before any concrete is supplied to the Works.

## 2.7 Evidence Of Suitability Of Concrete Mixes

### 2.7.1 General

Before any concrete is supplied to the Works, evidence shall be provided for each grade of concrete showing that, at the intended workability, the proposed mix proportions, manufacturing method and placing method e.g. pumped concrete will produce concrete of the required quality.

Sampling and testing shall be in accordance with BS EN 12350, BS EN 12390 and BS EN 1250.

Exposure conditions			Cement/ combination designations <sup>b</sup>	Strength class <sup>c</sup> , maximum w/c ratio, minimum cement or combination content (kg/m <sup>3</sup> ), and equivalent designated concrete (where applicable)							
Typical Example	Primary	Secondary		Nominal cover to reinforcement <sup>d</sup>							
				15 + ΔC <sub>dev</sub>	20 + ΔC <sub>dev</sub>	25 + ΔC <sub>dev</sub>	30 + ΔC <sub>dev</sub>	35 + ΔC <sub>dev</sub>	40 + ΔC <sub>dev</sub>	45 + ΔC <sub>dev</sub>	50 + ΔC <sub>dev</sub>
Internal mass concrete	X0	-	All	Recommended that this exposure is not applied to reinforced concrete.							
Internal elements (except humid locations)	XC1	-	All	C20/25, 0.70, 240 or RC20/25	<<<	<<<	<<<	<<<	<<<	<<<	<<<
Buried concrete in AC-1 ground conditions <sup>e</sup>	XC2	AC-1	All	-	-	C25/30, 0.65, 260 or RC25/30	<<<	<<<	<<<	<<<	<<<
Vertical surface protected from direct rainfall	XC3 & XC4	-	All except IVB-V	-	C40/50, 0.45, 340 or RC40/50	C30/37, 0.55, 300 or RC30/37	C28/35, 0.60, 280 or RC28/35	C25/30, 0.65, 260 or RC25/30	<<<	<<<	<<<
Exposed vertical surfaces		XF1	All except IVB-V	-	C40/50, 0.45, 340 or RC40/50	C30/37, 0.55, 300 or RC30/37	C28/35, 0.60, 280 or RC28/35	<<<	<<<	<<<	<<<
Exposed horizontal surfaces		XF3	All except IVB-V	-	C40/50, 0.45, 340 <sup>g</sup> or RC40/50XF <sup>g</sup>	<<<	<<<	<<<	<<<	<<<	<<<
		XF3 (air entrained)	All except IVB-V	-	-	C30/37, 0.55, 300 plus air <sup>g,h</sup>	C28/35, 0.60, 280 plus air <sup>g,h</sup> or PAV2	C25/30, 0.60, 280 plus air <sup>g,h,i</sup> or PAV1	<<<	<<<	<<<
Elements subject to airborne chlorides	XD1 <sup>f</sup>	-	All	-	-	C40/50, 0.45, 360	C32/40, 0.55, 320	C28/35, 0.60, 300	<<<	<<<	<<<

Exposed vertical surfaces near coast	XS1 <sup>f</sup>	XF1	CEM I, IIA, IIB-S, SRPC	-	-	-	See BS 8500	C35/45, 0.45, 360	C32/40, 0.50, 340	<<<	<<<
			IIB-V, IIIA	-	-	-	See BS 8500	C32/40, 0.50, 340	C28/35, 0.50, 340	C28/35, 0.55, 320	<<<
		-	IIIB	-	-	-	C32/40, 0.40, 280	C25/30, 0.50, 340	C25/30, 0.50, 340	C25/30, 0.55, 320	<<<
Exposed horizontal surfaces near coast		XF3 or XF4	CEM I, IIA, IIB-S, SRPC	-	-	-	See BS 8500	C40/50, 0.45, 360 <sup>g</sup>	<<<	<<<	<<<

\* The minimum cement contents specified in this Table relate to 20mm nominal maximum size of aggregate. For other sizes of aggregate, adjustment to be minimum cement content shall be in accordance with SS EN 1992.

**Table 1: Concrete Mix (Brooker, 2006)**

### 2.7.2 Strength

The evidence shall comprise either:

The results of cylinder tests on at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced within the preceding 12 months over a period not less than 5 days but not exceeding 5 months by the same plant under similar supervision.

These results shall demonstrate that the mean strength of the concrete mix exceeds the specified characteristic strength by more than 1.64 times the standard deviation of the results.

or :

The results of trial mixes from three separate batches of concrete each made using the proposed mix and constituent materials and under full scale production conditions.

The workability of each trial batch shall be determined and shall be within the tolerances stated in SS EN 206-1.

Three cylinders shall be made from each batch, and shall be tested at 28 days. The average strength of the nine 28 day cylinders shall exceed the specified characteristic strength by not less than 11.5 N/mm<sup>2</sup>. Alternatively, earlier tests on nine cylinders shall demonstrate that the specified characteristic strength will be exceeded by 11.5 N/mm<sup>2</sup>.

The trial mix design and the results of all preliminary tests shall be submitted for approval by the Superintending Officer as soon as they are available and at least seven clear working days before concrete works starts on Site.

### 2.8 Changes In Constituent Materials (\*)

The Contractor shall not make any changes in the source or nature of any of the constituent materials or any change greater than 20 kg/m<sup>3</sup> in the cement content without first providing evidence that the proposed changes will produce concrete of the required quality.

### 2.9 Reinforcement

#### 2.9.1 Types Of Reinforcement

The types of reinforcement bars will be identified by prefixes to the bars and the prefixes have the following meanings:

- i) R: Plain round hot rolled mild steel bars with a characteristic strength of 250 N/mm<sup>2</sup> and complying with SS EN1992.
- ii) H: Type 2 deformed high yield steel bars complying with SS EN1992 and BS EN10080 with a characteristic strength of 500 N/mm<sup>2</sup>.

Steel fabric shall comply with BS EN 10080 with a characteristic strength of 485 N/mm<sup>2</sup> and shall be delivered to Site in flat sheets.

### 2.10 Ready-Mix Concrete

#### 2.10.1 Approval Of Plant

Ready-mixed concrete shall be produced at an approved plant.

All delivery tickets shall be retained by the Contractor and made available for examination throughout the duration of the Contract.

#### 2.10.2 Additional Water (\*)

All the constituents for each mix shall be added at the manufacturer's depot. No extra water or other material shall be added after the concrete has left the plant.

#### 2.10.3 Rejected Concrete

Rejected concrete shall be removed from the Site. The delivery ticket shall be marked 'Rejected'.

### 2.11 Miscellaneous Materials

#### 2.11.1 Joint Fillers

Material : Kork-Pak (W.R. Grace Ltd) or equivalent approved.

#### 2.11.2 Joint Sealants

Material : Paraseal (W.R. Grace Ltd) or equivalent approved.

#### 2.11.3 Water-Bars

Water-bars shall be of high grade PVC compound formulated to give excellent flexibility and longevity characteristics and the Contractor shall propose externally placed 240 "groutite" Heavy Duty serviseal or equivalent approved.

#### 2.11.4 Grouts

Non-shrink grout applied by high pressure injection shall be sand-cement grout with Conbex 100 or equivalent approved added as an admixture. The 28-day grout cylinder compressive strength (50mm x 50mm cylinders) shall not be less than 65 N/mm<sup>2</sup>. The Contractor shall carry out tests on the fluidity, bleeding and strength of the grout to ensure that the grout being used has the right characteristics, both initially and throughout the course of the Works.

Non-shrink grout under column base plates shall have a minimum compressive strength at 28 days of 65N/m<sup>2</sup>. The grout is to be Conbextra GP manufactured by Fosroc Group of Companies or equivalent approved.

All grouts shall be used in accordance with manufacturer's written instructions.

#### 2.11.5 Curing Membranes

Curing membranes shall be an approved pigmented liquid membrane applied in accordance with the manufacturer's written instructions. The curing membrane shall have at least 90% water-retaining efficiency in the test conducted in accordance with ASTM C156-180.

The curing membranes shall not prevent bonding of finishing materials to the concrete and shall not stain or discolour the concrete or prevent subsequent application of hardener, dust-proofer, or other finishes.

### 2.12 Storage Of Materials

#### 2.12.1 Cement

Cement shall be used in the order that it is received on Site.

#### 2.12.2 Aggregates

Aggregates shall be stored on hard paved self-draining areas or in approved hoppers or containers.

Different types of aggregate shall be kept separate.

#### 2.12.3 Reinforcement

Reinforcement shall be stored clear of the ground, and protected from mud, oil and other substances which may adversely affect its use in the Works.

#### 2.12.4 Steel Fabric

Steel fabric shall be delivered and stored in flat sheets.

### 3.0 WORKMANSHIP

#### 3.1 Construction And Preparation Of Falsework And Formwork

##### 3.1.1 General

All falsework and formwork shall comply with BS 5975, and take account of the recommendations in 'Formwork : A guide to good practice' (Concrete Society, 1986).

The Contractor shall be solely responsible for the design and construction of formwork, and temporary works, taking due account of the surface finish required. All design shall be endorsed by the Contractor's Professional Engineer.

Formwork to exposed concrete surfaces shall produce a consistent and uniform texture in the exposed surface upon its removal.

Before construction of the formwork begins the Contractor shall provide details of the systems of falsework and formwork he proposes to use for all main structural members.

No metal part of any device for maintaining formwork in the correct location shall remain permanently within the specified concrete cover to the reinforcement.

Where the usage of formwork ties are permitted in the formwork construction, they shall be snap type or approved equivalent with deformation to prevent rotation or slippage of the tie. After the tie is snapped, the hole through the concrete section shall be plugged with an approved material.

