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Prepared by :
Civil Engineering Department,
Civil Engineering Building,
101, Princess Margaret Road,
Homantin, Kowloon,
Hong Kong.

Steering Committee members :

R.H. Pilling (Chairman)
C.L. Au
C.K. Au Yong
W.S. Chan
T.K. Cheung
D.J. Howells
T.L. Hsu
H.S. Kwong
I.M. Miller
K.P. Mok
H. Sanders
K.Y. Tang
H.S. Tse

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FOREWORD

This Specification lays down the quality of materials, the standards of workmanship, the testing methods and the acceptance criteria for civil engineering works undertaken for the Hong Kong Government. It supersedes “Public Works Department, Civil Engineering Office and Highways Office General Specification for Civil Engineering Works, 1977 Edition” and “Water Supplies Department, General Specification for Civil Engineering Works, 1987 Edition”.

The Specification is to be cited as “General Specification for Civil Engineering Works, 1992 Edition (Hong Kong Government)”. It is compatible with “General Conditions of Contract for Civil Engineering Works, 1990 Edition (Hong Kong Government)” and “Standard Method of Measurement for Civil Engineering Works, 1992 Edition (Hong Kong Government)”. Where necessary, it should be supplemented by a Particular Specification.

This new Specification was produced over a six-year period under the guidance of a Steering Committee which comprised members from all the main Government departments concerned with the execution of civil engineering works. The drafting of each Section was carried out by a Working Party consisting of individuals who possessed the appropriate knowledge and expertise. Drafts of the Sections were circulated for comment inside and outside the Government before finalization. The published document therefore takes account of recent technological advances and their application to civil engineering works in Hong Kong. The overall co-ordination for the document, and its final editing and production, were the responsibility of the Standards Unit of the Civil Engineering Department.

March 1992

GENERAL SPECIFICATION FOR CIVIL ENGINEERING WORKS

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**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 18
STEELWORK**

SECTION 18

STEELWORK

GENERAL

- | | | |
|-----------------------------------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Steelwork</i> | 18.01 | <p>(1) Steelwork shall comply with BS 5950:Part 2 unless it is stated in the Contract that the steelwork shall comply with BS 5400:Part 6.</p> <p>(2) Allowances shall be made for the deformation due to permanent loads and the process and sequence of fabrication, erection and construction such that steelwork is completed to within the specified tolerances.</p> <p>(3) The compatibility of the dimensions and setting-out data of steelwork shall be verified by the Contractor before the materials for steelwork are ordered.</p> |
| <i>Protection of steelwork</i> | 18.02 | Protection of steelwork against corrosion shall comply with BS 5493. |
| <i>Amendments to
BS 5400:Part 6</i> | 18.03 | <p>The following amendments shall apply to BS 5400:Part 6:</p> <p>(a) Contents page :</p> <p style="padding-left: 40px;">Delete '6.3.1 General'.</p> <p>(b) Page 2, Clause 3.1.4.1, lines 5, 8 and 14:</p> <p style="padding-left: 40px;">Delete 'C of DD21' and insert 'L1 of BS 5996'.</p> <p>(c) Page 2, Clause 3.1.4.1, line 10 and Clause 3.1.4.2, line 3:</p> <p style="padding-left: 40px;">Delete 'DD21' and insert 'BS 5996'.</p> <p>(d) Page 3, Clause 4.2.1, line 2:</p> <p style="padding-left: 40px;">Delete '4.4.2' and insert '4.2.2'.</p> <p>(e) Page 3, Clause 4.3.3(e), line 1:</p> <p style="padding-left: 40px;">Delete line 1 of text and insert 'the hardness of the edge is reduced to less than 350 HV 30 of BS 427 by a suitable heat treatment'.</p> <p>(f) Page 4, Clause 4.7.1, paragraph 2, line 4:</p> <p style="padding-left: 40px;">Delete '23 of BS 5135' and insert '20 of BS 5135'.</p> |

- (g) Page 5, Clause 4.14:

Delete and insert:

‘The Contractor shall determine the dead load camber of beams required to comply with Clause 18.01(2) of the GS. The camber of plate girders shall be formed by either of the two following alternatives, whichever is stated in the Contract :

Type A cambering	camber introduced by welding the flanges pressed against a web plate cut to a smooth cambered profile,
------------------	--------------------------------------------------------------------------------------------------------

or

Type B cambering	camber introduced by connecting straight sections of girder with a change of slope at their junctions.
------------------	--------------------------------------------------------------------------------------------------------

Type A camber shall be used if the alternative to be used is not stated in the Contract.

With Type B cambering the junctions shall not be positioned at bolted connections.’

- (h) Page 6, Clause 5.2.2, line 2:

Delete ‘DD21’ and insert ‘BS 5996’.

- (i) Page 7, Clause 5.5.2, paragraph 3, line 3:

Delete ‘grider’ and insert ‘girder’.

- (j) Page 9, Clause 6.3.1:

Delete Clause 6.3.1.

- (k) Page 15, Table 5, column 3,
Member component 4:

Delete ‘G=0’ and insert ‘G=D’.

MATERIALS

Structural steel

- 18.04 (1) Structural steel shall comply with BS 4360, including Clause B7 at Appendix B, and with BS 5950:Part 2, Section 2.1 or BS 5400:Part 6, Section 3.1 as appropriate.

(2) Hot rolled sections complying with BS 4:Part 1, BS 4848:Part 2, BS 4848: Part 4 or BS 4848:Part 5 shall not be replaced with sections complying with other standards unless approved by the Engineer; if approved, the sections shall have equivalent properties to, and the dimensional tolerances shall comply with, the relevant British Standard.

<i>Rivet steel</i>	18.05	Steel rivet bars for the manufacture of steel rivets shall comply with BS 5400:Part 6, Appendix A.
<i>Steel for shear connectors</i>	18.06	Steel for headed stud type shear connectors shall have a yield stress of at least 385 N/mm ² and a tensile strength of at least 495 N/mm ² . Steel for other types of shear connectors shall comply with BS 4360.
<i>Bolts, screws, nuts and washers</i>	18.07	<p>(1) Bolts, screws and nuts shall comply with the British Standards and strength grades stated in Table 18.1 unless other strength grades or British Standards are stated in the Contract.</p> <p>(2) Washers for high strength friction grip bolts and nuts shall comply with the following:</p> <div style="margin-left: 40px;"> <p>High strength friction grip bolts and associated nuts and washers for structural engineering:</p> <ul style="list-style-type: none"> - general grade : BS 4395:Part 1 - higher grade bolts and nuts and general grade washers : BS 4395:Part 2 - higher grade bolts (waisted shank), nuts and general grade washers : BS 4395:Part 3 </div> <p>Plain washers for other bolts, screws and nuts shall comply with BS 4320; tapered washers for other bolts, screws and nuts shall comply with BS 3410.</p>
<i>Welding consumables</i>	18.08	<p>(1) Welding consumables used in metal-arc welding of grades of steel complying with BS 4360 shall comply with BS 5135. Welding consumables used in the fusion welding of steel castings shall comply with BS 4570. Welding consumables used in metal-arc welding of austenitic stainless steels shall comply with BS 4677.</p> <p>(2) Welding consumables and the procedures used shall be such that the mechanical properties of the deposited weld metal shall not be less than the respective minimum values of the parent metal being welded.</p> <p>(3) Welding consumables used with grades of steel other than those complying with BS 4360 shall be such that the performance requirements stated in BS 5400:Part 6, Table 1 or BS 5950:Part 2, Table 1 as appropriate are achieved.</p>
<i>Rolled steel pins</i>	18.09	Rolled steel pins, including those made from slabs, shall comply with BS 970:Part 1 or BS 4360, grades 43, 50 or 55.

Table 18.1 : British Standards and strength grades for bolts, screws and nuts

Type of bolts, screws and nuts	British Standard	Strength grade of bolt	Strength grade of nut
High strength friction grip bolts and nuts	BS 4395: Part 1	General grade	as specified in BS4395 : Part 1
Precision bolts, screws and nuts	BS 3692	4.6	4.0
Cup head and countersunk head bolts, screws and nuts	BS 4933	4.6	4.0
Black bolts, screws and nuts	BS 4190	4.6	4.0
Other types of bolts, screws and nuts	BS 4190	4.6	4.0
Hexagon socket screws	BS 4168: Part 1	12.9	12.0

<i>Steel castings and cast steel pins</i>	18.10	Carbon managnese steel castings shall comply with BS 3100.
<i>Steel forgings and forged steel pins</i>	18.11	Steel forgings and forged steel pins shall comply with BS 29.
<i>Stainless steel</i>	18.12	<p>(1) Wrought stainless steel shall comply with BS 970:Part 1, grade 316 S 16.</p> <p>(2) Flat rolled stainless steel shall comply with BS 1449:Part 2, grade 316 S 16 in the softened condition.</p> <p>(3) Stainless steel tubes shall comply with BS 6323:Part 1 and BS 6323:Part 8, designation LW 23 GZF(S).</p> <p>(4) Stainless steel bolts and nuts shall comply with BS 6105, steel grade A4 and property class 80. Stainless steel washers shall comply with BS 1449:Part 2, grade 316 S 31 in the softened condition. The dimensions and tolerances of bolts and nuts shall comply with BS 3692. The dimensions and tolerances of tapered washers shall comply with BS 3410 and the dimensions and tolerances of flat washers shall comply with BS 4320, Form C.</p>
<i>Cast iron</i>	18.13	<p>(1) Grey cast iron shall comply with BS 1452, grade 10.</p> <p>(2) Malleable cast iron shall comply with BS 6681.</p> <p>(3) Spheroidal or nodular cast iron shall comply with BS 2789.</p>

<i>Grout for column bases</i>	18.14	<p>(1) Grout for bedding steel bases and for filling bolt pockets and pocket bases shall be based on OPC and shall have the same grade strength as the surrounding foundation concrete. The grout shall contain a non-metallic expanding admixture and shall have a total chloride content of not more than 0.1% by mass of cement.</p> <p>(2) Grout for bedding steel bases and for filling bolt pockets shall be a proprietary type approved by the Engineer and shall be suitable for filling the space by pouring under a suitable head. The proportions of the grout shall be in accordance with the manufacturer's recommendations.</p> <p>(3) A dry packed mortar may be used for bedding steel bases which exceed 75 mm thick. The mortar shall consist of 1 part by weight of cement to 2 parts by weight of fine aggregate together with the minimum amount of water necessary to achieve a consistency suitable for thorough ramming against supports such that the space is completely filled.</p> <p>(4) Grout for filling pocket bases shall be a mix approved by the Engineer with a nominal maximum aggregate size of 10 mm.</p>
<i>Lubricant for nut threads of HSFG bolts</i>	18.15	<p>Lubricant for lubricating nut threads of HSFG bolts shall be a wax based type approved by the Engineer; machine oil and other free flowing lubricants shall not be used.</p>
<i>Paint for steelwork</i>	18.16	<p>(1) Paint for steelwork shall comply with BS 5493, Section 2, Table 4. Organic zinc-rich paint shall comply with BS 4652. Lead-based paint shall not be used for finishing coats.</p> <p>(2) Paint shall be supplied in sealed containers of not more than 5 litres capacity. Each container shall be marked on the side to show the following:</p> <ul style="list-style-type: none"> (a) the name of the manufacturer, (b) the paint manufacturer's reference number, (c) intended purposes, type of pigment and binder, (d) batch number, date of manufacture, expiry date and pot life, and (e) colour, gloss, drying times and flash point.

SUBMISSIONS

<i>Particulars of steel</i>	18.17	<p>(1) The manufacturer's certificates for steel shall be submitted to the Engineer in accordance with BS 4360, Clause 12 and Appendix B 6.</p> <p>(2) The certificates shall be submitted to the Engineer not more than 2 days after the steel has been delivered to the place of fabrication.</p>
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Particulars of workshop drawings

- 18.18 (1) Two sets of drawings of the steelwork shall be submitted to the Engineer. The drawings shall show details of the following:
- (a) steelwork and welds, including any stud welds, marked with the relevant welding procedures,
 - (b) joints or non-standard welds proposed by the Contractor,
 - (c) locations and method of removal of any temporary welded attachments proposed by the Contractor,
 - (d) edges of steelwork complying with BS 5400:Part 6 to be formed by flame cutting or shearing procedures complying with BS 5400:Part 6, Clause 4.3.3(a), (d) or (e) with the edges marked with the procedures to be used, and
 - (e) parts of steelwork complying with BS 5400:Part 6 to be worked by hot processes complying with BS 5400:Part 6, Clause 4.8, 4.9 or 4.10 with the parts marked with the processes to be used.
- (2) The drawings shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts. Drawings shall not be approved until all procedures and details shown on the drawing have been approved by the Engineer.
- (3) A print and a diazo film of the approved drawings shall be submitted to the Engineer at least 7 days before fabrication of the steelwork starts.