In watertight construction, methods of fixing formwork which result in holes through the concrete section when the formwork is removed shall not be used. All wall ties shall have water baffles and wall kickers shall be cast monolithically with the base slab.

##### 3.1.2 Release Agents

Release agents shall be materials marketed as such and shall be of one of the following types :-

- i) Cream emulsion
- ii) Neat oil with surfactant added

iii) Chemical release agent

Where a concrete surface is to be permanently exposed, only one agent should be used throughout the entire area and the agent shall be colourless, non-staining and have no deleterious effect upon the concrete surfaces. Where the surface is to receive an applied finish, care should be taken by the Contractor to ensure that the bonding of subsequent paint or finishing materials are not adversely affected.

Release agents shall be stored and used strictly in accordance with the manufacturer's instructions.

3.1.3 Holes, Inserts And Fixings

Approval for the size, type and position of any holes, insert or fixing required by the Contractor or any Sub-contractor shall be obtained before work proceeds.

Unless otherwise specified or approved, all holes shall be formed and all inserts cast in at the time of pouring. No part of the concrete Works shall be drilled or cut away without approval.

The Contractor shall cast into the concrete those inserts and fixings (such as anchors, column corner guards, sleeves, bolts, plates, etc) shown on the drawings. They shall be securely fixed to ensure their correct location in the finished concrete.

Unless otherwise shown in the drawings, there shall be no recesses conduits, box-out and penetrations in the columns, walls, beams and slabs.

3.1.4 Stiffness Of Panels

Formwork panels shall be stiff enough to prevent damage to the concrete surface caused by excessive movements of the panel during vibration of the concrete.

3.1.5 Repair of Formwork

Damaged formwork shall not be reused if in the opinion of the Superintending Officer the making good would impair the surface appearance of the concrete.

3.1.6 Cambers

Unless otherwise directed all formwork to suspended concrete beams and slabs shall be constructed so that the following upward cambers exist immediately before striking :-

- i) Spanning between supports, 0.25% of span at centre.
- ii) Cantilevers, 0.4% of span at free end.

3.2 Falsework

3.2.1 Propping Details

Not less than two weeks before the start of any pour requiring props, the Contractor shall submit to the Superintending Officer for approval shop drawings indicating the props he proposes to use, linked to a detailed programme of work and including an estimate of the loads likely to be applied.

The Contractor shall produce evidence to ensure that the supporting slab has achieved sufficient strength and stiffness prior to the application of construction load from above.

### 3.2.2 Prop Removal

If formwork props are to be left in place after soffit forms have been removed they shall not be disturbed during the removal process without approval.

### 3.2.3 Prop Spacing

Formwork props shall be positioned between permanent supports so that all members are supported at no more than 3m centres in both directions.

### 3.2.4 Removal Of Falsework

The responsibility for the safe removal of any part of the falsework shall rest with the Contractor. Removal shall not cause shock and unacceptable deflection to the structure.

### 3.2.5 Propping of Beams and Slabs

Except for composite floor slabs, propping shall be arranged so that the load from the wet concrete and construction loads are carried by structures which have attained their specified 28-day concrete cylinder compressive strength. When props are carried through from one floor to another, the props shall be aligned vertically one above the other.

## 3.3 Construction Joints

### 3.3.1 General

If construction joints are not shown on the Drawings the Contractor shall obtain approval for their positions before work starts

### 3.3.2 Position Of Construction Joints

The position of construction joints proposed by the Contractor shall be such as to avoid distress or damage to the Works particularly from thermal movement or shrinkage effects.

The position and spacing of joints which will be acceptable will vary from place to place but the following table gives an indication of acceptable limits.

Construction	Max. Area (m <sup>2</sup> )	Max. Dimension (m)
Watertight walls	25	5
Watertight slabs	100	10
Slab with major restraint at both ends	100	13
Slabs with major restraint at one end only	250	20
Slabs with little restraint		

in any direction	500	30
Walls	40	10

---

Where the Contractor's proposals result in alterations to the reinforcement, the Contractor shall be responsible for providing full revised details for approval prior to the work commencing on Site.

### 3.3.3 Preparation Of Construction Joints

The Contractor shall obtain approval for his proposals for forming and preparing construction joints 2 weeks before work starts.

### 3.3.4 Starter Sections

Where used, starter sections (kickers) for walls, columns, etc, shall generally be 75mm high unless approved otherwise. Starter sections in watertight construction shall be 150mm high and cast integrally with the slab or footing.

## 3.4 Movement Joints

Concrete shall not be placed on both sides of a movement joint at the same time unless the method of doing so is approved.

## 3.5 Reinforcement

### 3.5.1 Cutting And Bending

Reinforcement shall not be bent without approval except as shown on the Drawings.

### 3.5.2 Fixing And Welding

Unless shown otherwise on the Drawings nominal concrete cover to reinforcement shall comply with SS EN1992 and SS EN 10080:2005.

All reinforcement shall be positively held in its correct position before concreting starts. Spacers between reinforcement and formwork shall be of either concrete or plastic unless otherwise approved. Plastic spacers shall be of approved design.

The Contractor shall supply and fix all chairs required to maintain the reinforcements in its correct position.

Reinforcement shall not be welded without approval.

Galvanised reinforcement shall not be welded.

Where concrete spacer blocks are required in exposed concrete they shall be made from the materials used in the surrounding concrete.

### 3.5.3 Rust Staining

Concrete surfaces which will be exposed to view in the finished Works shall be protected from staining due to rusting of projecting reinforcement either by coating the reinforcement with cement grout or by another approved method.

#### 3.5.4 Surface Condition

Reinforcement should not be surrounded by concrete unless it is free from mud, oil, paint, retarders, loose rust, loose mill scale, grease or any other substance which can be shown to affect adversely the steel or concrete chemically, or to reduce the bond. Reinforcement with pitted surfaces will be rejected.

#### 3.5.5 Corrosion Protection Of Rebars

All starter reinforcement and reinforcement projecting beyond all the construction joints are to be protected from corrosion by painting with anti-rust paint within 7 days after concreting.

### 3.6 Concreting

#### 3.6.1 Final Preparation And Inspection

Unless directed otherwise, the Contractor shall give notice before each concrete pour so that an examination by the Superintending Officer may be made before the concreting is placed.

#### 3.6.2 Transporting

Runs or gangways for concrete transporters, main runs for foot traffic and pipeworks for pumped concrete etc, shall not be supported or allowed to bear on the fixed reinforcement.

Concrete may be pumped subjected to the approval of the Superintending Officer. All pumping machinery shall be of an approved type. Complete set of standby equipment shall be provided in order to maintain a continuous concrete supply in the event of a breakdown. All machinery and pipes shall be kept clean and shall be thoroughly washed when concrete placing is completed. All pipework shall be so laid out that during concrete placing, a continuous "wet edge" is maintained.

The Contractor shall ensure that the construction load imposed on the bare steel decking will not cause damage and excessive deformation.

#### 3.6.3 Placing

Concrete shall be placed continuously up to construction joints while, in the opinion of the Superintending Officer, it is still sufficiently plastic or adequate compaction.

Care must be taken to prevent contamination and segregation.

#### 3.6.4 Compacting

Unless otherwise specified all structural concrete shall be compacted by mechanical vibrator of appropriate type.

The Contractor shall provide details of the type, size and number of vibrators to be used in the Works. Whenever concrete is being vibrated at least one spare vibrator of each type in use shall be available in case of breakdown.

Compaction shall start as soon as casting starts and shall continue during the placing operation so that at no time shall there be a large volume of un-compacted concrete in

the formwork.

#### 3.6.5 Cleaning

All equipment used for mixing, transporting, placing and compacting concrete shall be thoroughly cleaned before changing from one type of aggregate or cement to another and whenever mixing ceases.

### 3.7 Curing

#### 3.7.1 Curing Methods

The Contractor shall propose suitable methods of curing the cast concrete, which shall be subject to approval.

Concrete shall be cured by the application of an approved pigmented liquid membrane of the type specified in accordance with the manufacturer's written instructions, followed by wetting with water and then covering it as soon as practicable with a polythene sheeting, kept in contact with the concrete surface throughout the curing period, or by other approved methods.

On concrete surfaces exposed to direct sun temperatures the Contractor shall use a curing method, which also shields the concrete from the direct sun. This shall be placed in position no later than half an hour after final tamping.

If the surface exhibits cracking while the concrete is still plastic then it shall be re-tamped to close the cracks. The shield is to be shade or fog spraying, or an approved method, which achieves the same effect.

#### 3.7.2 Curing Periods

Unless the concrete is steam cured, curing procedures shall be maintained for a period of not less than 7 days after casting.

### 3.8 Protection From Rain

In the event that the concreting operation is carried out in inclement weather, the Contractor shall take all necessary precautions to protect the concrete from rain by providing tarpaulins, polythene sheets, etc whilst the concrete is being transported. Freshly placed concrete in the Works, which is exposed to weather shall be afforded similar protection. If it rains in the midst of the concreting operation, the Contractor shall temporarily suspend the concreting until all the abovementioned measures to protect the concrete from rain have been implemented. Prior to the commencement of Works on the Site, the Contractor shall submit his proposals for such rain protection for approval.

### 3.9 Concreting In Hot Weather

Special precautions shall be taken in hot weather.

Any formwork made of metal, concrete or other material of high thermal capacity shall be cooled with water before concrete is placed against it.

Curing shall commence immediately after compaction. Protection from direct radiation shall be in place within 30 minutes after final tamping.

### 3.10 Striking Of Formwork

### 3.10.1 General

Before any formwork is removed, the Contractor shall ensure that the concrete has attained sufficient strength for striking to proceed.

The Contractor shall carefully loosen complete sections of formwork, which can be removed without exerting pressure or stresses against corners, offsets or reveals and shall carefully remove all formwork ties. Prying against architectural or exposed concrete surfaces with tools is not permitted and the Contractor shall protect all sharp edges of concrete and in general maintain the integrity of the design.

The structure shall not be distorted, damaged or overloaded in any way by the removal of the formwork.

The responsibility for the safe removal of any part of the formwork or props shall rest with the Contractor.

### 3.10.2 Minimum Striking Period

The Contractor's method of measuring the surface temperature of the concrete shall be submitted for approval.

The earlier striking of forms (but not props) may be approved if the Contractor can show that this can be done without damage to the concrete.

The making and testing of extra cylinders to establish the period before striking shall be at the Contractor's expense. These cylinders shall comply with SS EN1992. Permission to strike formwork on the basis of the strength of specially cast cylinders will be withdrawn if the Superintending Officer is not satisfied that the strength of the cylinders is representative of the strength of the concrete.

### 3.11 Treatment Of Cast Concrete

No treatment of any kind, other than that required for curing the concrete, shall be applied to the concrete after removal of the forms unless otherwise approved in writing. The Contractor's methods of making good any defects are to be subjected to approval in each case.

## 4.0 QUALITY CONTROL

### 4.1 General (\*)

For all cement and reinforcement delivered to the Site the Contractor shall provide a copy of the manufacturer's certificates of tests carried out at the frequency and using the methods specified in the relevant Eurocodes.

Certificates for reinforcement shall be accompanied by details of the manufacturer's identification marks rolled into each brand of bar supplied. During the progress of the building operation, the Contractor shall arrange for tests on samples of cement and steel reinforcement to be carried out fortnightly.

All the tests of cement, aggregate, water, steel reinforcement, etc shall be carried out at laboratories accredited by PSB and the reports certified by its Professional Engineer.

### 4.2 Testing Facilities

The Contractor shall supply and maintain on Site the following equipment:

- a) Apparatus for making and curing concrete test cylinders, all in accordance with BS EN

12350-1.

- b) Testing of the concrete cylinder compressive strength in accordance with BS EN 12350-1 shall be conducted by an approved independent laboratory accredited under the Singapore Laboratory Accreditation Scheme for the above test by PSB.
- c) A maximum and minimum thermometer, to be sited close to the Works, for measuring atmospheric shade temperature.
- d) A soil thermometer for measuring ground and concrete temperatures.
- e) Apparatus for assessing the workability of concrete by the slump cone method in accordance with BS EN 12350-1.
- f) Apparatus for assessing the workability of concrete by the compaction factor method in accordance with BS EN 12350-1.
- g) Apparatus for assessing the flow of concrete in accordance with BS EN 12350-1.

If concrete is batched and mixed on Site, the Contractor shall provide all additional testing facilities necessary to verify compliance with the requirements of this section of the Contract Specification. These facilities shall be subject to approval.

#### 4.3 Testing Of Aggregates

##### 4.3.1 General

All sampling and testing of aggregates shall be carried out in accordance with BS EN 1097-3:1998 fortnightly. Rejected aggregates shall be removed from the Site.

##### 4.3.2 Preliminary Tests

As soon as the sources of supply of aggregates have been selected, the Contractor shall provide the information which shall include but not limited to the following:-

- a) Sieve analysis
- b) Tests for clay, silt and dust content
- c) Tests for salt content

The results of these tests shall be submitted for approval as soon as they are available.

Tests (a) and (b), with tests of the moisture content of each aggregate, shall be carried out on the samples used for each trial mix.

The Contractor shall submit for approval certificates of recent tests giving the following information about the aggregates:

Specific gravity  
Water absorption  
Ten percent fines value

##### 4.3.3 Works Tests

The Contractor shall carry out such tests on the aggregates as are necessary for the production of the specified concrete.

For the grades of concrete other than 10 and 15, the grading of each size of aggregate

from each pit, quarry or other source of supply shall be determined at least once weekly. The results of such tests shall be used to check whether the gradings are similar to those of the samples used in the establishment of the batch weights. The results of routine control tests carry out by the aggregate producer will be accepted for this purpose.

#### 4.4 Sampling And Testing

##### 4.4.1 General

The results of all tests shall be provided weekly.

##### 4.4.2 Strength (\*)

Samples shall be taken at point of discharge from the mixer or delivery vehicle, or at the point of placing the concrete, as directed.

Unless directed otherwise, the rate of sampling shall be the greatest of :

- a) One per 10m<sup>3</sup> or 10 batches, whichever is the lesser volume, for the first 40 samples of each grade of concrete.  
or
- b) one per 10m<sup>3</sup> of concrete placed in columns or cantilevers.  
or
- c) One per 50m<sup>3</sup> of concrete in beams and slabs (other than cantilevers) walls and footings.  
or
- d) One per 100m<sup>3</sup> of concrete in solid raft foundation.  
or
- e) One on each day that concrete of that grade is used.

Where more than one rate of sampling is carried out on the same concrete mix the results of all cylinder tests from these samples shall be considered together for assessments of compliance with the strength requirements of this Specification.

In addition, for each sample, one cylinder shall be made for testing at 7 days and 3 cylinders made for testing at 28 days.

##### 4.4.3 Workability (\*)

Tests shall be made at point of discharge from the mixer or delivery vehicle, or at the point of placing the concrete, as directed.

One test shall be made from each delivery, or each batch, whichever is the lesser volume.

#### 4.5 Compliance (\*)

Any concrete which does not comply with the requirements of SS EN1992, BS EN 206:2013 and this section of the Contract Specification will not be accepted, and shall be classified as

defective.

Where compressive strength is specified, compliance with the characteristic strength shall be assumed if the conditions given in both (a) and (b) are met, on top of compliance with requirements of SS EN1992, BS EN 206:2013 and :-

- (a) the average strength determined from any group of four consecutive test results exceeds the specified characteristic strength by :

3 N/mm<sup>2</sup> for concrete of grade C20 and above,  
2 N/mm<sup>2</sup> for concrete of grade C7.5 to C15

- (b) the strength determined from any test result is not less than the specified characteristic strength minus :

3 N/mm<sup>2</sup> for concrete of grade C20 and above,  
2 N/mm<sup>2</sup> for concrete of grade C7.5 to C15

If only one cylinder result fails to meet the second requirement then that result may be considered to represent only the particular batch of concrete from which that cylinder was taken provided the average strength of the group satisfies the first requirement.

If more than one cylinder in a group fails to meet the second requirement or if the average strength of any group of four consecutive test cylinder s fails to meet the first requirement then all the concrete in all the batches represented by all such cylinder s shall be deemed not to comply with the strength requirements. For the purposes of this section of the Contract Specification the batches of concrete represented by a group of four consecutive test cylinders shall include the batches from which samples were taken to make the first and the last cylinders in the group of four, together with all the intervening batches.

#### 4.6 Batching Plant

##### 4.6.1 Recalibration

The Contractor shall ensure that recalibration of the measuring equipment by the manufacturer or his agent is undertaken at intervals of not more than 3 months.

#### 4.7 Accuracy Of Construction

##### 4.7.1 General

Before work commences on Site, the Contractor shall submit for approval his methods of dimensional setting out, construction and checking which must be such that the tolerances achieved in the Works will comply with the Contract Specification.

All setting out of the Works shall be carried out by an independent registered land surveyor.

The Contractor shall provide all reasonable facilities to the Superintending Officer to allow him to carry out dimensional checks on the accuracy of construction, including the provision of plumbs, tapes, etc and the provision of equipment such as levels, theodolites, skilled labour needed for survey work. Any such checks carried out by the Superintending Officer will in no way relieve the Contractor of his responsibility for setting out the Works.

##### 4.7.2 References

At the beginning of the Contract, the Contractor shall establish an approved site datum

horizontal reference grid and benchmark on which all subsequent setting out and levelling on the Site shall be based.

The reference points shall be checked and certified by an independent registered land surveyor, approved by the Superintending Officer. The bench mark and reference points shall be adequately protected and shall not be disturbed, buried or removed during the course of the Contract.

#### 4.7.3 Measuring Equipment

An approved reference tape shall be kept to check the accuracy of all working tapes.

The Contractor shall ensure that all other setting out and measuring equipment is adequate to achieve the accuracies required by this section of the Contract Specification.

#### 4.7.4 Dimensions Of Completed Work

The Contractor shall keep records in an approved form of the dimensions of all work as constructed.

These records shall be available for inspection at any time and shall be submitted immediately after completion of each section as directed.