Particulars of delivery of steelwork

- 18.19 (1) The following particulars of steelwork fabricated off the Site shall be submitted to the Engineer:
- (a) expected and actual arrival dates,
 - (b) name of carrier,
 - (c) duplicate copies of bill of lading and packing list for steelwork transported by sea, and
 - (d) duplicate copies of delivery note and a list showing the marking and weight of each component for steelwork transported by land.
- (2) The particulars of expected arrival date and name of carrier shall be submitted to the Engineer at least 14 days before the due date; other particulars shall be submitted to the Engineer within 3 days after delivery of the steelwork to the Site.

Particulars of method of erecting steelwork

- 18.20 (1) The following particulars of the proposed method of erecting steelwork shall be submitted to the Engineer:
- (a) sequence and method of erection of steelwork,
 - (b) method of lifting and handling the components,

- (c) method of preventing damage to protective coatings on steelwork during handling,
- (d) procedure for aligning, levelling and plumbing steelwork, including temporary supports and method of making beddings for column bases, and
- (e) sequence of casting concrete bonded to the steelwork.

(2) The particulars shall be submitted to the Engineer at least 6 weeks before erection of the steelwork starts.

Welder certificates

18.21 (1) Certificates endorsed by an inspecting authority approved by the Engineer shall be submitted to the Engineer to show that each welder has been approved in accordance with BS 4570, BS 4871:Part 1 or BS 4872:Part 1 as appropriate. The extent of approval of the welder shall be appropriate to the categories of welds which he will carry out.

(2) The welder certificates shall be submitted at least 4 weeks before fabrication of the steelwork starts.

Particulars of welding procedures

18.22 (1) The following particulars of the proposed welding procedures shall be submitted to the Engineer:

- (a) welding procedures in accordance with BS 5135, Clause 20 for each type and size of weld other than welds stated in Table 18.2,
- (b) documentation endorsed by an inspecting authority approved by the Engineer to show that the welding procedure has complied with the procedure trial requirements stated in the Contract in previous tests, or that the welding procedure for steel castings complies with the exemption criteria stated in BS 4570, Clause 20.1.1, and
- (c) records of approval tests as stated in Clause 18.35(1) if procedure trials are required under Clause 18.29(1).

(2) The welding procedures for permanent welds shall be submitted to the Engineer at the same time as welder certificates are submitted. The welding procedures for temporary welds shall be submitted to the Engineer at the same time as welder certificates are submitted.

Table 18.2 : Welds for which submission of welding procedures is not required

Weld type	Weld size
Fillet weld	Leg length not exceeding 4 mm
Butt weld	Thickness of the parts or, if the parts are of different thicknesses, the thickness of the thinner part to be joined not exceeding 4 mm

Particulars of stud welding, flame cutting and shearing procedures

- 18.23 (1) The following particulars of the proposed stud welding, flame cutting and shearing procedures for steelwork complying with BS 5400:Part 6 shall be submitted to the Engineer:
- (a) procedures for stud welding, flame cutting and shearing processes complying with BS 5400:Part 6, Clause 4.3.3(a), (d) or (c),
 - (b) documentation endorsed by an inspecting authority approved by the Engineer to show that the stud welding, flame cutting or shearing procedure has complied with the procedure trial requirements stated in the Contract in previous tests, and
 - (c) report of procedure trials as stated in Clause 18.35(2) if procedure trials are required under Clause 18.29(1).
- (2) The particulars shall be submitted to the Engineer at least 6 weeks before fabrication of the steelwork starts.

Particulars of vent holes for galvanizing

- 18.24 Particulars of the method of plugging vent holes required for hot-dip galvanizing hollow or box sections shall be submitted to the Engineer at least 3 weeks before fabrication of the steelwork starts.

Particulars of method of non-destructive testing

- 18.25 Particulars of the proposed method for carrying out non-destructive testing on welds shall be submitted to the Engineer at least 4 weeks before the tests start.

Particulars of inspection authority and testing consultant

- 18.26 (1) The name of the proposed inspecting authority endorsing welder certificates and records of approval tests for welding procedures shall be submitted to the Engineer. The name shall be submitted at least 3 weeks before approval tests start or, if approval tests are not required, at the same time as the welder certificates are submitted.
- (2) The name of the proposed testing consultant stated in Clause 18.87 shall be submitted to the Engineer at least 3 weeks before the testing consultant commences work.

<i>Particulars of paint</i>	18.27	<p>(1) The following particulars of the proposed paints and associated products shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) name of manufacturer, (b) duplicate copies of the manufacturer's data sheets including temperature, humidity and other conditions at the workshop or on the Site under which the paint is to be applied, and (c) manufacturer's product specifications, product range and technical information, <p>(2) The particulars shall be submitted to the Engineer at least 6 weeks before the painting starts.</p>
<i>Samples of materials</i>	18.28	<p>(1) A sample of blast cleaned steel plate shall be submitted to the Engineer at least 14 days before blast cleaning starts. The sample shall be 150 mm x 150 mm x 6 mm and shall be enclosed in a sealed, colourless, transparent wrapping. The grade of steel and the method of blasting shall be representative of those which will be used in the permanent work.</p> <p>(2) Two samples of painted tin plates for each painting system shall be submitted to the Engineer at least 14 days before painting starts. Each plate shall be 150 mm x 75 mm x 1 mm and shall have smooth edges and 10 mm corner radii. The plates shall be brush cleaned and painted on one face with the painting system in such a manner that each coat is stepped back from the underlying coat in equal strips. The degree of gloss of the finishing coat shall be as agreed by the Engineer.</p> <p>(3) Samples of each type of nut, bolt, washer, stud and rivet shall be provided within 3 days after the material is delivered to the Site.</p>

TRIALS

<i>Procedure trials for welding, flame cutting and shearing</i>	18.29	<p>(1) If in the opinion of the Engineer the proposed welding procedure submitted as stated in Clause 18.22 or the proposed stud welding, flame cutting or shearing procedure for steelwork complying with BS 5400:Part 6 submitted as stated in Clause 18.23 has not complied with the procedure trial requirements for the procedure stated in the Contract in previous tests, a procedure trial shall be carried out as stated in Clause 18.29(2) to (8).</p> <p>(2) Procedure trials for welding for structural steel shall comply with BS 5400:Part 6, Clauses 4.7.3, 5.4.1.1 and 5.4.1.2.</p> <p>(3) Procedure trials for welding for steel castings shall comply with BS 5400:Part 6, Clauses 4.7.3 and 5.4.2.</p> <p>(4) Procedure trials for welding of studs shall comply with BS 5400:Part 6, Clauses 4.7.4 and 5.4.4.</p> <p>(5) Procedure trials for flame cutting and shearing shall comply with BS 5400:Part 6, Clauses 4.7.3 and 5.4.3.</p>
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(6) Welds for grade A steels complying with BS 4360 are not required to comply with the requirements for Charpy V-notch impact tests. The temperature of -20°C stated in BS 5400:Part 6, Clause 5.4.1.2(a)(3) shall be amended to 0°C.

(7) If in a welding procedure one or more of the parts to be welded is coated with a prefabrication primer or metal coating before welding, the same primer or coating shall be applied to the sample before the procedure trial for the welding procedure is carried out.

(8) The thickness of the sample of material to be used in procedure trials for flame cutting shall be:

- (a) 20 mm for material not exceeding 20 mm thick,
- (b) 40 mm for material exceeding 20 mm and not exceeding 40 mm thick, and
- (c) T mm for material exceeding (T-10) mm and not exceeding T mm thick, where T is any multiple of 10 from 50 up.

Inspection of procedure trials for welding, flame cutting and shearing

18.30 Procedure trials for welding, flame cutting and shearing shall be carried out in the presence of an inspecting authority approved by the Engineer.

Results of procedure trials for welding, flame cutting and shearing

18.31 If a procedure trial for welding, flame cutting or shearing does not comply with the specified requirements for the procedure trial, the cause of failure shall be established by the Contractor and particulars of proposed changes shall be submitted to the Engineer. Further procedure trials shall be carried out to establish the amended procedure unless otherwise permitted by the Engineer.

Approved procedures for welding, flame cutting and shearing

18.32 (1) A welding, flame cutting or shearing procedure which complies with the specified requirements for the procedure trial shall become an approved procedure.

(2) If a procedure trial is not required, the procedure for welding, flame cutting or shearing submitted as stated in Clauses 18.22 and 18.23 shall become an approved procedure.

Commencement of welding, flame cutting and shearing

18.33 Welding, flame cutting or shearing shall not commence until the procedure has been approved by the Engineer.

Changes in procedures for welding, flame cutting and shearing

18.34 Unless permitted by the Engineer, approved procedures for welding, flame cutting or shearing shall not be changed. Further procedure trials shall be carried out to demonstrate proposed changes to the procedure unless otherwise permitted by the Engineer.

Records of procedure trials for welding, flame cutting and shearing

18.35 (1) A record of the approval test for welding procedures shall be submitted to the Engineer for approval at least 3 weeks before fabrication of the steelwork starts. The record shall be in the form stated in BS 4870:Part 1, Appendix B or BS 4570, Appendix A as appropriate and shall be endorsed by the inspecting authority approved by the Engineer.

(2) Reports of procedure trials for stud welding, flame cutting and shearing shall be submitted to the Engineer at least 3 weeks before fabrication of the steelwork starts.

<i>Painting trials</i>	18.36	<p>(1) A painting trial shall be carried out for each painting system which will be applied to areas exceeding 100 m² to demonstrate that the proposed materials and methods of application will produce a painted surface which complies with the specified requirements.</p> <p>(2) Painting trials shall be carried out at the place where painting to the permanent work will be carried out and using the employees and equipment which will be used to carry out painting to the permanent work.</p> <p>(3) Painting trials shall be carried out on blast cleaned steel.</p>
<i>Results of painting trials</i>	18.37	If the painted surface produced in a painting trial does not comply with the specified requirements for the paintwork, the cause of failure shall be established by the Contractor and particulars of proposed changes shall be submitted to the Engineer. Proposed changes to the paint formulation, other than an adjustment in the amount of thinners, shall be carried out at the paint manufacturer's works before the final painting trial and before the first batch of paint is delivered.
<i>Commencement of painting</i>	18.38	Painting shall not commence until the painted surface produced in painting trials complies with the specified requirements for paintwork.
<i>Changes in materials and methods of application for painting</i>	18.39	Unless permitted by the Engineer, the materials and methods of application used in a painting trial which complies with the specified requirements shall not be changed.

HANDLING, STORAGE AND TRANSPORT OF MATERIALS

<i>Handling and transport of steelwork</i>	18.40	<p>(1) Steelwork shall not be subject to rough handling, shock loading or dropping from a height.</p> <p>(2) During handling and transport of coated steelwork, the steelwork shall be separated from wires and lashings by rubber padding in such a manner that the coatings are not damaged or discoloured. Free ends shall be stiffened, measures shall be taken to prevent permanent distortion and machined surfaces and faying surfaces shall be protected.</p> <p>(3) Steelwork shall not be lifted from the painting bed until the last applied coating is sufficiently dry or cured for handling.</p> <p>(4) Rivets, bolts, nuts, washers, screws and small plates and articles shall be packed in containers marked to identify the contents.</p>
<i>Storage of steelwork</i>	18.41	(1) Steelwork shall be stored off the ground on level supports in well drained areas in a manner which will not result in damage or deformation to the steelwork or coatings or in contamination of the steelwork or coatings. Packings shall be placed between steelwork which is stacked.

- (2) Covered places in which steelwork is stacked shall be ventilated.
- (3) Different types and sizes of steelwork shall be stored separately.
- (4) Steelwork shall not be stored on or adjacent to concrete surfaces which form part of the permanent work.
- (5) Steelwork shall be protected from exposure to conditions which may affect the steelwork or coatings.
- (6) Wet paint films, steelwork surfaces which are to be primed or overcoated and joint surfaces which are to be assembled shall be protected from exposure to conditions which may affect the film or surface. Undercoats which contain anatase titanium dioxide shall be protected from exposure to direct sunlight.
- (7) Except as stated in Clause 18.41(8) and (9), steelwork shall be stored in an enclosed workshop and protected from conditions which may affect the steelwork after the steelwork has been cleaned as stated in Clause 18.53 until the following times:
 - (a) when the second undercoat to painted steelwork has hard dried,
 - (b) when the coating process to galvanized, electroplated or metal sprayed steelwork has been completed,
 - (c) when the sealer to metal sprayed and sealed steelwork has been completely absorbed, and
 - (d) when the first undercoat to metal sprayed and painted steelwork has hard dried.
- (8) Primed steelwork surfaces may be exposed outside the enclosed workshop for a period not exceeding two weeks.
- (9) Micaceous iron oxide undercoats to steelwork may be exposed outside the enclosed workshop for the minimum period necessary to move the steelwork from one part of the workshop to the other; the undercoated surfaces shall be covered when the steelwork is being moved.

Storage of paint

- 18.42 Paint and associated materials shall be stored in sealed containers marked as stated in Clause 18.16(2) and protected from exposure to conditions which may affect the material. The materials shall be stored in accordance with the manufacturers' recommendations and shall not be used after the recommended expiry date has been exceeded. The materials shall be stored in a locked store.