#### 4.7.5 Permissible Deviation (PD) Of Structural Work

All work shall be constructed within the permissible deviation specified below :

##### a) Foundation

Reinforced concrete, pile caps

- |      |  |                   |
|------|--|-------------------|
| i)   | Position on plan. PD in plan of any point measured from the nearest reference grid line.   | $\pm 25\text{mm}$ |
| ii)  | Dimensions on plan. PD per 300mm   | $\pm 10\text{mm}$ |
|      | Maximum permissible deviation  | $\pm 25\text{mm}$ |
| iii) | Levels. PD in level of upper surface with reference to the nearest transferred bench mark. | $\pm 20\text{mm}$ |

##### b) Elements or Components above Foundations

- |      |   |                   |
|------|---|-------------------|
| i)   | Position on plan. PD in plan of any point measured from the true reference grid line at the base          | $\pm 10\text{mm}$ |
| ii)  | Verticality Plumbness in height of up to and including 0.5m   | $\pm 3\text{mm}$  |
|      | Over 0.5m up to and including 1.5m  | $\pm 5\text{mm}$  |
|      | Over 1.5m up to and including 15m   | $\pm 10\text{mm}$ |
|      | Over 15m up to and including 150m   | $\pm 15\text{mm}$ |
| iii) | Cross section, linear dimensions and openings.<br>PP from dimensions of beams, slabs, columns and walls : |                   |

	Up to and including 300mm	$\pm 3\text{mm}$
	Over 300mm up to and including 600mm	$\pm 5\text{mm}$
	Over 600mm up to and including 1.5m	$\pm 5\text{mm}$
	Over 1.5m	$\pm 10\text{mm}$ (max)
	The top surface of the slab shall be levelled between beams so that the maximum out of flatness when measured with a 3m straight edge laid perpendicular to beam axes is 3mm.	
iv)	Bow and camber other than designed camber. PD of any point of the surface from a straight line joining the extremities of that surface.	
	For extremities up to and including 3m apart	$\pm 10\text{mm}$
	Over 3m up to and including 9m apart	$\pm 15\text{mm}$
	Over 9m	$\pm 20\text{mm}$ (max)
v)	Twist (distance of any one corner from the plane containing the other three corners)	
	For diagonal up to and including 3m	5mm
	For diagonal over 3m up to and including 8m	10mm
	For diagonal over 8m	15mm (max)
vi)	Squareness of corner (the longer of two adjacent sides should be taken as the base line, and the PD of the shorter side from a perpendicular to the base line is to be related to the length of the shorter side).	
	Short side up to and including 0.5m	$\pm 5\text{mm}$
	Over 0.5m up to and including 2m	$\pm 10\text{mm}$
	Over 2m	$\pm 10\text{mm}$ (max)
vii)	Level (PD from designed level with reference to the nearest TBM)	
	Length up to and including 8m	$\pm 5\text{mm}$
	Over 9m up to and including 15m	$\pm 10\text{mm}$
	Over 15m	$\pm 15\text{mm}$ (max)

#### 4.7.6 Checking Verticality, Eccentricity And Levels Of The Structures

During the progress of the construction, the Contractor shall check the levels and eccentricity of all the pile caps. Such checking shall be carried out with appropriate survey equipment by an independent registered land surveyor as soon as the structural

works are completed.

The Contractor shall submit surveyor's reports and field readings compiled in an approved format to the Superintending Officer. Such reports shall indicate the levels, verticality, eccentricity and deviation, if any, of the structures.

The checking of the levels, verticality and eccentricity of the structures and the submission of such reports to the Superintending Officer shall not relieve the Contractor of any of his duties or responsibilities under the Contract.

#### 4.8 Defective Work

##### 4.8.1 General

Where, in the opinion of the Superintending Officer, any of the finished Works, or the materials or workmanship in any part of the Works fails to comply with this Specification, that part of the Works will not be accepted and shall be classified as defective.

All work classified as defective shall be cut out and removed from the Works and replaced or otherwise dealt with in an approved manner.

##### 4.8.2 Testing for Watertightness

On completion of the structural works of all the swimming pools, inspection chambers and grease traps etc, which are made of concrete, and prior to the application of any waterproofing membranes and rendering, the interior of the concrete enclosure shall be filled full with water and a period allowed for absorption. A test period of 7 days should then follow, during which the exposed faces should show no signs of leakage and remain dry when the interior faces are fully immersed in water. In the case of basement walls and slabs, the interior should be completely dry with water outside up to the ground level.

Any presence of water including dampness on the surfaces of the exposed faces shall be classified as defective.

##### 4.8.3 Unacceptable Appearance

Where for any reason the casting of a part of the work is interrupted before the designed position of a construction joint is reached and the intended appearance of the concrete is thereby spoilt that part of the work will not be accepted.

Any surface, which is marred by rubbish left in the mould and (when using smooth surface formwork) any surface, which is discoloured by leakage of water or grout or dampness will be treated as defective work.

#### 4.9 Load Tests

Test procedures and standards of acceptance will be as directed.

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## STRUCTURAL STEELWORK SPECIFICATION

### 1.0 GENERAL

#### 1.1 Description Of The Works

To supply, fabricate and erect all the structural steelwork as shown on the Contract Drawings.

#### 1.2 Design

The structural steelwork shown on the Drawings and described in this Specification has been designed to SS EN 1993.

#### 1.3 Definitions

##### 1.3.1 Shop Drawings

Drawings showing all necessary information to fabricate and erect the structural steelwork including drawings showing the dimensional layout of the steel structure and which correlate the piece markings with the location in the structure.

##### 1.3.2 Inspecting Authority

Shall mean an organisation/laboratory accredited under the Singapore Laboratory Accreditation Scheme (SINGLAS), and fully equipped to carry out all tests and checks required by this Specification.

#### 1.4 Contractor's Drawings

Approval by the Superintending Officer of drawings prepared by the Contractor does not relieve the Contractor of the responsibility for accuracy of detail dimensions on the Contractor's drawings, nor for the general fit-up of parts to be assembled on Site.

#### 1.5 Quality Assurance/Quality Control

All the clauses in this Specification are mandatory. They describe an acceptable level of quality to be achieved by the Contractor, and they describe the tests that the Contractor shall carry out to demonstrate that he has achieved the required quality.

#### 1.6 Substitutions

No substitutions to the Specification or Contract Drawings may be made without approval.

#### 1.7 Commencement Of The Work

No item of work shall be commenced until the results of any related preliminary tests required by the Specification have been approved.

#### 1.8 Sub-Letting

No work shall be sublet without prior approval by the Superintending Officer.

#### 1.9 Redundant Materials

Redundant materials shall be all materials procured, fabricated and/or delivered to site but not installed which due to amendments in design, such materials could not be altered re-welded or re-formed for re-use. The Superintending Officer's approval is required for establishing the extent

and details of redundant materials.

The Contractor shall be required to show proof to the Superintending Officer all materials he deems to be redundant and provide for all incidental costs necessary for the verification by the Superintending Officer.

## 2.0 GENERAL REQUIREMENTS

### 2.1 Code Of Practice

Comply with SS EN 1993 and specifications in SS EN 1994. In cases of conflict, the requirements of this specification take precedence.

### 2.2 Connection Details

Design and detail those connections, which are not shown on the Contract Drawings. The type of joint is to follow the form of the typical details shown on the Contract Drawings and is to be designed to carry loads, which shall be specified. All details designed by the Contractor are to be substantiated by full calculations certified by a Professional Engineer registered in Singapore.

### 2.3 Temporary Works

Design, fabricate, erect and remove all temporary works. The Contractor shall engage a Professional Engineer registered in Singapore for the design and supervision of the erection of all temporary works and he shall be responsible for ensuring the safety and stability of the structure during all stages of the construction.

### 2.4 Construction Information

#### 2.4.1 Fabrication

Provide the following information at least 2 weeks before commencing fabrication.

- i) Complete and coordinated Shop Drawings.
- ii) Calculations to substantiate connections detailed by the Contractor.
- iii) Detailed method statements for fabrication.
- iv) Details of welding procedures in accordance with SS EN 1993 and BS EN 1990 for all welds, including tack and sealing welds.
- v) Details of proposed shop inspection system and non-destructive testing arrangements.

No steelwork shall be fabricated until final approval of the above item has been received by the Contractor.

#### 2.4.2 Erection

Provide the following information at least 2 weeks before commencing erection.

- i) Detailed method statement for erection, including type of craneage.
- ii) Detailed drawings and calculations for all temporary works.
- iii) Details of proposed site inspection system.

#### 2.4.3 As-Built Drawings

Provide as-built drawings which show the Contract Works as finally fabricated and erected.

## 2.5 Programme

### 2.5.1 Detailed Programme

Provide a detailed programme to show the planned timing of the various items of work to be done, including :

- i) Preparation and submission of construction information
- ii) Order and delivery of materials
- iii) Fabrication
- iv) Application of protective coatings
- v) Transport to Site
- vi) Erection

### 2.5.2 Inspection And Testing

Include in the programme the necessary time for all procedural trials, inspection and testing, and trial assemblies.

### 2.5.3 Progress

Arrange the programme so that actual progress can be monitored against each item.

## 2.6 Quality Control

### 2.6.1 Inspection System

Operate an inspection system to verify that all materials, workmanship and completed work conform with the specified requirements.

### 2.6.2 Tests, Procedural Trials, Trial Assemblies

Carry out or arrange to be carried out all tests on operatives, procedural trials, tests on materials and workmanship and trial assemblies.

### 2.6.3 Personnel

Ensure that all personnel performing inspections and tests have appropriate qualifications, experience or training.

### 2.6.4 Inspection Status

Operate a system for identifying the inspection status at all stages of fabrication and erection.

### 2.6.5 Records

Keep records of all tests on operatives, procedural trials and tests on materials and workmanship. Make records available to the Superintending Officer for examination.

### 2.6.6 Period Of Notice

Agree a period of notice to the Superintending Officer for all tests and before commencing any trial assembly.

#### 2.6.7 Quality Manual

The Contractor's quality programme shall be defined in a Quality Manual in which the organisational plan, systems and procedures are fully described to ensure that all essential quality control activities as described above in Clause 2.6.1 to 2.6.5 are consistently and accurately carried out throughout all phases of the work.

As a minimum, the Quality Manual shall include information and procedures under the following heading :-

Organisation and Management

Facilities, Measuring and Test Equipment

Personnel Training and Certification

Documentation

Receipt, Storage, Handling and Transportation

Materials

Welding

Fabrication and Erection

Painting and Coating

Inspection

Non-Conforming Items

An outline of the Quality Manual including brief descriptions under each of these categories shall be submitted with the Contractor's tender.

The Contractor shall produce the fully comprehensive Quality Manual within 4 weeks of the award of the contract.

#### 2.7 Welds

Welds to be 6mm continuous fillet welds unless otherwise noted. But welds are to be complete penetration butt welds unless otherwise noted.

#### 3.0 MATERIALS - SECTIONS, PLATES, BARS AND PURLINS

##### 3.1 Hot Rolled Sections, Plates And Bars

Steel to EN 10025: 1990. Quality Grade 43A, 50B & 50C as noted on the Contract Drawings.

##### 3.2 Dimensions And Tolerances

###### 3.2.1 Plates And Bars

To comply with EN 10025: 1990.

###### 3.2.2 Hot Rolled Sections

To comply with EN 10025: 1990.

#### 3.2.3 Angler

To comply with EN 10025: 1990.

#### 3.2.4 Hot Rolled Hollow Sections

To comply with EN 10025: 1990.

#### 3.2.5 Cold Rolled Sections

To comply with EN 10025: 1990.

### 3.3 Condition of Steel

Steel for fabrication is not to be more heavily pitted or rusted than Grade C of Swedish Standard 05 59 00. The same standard shall apply to condition of erected steelwork prior to encasement where applicable.

## 4.0 MATERIALS - STRUCTURAL FASTENERS

### 4.1 Ordinary Bolts And Nuts

All bolts to comply with EN 10025 : 1993 and SS EN 1993 and to be Grade 8.8 snug tightened unless specifically noted otherwise.

### 4.2 Grade 8.8 Bolts

Unless specifically called for by Contract Drawings, all bolts to be grade 8.8.

### 4.3 High Strength Friction Grip (HSFG) Bolts

Where specifically called for by the Contract Drawings, and in all connections to plant room beams, unless otherwise noted, bolts to be high strength friction grip.

### 4.4 Washers

Use plain and tapered steel washers to EN 15048 with ordinary bolts.

### 4.5 Spring Washers

To EN 15048.

### 4.6 Load Indicating Washers

Use 'Cornet' load indicating washers manufactured by Cooper and Turner in friction grip joints.

### 4.7 Surface Finish

Galvanised : bolt assemblies in externally exposed locations & plant rooms are to be galvanised in accordance with relevant standards to Eurocode.

All other bolt assemblies to be either zinc or cadmium plated. Electroplating is to comply with relevant standards to Eurocode.

In addition to all other testing requirements, galvanised grade 8.8 bolts and galvanised HSFG bolts shall be tested for head soundness and also subjected to supplementary tensile testing to confirm their mechanical properties. Tests are to be carried out on 1% of total number in each batch of galvanised bolts.

#### 4.8 Anchor Bolts

Anchor bolts to concrete structure shall be in accordance with the HILTI Fastening Manual, or approved equivalent.

#### 5.0 MATERIALS - WELDING CONSUMABLES

##### 5.1 Welding Consumable

###### 5.1.1 Welding Consumables

All welding consumables used for the arc welding of carbon and carbon manganese steels are to comply with EN1011-2:2001.

###### 5.1.2 Mechanical Properties

Welding consumables and procedures are to give mechanical properties for the deposited weld metal not less than the minima specified for the parent metal.

#### 6.0 MATERIAL - GROUT

##### 6.1 Grout

Grout around foundation bolts and under column base plates is to have a minimum compressive strength at 28 days of 65 N/mm<sup>2</sup>. The grout is to be Conbextra GP manufactured by Fosroc Group of Companies, or approved equivalent.

#### 7.0 WORKMANSHIP - IDENTIFICATION, STORAGE AND HANDLING

##### 7.1 Identification

###### 7.1.1 Marking

Mark and document all materials to ensure that they are used as specified.

###### 7.1.2 Additional Paint Marking

Where appropriate, steel is to have the additional paint marking described in EN 10025: 1990.

###### 7.1.3 Location Of Marks

Piece markings are to be in position, which are not masked by other material after erection.

###### 7.1.4 Hard-stamping

Mark steel which is to be blast-cleaned, acid-pickled, metal-sprayed or galvanised by hard-stamping using 'low stress' stamps. Marks are to be of adequate depth to prevent obliteration.

## 7.2 Storage

### 7.2.1 Holding Areas

Lay out steelwork in separate holding areas and keep clean.

### 7.2.2 Support

Steelwork is to be adequately supported clear of the ground. Individual piece markings are to be visible when members are stacked.

## 7.3 Handling

Plan and carry out bundling, packing, handling and transport in a manner designed to prevent damage to the steelwork and any protective coating.

## 8.0 WORKMANSHIP - GENERAL

### 8.1 Cutting

#### 8.1.1 Process

Cut steel by an automatic or semi-automatic process.

#### 8.1.2 Hand Flame Cutting

Use only where it is impractical to use machine flame cutting.

### 8.2 Dressing

#### 8.2.1 Dressing The Edges

Dress the edges of all plate cut by flame to remove slag, scale, irregularities and excessive hardening. The hardness value after dressing for flame cut surfaces of all grades of steel is not to exceed 350 HV when tested to BS 427 : Part 1 with 10 kgf.

#### 8.2.2 Grinding

Remove burrs, sharp arises and ragged edges by grinding.

### 8.3 Bearing

#### 8.3.1 Compression Joints

Joints that depend on contact bearing are to have the bearing surfaces prepared to a common plane by milling, sawing or other suitable means. The bearing surfaces are to be at right angles to the nominal axis of the member or such other angles noted on the Contract Drawings.

No work needs to be carried out on a bearing surface, which is to be grouted direct to a foundation.

#### 8.3.2 Stiffeners

Cut and grind bearing stiffeners to ensure a tight bearing along edges in contact with flanges.

#### 8.4 Straightening And Pre-Cambering

##### 8.4.1 Properties

No straightening or pre-cambering is to be carried out in a manner, which may result in material properties that do not conform with the specified requirements for the as-supplied material.

##### 8.4.2 Procedures

Provide straightening and pre-cambering procedure before commencement of the work.

#### 8.5 Heating

##### 8.5.1 Properties

No heating is to be carried out which may result in material properties that do not conform with the specified requirements for the as-supplied material.

##### 8.5.2 Procedures

Provide heating procedures before commencement of the work.

#### 8.6 Temporary Attachments

All temporary attachments required for fabrication or erection, are to be shown on shop drawings and subject to approval. Temporary attachments are to be removed after use. Removal of welded attachments is to comply with BS EN 12062.

#### 8.7 Accuracy of Fabrication

##### 8.7.1 Accuracy

Fabricate steelwork to an accuracy that will enable erection within the specified limits to take place without inducing excessive stresses, deflection or distortion into the structure.

##### 8.7.2 Built-Up Members

Tolerances on built-up members, including castellated beams, are to comply with SS EN 1993.

##### 8.7.3 Length

Members with both ends prepared for contact bearing are not to deviate from the detailed length by more than 1mm.

##### 8.7.4 Straightness

The deviation of a member from a straight line drawn between adjacent points of subsequent effective lateral restraints is not to exceed the greater of 3mm or 0.1% of the distance between restraints unless noted otherwise on the drawings.

##### 8.7.5 Camber

The deviation from specified or proposed camber is not to exceed 5mm.

#### 8.7.6 Compression Joints

Joints that depend on tight bearing contact when assembled are to be fabricated and milled such that when the flatness is measured against a straight edge laid against the full length bearing surface in any direction :-

- i) Over at least 50% of the length the gap does not exceed 0.25mm.
- ii) Over 90% of the length the gap does not exceed 0.75mm.

#### 8.8 Sealing Of Hollow Sections

The ends of all hollow sections shall be sealed with 4mm end plates.

### 9.0 WORKMANSHIP - WELDING

#### 9.1 General

##### 9.1.1 Arc Welding

Arc welding of carbon and carbon manganese steels is to comply with SS EN 1011.

##### 9.1.2 Welding Technologist

Welding is to be carried out under the direction of a welding technologist with appropriate qualifications, experience or training.

#### 9.2 Welding Procedures

##### 9.2.1 Welding Procedures

The Contractor shall carry out procedure tests in accordance with BS EN 287. The test weld shall include weld details from the actual construction and it shall be welded in a manner simulating the most unfavourable instances of fit-up, electrode conditions, etc. The welding procedure test shall be carried out on material with the highest carbon equivalent. After welding but before the relevant tests given in BS EN 287: Part 1 are carried out, the test weld shall be held at room temperature for not less than 72 hours.

##### 9.2.2 Distortion

Welding procedures and sequence of fabrication are to be such that distortion is reduced to a minimum.

#### 9.3 Welders

Evidence shall be submitted of welders' competence to undertake the specified work. Welders shall have been tested to BS EN 287.

#### 9.4 Welding Consumables

Store, handle and use in accordance with the manufacturer's recommendations.

#### 9.5 Tack Welding

To comply with SS EN 1011.

## 9.6 Temporary Attachments

Welding of temporary attachments required for fabrication or erection is to comply with SS EN 12062.

## 9.7 Butt Welds

Where possible, use run-on and run-off plates in making butt welds to ensure full throat thickness at the ends. They are to comply with the following requirements:

- i) The Specification for the plates is to be identical to that for the material being welded.
- ii) The plates are to be prepared in the same manner as the parts being joined.
- iii) After completion of welding the plates are to be removed by cutting. The surfaces where they were attached are to be ground smooth and inspected for cracks.

## 9.8 Removal Of Slag

Remove slag by light hammering, wire brushing or other methods that do not deform the surface of the weld.

## 10.0 WORKMANSHIP - BOLTING

### 10.1 Holes

#### 10.1.1 Forming

Drill or punch and ream all holes unless agreed otherwise.

#### 10.1.2 Size

Holes for ordinary bolts are to be of diameter not more than mm greater than the diameter of the bolt for bolts up to and including 24mm diameter, and not more than 3mm greater than the diameter of the bolt for bolts over 24mm diameter, except in steel base plates and where noted on the Drawings.