FABRICATION OF STEELWORK

Fabrication of steelwork

Fabrication of steelwork shall comply with BS 5400:Part 6, Clauses 4.1 to 4.16 or BS 5950:Part 2, Sections 3 and 4 as appropriate except as stated in Clauses 18.44 to 18.52.

<i>Welding, heating and cutting</i>	18.44	<p>(1) Welding shall be carried out by welders who possess a valid welding certificate for the appropriate category of welding. A welder shall cease to carry out welding if any of the circumstances stated in BS 4570, Clause 21.1, BS 4871:Part 1, Clause 11 or BS 4872:Part 1, Clause 6 as appropriate occurs.</p> <p>(2) Pre-setting, pre-bending, skip welding, back-step techniques and other measures shall be taken as necessary to counteract shrinkage or distortion due to welding, gouging, thermal cutting or heat treatment.</p> <p>(3) Butt welds shall be complete penetration butt welds made between fusion faces.</p> <p>(4) Butt welds in each component part shall be completed before the final assembly of built-up assemblies.</p> <p>(5) Welding of austenitic stainless steel shall be carried out in accordance with BS 4677.</p> <p>(6) Temporary welded attachments shall not be used unless permitted by the Engineer.</p> <p>(7) Welding, heating or thermal cutting processes which give off toxic or irritant gases shall not be used unless permitted by the Engineer; if permitted, precautions, including the provision of exhaust ventilation, breathing apparatus and display of warning signs, shall be taken to enable the work to be carried out in safe conditions. Welding, heating or thermal cutting shall not be carried out within 2 m of lead-based, cadmium or carbonaceous coatings.</p>
<i>Length of bolts</i>	18.45	The length of HSFG bolts shall comply with BS 4604:Part 1 or BS 4604:Part 2 as appropriate. The length of bolts complying with BS 3692, BS 4190 and BS 4933 shall be such that the end of the bolt will project above the nut by at least one thread, but by not more than one nominal bolt diameter, after tightening.
<i>Length of threads</i>	18.46	The length of threads on bolts shall be determined in accordance with BS 3692, BS 4190, BS 4395:Part 1, BS 4395:Part 2, BS 4395:Part 3 or BS 4933 as appropriate. If additional locknuts or other nuts are specified, the thread length shall be increased by one nominal bolt diameter for each additional nut.
<i>Use of nuts</i>	18.47	Nuts shall not be used with bolts or screws which comply with a different standard.
<i>Use of washer</i>	18.48	Washers for HSFG bolts shall be provided in accordance with BS 4604:Part 1 or BS 4604:Part 2 as appropriate. Washers shall be provided for bolts complying with BS 3692, BS 4190 and BS 4933 under the nut or bolt head, whichever is rotated during tightening, if the parts to be connected are to be coated with protective coatings before assembly. Washers shall be provided under the nuts and heads of bolts in oversized and slotted holes.
<i>Tightening of bolts</i>	18.49	Bolts shall be tightened in such a manner that the contact surfaces of permanent bolted joints are drawn into close contact.

Tightening of HSFG bolts

- 18.50 (1) The degree of preliminary tightening of bolts and nuts complying with BS 4395:Part 1 which are tightened by the part turn method shall be torque controlled. The tightening equipment for preliminary tightening shall be calibrated with a bolt load meter. The value of bedding torque for the preliminary tightening shall be within 10% of the values stated in Table 18.3.
- (2) Bolts and nuts at each joint with bolts or washers with load indicating devices shall be initially tightened to bring the faying surfaces into close contact over the full area. The range of the average gap after initial tightening shall be as agreed by the Engineer. The bolts and nuts shall be re-tightened if necessary to close the average gap back to the agreed range. After all bolts and nuts at the joint have been initially tightened, the bolts and nuts shall be finally tightened to attain the shank tension stated in BS 4604:Part 1 or BS 4604:Part 2 as appropriate. The range of average gap corresponding to the required shank tension shall be established for each batch as defined in BS 4395:Part 1, BS 4395:Part 2 or BS 4395:Part 3 as appropriate, by testing at least three bolt, nut and washer assemblies in a bolt load meter and shall be as agreed by the Engineer. The average gap after final tightening shall be within the established range.
- (3) The threads of nuts for HSFG bolts which are to be tightened by the part turn method or the load indicating method shall not be lubricated unless approved by the Engineer. If the use of lubricant is approved in the part turn method, the bedding torque shall be established by a bolt load meter and shall be as agreed by the Engineer. The lubricant shall be applied at the place of manufacture and shall only be applied to the nut threads. The bearing surfaces of the nuts and the faying surfaces shall not be contaminated with the lubricant.
- (4) The bolt load meter for measuring bolt shank tension in the part turn, torque control or load indicating methods of tightening shall be calibrated by a laboratory approved by the Engineer before tightening of bolts and nuts starts and at regular intervals agreed by the Engineer. During re-calibration, a replacement calibrated bolt load meter shall be provided on the Site. Calibration results shall be submitted to the Engineer at least one week before the bolt load meter is used.

Table 18.3 : Bedding torque for HSFG bolts

Nominal diameter of bolt (mm)	Bedding torque (N.m)
16	80
20	160
22	210
24	270
27	340
30	460

<i>Defects in steelwork</i>	18.51	Defective components for steelwork shall not be used in the permanent work unless repair of the defects is permitted by the Engineer; if permitted, defective components shall be repaired by methods agreed by the Engineer.
<i>Approval of fabricated steelwork</i>	18.52	<p>Fabricated steelwork shall not be:</p> <ul style="list-style-type: none"> (a) covered with protective coatings, concrete or other materials, (b) erected, or (c) despatched from the place of fabrication if fabricated off the Site <p>until the steelwork, including any repaired areas, complies with the specified test and inspection requirements and has been approved by the Engineer.</p>

PREPARATION OF STEELWORK SURFACES

<i>Cleaning of steelwork and coated surfaces</i>	18.53	<p>(1) Soil, concrete and other adherent matter shall be removed immediately from steelwork or coated surfaces and the surfaces shall be made good by methods agreed by the Engineer.</p> <p>(2) Dust, soot, grit, detritus, metallic or other loose particles shall be removed by vacuuming after steelwork surfaces have been blast cleaned or before coated surfaces are washed or steam cleaned.</p> <p>(3) Oil and grease shall be removed by emulsion cleaners, by steam cleaning or by high pressure water jets before removing rust and mill scale or overcoating. Oil and grease shall not be removed by turpentine or other solvents. If steam cleaning is used, steam cleaning shall be carried out after the greasy deposits have been removed by scraping and a detergent shall be added to the feed water of the steam generator.</p> <p>(4) Salts, chemicals, corrosion or paint degradation products, including rust-spotting on blast cleaned surfaces and zinc salts on zinc coatings or zinc-rich paints, shall be removed by washing with detergent solution before coating steelwork surfaces or overcoating.</p> <p>(5) The final shop coats on external surfaces shall be thoroughly washed with a detergent solution at the Site before being overcoated.</p> <p>(6) Unless otherwise permitted by the Engineer finished coated surfaces shall be cleaned as stated in Clause 18.53(2) to (4) not more than 14 days before handover of the steelwork.</p> <p>(7) Cleaning agents to be used shall be as agreed by the Engineer. Surfaces which have been cleaned using cleaning agents shall be rinsed with fresh water to remove all traces of the cleaning agent.</p> <p>(8) Cleaning tools shall be a type which will not result in damage to the surfaces being cleaned. Wire brushes and brooms shall not be used for cleaning coated surfaces.</p>
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***Preparation of
steelwork surfaces***

- 18.54 (1) Bare metal surfaces of steelwork which are to be painted or metal coated shall be treated before rust and mill scale are removed in accordance with the following requirements:
- (a) Burrs, arrises and serrations shall be smoothed by grinding or filing.
 - (b) Weld spatter, weld slag and raised metal laminations shall be removed by grinding or chipping and the surface shall be made good.
- (2) Rust and mill scale shall be removed from steelwork which is to be metal coated in factories by a pickling process which is compatible with the metal coating process.
- (3) Rust and mill scale shall be removed from steelwork which is to be metal sprayed by blast cleaning carried out in accordance with BS 2569:Part 1, Clause 3.
- (4) Rust and mill scale shall be removed from steelwork which is to be painted by blast cleaning as stated in Clause 18.55 unless the use of acid-pickling, mechanical cleaning or flame cleaning as stated in Clause 18.56 to 18.58 has been approved by the Engineer.
- (5) Excess acid or other chemicals used in the pickling process shall be removed from steelwork which has been prepared by pickling before the application of the metal coating. Pickling shall not be carried out for longer than is necessary to remove the rust and mill scale.

***Blast cleaning of
steelwork***

- 18.55 (1) Blast cleaning of steelwork shall be carried out to second quality of surface finish in accordance with Sa2½ in Swedish Standard SIS 05 59 00 using chilled iron abrasive.
- (2) Chilled iron grit shall be graded in accordance with BS 2451. The maximum size of grit shall be G17 for use in automatic impeller type equipment and shall be G12 for manual or compressed air equipment. The difference in level between a peak and the adjacent trough of the blasted surface profile shall not exceed 0.1 mm.
- (3) Non-metallic abrasives with a maximum particle size not exceeding 1 mm shall not be used other than with portable equipment.
- (4) Abrasives shall not contain materials which may contaminate the steel surfaces. Sand containing salt or excessive amounts of silt shall not be used. Contaminants shall be removed from recovered abrasives before re-use.
- (5) Blast cleaning shall be carried out in a fully enclosed space separated from the place of painting. The enclosed space shall be fitted with dust extractors and filters to prevent the dispersal of dust outside the enclosed space.

***Acid-pickling of
steelwork***

- 18.56 Acid-pickling of steelwork shall be carried out by the Footner process in accordance with BS 5493, Clause 14.3.2. The first priming coat of paint shall be applied as soon as the steel has dried and is still warm.

<i>Mechanical cleaning of steelwork</i>	18.57	Mechanical cleaning of steelwork shall be carried out using carborundum grinding discs or other power-driven tools followed by steel wire brushing and dusting to remove all loosened material which is not firmly bonded to the metal surface. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall not be carried out. Visible peaks and ridges shall be removed. Pneumatic chipping hammers shall not be used.
<i>Flame cleaning of steelwork</i>	18.58	<p>(1) Flame cleaning of steelwork shall not be carried out at the following locations:</p> <ul style="list-style-type: none"> (a) within 2 m of HSFG bolts, cold worked high tensile steel and surfaces already coated with paint or cadmium, lead-based or carbonaceous materials, and (b) on sections thinner than 0.5 mm. <p>(2) Flame cleaning shall be carried out without distorting the steelwork and without adversely affecting the properties of the steel. The temperature of the steel surface being flame cleaned shall not exceed 200°C.</p> <p>(3) Loose materials shall be removed from the flame-cleaned surface by wire brushing followed by blowing dry air or vacuuming. The priming coat shall be applied when the surface temperature of the steel is between 35°C and 40°C. Surfaces with temperatures of less than 35°C shall be reheated.</p>
<i>Cleaning of bolts, nuts and washers</i>	18.59	Bolts, nuts and washers for steelwork shall be kept free from dirt and deleterious material. Oil and grease on bolts, nuts and washers, other than approved lubricants for nuts of HSFG bolts, shall be removed before assembling and coating the exposed parts of assembled bolts, nuts and washers.
<i>Approval of surface preparation</i>	18.60	Surfaces shall not be coated until the cleaning and preparation of the surfaces have been approved by the Engineer.

METAL COATINGS TO STEELWORK

<i>Metal coatings to steelwork</i>	18.61	<p>(1) Metal coatings to steelwork shall be as stated in Clause 18.61(2) to (9).</p> <p>(2) Galvanized coatings shall be applied by hot-dip galvanizing in accordance with BS 729. The coating thickness shall comply with BS 729, Table 1.</p> <p>(3) Sheradized zinc coatings shall comply with BS 4921, Table 1, Class 1.</p> <p>(4) Sprayed zinc and aluminium coatings shall comply with BS 2569:Part 1. The nominal coating thickness shall be 100 µm. The sprayed metal shall be pre-treated with product CP1 and sealed with product CP3C in accordance with BS 5493.</p>
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(5) Electroplated zinc and cadmium coatings on threaded components with a diameter not exceeding 36 mm shall comply with BS 3382:Parts 1 and 2. The coating thickness shall be at least 5 μm .

(6) Metal coatings which will be overcoated with paint shall be passivated.

(7) Allowance for the thickness of the metal coating shall be made in the sizes of the threads of metal coated threaded components. Nuts shall not be tapped oversize by more than 0.4 mm. Metal coated HSFG bolts and nuts shall not be tapped oversize unless approved by the Engineer.

(8) Damaged areas of metal coatings shall be rubbed down to remove excessive roughness, cleaned and made good with a compatible coating of a type approved by the Engineer.

(9) Metal coatings required on part of a component shall be completed before the rest of the component is painted.

PAINTING STEELWORK PAINTING STEELWORK

Painting systems for steelwork

18.62

(1) The painting system to be used for steelwork shall be one or more of the following systems as stated in the Contract, where DFT is the dry film thickness:

System A:

- primer : 1 coat of high build zinc phosphate paint,
- undercoat : 2 coats of oil based with micaceous iron oxide phenolic paint,
- finish : 1 coat of alkyd resin paint,
- minimum total DFT : 250 μm

System B:

- primer : 1 coat of epoxy resin with aluminium mastic paint,
- undercoat : 1 coat of epoxy resin paint,
- finish : 1 coat of epoxy resin paint,
- minimum total DFT : 280 μm

System C:

- primer : 1 coat of inorganic zinc silicate paint, DFT 75 μm ,
- undercoat : 2 coats of high build micaceous iron oxide epoxy paint,
- finish : 1 coat of high build amine adduct cure epoxy paint,
- minimum total DFT : 320 μm

System D:	- primer	:	1 coat of two pack wash primer, DFT 5 µm,
	- undercoat	:	1 coat of epoxy resin paint,
	- finish	:	1 coat of epoxy resin paint or 2 coats of polyurethane paint,
	- minimum total DFT	:	180 µm
System E:	- Inhibitor	:	Rustoleum or other rust inhibitor paint approved by the Engineer,
	- primer	:	zinc phosphate or, for hot-dip galvanized or GI surface, 'T' wash as specified in BS 5493, Section 2, Clause 11.3.2,
	- undercoat	:	2 coats of micaceous iron oxide paint,
	- finish	:	1 coat of oil based paint or 1 coat of micaceous iron oxide paint,
	- DFT of each coat	:	as recommended by the manufacturer

(2) The different types of paints within each painting system shall be compatible with each other and shall be manufactured by the same manufacturer. Successive coats in a painting system, including stripe coats, shall be in contrasting colours to aid identification.

***Application of paint to
steelwork***

18.63

(1) Surfaces which are to be painted shall be dry immediately before paint is applied.

(2) Paint shall be taken from the paint store ready for application. Thinning, if necessary, shall be carried out in the paint store in the presence of the Engineer and using the type of thinner in the ratio stated in the manufacturer's data sheets.

(3) Paint shall be applied by brush, by air pressure spray or by airless spray. Sealer and primers shall be applied by continuous spraying.

(4) Each coat in the paintwork system shall be sufficiently dry or cured before the next coat is applied. The time between the application of successive coats shall be within the limits recommended by the manufacturer and the limits stated in Clause 18.65.

(5) Paints having a pot life specified by the manufacturer, including two pack paints and moisture cured paints, shall be discarded on expiry of the pot life or at the end of each working day, whichever comes first. Other paints in opened containers shall be kept in sealed containers with not more than 10% ullage in store after each day's work and shall not be thinned or mixed with fresh paint when re-issued for another day's work.

***Working conditions for
painting***

18.64

(1) Paint shall not be applied to steelwork under the following conditions:

- (a) when the ambient temperature falls below 4°C or the relative humidity rises above 90%,

- (b) for outdoor work, during periods of inclement weather including fog, frost, mist and rain or when condensation has occurred or is likely to occur on the metal,
- (c) when the surface temperature of the metal to be painted is less than 3°C above the dew point of the ambient air, and
- (d) when the amount of dust in the air or on the surface to be painted is in the opinion of the Engineer excessive.

(2) Two pack paints of the epoxide resin type shall not be applied and cured when the temperature is below that recommended by the paint manufacturer.

***Priming and
overcoating time limits***

- 18.65
- (1) Blast cleaned steel shall be primed or metal coated within 4 hours after blast cleaning.
 - (2) Primed steel surfaces shall be overcoated within 8 weeks after priming.
 - (3) Second undercoats shall be applied within 72 hours after application of the first undercoat.
 - (4) Sealer or etch primer to sprayed metal shall be applied within 4 hours after spraying. The etch primed surfaces shall be overcoated within 72 hours after priming.
 - (5) Etch primer to galvanized steelwork shall be applied within 14 days after delivery of the steelwork to the Site. The etch primed surfaces shall be overcoated within 48 hours after priming.
 - (6) Overcoats to two pack paints of the epoxide or polyurethane type shall be applied within 48 hours after application of the two pack paint. If it is not possible to overcoat within 48 hours, the two pack paint shall be abraded to produce a roughened surface and shall be given a flash coat of primer of a type approved by the Engineer; the primer shall be allowed to dry for at least 4 hours before application of the next coat of the system.

***Stripe coats to
steelwork***

- 18.66
- Immediately after the first undercoat of the painting system to steelwork has dried, a stripe coat of undercoat paint shall be applied by brush to edges, corners, crevices, exposed parts of bolts, nuts, rivets and welds. Another stripe coat of finishing paint shall be applied in the same manner after the last undercoat has dried.

Paint coats to steelwork

- 18.67
- (1) The dry film thickness of the paint coats to steelwork shall be measured using a magnetic dry film thickness gauge or other apparatus approved by the Engineer. The total dry film thickness shall be measured at spacings of approximately 1.0 m. If the measured dry film thickness is less than 75% of the specified nominal dry film thicknesses or if more than 10% of the measured dry film thickness are less than 95% of the specified nominal dry film thickness, repair work shall be carried out as stated in Clause 18.69.

(2) Wet film thickness gauges shall not be used as a means of determining whether the dry film thickness of the painting system complies with the specification.

(3) Each coat of paint shall be free from embedded foreign matter, mechanical damage and surface defects, including bittiness, blistering, brush marks, bubbling, cissing, cracking, cratering, dry spray, floating, pinholing, rivelling, runs, sagging, spotting and spray mottle as stated in BS 2015. The finished paintwork system shall have an even and uniform appearance.

(4) Each coat of paint shall adhere firmly to the substrate without blistering, chipping, flaking or peeling.

<i>Etch primers and blast primers</i>	18.68	Etch primers and blast primers shall not be applied on phosphated steel and shall not be overcoated with zinc-rich primers.
<i>Repairs to damaged areas of paint</i>	18.69	<p>(1) Areas of paint to steelwork which have been damaged shall be cleaned to bare metal or to the metal coating; the edges of the undamaged paint shall be bevelled.</p> <p>(2) The full specified painting system shall be restored in such a manner that each new paint coat overlaps the existing paint by at least 50 mm all round the affected part.</p>

PROTECTION OF JOINTS IN STEELWORK

<i>Protection of HSFG bolted joints</i>	18.70	<p>(1) The faying surfaces of HSFG bolted joints in steelwork which is metal sprayed overall and sealed or metal sprayed and painted overall shall be coated with the sprayed metal. The sealer on the parent material shall extend for a distance of between 10 mm and 20 mm inside the perimeter of the faying surfaces. Free surfaces and edges of the joint material shall be coated with the same sealer.</p> <p>(2) The joint material and the faying surfaces on the parent material of steelwork which is metal sprayed only at joints and painted overall shall be metal sprayed. The sprayed metal on the parent material shall extend for a distance of between 10 mm and 20 mm outside the perimeter of the faying surfaces. The primer on the parent material shall extend for a distance of between 10 mm and 20 mm inside the perimeter of the faying surfaces. Sprayed metal on the free surfaces and edges of the joint material shall be coated with a sealer which is compatible with the painting system.</p> <p>(3) The primer on the parent material of steelwork which is painted overall and uncoated at faying surfaces of HSFG bolted joints shall extend for a distance of between 10 mm and 20 mm inside the perimeter of the faying surfaces.</p>
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<i>Protection of other shop-bolted joints</i>	18.71	Blast primer for painted steelwork or sprayed metal plus sealer for metal sprayed steelwork shall be applied to the joint and parent material of shop-bolted joints other than HSFG bolted joints; joints for painted steelwork shall be assembled after the first undercoat of the painting system has been applied to the contact surfaces and while the undercoat is still wet.
<i>Protection of other site-bolted joints</i>	18.72	Surfaces of the parent and joint material of site-bolted joints other than HSFG bolted joints shall be coated with the same protective system as the parent material.
<i>Protection of welded joints</i>	18.73	Welds and steelwork surfaces which have been affected by welding shall be coated with the same protective system as the parent material.
<i>Joints made after coating the parent material</i>	18.74	<p>(1) Hot-dip galvanizing and electroplating to steelwork shall not be carried out until all welds for the steelwork which is to be galvanized or electroplated have been completed.</p> <p>(2) Except as stated in Clause 18.74(4), sprayed metal on the parent material shall be kept at least 15 mm, but not more than 300 mm, clear of areas which are to be welded. The restricted area shall be masked during metal spraying.</p> <p>(3) Except as stated in Clause 18.74(4), successive coats of paint on the parent material shall be stepped back at 30 mm intervals commencing at 100 mm from welded joints and at 10 mm from the perimeter of HSFG bolted joints.</p> <p>(4) If the parent metal in the approved welding procedure is coated with the pre-fabrication primer or sprayed metal such coatings are permitted to cover the area to be welded. After welding the pre-fabrication primer or sprayed metal adjacent to the weld shall be made good.</p> <p>(5) The parent material, jointed material, exposed parts of bolts, nuts and washers, welds and weld affected areas shall be cleaned, prepared and brought up to the same protective system as the adjoining surfaces not more than 14 days after the joints have been made.</p>
<i>Sealing of joints in steelwork</i>	18.75	<p>(1) The different parts of joints in steelwork shall be dry immediately before the joints are assembled.</p> <p>(2) Gaps around the perimeter of bolted joints and load indicator gaps of HSFG bolts in steelwork painted overall shall be sealed by brush application of the same painting system as the parent material; gaps shall be plugged if necessary with soft solder wire without flux core as a backing before sealing with paint.</p>

PROTECTION OF SPECIAL SURFACES OF STEELWORK

<i>Protection of hollow steel sections</i>	18.76	The ends of hollow steel sections shall be sealed by welding mild steel plates over the open ends; the plates shall be at least 5 mm thick.
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<i>Protection of bearing surfaces for bridge bearings</i>	18.77	Immediately before hollow steel sections are sealed, bags of anhydrous silica gel shall be inserted in each void at the rate of 0.25 kg/m ³ of void. Dirt, oil, grease, rust and mill scale shall be removed from the metal bearing surfaces for bridge bearings. The surfaces shall be masked with tape or other methods agreed by the Engineer and shall not be primed or painted until the bonding agent has been applied.
<i>Protection of uncoated steelwork surfaces</i>	18.78	The coated surfaces of steelwork coated over part of the surface shall be protected from rust which may form on the uncoated surfaces. Temporary coatings which may affect the bond between concrete and uncoated surfaces against which the concrete is to be placed shall be removed and the uncoated surfaces shall be cleaned before the concrete is placed. The full coating system shall extend 25 mm, or 75 mm for steel piles, into areas against which concrete is to be placed.

ERECTION OF STEELWORK

<i>Temporary supports and fastenings to steelwork</i>	18.79	<p>(1) Steelwork shall be secured in position by temporary supports and fastenings until sufficient permanent connections are complete to withstand the loadings liable to be encountered during erection. The temporary supports and fastenings shall be capable of withstanding loadings which may be encountered during erection and shall not damage the steelwork or the protective coatings.</p> <p>(2) Riveted and bolted connections shall be aligned using drifts complying with BS 5400:Part 6, Clause 4.12 and shall be temporarily fastened using service bolts.</p>
<i>Alignment of steelwork</i>	18.80	<p>(1) Steelwork shall be erected in such a manner that the alignment and levels of the steelwork comply with the tolerances stated in Clause 18.86; allowance shall be made for the effects of temperature on the steelwork.</p> <p>(2) Measures shall be taken to ensure that the steelwork will remain stable before temporary supports and fastenings are slackened or removed for lining, levelling, plumbing or other purposes. The temporary supports and fastenings shall be re-tightened or replaced as soon as the adjustments are complete and at the end of each continuous period of working.</p> <p>(3) Permanent connections shall be made as soon as a sufficient portion of the steelwork has been lined, levelled and plumbed. Temporary supports and fastenings shall be replaced by permanent connections progressively and in such a manner that the parts connected are securely restrained in the aligned position at all times.</p> <p>(4) Permanent connections for each portion of steelwork shall be completed not more than 14 days after the portion has been erected.</p>
<i>Foundation bolts for steelwork</i>	18.81	<p>(1) Foundation bolts for steelwork shall be held firmly in the set position during fixing. Measures shall be taken to ensure that the full movement tolerances are achieved and the bolts are not displaced during concreting. Bolts and nuts, including the threads, shall be protected against damage, corrosion and contamination.</p> <p>(2) Bolt pockets shall be kept dry and clean. Tubes which are cast in</p>

concrete for grouting bolt pockets shall be securely fixed and sealed to prevent ingress of grout during concreting.

(3) Bolts in bolt pockets shall be installed in such a manner that the bolt can be moved inside the pocket as designed without hindrance.