#### 10.1.3 HSFG Fasteners

Holes are to comply with SS EN 1993.

#### 10.1.4 Drifting

Drifting to align holes is not to enlarge the holes or distort the metal. Drifts shall not be used to correct gross misalignment of holes.

### 10.2 Holes In Hollow Sections

Seal bolt holes and vent holes in hollow sections to prevent the ingress of moisture. If not being specified on the Contract Drawings, show the proposed method on the Shop Drawings.

### 10.3 Make-Up Of Bolt Assemblies

For all bolt assemblies the strength grade combination of bolt/nuts/washers is to be prescribed as per Eurocode recommendations.

#### 10.4 Condition Of Bolts

Bolt assemblies are to be in such condition immediately before installation that the nut turns freely on the bolt.

#### 10.5 Galvanised Nuts

Re-tap nuts in galvanised bolt assemblies after galvanising.

#### 10.6 Washers

##### 10.6.1 Bolt Assembly

Each bolt assembly is to contain at least one washer placed under the part being rotated.

##### 10.6.2 Taper Washers

Place under bolt heads and nuts bearing on surfaces sloping 3° or more from a plane at right angles to the bolt axis. Taper washers are to be prevented from rotating during tightening.

#### 10.7 Installation Of Spring Washers

Tighten bolt assemblies containing spring washers until the spring washer is completely flattened.

#### 10.8 Locking Of Nuts

Secure nuts used in connections subject to vibration or reversal of stresses to prevent loosening. If not specified on the Drawings, include the proposed method in the erection details.

#### 10.9 Limits To length

The length of bolts is to be such that at least one clear thread shows above the nut after tightening, and at least one thread plus the thread run out is clear between the nut and the unthreaded shank of the bolt.

#### 10.10 Movement Connections

##### 10.10.1 Slotted Holes

Where slotted holes are provided for movement connections, the joint is to be free to move.

##### 10.10.2 Method

Make slotted movement connections in the following manner :

- i) The slotted holes is to be wider than the un-slotted hole.
- ii) A shouldered bolt is to be used, with a spring washer under the head and the shoulder bearing on the faying surface of the un-slotted member.
- iii) A flat washer is to be provided under the nut and the nut tightened onto the un-slotted member.

#### 10.11 High Strength Friction Grip (HSFG) Fasteners

10.11.1 Use

The use of high strength friction grip bolts is to comply with SS EN 1993.

10.11.2 Tightening Method

Tighten High Strength Friction Grip bolts using the "load indicating washer" method.

10.11.3 Load Indicating Washers

Use in accordance with the manufacturer's recommendations.

10.11.4 Discarded Bolt Assemblies

If after tightening a bolt or nut is slackened off for any reason the complete bolt assembly is to be discarded and not re-used in the Sub-Contract Works.

10.12 Faying Surfaces For HSFG Fasteners

10.12.1 Mill-Scale

Remove all mill-scale from the faying surfaces of friction grip joints.

10.12.2 Slip Factor

The faying surfaces of friction grip joints are to be free of distortion, deformities or contaminants, which may reduce the slip factor below the design value.

10.12.3 Deformed Surfaces

Machine flat to ensure a slip factor after machining greater than or equal to the design value. Carry out tests to SS EN 1993 to determine the slip factor after machining.

11.0 WORKMANSHIP - ERECTION

11.1 General

11.1.1 Position Of Adjoining Work

Check before erection of any steelwork that work abutting the steelwork to be erected has been correctly placed in position and level.

11.1.2 Erection Sequence

The erection sequence shall comply with the assumed sequence shown on the Contract Drawings.

11.2 Foundation Bolts

11.2.1 Setting-In

Hold foundation bolts firmly in position during all setting-in operations.

11.2.2 Damage

Protect bolts, threads and nuts against damage, corrosion and contamination at all

stages of construction.

11.2.3 Pockets

Keep pockets formed around foundation bolts clean and free from all extraneous matter.

11.2.4 Template

The Contractor shall use templates in setting in foundation bolts.

11.3 Erection Stresses

Do not exceed the stress limits given in SS EN 1993 during handling and erection.

11.4 Temporary Works

11.4.1 Loadings

Ensure that the steelwork is adequately braced or restrained to withstand all loadings, which are liable to be encountered during construction without inducing excessive stresses, deflection or distortion in the structure.

11.4.2 Removal

Leave any temporary works in position until such time as construction is sufficiently advanced to allow its safe removal.

11.4.3 Connections

Any connections for temporary works are not to weaken the permanent structure or impair serviceability.

11.5 Alignment

Align each part of the structure as soon as practicable after it has been erected. Do not make permanent connections between members until sufficient of the structure has been aligned, levelled, plumbed and temporarily connected to ensure that members will not be displaced during the subsequent erection or alignment of the remainder of the structure. Where misalignment of bolt holes occurs, submit proposals for remedial action to Superintending Officer for approval.

11.6 Temperature Adjustments

Take due account of the effects of temperature on the structure and measuring equipment when measurements are made for setting-out and erection, and for dimensional checks carried out subsequently.

11.7 Packings

11.7.1 Packs And Wedges

Plumb and level all columns using steel packs and wedges not larger than necessary for the purpose and of adequate strength and stiffness.

11.7.2 Grouting

Where packings are to be left in position and subsequently grouted, they are to be placed such that they are totally enclosed by the grout.

## 11.8 Grouting

### 11.8.1 Grouting

Do not carry out grouting under column base plates until a sufficient portion of the structure has been aligned, levelled, plumbed and adequately braced by other structural components which have been levelled and are securely held by their permanent connections.

### 11.8.2 Space Under Base Plate

Immediately before grouting, the space under column base plates is to be clean and free of all extraneous matter.

### 11.8.3 Proprietary Grout

Prepare, Mix and place in accordance with the manufacturer's recommendations.

## 11.9 Sliding Surfaces

Treat the sliding surfaces of uncoated expansion joints with molybdenum disulphide grease before making the connection.

## 11.10 Thermal Cutting

Do not use thermal cutting equipment on site unless agreed otherwise for specific applications.

## 11.11 Site Welding

No site welding shall take place unless shown on the Contract Drawings or otherwise approved. Where site welding is required or permitted the Contractor shall submit details of staging, platforms and weather protection of welders and materials. Site welding shall be subject to all the requirements of welding defined in this Specification.

## 11.12 Accuracy Of Construction

Erect steelwork within the following limits. Make all necessary allowances and adjustments to achieve this accuracy.

### 11.12.1 Base Of Column

The position in plan of a column at the base is not to deviate from the specified position by more than 5mm.

### 11.12.2 Level Of Base Plate

The level of the underside of a column base plate is not to deviate from the specified level by more than 5mm.

### 11.12.3 Space Beneath Base Plate

To be not less than 25mm and not more than 50mm without prior approval of Superintending Officer.

### 11.12.4 Column Verticality

The deviation of a column is not to exceed the lesser of 20mm or 1/600 of the column height.

11.12.5 Position On Plan

Members other than columns are not to deviate from their specified position on plan relative to the columns to which they are connected by more than 5mm.

11.12.6 Level

The level of the top of the steelwork at any location is to be within 10mm of the specified level, and is not to vary by more than 0.1% unless noted otherwise on the Contract Drawings.

11.12.7 Difference In Level

The difference in levels between two or more beams meeting at a column is to be less than 5mm unless noted otherwise on the Contract Drawings.

11.13 Dimensional Adjustments

All steelwork dimensions shown on the Contract Drawings refer to the completed building at 25°C.

12.0 QUALITY CONTROL

12.1 Test Certificates

12.1.1 Steels

Provide test certificate to demonstrate that steels used in the Contract Works conform with this Specification.

12.1.2 Bolts

Provide test certificates to demonstrate that bolts used in the Contract Works conform with this Specification.

12.2 Additional Tests On Steels

12.2.1 Additional Tests

In the areas noted on the Contract Drawings, and where required by the Contractor to prevent the formation of lamellar defects during welding, the material is to be subject to the following additional tests:

- i) Ultrasonic grading to BS 5996, Grade L4.
- ii) Through-thickness tensile tests to BS 6780, Level 225.

12.2.2 Testing Standards

Tests are to be carried out by an approved agency.

12.3 Scope Of Weld Examination

12.3.1 Butt Welds

Subject to the following non-destructive examinations :

- i) Visual inspection to BS 5289.
- ii) Ultrasonic examination to BS 3923 : Part 1 or to an equivalent standard. Ultrasonic examination of all butt welds shall include the parent material to a distance of 3t on

each side of the weld to confirm the absence of both laminations and lamellar tearing. The presence of either shall be considered as planar flaws and thus a cause for rejection.

#### 12.3.2 Fillet Welds

Subject to the following non-destructive examinations :

- i) Visual inspection to BS 5289.
- ii) Penetrant test to BS 6443 or magnetic particle test to BS 6072.
- iii) Ultrasonic examination to BS 3923 : Part 1 or to an equivalent standard for welds with a leg length of 12mm or larger. Ultrasonic examination of all fillet welds of 12mm leg length or larger shall include the parent material to a distance of 3t confirm the absence of both laminations and lamellar tearing. The presence of either shall be considered as planar flaws and thus a cause for rejection.

#### 12.3.3 Inspecting Authority

Examination of welds is to be carried out by approved personnel under Clause 1.3.2.

#### 12.3.4 Records

Keep records of all weld examinations, and make available for review.

### 12.4 Defect Acceptance Criteria

#### 12.4.1 Ultrasonic Examination

Welds subject to ultrasonic examination are to satisfy the following criteria :

- i) The weld is to have no reflectors, which could be interpreted as planar defects such as cracks, tears, lack of fusion or lack of penetration.

A planar defect is deemed to be any flaw whose thickness is less than 25% of its width.

N.B. In the case of partial penetration welds the nominated un-fused land shall not be subject to rejection. The amount of un-fused land is to be measured and recorded. It is not to exceed the nominated width.

- ii) All volumetric defects, where the thickness is equal to or greater than 25% of its width, are to be sized and the weld rejected if :
  - a) the width exceeds 6mm or  $T/6$ , whichever is the lesser , or
  - b) where the width exceeds 1.5mm (but is less than 6mm or  $T/6$ , whichever is the lesser), the length exceeds 20mm.  
(T = Plate Thickness mm)
- iii) Two adjacent defects, if not separated by at least twice the length of the longer defect, are to be regarded as one continuous defect.
- iv) A defect is not to begin at a distance less than twice its own length from the end of the weld.

#### 12.4.2 Magnetic Particle Or Penetrant Examination

Welds subject to magnetic particle or penetrant examination are to satisfy the following criteria :

- i) The weld is to have no cracks, tears, or lack of fusion.
- ii) Any undercut is to be intermittent and not greater than 0.5mm deep.
- iii) The sum of diameters of piping or porosity is not to exceed 10mm in any linear 25mm of weld and 20mm in any 300mm length of weld.
- iv) The maximum length of a single defect is to be less than 2/3 of the effective throat of the weld up to a maximum of 20mm.
- v) The defect is to be further than three times the large of its own width or length from the end of the weld or from an adjacent defect.
- vi) Any indication, which is believed to be spurious is to be regarded as a defect unless on re-evaluation by the same method or by an alternative technique subsequent to surface dressing the indication has been removed.
- vii) Any defect, which appear to be subsurface are to be exposed by surface grinding to display their nature, full size, and shape.

#### 12.5 Frequency Of Weld Examination

##### 12.5.1 Visual Inspection

Visually inspect all welds.

##### 12.5.2 Non-Destructive Examination

Frequency of non-destructive examination is to be as follows :-

- i) Full penetration butt welds ] 100% min Ultrasonic
- ii) Partial Penetration butt welds and  
fillet welds with a leg length greater than 12mm ] 50% min. Ultrasonic  
]
- iii) Fillet welds - 25% min. magnetic particle or penetrant inspection.

##### 12.5.3 Selection Of Welds To Be Examined

Where there is a requirement for less than 100% examination the method of selection of welds to be examined is to be agreed with the Superintending Officer before commencement of Work.

Where examination reveals unacceptable defects in a joint, examine two additional joints in the group represented by the joint. If the results on these two additional joints are acceptable then the original weld may be repaired and re-examined by similar means. If the non-destructive examination of the two additional joints reveals unacceptable defects, examine each joint in the group.

#### 12.6 Bolted Connections

Following complete assembly of all bolted connections, check the fit and tightness of at least

5% of the bolts at locations to be agreed with the Superintending Officer.

13.0 LIST OF CODES AND STANDARDS

13.1 British Standards

BS 4	Structural Steel Sections. Part 1 : Specification For Hot Rolled Sections
BS 427	Method For Vickers Hardness Test. Part 1 : Testing Of Metals
BS 729	Hot Dip Galvanised Coatings On Iron And Steel Articles.
BS 1449	Steel Plates, Sheet And Strip. Part 1 : Specification For Carbon And Carbon Manganese Plate, Sheet And Strip.
BS 1706	Electroplated Coatings Of Cadmium And Zinc On Iron And Steel.
BS 2853	The Design And Testing Of Steel Overhead Runway Beams.
BS 2989	Specification For Continuously Hot-Dip Zinc Coated And Iron-Zinc Alloy Coated Steel : Wide Strip, Sheet/Plate And Slit Wide Strip.
BS 2994	Specification For Cold Rolled Steel Sections.
BS 3382	Electroplated Coatings On Threaded Components.
BS 3923	ISO Metric Precision Hexagon Bolts, Screws And Nuts.
BS 3923	Methods For Ultrasonic Examination Of Welds. Part 1 : Manual Examination Of Fusion Welds In Ferritic Steels
BS 4190	ISO Metric Black Hexagon Bolts, Screws And Nuts.
BS 4320	Metal Washers For General Engineering Purposes.
BS 4360	Specification For Weldable Structural Steels.
BS 4395	High Strength Friction Grip Bolts And Associated Nuts And Washers For Structural Engineering. Part 1 : General Grade Part 2 : Higher Grade Bolts And Nuts And General Grade Washers Part 3 : Higher Grade Bolts (Waisted Shank), Nuts And General Grade Washers
BS 4464	Spring Washers For General Engineering And Automobile Purposes (Metric Series)
BS 4604	The Use Of High Strength Friction Grip Bolts In Structural Steelwork. Metric Series. Part 1 : General Grade Part 2 : Higher Grade Bolts And Nuts And General Grade Washers Part 3 : Higher Grade Bolts (Waisted Shank), Nuts And General Grade Washers

BS 4848	Hot-Rolled Structural Steel Sections. Part 2 : Hollow Sections Part 4 : Equal And Unequal Angles
BS 4870	Specification For Approval Testing Of Welding Procedures.
BS 4921	Sherardized Coatings On Iron And Steel Articles.
BS 4933	ISO Metric Black Cup And Countersunk Head Bolts And Screws With Hexagon Nuts.
BS 5135	Specification For the Process Of Arc Welding Of Carbon And Carbon Manganese Steels.
BS 5289	Code Of Practice For Visual Inspection Of Fusion Welded Joints.
BS 5950	Structural Use Of Steelwork In Building. Part 1 : Code Of Practice For Design In Simple And Continuous Construction : Hot Rolled Sections Part 2 : Specification For Materials, Fabrication And Erection : Hot Rolled Sections
BS 5996	Methods For Ultrasonic Testing And Specifying Quality Grades Of Ferritic Steel Plate.
BS 6072	Method For Magnetic Particle Flaw Detection.
BS 6363	Specification For Welded Cold Formed Steel Structural Hollow Sections.
BS 6443	Method For Penetrant Flaw Detection.
BS 6780	Specification For Through-Thickness Reduction Of Area Of Steel Plates And Wide Flats.

### 13.2 Euro Standards

BS EN ISO 8501	Preparation of steel substrates before application of paints and related products.
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### 14.0 TO 19.0 NOT USED

### 20.0 CORROSION PROTECTION : GENERAL

#### 20.1 Definitions

##### 20.1.1 DFT

Minimum dry film thickness of a paint coating means minimum local thickness of a sprayed metal or galvanise coating.

##### 20.1.2 HDG Galvanising

Galvanising in accordance with BS 729.

### 21.0 CORROSION PROTECTION : GENERAL REQUIREMENTS

## 21.1 Protective Systems :

Tables in this Specification list the protective systems to be used. HDG Galvanising is default corrosion protection to adopt, unless otherwise approved by Superintending Officer.

### 21.1.1 Location

The locations in which each of the systems is to be used are as described below unless noted otherwise on the drawings.

#### i) STEELWORK WHICH IS TO BE FULLY ENCASED IN CONCRETE

No protection required in permanent condition. The Contractor is advised, however, that he is required to ensure that this steelwork satisfies clauses 3.4 & 24.1 prior to encasement, and shall provide at his own cost any temporary protection required during transportation and storage.

#### ii) STEELWORK WHICH IS NOT ENCASED IN CONCRETE IN FINISHED BUILDING : See Table 1.

## 22.0 CORROSION PROTECTION : MATERIALS

### 22.1 Proprietary Materials

#### 22.1.1 Evidence Of Compliance

Before commencement of the Work, provide evidence to demonstrate that the proposed materials comply with descriptions in the Table 1.

#### 22.1.2 Complying Materials

This Specification lists proprietary materials, which are deemed to comply with coating descriptions referred to in the Table 1.

### 22.2 Manufacturer's Instructions

#### 22.2.1 Manufacturer's Instruction

Obtain from the manufacturer of any proprietary produce detailed instructions on the use of the product, specific to the situation found on the Contract.

Refer to the recommendations of the Zinc Development Association for galvanising and zinc metal-spraying.

#### 22.2.2 Use Of Product

Comply with the manufacturer's instructions for the use of any product. If these are in conflict with the requirements of the Specification, notify the Superintending Officer before commencement of Work.

### 22.3 Source Of Paint Materials

All products in any particular paint scheme are to be obtained from a single manufacturer.

### 22.4 Multiple Coats Of A Product

Where two or more coats of a product are to be applied, use a different colour for alternate coats

22.5 Zinc-Rich Primers

Zinc-rich primers are to comply with BS 4652.

22.6 Pigments

22.6.1 Volume

Where a paint is defined in the Tables as having a specific pigment, the total pigment is to contain at least 50% by volume of the pigment specified.

22.6.2 Primers

Primers are not to be so coloured that early signs of rust breakthrough may be masked. Red iron oxide (red oxide) is not to be used as the principle colouring agent of any primer, including optional prefabrication primers.

23.0 CORROSION PROTECTION : WORKMANSHIP - IDENTIFICATION, STORAGE AND HANDLING

23.1 Identification

All paints and other products are to be marked or labelled and stored in such a way that identification of product and batch numbers is possible at all times.

23.2 Storage And Handling

23.2.1 Damage

Establish storage and handling procedures for steelwork to avoid contamination, damage or breakdown of the protective system.

23.3.2 Galvanised Materials

Store and transport in such a way as to avoid white rust formation.