<i>Supporting devices for steelwork</i>	18.82	The material, size, position and cover of packs, shims and other supporting devices for steelwork which are to be embedded shall be as approved by the Engineer.
<i>Bedding and grouting of column bases</i>	18.83	<p>(1) Column bases for each portion of steelwork shall not be bedded or grouted until the portion has been lined, levelled, plumbed and permanently connected. Spaces below the steel shall be dry, clean and free from rust immediately before bedding or grouting.</p> <p>(2) Proprietary types of grout shall be used in accordance with the manufacturer's recommendations.</p> <p>(3) Temporary timber wedges holding steel columns in position shall not project into pocket bases by more than one-third of the embedded length of the steel column. The pocket shall be initially concreted up to the underside of the wedges and the steel column shall be left undisturbed until 48 hours after concreting; the wedges shall then be removed and the remainder of the pocket shall be concreted.</p>

TOLERANCES

<i>Tolerances fabrication of steelwork</i>	18.84	Fabrication tolerances for steelwork shall comply with BS 5400:Part 6, Clause 4.2 or BS 5950:Part 2, sub-section 7.2 as appropriate.
<i>Tolerances: foundation bolts</i>	18.85	The position of castin foundation bolts at the top of base plates shall be within 3 mm of the specified position. The position of foundation bolts in bolt pockets at the top of base plates shall be within 5 mm of the specified position. The line of bolts shall not be tilted from the specified line by more than 1 in 40.
<i>Tolerances: erection of steelwork</i>	18.86	<p>(1) Steelwork shall be erected to within the tolerances stated in Clause 18.86(2) to (9) after lining, levelling, plumbing and making the permanent connections.</p> <p>(2) The position in plan of vertical components at the base shall be within 10 mm of the specified position.</p> <p>(3) The level of the top of base plates and the level of the lower end of vertical or raking components in a pocket base shall be within 10 mm of the specified level.</p> <p>(4) The thickness of bedding shall be within one-third of the nominal thickness or 10 mm, whichever is less, of the specified nominal thickness.</p> <p>(5) The line of vertical or raking components other than in portal frames shall be within 1 in 600 and within 10 mm of the specified line in every direction.</p>

(6) The line of vertical or raking components in portal frames shall be within 1 in 600 and within 10 mm of the specified line normal to the plane of the frame.

(7) The position and level of components connected with other components shall be within 5 mm of the specified position and level relative to the other components at the point of connection.

(8) The position of components supported on a bearing shall be within 5 mm of the specified position relative to the bearing along both principal axes of the bearing.

(9) The difference in level between adjacent sloping or horizontal components connected by a deck slab shall be within 10 mm of the specified difference in level.

TESTING CONSULTANT

<i>Testing consultant</i>	18.87	Tests which are stated in the Contract to be carried out by an approved testing consultant shall be carried out by a testing consultant employed by the Contractor and approved by the Engineer.
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TESTING : TESTS ON STEELWORK AT MANUFACTURER'S WORKS

<i>Testing: tests on steelwork at manufacturer's works</i>	18.88	<p>(1) Tests shall be carried out on structural steel in accordance with BS 5400:Part 6, Clauses 5.2.1, 5.2.2 and 5.3.</p> <p>(2) Tests shall be carried out on bolts, nuts and washers in accordance with BS 3692, BS 4190, BS 4395:Part 1, BS 4395:Part 2, BS 4395:Part 3 or BS 4933 as appropriate; the tests shall be carried out on full size bolts. The rates of sampling and testing shall be in accordance with BS 4395:Part 1.</p> <p>(3) The tests shall be carried out by the manufacturer at the manufacturer's works on samples selected by the manufacturer.</p>
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TESTING : STEELWORK

<i>Batch: steelwork</i>	18.89	<p>(1) A batch of steelwork is the amount of steelwork stated in the Contract and which is completed or delivered to the Site at any one time.</p> <p>(2) The Contractor shall submit to the Engineer a list of the parts included in each batch at least 7 days before testing starts.</p>
<i>Samples: steelwork</i>	18.90	<p>(1) Samples to be tested shall be selected by the Engineer if testing is to be carried out in Hong Kong and shall be selected by the approved testing</p>

consultant if testing is not to be carried out in Hong Kong.

(2) Samples shall be selected from positions which in the opinion of the Engineer or approved testing consultant are representative of the batch as a whole.

(3) The Engineer shall inform the Contractor of the samples selected for testing at least 3 days before testing starts.

***Testing:
steelwork***

18.91 (1) The relevant tests stated in Clauses 18.95 to 18.99 shall be carried out on each batch of steelwork.

(2) The Contractor shall inform the Engineer at least 7 days before tests in Hong Kong are carried out.

***Reports of tests on
steelwork***

18.92 (1) Records of tests on steelwork carried out by the Contractor or the approved testing consultant shall be kept by the Contractor and a report shall be submitted to the Engineer at least 7 days before approval of the batch of steelwork tested is required. The report shall contain the following details:

- (a) procedure tested and exact test location in the steelwork,
- (b) results of tests compared to the required values, with any non-complying results highlighted,
- (c) any tearing, cracking or other defects, and
- (d) conclusion as to the overall acceptability of the parts of steelwork examined by the approved testing consultant.

(2) Reports shall be certified by the Contractor's authorised representative or by the approved testing consultant who carried out the tests.

***Non-compliance:
steelwork***

18.93 (1) If the result of any test on steelwork stated in Clauses 18.95 to 18.99 does not comply with the specified requirements for the test, the test shall be carried out on additional samples from the batch. The number of additional tests shall be twice the number of original tests.

(2) The batch shall be considered as not complying with the specified requirements for the test if the result of any additional test does not comply with the specified requirements for the test.

Samples: steel

18.94 Samples of steel shall be provided from each batch of steel within 3 days after delivery of the batch to the fabricator's works or to the Site. The rate of sampling shall be as stated in the Contract, and the position and direction of the samples shall be in accordance with BS 4360.

Testing: steel

18.95 (1) The tensile test and the impact test shall be carried out on each sample of steel. The method of testing shall be in accordance with BS 4360.

(2) Quality grading of structural steel shall be carried out on steel which has not been tested for quality grades by the manufacturer. Quality grading

shall be carried out in accordance with BS 5400:Part 6, Clause 3.1.4 or BS 5950:Part 2, Clause 2.1.6 as appropriate.

(3) Testing and quality grading shall be carried out by the approved testing consultant.

Testing: welds

18.96

(1) Examination and testing of welds shall be carried out after post-weld heat treatment and before the application of corrosion protective coatings. De-burring, dressing, grinding, machining and peening shall be carried out after the visual inspection for cracks, surface pores and joint fi-up and before other inspections and tests are carried out.

(2) Destructive testing of welds for steelwork complying with BS 5400:Part 6 shall be carried out in accordance with BS 5400:Part 6, Clauses 5.5.1.1, 5.5.1.2 and 5.5.1.3.

(3) Welds for structural steel and steel castings shall be visually inspected in accordance with BS 5289. No-destructive testing shall be carried out on a proportion of welds after visual inspection. The compliance criteria and the proportion of welds to be tested are denoted by quality categories as stated in BS 5135, Table 18 for butt welds and in BS 5135, Table 19 for fillet welds. The quality categories of welds shall be as stated in Table 18.4.

(4) No-destructive testing of butt welds shall be carried out by ultrasonic examination in accordance with BS 3923:Part 1 or BS 3923:Part 2 or by radiographic examination in accordance with BS 2600:Part 1, BS 2600:Part 2 or BS 2910. No-destructive testing of fillet welds shall be carried out by either the liquid penetrant method in accordance with BS 6443 or the magnetic particle flaw detection method in accordance with BS 6072. The particular standard or part of standard to be used shall be appropriate for the joint geometry, material and production requirements and shall be as agreed by the Engineer. Welds shall be dressed to facilitate ultrasonic examinations.

(5) If the parent metal adjacent to a length of weld subject to non-destructive testing has been tested for laminations in accordance with BS 5996, the same areas on the parent metal shall be tested by ultrasonic examination in accordance with BS 3923:Part 1 or BS 3923:Part 2 as appropriate when no-destructive testing is carried out on that length of weld.

(6) Welds for steelwork which has been fabricated and tested by no-destructive testing at the fabricator's works shall be visually inspected for cracks when the steelwork is delivered to the Site. 5% of the welds other than welds stated in Table 18.2 shall be examined for cracks by the magnetic particle flaw detection method in accordance with BS 6072.

(7) Testing shall be carried out by the approved testing consultant except as stated in Clause 18.96(8).

(8) Inspection of welds will be carried out by the Engineer for welds stated in Table 18.2.

Table 18.4 : Quality categories of welds

Type of welds	Steelwork Complying with BS 5400:Part 6		Steelwork Complying with BS 5950:Part 2	
	Butt welds	Fillet welds	Butt welds	Fillet welds
Welds stated in the Contract for 100% non-destructive testing	A	A	A	A
Welds stated in Table 18.2	D	D	D	D
Other welds	B	B	C	C

**Testing: stud shear
connectors and rivets**

18.97

(1) Tests shall be carried out on 5% of welded stud shear connectors in accordance with BS 5400:Part 6, Clause 5.5.4.

(2) Tests shall be carried out on 5% of driven rivets in accordance with BS 5400:Part 6, Clause 5.8.

(3) Testing shall be carried out by the Contractor in the presence of the Engineer.

**Testing:
fabrication tolerance**

18.98

(1) Rolled and built-up sections of steelwork complying with BS 5400:Part 6 shall be tested to determine compliance with fabrication tolerances in accordance with BS 5400:Part 6, Clauses 5.6.1 to 5.6.6.

(2) Testing shall be carried out by the Contractor in the presence of the Engineer.

Testing: repairs

18.99

Defects which have been repaired and adjoining areas which in the opinion of the Engineer may have been affected by the repair shall be retested as instructed by the Engineer.

**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 19
HANDRAILING, LADDERS, STAIRS AND FLOORING**

SECTION 19

HANDRAILING, LADDERS, STAIRS AND FLOORING

GENERAL

<i>General requirements</i>	19.01	The works and materials specified in Clauses 19.02 to 19.06 shall comply with the sections stated, unless otherwise stated in this Section.
<i>Fencing</i>	19.02	Fencing shall comply with Section 4.
<i>Pedestrian handrailing</i>	19.03	Pedestrian guardrailing shall comply with Section 11.
<i>Materials for grout</i>	19.04	Materials for grout shall comply with Section 16.
<i>Steelwork</i>	19.05	Steelwork, including protective treatment, shall comply with Section 18.
<i>Vehicular parapets</i>	19.06	Vehicular parapets shall comply with Section 20.

MATERIALS

<i>Steel</i>	19.07	Steel for handrailing, ladders, stairs and flooring shall comply with the following:
		<div>Steel tubes and tubulars suitable for screwing to BS 21 pipe threads : BS 1387</div> <div>Hot rolled sections : BS 4:Part 1</div> <div>Hot rolled structural steel sections</div> <div>- equal and unequal angles : BS 4848:Part 4</div> <div>- hollow sections : BS 4848:Part 2</div> <div>Weldable structural steels : BS 4360.</div>
<i>Stainless steel</i>	19.08	Stainless steel for handrailing, ladders, stairs and flooring shall be grade 304 S 15 complying with BS 970:Part 1. Stainless steel tubes shall be longitudinally welded tubes complying with BS 6323:Part 8, designation LW 21 GZF(S). Tubes for handrails shall be polished.

Aluminium

- 19.09 (1) Aluminium for handrailing, ladders, stairs and flooring shall be type H 30 TF and shall comply with the following:

Wrought aluminium and
aluminium alloys for
general engineering
purposes

- plate, sheet and strip : BS 1470
- drawn tube : BS 1471
- bars, extruded round
tubes and sections : BS 1474

- (2) Aluminium shall be anodised to Grade AA 25 in accordance with BS 1615.

**Bolts, nuts, screw,
washers and rivets**

- 19.10 (1) Bolts, nuts, screws, washers and rivets shall comply with the following:

ISO metric black hexagon
bolts, screws and nuts : BS 4190

ISO metric black cup and
countersunk headbolts and
screws with hexagon nuts : BS 4933

Metal washers for general
engineering purposes : BS 4320

Rivets for general
engineering purposes : BS 4620

Wrought aluminium and
aluminium alloys for
general engineering
purposes
- rivet, bolt and
screw stock : BS 1473

Stainless steel fasteners : BS 6105

- (2) The length of bolts shall be such that the threaded portion of each bolt projects through the nut by at least one thread and by not more than four threads.

- (3) Rag, indented bolts, expansion bolts and resin bonded bolts shall be a proprietary type approved by the Engineer and shall be capable of withstanding the design working load.

- (4) Galvanized bolts, nuts, screws, washers and rivets shall be used with galvanized handrailing, ladders, stairs and flooring and aluminium bolts, nuts, screws, washers and rivets shall be used with aluminium handrailing, ladders, stairs and flooring; stainless steel bolts, nuts, screws, washers and rivets shall be used with other types of handrailing, ladders, stairs and flooring. Bolts, nuts, screws and washers shall be insulated from aluminium by non-metallic washers and sleeves.

<i>Cement mortar</i>	19.11	<p>(1) Mortar for grouting fixing bolts shall consist of 1 part of cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the bolt holes. The mix shall contain a non-shrink admixture.</p> <p>(2) Resin grout shall be proprietary type approved by the Engineer and shall contain a non-shrink admixture.</p> <p>(3) Mortar for building in curbs for metal flooring shall consist of 1 part of cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for the work. The mix shall contain a non-shrink admixture.</p>
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DESIGN BY CONTRACTOR

<i>Design by Contractor</i>	19.12	<p>Handrailing, ladders, stairs and flooring which are to be designed by the Contractor shall comply with the following requirements:</p> <p>(a) Handrailing shall be capable of withstanding a horizontal loading of 740 N/m. The deflection of handrailing shall not exceed 1 in 200 at mid-span.</p> <p>(b) Stairs shall be designed for a live loading of 5 kPa.</p> <p>(c) Flooring shall be designed for a live loading of 5 kPa. The deflection of flooring shall not exceed 1/200 of the span.</p>
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FABRICATION OF HANDRAILING, LADDERS, STAIRS AND FLOORING

<i>Fabrication of steelwork</i>	19.13	Steelwork for handrailing, ladders, stairs and flooring shall be fabricated in accordance with BS 5950:Part 2.
<i>Galvanizing to steel</i>	19.14	<p>(1) Steel which is to be galvanized shall be hot-dip galvanized in accordance with BS 729 to a coating thickness of at least 500 g/m².</p> <p>(2) Galvanizing to steel shall be applied after welding, drilling and cutting are complete.</p>
<i>Welding steel</i>	19.15	<p>(1) Welds to steel for handrailing, ladders, stairs and flooring shall be full depth fillet welds. The welded surface shall be clean and flush before application of the protective coating.</p> <p>(2) Steel shall not be welded after galvanizing unless permitted by the Engineer; if permitted, the welded areas shall be free from scale and slag and shall be treated with an alternative galvanizing system approved by the Engineer.</p>
<i>Fabrication of handrailing</i>	19.16	Handrailing shall be discontinued at movement joints in structures. The spacing between standards shall be regular and shall not exceed 1.6 m. Curved handrailing shall not be made up of a series of straights.

<i>Fabrication of ladders</i>	19.17	<p>(1) Ladders shall comply with BS 4211</p> <p>(2) Steel ladders shall be hot-dip galvanized.</p> <p>(3) Aluminium ladders shall be Grade 6082 aluminium.</p> <p>(4) Rungs, extended stringers, safety cages and brackets shall be welded to the stringers of ladders.</p> <p>(5) Rungs on aluminium ladders shall have longitudinal grooves and pressed aluminium alloy caps shall be fixed to open ends.</p>
<i>Fabrication of stairs</i>	19.18	Stairs shall comply with BS 5395:Part 1.
<i>Fabrication of flooring</i>	19.19	<p>(1) The shape of each panel of flooring shall be such that the panel can be easily removed. The mass of each panel shall not exceed 40 kg. Where intermediate supports are provided to support flooring they shall be capable of being removed to provide the specified clear opening.</p> <p>(2) Curbs shall be provided in concrete surfaces for flooring.</p> <p>(3) Cut-outs in flooring shall be neatly shaped and shall be provided with toe plates. Cut-outs in open mesh flooring shall be trimmed with edge bars welded to the bearing bars. The clearance between the edge of cut-outs and the component passing through the cut-out shall not exceed 30 mm.</p> <p>(4) The bearing bars in open mesh flooring shall be welded to the nosing bars. The transverse bars shall be rivetted or welded to the bearing bars. Panels of open mesh flooring shall be secured with adjustable fixing clips.</p> <p>(5) Chequer plate flooring shall have a non-slip pattern of a type approved by the Engineer and shall be provided with lifting holes. The flooring shall be secured to curbs by countersunk screws.</p>
<i>Fabrication of toe plates</i>	19.20	Toe plates shall be fixed to handrail standards by brackets and shall be bolted or welded to stairs and flooring.
<i>Fabrication of safety chains</i>	19.21	<p>(1) Safety chains shall comply with BS 4942 and shall be capable of withstanding a breaking force of 30 kN and a proof force of 15 kN.</p> <p>(2) Steel safety chains shall be 8 mm nominal size, Grade M4 non-calibrated chain Type 1 and shall be hot-dip galvanized.</p> <p>(3) The links of stainless steel safety chains shall be welded and shall have an internal length exceeding 45 mm and an internal width of between 12 mm and 18 mm. Fins caused by welding shall be removed.</p> <p>(4) Hooks on chains shall be fitted with a sprung securing device.</p>

SUBMISSIONS

***Particulars o
handraining, stairs,
ladders and flooring***

- 19.22 (1) The following particulars of the proposed handrailing, ladders, stairs and flooring shall be submitted to the Engineer:
- (a) details of manufacturer's name and place of manufacture,
 - (b) a certificate showing that the materials comply with the requirements stated in the Contract,
 - (c) drawings showing layout and details of handrailing, including positions of the different type of standards,
 - (d) drawings showing details of ladders, stairs, toe plates and safety chains,
 - (e) drawing showing layout and details of flooring, including positions and sizes of panels and supports,
 - (f) details of methods of fixing and of rag, indented, expansion and resin bonded bolts, including manufacturer's literature, and
 - (g) design details in accordance with Clause 19.12.
- (2) The particulars shall be submitted to the Engineer at least 14 days before fabrication starts.

Samples o materials

- 19.23 (1) The following samples of the proposed handrailing, ladders, stairs and flooring shall be submitted to the Engineer at least 14 days before the relevant work starts:
- (a) handrails,
 - (b) standards,
 - (c) ladders, including rungs,
 - (d) toe plates,
 - (e) flooring and curbs,
 - (f) safety chains, and
 - (g) rag, indented, expansion and resin bonded bolts.
- (2) The details of samples shall be as instructed by the Engineer.
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STORAGE OF MATERIALS

<i>Storage of handrailing, ladders, stairs and flooring</i>	19.24	Handrailing and flooring shall be stored on level supports in a dry weatherproof store and in a manner which will not result in damage or deformation to the materials or in contamination of the materials. Handrailing, ladders, stairs and flooring shall be protected from damage and damaged handrailing, ladders, stairs and flooring shall not be used in the permanent work unless permitted by the Engineer.
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INSTALLATION OF HANDRAILING, LADDERS, STAIRS, AND FLOORING

<i>Installation of handrailing, ladders and</i>	19.25	<p>(1) Handrailing shall be installed to a smooth alignment.</p> <p>(2) Handrail standards, flanges, ladders and stairs shall be bolted to metalwork and shall be fixed to concrete using rag, indented, expansion or resin bonded bolts. The bolts shall be fitted into pockets left in the concrete and the pockets shall be filled with cement mortar or resin grout.</p>
<i>Installation of flooring</i>	19.26	<p>(1) Flooring and curbs shall be flush with the adjoining surfaces.</p> <p>(2) Curbs shall be fitted into rebates left in the concrete and the rebates shall be filled with cement mortar.</p> <p>(3) Flooring shall be closely butted and the gap between panels and curbs, adjacent panels and other surfaces shall not exceed 10 mm.</p>

TOLERANCES

<i>Tolerances: handrailing, ladders, stairs and flooring</i>	19.27	<p>Handrailing, ladders, stairs and flooring shall comply with the following requirements:</p> <p>(a) The position and height of handrailing shall be within 10 mm of the specified position and height.</p> <p>(b) The level of the top rung of ladders and the top tread of stairs shall be within 75 mm of the specified level.</p> <p>(c) The level of flooring and curbs shall be within 3 mm of the specified level.</p>
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**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 20
BRIDGEWORKS**

SECTION 20

BRIDGEWORKS

PART 1 : WATERPROOFING

MATERIALS

- | | | |
|--------------------------------------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Prefabricated sheeting</i> | 20.01 | <p>(1) Prefabricated sheeting for waterproofing shall be a proprietary type approved by the Engineer.</p> <p>(2) Prefabricated sheeting shall not rot or support the growth of mildew and shall be compatible with the materials with which it is in contact. Prefabricated sheeting which will be exposed to sunlight after installation shall be of a type which is unaffected by ultraviolet light.</p> <p>(3) Prefabricated sheeting shall have a tensile strength, pliability and puncture resistance such that the sheeting will withstand the stresses induced during handling and laying without damage. The elongation properties of prefabricated sheeting shall be such that the sheeting can accommodate the creep, shrinkage and thermal movements of concrete without distress.</p> <p>(4) Prefabricated bituminous sheeting shall be a self-adhesive, self-sealing type and shall have a thickness of at least 1.2 mm.</p> <p>(5) Prefabricated rubberised base sheeting shall be of a type which is unaffected by fuels, oils or grease.</p> <p>(6) Primers and mastic for prefabricated sheeting shall be a proprietary type recommended by the sheeting manufacturer and approved by the Engineer.</p> |
| <i>Bentonite panels</i> | 20.02 | <p>(1) Bentonite panels shall consist of bentonite filler enclosed in self-degradable boards. The panels shall have a permeability of less than 1×10^{-7} mm/sec under simulated test conditions similar to those of the as-built conditions. The performance of bentonite panels shall not be affected by contaminants present in the groundwater.</p> <p>(2) Bentonite panels for slabs less than 200 mm thick or with soil cover of less than 450 mm shall be special panels with specific provision for swelling to prevent lifting of the slab.</p> <p>(3) Bentonite joint seal and bentonite granules shall be a proprietary type recommended by the bentonite panel manufacturer and approved by the Engineer.</p> <p>(4) Polyethylene sheeting for use with bentonite panels shall be a heavy duty type.</p> |

<i>Bituminous paint</i>	20.03	Bituminous paint for waterproofing shall be cut-back bitumen complying with BS 3690:Part 1. The bitumen shall have a viscosity grade as determined by a standard tar viscometer within the range 25-50 seconds with a coverage of 0.5 L/m ² . Primers for bituminous paint shall be a proprietary type recommended by the bituminous paint manufacturer and approved by the Engineer.
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SUBMISSIONS

<i>Particulars of waterproofing systems</i>	20.04	<p>(1) The following particulars of the proposed waterproofing systems shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) manufacturer's literature and a certificate for prefabricated sheeting showing the manufacturer's name, the date and place of manufacture and showing that the prefabricated sheeting complies with the requirements stated in the Contract and including results of tests for: <ul style="list-style-type: none"> - tensile strength - pliability - puncture resistance - elongation, (b) manufacturer's literature and a certificate for bentonite panels showing the manufacturer's name, the date and place of manufacture and showing that the bentonite panels comply with the requirements stated in the Contract and including results of tests for permeability, (c) manufacturer's literature and a certificate for bituminous paint showing the manufacturer's name, the date and place of manufacture and showing that the bituminous paint complies with the requirements stated in the Contract and including results of tests for viscosity, (d) particulars of primers and mastic for prefabricated sheeting, bentonite joint seal and bentonite granules and primers for bituminous paint, and (e) methods of laying prefabricated sheeting and bentonite panels. <p>(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.</p>
<i>Samples of materials for waterproofing systems</i>	20.05	<p>Samples of the following proposed materials for waterproofing systems shall be submitted to the Engineer at the same time as particulars of the material are submitted:</p> <ul style="list-style-type: none"> (a) prefabricated sheeting, and (b) bentonite panels.

DELIVERY AND STORAGE OF MATERIALS

<i>Delivery of bentonite panels</i>	20.06	Bentonite panels shall be delivered in original unbroken packages bearing the manufacturer's label.
<i>Storage of materials for waterproofing systems</i>	20.07	<p>(1) Prefabricated sheeting and bentonite panels shall be stored in accordance with the manufacturers' recommendations in a dry weatherproof store with a raised floor.</p> <p>(2) Bituminous paint shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions which may affect the bituminous paint. The bituminous paint shall be stored in accordance with the manufacturer's recommendations and shall not be used after the recommended shelf life has been exceeded.</p>

INSTALLATION OF WATERPROOFING SYSTEMS

<i>Installation of waterproofing systems</i>	20.08	<p>(1) Surfaces on which waterproofing systems will be laid shall be clean, dry and free from voids, loose aggregate, sharp protrusions, projecting tying wire, release agents and other substances which are likely to damage or affect the waterproofing system.</p> <p>(2) Waterproofing systems shall be laid in accordance with the manufacturer's recommendations.</p> <p>(3) Before waterproofing systems are laid on concrete surfaces, the concrete surface shall have been cured for at least 7 days and shall be cleaned with a broom and sealed with one coat of primer. Primed surfaces shall not be covered until the solvent constituent has evaporated. Water shall be allowed to evaporate from primers containing bituminous emulsion before the surface is covered. Primed surfaces shall be protected from contamination.</p>
<i>Installation of prefabricated sheeting</i>	20.09	<p>(1) Prefabricated sheeting shall be laid one sheet at a time from low points and drains towards high points. The sheeting shall be firmly and tightly brought into contact with the primer or underlying sheeting.</p> <p>(2) Laps shall be formed at joints between individual sheets of prefabricated sheeting. Unless otherwise approved by the Engineer, end laps shall be at least 150 mm and side laps shall be at least 100 mm. Joints shall be arranged in such a manner that the number of layers of sheeting at any joint does not exceed three.</p> <p>(3) The perimeter of prefabricated sheeting laid each day shall be sealed with a trowelled bead of mastic.</p> <p>(4) A double layer of prefabricated sheeting shall be laid around pipes, posts or other components which pass through the sheeting and the edges shall be sealed with a trowelled bead of mastic.</p>
<i>Installation of bentonite panels</i>	20.10	<p>(1) Bentonite panels shall not be laid in water or during wet weather.</p> <p>(2) Immediately before bentonite panels are laid on a surface, joints and cracks in the surface shall be sealed with bentonite joint seal.</p> <p>(3) Polyethylene sheeting shall be laid below and above bentonite panels to prevent prehydration. Laps of at least 100 mm shall be formed at</p>

joints in the sheeting.