24.0 CORROSION PROTECTION : WORKMANSHIP - GENERAL

24.1 Surface Preparation

24.1.1 Cleanliness

Before surface preparation in accordance with Table requirements, clean the steel surfaces of dirt, grease and other contaminants. They shall at no stage have rusted beyond Rust Grade C of Euro Standard BS EN ISO 8501.

24.1.2 Surface Roughness

After surface preparation, the surface roughness is to be compatible with the coating to be applied but nowhere exceeding a peak-to-trough amplitude of 80 micrometres.

24.1.3 Rectification Of Defects

Rectify all defects in the substrate surface exposed during surface preparation, and which are not acceptable to BS 4360, in accordance with BS 4360.

Defects which are acceptable to BS 4360, but which nonetheless will prevent the

satisfactory coating of the steelwork, are to be rectified in such a way as to allow coating to be carried out in accordance with the Specification.

## 24.2 Surface Condition

### 24.2.1 Contaminants

Surfaces to which paint is to be applied, whether steel or previous coatings, are to be clean and free of any detrimental contaminants.

### 24.2.2 Quality Of Surface

The quality of surface preparation specified in the Tables is required to be present at the time of painting. If the surface has degraded beyond this level, re-cleaning is to be carried out.

## 24.3 Prefabrication Coatings

### 24.3.1 Prefabrication Coating

The Contractor may apply a prefabrication coating at his discretion. This coating, if applied, is to be additional to the main protective system.

### 24.3.2 Evidence Of Compatibility

If a prefabrication coating is applied, provide evidence to demonstrate that it is fully compatible with the main protective system.

### 24.3.3 Blast-Cleaning

If a prefabrication coating is used, all areas in which this coating is not intact after fabrication are to be locally blast-cleaned to the standard required by the Tables before over-coating.

## 24.4 Method Of Application

Where shop applied paint coatings are to be applied by other than airless spray, or site applied paint coatings by other than brush or airless spray, ensure that the method of application will result in work in accordance with the Specification.

## 24.5 Stripe Coats

All steelwork that will be externally exposed in the finished works is to have an extra stripe coat of primer applied to all edges and corners, end to seal gaps between adjacent components such as bolted connections.

## 24.6 Galvanising

### 24.6.1 Condition

Supply material to the galvaniser in a suitable condition to be acid-pickled and then galvanised.

### 24.6.2 Uniformity

Carry out galvanising in such a way as to maximise the smoothness and uniformity of the deposited coating. Only use double-dipping where no alternative exists.

### 24.6.3 Touch-Up

To be done in accordance with Appendix D of BS 729. Preparation is to be as required by the

manufacturer of the touch-up product being used.

The maximum size of an area of touch-up is to be determined by locating the point on the damaged surface which is furthest from an intact galvanise coating. If the distance from this point to the galvanising is in excess of 10mm, then the member is to be re-galvanised or rejected.

#### 24.7 Life Of Shop Applied Protection

##### 24.7.1 Programme

In conjunction with the paint manufacturer, ensure that the expected life of the shop applied protection is compatible with erection and site painting programmes.

##### 24.7.2 Failure

If failure of the shop applied protection should occur, reinstate the steelwork to an equivalent condition to the un-failed protection. The scheme used is to be compatible with any further coatings.

#### 24.8 Making Good

##### 24.8.1 Damage

Make good to damages, weld areas and other areas, which are not coated in accordance with the Specification.

##### 24.8.2 Method

Provide details of the proposed method for making good that will result in protection in accordance with the Specification. Details are to include surface preparation of both exposed steel and other coatings, choice of materials if these differ from those originally specified, means of application and any other relevant considerations.

#### 25.0 CORROSION PROTECTION : WORKMANSHIP - CONNECTIONS

##### 25.1 General

##### 25.1.1 Equivalent Standard

Prepare and paint all connections, including fasteners, items of bracketry and other small pieces fabricated separately to the main steelwork, to an equivalent standard to the adjacent steel unless noted otherwise on the Contract Drawings.

##### 25.1.2 Different System

Where the Contractor proposes to use a difference protective system for any part of a connection to that used for the adjacent steel, provide evidence to demonstrate its equivalent and compatibility.

##### 25.2 Friction Grip Interfaces

Do not apply paint to friction grip interfaces. The faying surfaces are to be masked, if necessary, to prevent rusting beyond Rust Grade C of Euro Standard BS EN ISO 8501. If galvanising or other metal coatings have been applied, provide evidence to demonstrate that a slip factor not less than the design value will be achieved.

### 25.3 Assembly Of Bolted Connections

Assemble bolted connections is externally exposed steelwork, other than friction grip connections, with a coat of primer still wet on the contact faces.

### 25.4 Coated Bolts

Prime plated, galvanised or sherardised bolt assemblies with a compatible etch primer or treat with a mordant solution prior to over-coating.

### 25.5 Sealing Of Bolted Connections

Seal all externally exposed bolted joints against the ingress of water. Before site painting commences, plug gaps at joints with compatible and suitable filler. Take care that water is not sealed within the joint.

### 25.6 Site Welds

#### 25.6.1 Paint

At the time of welding there is to be no paint, other than suitable prefabrication primer, within 50mm of the weld.

#### 25.6.2 Temporary Protection

Apply and remove before welding if this is necessary to ensure that rusting does not occur to a level beyond that allowed by the Specification.

## 26.0 CORROSION PROTECTION : QUALITY CONTROL

### 26.1 General

#### 26.1.1 Inspections And Tests

Before commencement of the work, provide details of the scope and frequency of all inspections and tests to be carried out to assure compliance with the Specification. As a minimum, include all relevant inspections and tests in Table 8 of BS 5493.

The frequency of inspection and testing must be sufficient to detect any non-conformance.

#### 26.1.2 Notice

Agree a period of notice for all tests.

### 26.2 Method Statement

#### 26.2.1 Method Statement

Provide a method statement explaining how it is intended to carry out the work in accordance with the Specification.

#### 26.2.2 Work

Carry out work in accordance with the method statement.

### 26.3 Test Pieces

#### 26.3.1 Test Pieces

Prepare two sets of test pieces representative in all relevant respects of the work to be carried out.

#### 26.3.2 Coating

Coat test pieces in accordance with the method statement.

#### 26.3.3 Tests

Confirm, by means of tests on one set of test pieces, that the proposed method will result in work, which complies with the Specification.

#### 26.3.4 Retention Of Test Pieces

Protect and retain the second set of test pieces until the issue of the Completion Certificate by the Superintending Officer.

#### 26.3.5 Results Of Tests

No work is to be carried out until the Contractor has confirmed in writing that the results of the tests comply with the Specification. Provide the Superintending Officer with a copy of the test results.

#### 26.3.6 Quality Standards

The quality standards established by the test pieces are to become the minimum standard for the Work.

### 26.4 Modification To Method Statement

#### 26.4.1 Test Pieces

If it is proposed to modify the method statement, produce two sets of test pieces, identical with the initial test pieces, using the proposed modified method.

#### 26.4.2 Tests

Confirm, by means of tests on one set of test pieces, that the proposed modification will not result in a reduction in the quality of work produced below that being produced by the current method.

#### 26.4.3 Retention Of Test Pieces

Protect and retain the second set of test pieces until the issue of the Completion Certificate by the Superintending Officer.

#### 26.4.4 Results Of Test

No work is to be carried out using the modified method until the Contractor has confirmed in writing that the results of the tests comply with the Specification. Provide the Superintending Officer with a copy of the test results.

#### 26.4.5 Quality Standards

The quality standards established by the test results are to become the minimum standard for the Work.

## 26.5 Testing

### 26.5.1 Coating Thickness

After the application of each coat of paint, and before the application of following coats, ensure that the coat has been applied to the required dry film thickness by the use of any of the methods in BS 3900 : Part C5 for measuring dry film thickness. Wet film thickness measurement is not to be used for this purpose.

### 26.5.2 Adhesion

Ensure, by means of adhesion tests to BS 3900 : Part E6, carried out on representative areas chosen to be non-obstructive in the final condition, that the adhesion of any completed paint scheme is not worse than classification 2 of that standard.

The test area is to be touched-up in accordance with the Specification.

### 26.5.3 Galvanised Steel Elements

Test in accordance with Appendix A of BS 729, using coupons of the same material as the element, and galvanised with the element.

## 27.0 CORROSION PROTECTION : LIST OF CODES AND STANDARDS

### 27.1 British Standards

BS 729	Hot dip galvanised coatings on iron and steel articles.
BS 2569	Sprayed metal coatings. Part 1 : Protection of iron and steel by aluminium and zinc against atmospheric corrosion.
BS 3900	Methods of test for paints. Part C5 : Determination of film thickness Part E6 : Cross-cut test.
BS 4360	Specification for weldable structural steels.
BS 4652	Metallic zinc-rich priming paint (organic media)
BS 5493	Code of practice for protective coating of iron and steel structures against corrosion.

### 27.2 Euro Standards

BS EN ISO 8501 Preparation of steel substrates before application of paints and related products

Table 1

PROTECTIVE SYSTEM : STEELWORK NOT ENCASED IN CONCRETE  
(SEE CLAUSE 21.1.1 (iv))

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Surface Preparation : Euro Standard BS EN ISO 8501

Prefabrication Primer – Clause 24.3

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#### Shop Applied Coatings

Coat No.	Description	DFT (um)
1	Flame Sprayed Zinc (Class Zn7) BS 2569 : Part 1	127
2	2-Pack PVB Etch Primer	10
3	High Building 2-Pack Micaceous Iron Oxide	75

#### Site Applied Coatings

Joints (bolts, welds) and Making Good – See Relevant Clauses

Coat No.	Description	DFT (um)
4	Silicone Aklyd Enamel	35
5	Silicone Aklyd Enamel	35