(4) Laps shall be formed at the edges of bentonite panels or the edges shall be closely butted together and the seam filled with loose bentonite granules.

(5) Bentonite panels shall not be fixed to the underlying surface unless permitted by the Engineer; if permitted, the method of fixing shall be by 25 mm masonry washerhead nails or by other methods agreed by the Engineer.

(6) Bentonite panels shall be laid continuously around wall bases and corners. Flat panels shall not be folded or bent if the panels will be damaged or bentonite filler will be lost.

(7) Bentonite which is exposed at the edges of bentonite panels cut to fit around pipes, posts or other components which pass through the panel shall be taped or sealed by other methods agreed by the Engineer to prevent loss of the bentonite filler. The joint between panels and the pipe, post or component shall be sealed with a continuous bentonite seal.

(8) Exposed bentonite panels shall be protected from moisture by polyethylene sheeting unless panels with a water repellent coating are used. The sheeting shall be removed before fill material is deposited. As soon as practicable after each course of panels has been laid, fill material shall be deposited and compacted up to a level which is within 50 mm of the top edge of the panel.

(9) Damaged or expanded bentonite panels shall be replaced before being covered by the permanent work.

***Bituminous paint
waterproofing systems***

20.11

Surfaces to which bituminous paint will be applied shall be treated with a primer before the paint is applied if recommended by the paint manufacturer. Bituminous paint shall be applied in two coats; the first coat shall be allowed to dry before the second coat is applied.

PART 2 : BRIDGE BEARING

GLOSSARY OF TERMS

<i>Schedule of bearings</i>	20.12	Schedule of bearings is the schedule of bearings stated in the Contract.
<i>Type of bridge bearing</i>	20.13	Type of bridge bearing is a term used to identify bridge bearings of exactly the same design and same capacity for all bearing loads, movements and rotations.

MATERIALS

<i>Holding down bolts for bridge bearings</i>	20.14	Holding down bolts for bridge bearings shall be a proprietary type approved by the Engineer.
<i>Cement mortar, grout and adhesive for bridge bearings</i>	20.15	<p>(1) Cement mortar for bedding and construction of unreinforced plinths for bridge bearings shall be a proprietary non-shrink type approved by the Engineer having a grade strength of at least 50 MPa.</p> <p>(2) Chemical-resin mortar for the construction of plinths for bridge bearings shall be a proprietary non-shrink type approved by the Engineer having a grade strength of at least 50 MPa.</p> <p>(3) Grout for grouting base plates and holding down bolts shall be a proprietary non-shrink cementitious type approved by the Engineer having a grade strength of at least 50 MPa. The grout shall be flowable and shall not bleed or segregate. The suitability of the grout shall be demonstrated by site trials to the satisfaction of the Engineer. Chemical-resin based grout shall not be used.</p> <p>(4) Adhesives and chemical resin mortars for locating and bedding elastomeric bridge bearings shall be a proprietary type approved by the Engineer. They shall be compatible with the elastomer.</p>
<i>Dowel bars for bridge bearings</i>	20.16	Dowel bars for bridge bearings shall be grade 316 S 31 or 316 S 33 stainless steel complying with BS 970:Part 1.

DESIGN OF BRIDGE BEARINGS

<i>Design of bridge bearings</i>	20.17	<p>(1) Bridge bearings shall be designed by the Contractor unless otherwise stated in the Contract.</p> <p>(2) The design and manufacture of bridge bearings and the materials used shall comply with BS 5400:Part 9, including the guidance notes, except as stated in Clauses 20.18 and 20.19. Inspection and maintenance of bridge bearings shall be easy to carry out and the bearings shall be easily replaceable.</p>
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(3) The maximum bearing stress in concrete underlying or overlying a bridge bearing under the design load at the ultimate limit state shall not exceed 40% of the specified grade strength of the concrete. Higher bearing stresses may be adopted provided that in the opinion of the Engineer sufficient steel reinforcement is provided to resist the resulting bursting forces and that the bearing stresses are within the limits stated in Clause 7.2.3.3 of BS 5400:Part 4.

(4) The deflection of bridge bearings which have a specified zero horizontal movement in a particular direction shall not exceed 1 mm in that direction under the maximum horizontal loadings.

<i>Design of sliding bearings</i>	20.18	(1) Clause 4.3.4.2 of BS 5400:Part 9:Section 9.2 shall not apply to sliding bearings. (2) Stainless steel sliding surfaces of sliding bearings which are attached to backing plates by mechanical fasteners instead of continuous welding along the edges shall be bonded to the backing over the full area and supplemented with peripheral sealing if necessary. Mechanical fixing with peripheral sealing only shall not be used.
<i>Design of elastomeric bearings</i>	20.19	The requirements for use of elastomer in elastomeric bearings at subzero temperatures stated in Clause 3.7.1 of BS 5400:Part 9:Section 9.2 shall not apply.
<i>Design of guides for bridge bearings</i>	20.20	The clearance between guides and complementary sliding surfaces of a guided bearing shall not exceed 1 mm.
<i>Design of fixings for bridge bearings</i>	20.21	(1) Except for elastomeric bearings, bridge bearings, including bearings which are not required to provide horizontal restraint, shall be fixed to the superstructure and substructure with mechanical fixings or by other methods approved by the Engineer. The friction between the bearing and the superstructure or substructure may be used to resist the horizontal forces provided that a factor of safety of at least 2 is applied to the proven coefficient of friction and that the worst combination of vertical load and horizontal load is considered. (2) The ultimate capacity of the mechanical fixings for bridge bearings shall not be less than the worst combination of loading at ultimate limit state stated in the schedule of bearings.
<i>Protective coatings to bridge bearings</i>	20.22	Metal components of bridge bearings shall be protected against corrosion by a protective coating complying with, and selected in accordance with, BS 5493. For the purpose of selecting the coating system, the environment shall be classified as 'exterior exposed - polluted coastal' and the typical time to first maintenance shall be 'very long' (20 years or more).
<i>Marking of bridge bearings</i>	20.23	(1) Bridge bearings shall be marked by the manufacturer either with the type numbers stated in the schedule of bearings or with the manufacturer's own type or other numbers. A schedule shall be provided which relates the manufacturer's own type or other numbers to the type numbers stated in the schedule of bearings.

(2) The design movement directions and magnitudes and the axes of bearing shall be marked on the upper faces of bridge bearings to facilitate checking of the installation. Movement indicators shall be provided for sliding and roller bearings to permit checking of movements of the bearings before and after installation.

SUBMISSIONS

Particulars of bridge bearings

20.24

(1) The following particulars of the proposed bridge bearings shall be submitted to the Engineer:

- (a) details of type of bridge bearings, including materials, and the name and address of the manufacturer,
- (b) design calculations, including calculations of bearing stresses above and below the bearings and calculations for bursting or other necessary additional or revised reinforcement,
- (c) shop drawings and drawings of any additional or revised reinforcement details,
- (d) a certificate for each type of bridge bearing showing the manufacturer's name, the date and place of manufacture and showing that the bridge bearings comply with the requirements stated in the Contract and including results of:
 - friction tests
 - load tests
 - tests on elastomers
 - quick production tests
 - stiffness tests,
- (e) values of stiffness in compression and in shear of elastomeric bearings,
- (f) details of fixings to superstructures and substructures,
- (g) details of protective coatings,
- (h) methods of installation, and
- (i) programme of manufacture, testing and delivery, including name and address of testing laboratory.

(2) The particulars shall be submitted to the Engineer at least 28 days before the Engineer's approval of the bridge bearings is required. Certificates shall be submitted for each batch of bridge bearings delivered to the Site.

STORAGE OF MATERIALS

<i>Storage of bridge bearings</i>	20.25	Bridge bearings shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the bearings or in contamination of the bearings.
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INSTALLATION OF BRIDGE BEARINGS

<i>Installation of bridge bearings</i>	20.26	<p>(1) Bridge bearings shall be installed as recommended in BS 5400:Part 9 and as stated in Clauses 20.26(2) to (7).</p> <p>(2) Bridge bearings which have been pre-assembled shall not be dismantled unless approved by the Engineer.</p> <p>(3) The levels of substructures stated in the Contract on which bridge bearings will be installed shall be adjusted to suit the thickness of the bearing so that the superstructure will be at the specified level after completion.</p> <p>(4) Bridge bearings, other than elastomeric bridge bearings, shall be set level on substructures using only a thin layer of cementitious mortar, unless the Engineer permits the bearings to be set on plinths. If setting on plinths is permitted, the plinths shall be constructed of cementitious mortar or grout, unless otherwise approved by the Engineer, and the thickness of such plinths shall be at least 25 mm and shall not exceed 40 mm. If approved by the Engineer, the plinths may be constructed of chemical resin mortar, having a thickness of at least 5 mm and not exceeding 10 mm.</p> <p>(5) Elastomeric bearings shall be set directly on the substructure. A thin layer of cementitious mortar may be used to level the surface if the substructure is concrete. Elastomeric bearings shall not be set in position by grouting between the substructure and the underside of the bearing.</p> <p>(6) The top surface of bridge bearings which will support precast concrete or other prefabricated beams shall be covered with a thin layer of cementitious mortar immediately before the beam is placed. The beam shall be temporarily supported on folding wedges or by other methods agreed by the Engineer until the mortar has achieved sufficient strength to transmit the weight of the beam to the bearings; the temporary supports shall then be removed.</p> <p>(7) Temporary locking devices for bridge bearings shall be removed before post-tensioned superstructures are stressed. Temporary locking devices for other types of superstructures shall be removed at times agreed by the Engineer.</p>
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TOLERANCES

<i>Tolerances: bridge bearings</i>	20.27	<p>(1) The centreline of bridge bearings shall be within 3 mm of the specified position.</p> <p>(2) The level of bridge bearings shall be within 0.0001 times the</p>
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adjacent span or the lesser of the adjacent spans or within 5 mm of the specified level, whichever is less.

(3) The inclination of bridge bearings shall be within 1 in 200 of the specified inclination.

(4) The horizontal axis of bridge bearings shall be within 0.005 radian of the specified alignment.

(5) Departure from the common plane between twin or multiple bridge bearings shall be within the tolerances stated in the Contract.

TESTING : BRIDGE BEARINGS - GENERAL REQUIREMENTS

<i>Batch: bridge bearings</i>	20.28	A batch of bridge bearings is any quantity of bridge bearings of the same type fabricated by the same manufacturer and which for the purpose of testing elastomeric bearings contains the same type of elastomer.
<i>Testing: bridge bearings</i>	20.29	<p>(1) Bridge bearings shall be tested by the Contractor at a laboratory approved by the Engineer.</p> <p>(2) The Contractor shall inform the Engineer of the date and place of testing at least 28 days before testing starts.</p> <p>(3) The specified procedures for testing bridge bearings shall not be changed unless permitted by the Engineer.</p> <p>(4) The reports of tests on bridge bearings shall include load/deflection graphs and shall be submitted to the Engineer for approval at least 28 days before installation of the bridge bearings starts.</p>

TESTING : FRICTION TEST FOR BRIDGE BEARINGS

<i>Samples: friction test for bridge bearings</i>	20.30	One sample of bridge bearing shall be provided from each batch of sliding bearings and from each batch of other types of bridge bearings which contain sliding parts.
<i>Testing: friction test for bridge bearings</i>	20.31	<p>(1) The friction test shall be carried out on each sample of bridge bearing provided as stated in Clause 20.30 to determine the coefficient of friction, flatness, bonding properties and resistance to mechanical damage. The method of testing shall be in accordance with Appendix 20.1.</p> <p>(2) The friction test shall be carried out at room temperature.</p>
<i>Compliance criteria: friction test for bridge bearings</i>	20.32	<p>The results of friction tests for bridge bearings shall comply with the following requirements:</p> <p>(a) The coefficient of friction in any test position shall not exceed 0.04.</p> <p>(b) The flatness of the stainless steel shall be within the specified limits after testing.</p>

- (c) The bond to the backing plate shall be unaffected by the friction test.
- (d) The PTFE shall be free from mechanical damage after testing.

TESTING : BRIDGE BEARINGS OTHER THAN ELASTOMERIC BEARINGS

<i>Samples: bridge bearings other than elastomeric bearings</i>	20.33	One sample of bridge bearing shall be provided from each batch of bridge bearings other than elastomeric bearings.
<i>Testing: bridge bearings other than elastomeric bearings</i>	20.34	Vertical load tests and horizontal load tests shall be carried out on each sample of bridge bearing provided as stated in Clause 20.33. The test loads shall be the serviceability limit state loads. If stated in the Contract, additional tests with test loads up to the ultimate limit state loads shall be carried out. The method of testing shall be in accordance with Clause 7.2(b)(1) of the guidance notes to BS 5400:Section 9.2.
<i>Compliance criteria: bridge bearings other than elastomeric bearings</i>	20.35	The results of tests on bridge bearings other than elastomeric bearings shall comply with the requirements stated in Clause 7.2(b)(1) of the guidance notes to BS 5400:Section 9.2.

TESTING : ELASTOMERIC BEARINGS

<i>Samples: elastomeric bearings</i>	20.36	<p>(1) Except as stated in Clause 20.36(2), one sample of elastomeric bearing shall be provided from each batch of elastomeric bearings for testing by the “Quick Production Test”.</p> <p>(2) Samples shall not be provided for the “Quick Production Test” if in the opinion of the Engineer there is sufficient evidence that tests have been carried out within the previous 18 months on identical materials and that the results of the tests comply with the specified requirements for the test.</p> <p>(3) Two samples of elastomeric bearings shall be provided from each batch of ten or part thereof of elastomeric bearings to determine the stiffness in compression and stiffness in shear.</p>
<i>Testing: elastomeric bearings</i>	20.37	<p>(1) Each sample of elastomeric bearing provided as stated in Clause 20.36(1) shall be tested to determine the physical and weathering properties of the elastomer and the bond of the elastomer to metal. The method of testing shall be the “Quick Production Test” in accordance with the guidance notes to BS 5400:Section 9.2.</p> <p>(2) One sample of elastomeric bearing provided as stated in Clause 20.36(3) shall be tested to determine the stiffness in compression and the other sample shall be tested to determine the stiffness in shear.</p>

The method of testing to determine the stiffness in compression shall be in accordance with Clause 7.2(b)(2) of the guidance notes to BS 5400:Section 9.2. The method of testing to determine the stiffness in

compression shall be in accordance with BS 5400:Section 9.2, Appendix A.

***Compliance criteria:
elastomeric bearings***

20.38 The results of tests on elastomeric bearings shall comply with the following requirements:

- (a) There shall be no evidence of surface flaws in the bearings during or after the test.
 - (b) There shall be no irregularities in the deflected shape of laminated bearings during or after the test.
 - (c) The stiffness in compression shall be within 20% of the value quoted by the manufacturer and approved by the Engineer.
 - (d) The stiffness in shear shall be within 20% of the value quoted by the manufacturer and approved by the Engineer.
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PART 3 : VEHICULAR PARAPETS

MATERIALS

<i>Vehicular parapets</i>	20.39	<p>(1) Vehicular parapets shall be of the types stated in the Contract.</p> <p>(2) Steel for vehicular parapets, including welding, shall comply with Section 18 except that the requirements for testing shall not apply.</p> <p>(3) Protective treatment to steel for vehicular parapets shall comply with Section 18 and shall be applied after welding, drilling and cutting is complete.</p> <p>(4) Aluminium for vehicular parapets shall comply with the following:</p> <div style="margin-left: 40px;"> <p>Wrought aluminium and aluminium alloys for general engineering purposes</p> <p>- plate, sheet and strip : BS 1470</p> <p>- rivet, bolt and screw stock : BS 1473</p> <p>- bars, extruded round tubes and sections : BS 1474.</p> </div> <p>(5) Aluminium shall be anodised to Grade AA 25 in accordance with BS 1615.</p> <p>(6) Welding of aluminium for vehicular parapets shall comply with the following:</p> <div style="margin-left: 40px;"> <p>TIG welding of aluminium, magnesium and their alloys : BS 3019:Part 1</p> <p>Aluminium and aluminium alloys : BS 3571:Part 1</p> </div> <p>(7) Stainless steel bolts, nuts and washers for vehicular parapets shall be grade A4-80 and shall comply with BS 6105.</p>
<i>Holding down bolts for vehicular parapets</i>	20.40	Holding down bolts for vehicular parapets shall be a proprietary type approved by the Engineer.
<i>Grout for vehicular parapets</i>	20.41	Grout for holding down bolts for vehicular parapets shall be based on polyester resins and shall be a proprietary type approved by the Engineer. Epoxy resin based grout shall not be used.

SUBMISSIONS

<i>Samples of materials for vehicular parapets</i>	20.42	Samples of the proposed posts and rails for vehicular parapets shall be submitted to the Engineer at least 14 days before installation of the parapets starts.
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STORAGE OF MATERIALS

<i>Storage of vehicular parapets</i>	20.43	Vehicular parapets shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the parapets or in contamination of the parapets.
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INSTALLATION OF VEHICULAR PARAPETS

<i>Installation of vehicular parapets</i>	20.44	<p>(1) Vehicular parapets shall be installed to a smooth alignment and with the posts vertical.</p> <p>(2) Grouting shall be carried out by setting the vehicular parapets in position and grouting the gap between the vehicular parapets and the structure. Vehicular parapets shall be held in position until connections and fixings are complete and until the fixings have gained sufficient strength.</p>
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TOLERANCES

<i>Tolerances: vehicular parapets</i>	20.45	Vehicular parapets shall be within 10 mm of the specified position and height.
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PART 4 : MOVEMENT JOINTS

GENERAL

<i>Movement joints formed in place</i>	20.46	Movement joints formed in place shall comply with Section 16 except as stated in this Section.
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GLOSSARY OF TERMS

<i>Fabricated movement joint</i>	20.47	Fabricated movement joint is a manufactured assembly, including nosings, designed to carry traffic smoothly over a movement joint and to seal the joint against the ingress of water and debris.
<i>Movement joint</i>	20.48	Movement joint is a permanent joint or hinge throat which allows expansion, contraction or angular rotation to occur.
<i>Movement joint formed in place</i>	20.49	Movement joint formed in place is a movement joint formed during construction of a structure to permit adjacent structural elements to move relative to each other without damage.

MATERIALS

<i>Joint filler</i>	20.50	Joint filler for movement joints formed in place shall be non-absorbent.
<i>Joint sealant</i>	20.51	<p>(1) Joint sealant for movement joints formed in place shall be a polysulphide-based sealant. Polyurethane-based sealant shall not be used unless approved by the Engineer.</p> <p>(2) Joint sealant shall be resistant to attack by petrol, diesel oil, dilute acids and alkalis, synthetic and mineral oils, hydraulic fluids and paraffin. The sealant shall have a transverse butt joint movement range for repeated cyclic movement of at least 25% of the width of the joint.</p>
<i>Compression seals</i>	20.52	Compression seals shall be a proprietary type approved by the Engineer and shall be manufactured from natural rubber, neoprene or other synthetic material. Compression seals shall have the dimensions specified by the manufacturer for each joint width.
<i>PVC capping strip</i>	20.53	PVC capping strip shall be a proprietary type approved by the Engineer.
<i>Holding-down bolts for movement joints</i>	20.54	Holding-down bolts for movement joints shall be a proprietary type approved by the Engineer.
<i>Grout for movement joints</i>	20.55	Grout for holding-down bolts for movement joints shall be based on polyester resins and shall be a proprietary type approved by the Engineer. Epoxy-resin based grout shall not be used.

DESIGN OF FABRICATED MOVEMENT JOINTS

Design of fabricated movement joints

- 20.56 (1) Fabricated movement joints shall be a proprietary type approved by the Engineer.
- (2) Fabricated movement joints shall be capable of withstanding the following loads, either separately or in combination:
- (a) vertically: two 112.5 kN wheel loads, 1 m apart, each spread over a contact area giving an average pressure of 1 MPa and applied in such a manner as to produce the worst possible effect, and
 - (b) horizontally: a traction force of 75 kN/m run of the joint applied perpendicular to the alignment of the joint, together with any forces arising from strain of the joint.

Allowance for additional loading due to impact is not necessary.

- (3) Fabricated movement joints shall be capable of accommodating the movements and rotations stated in the Contract without damaging the joint and without loading the supporting structure with forces which arise from strain of the joint exceeding 5 kN/m run of the joint.
- (4) Fabricated movement joints shall either be watertight or shall be provided with a drainage layer or channel to collect water passing through the joint and to divert the water away from the underlying structure.
- (5) Facilities shall be provided in fabricated movement joints for easy clearance of grit or silt entering slots, grooves or channels forming or associated with the joint.
- (6) Surfaces of fabricated movement joints which will be exposed at finished road level shall be treated to provide a resistance to skidding not less than that of the adjacent road surface.
- (7) Fabricated movement joints shall not impair the riding quality of the road surface for vehicular traffic and the passage of vehicular traffic shall not cause undue noise or vibration. The size of gaps, including gaps sealed with flexible material, on the riding surface of the joint shall not exceed 65 mm.
- (8) The passage of pedestrians and cyclists shall not be impeded or endangered by fabricated movement joints.

Design of fixings for fabricated movement joints

- 20.57 (1) The holding down and fixing arrangements for fabricated movement joints shall be capable of withstanding the loads stated in Clause 20.56(2). The diameter of bolts fixed as double row bolts on one side shall be at least 12 mm and the diameter of other holding down bolts and studs shall be at least 16 mm.
- (2) Fixings for fabricated movement joints shall be compatible with the reinforcement in the underlying concrete. Any revisions to the reinforcement required to suit the fixings shall be designed by the Contractor and submitted to the Engineer for approval.
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SUBMISSIONS

Particulars of movement joints

- 20.58 (1) The following particulars of the proposed movement joints shall be submitted to the Engineer:
- (a) details of type of movement joint and the name and address of the manufacturer,
 - (b) design calculations and drawings,
 - (c) details of fixings, including the size, length and spacing of holding down bolts and any necessary revisions to the reinforcement,
 - (d) details of materials for making good adjoining road surfaces and nosings, including reinforcement, jointing and curing details,
 - (e) programme of manufacture, testing and delivery, and
 - (f) for fabricated movement joints, a written undertaking from the supplier that he will install the proposed movement joint.
- (2) The particulars shall be submitted to the Engineer at least 28 days before construction of the movement joint starts.

STORAGE OF MATERIALS

Storage of fabricated movement joints

- 20.59 Fabricated movement joints shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the movement joint or in contamination of the movement joint.

INSTALLATION OF FABRICATED MOVEMENT JOINTS

Installation of fabricated movement joints

- 20.60 (1) Fabricated movement joints shall be installed in accordance with the manufacturer's recommendations. The installation shall be carried out by the supplier of the movement joint.
- (2) The vertical faces of recesses in bridge decks for fabricated movement joints shall be formed by saw-cutting. Holding-down bolts shall be cast into the concrete for direct mounting of the joints unless the Engineer permits the bolts to be grouted. If grouting is permitted, the grouting shall be carried out by setting the movement joint in position and grouting the gap between the movement joint and the structure. Rebates and pockets for subsequent trimming to line and level or for holding-down bolts shall not be used unless permitted by the Engineer.
- (3) The bedding to fabricated movement joints shall be formed such that there shall be no gaps between the joint and the bedding.

(4) Relative movement between components and supports of a fabricated movement joint shall be prevented during installation of the joint and during placing and hardening of concrete and mortar under the components. Joint components shall be free to move longitudinally relative to each other.

(5) When one side of a fabricated movement joint is being set, the other side shall be free from longitudinal restraint. Strongbacks or templates used to locate the sides of a joint shall not be fixed to both sides at any one time.

***Road surface adjoining
fabricated movement
joints***

20.61

(1) The gap between fabricated movement joints and the adjoining road surface or nosing shall be made good after installation of the joint with material which has properties as similar as practicable to those of the material in the adjoining road surface.

(2) Bituminous road surfaces shall be made good with a bituminous mixture or elastomeric concrete. Concrete road surfaces shall be made good with a cementitious matrix reinforced with metal or glass fibres or with elastomeric or polymer concrete. Epoxy resin mortar shall not be used.

(3) Elastomeric and polymer concrete shall be prepared, laid and cured in accordance with the manufacturer's recommendations.

***Protection of
fabricated movement
joints***

20.62

(1) The permission of the Engineer shall be obtained before Constructional Plant or other vehicles cross a fabricated movement joint or the adjacent road surface.

(2) Constructional Plant or other vehicles shall not cross fabricated movement joints or adjacent road surfaces until installation of the joint is complete unless permitted by the Engineer. If permitted, ramps shall be provided to allow the vehicles to cross without loads being applied to the joint.

CONSTRUCTION OF MOVEMENT JOINTS FORMED IN PLACE

***Forming movement
joints***

20.63

Gaps forming part of movement joints formed in place shall be filled with joint filler fixed in position with adhesive. The edge of the joint filler shall be covered with bond breaker tape or a PVC capping strip.

Forming grooves

20.64

Grooves for joint sealant and compression seals for movement joints formed in place shall be formed by saw cutting.

Sealing grooves

20.65

Grooves for movement joints formed in place shall be sealed with joint sealant or with a compression seal.

TOLERANCES

***Tolerances:
fabricated movement
joints***

20.66 The surface of fabricated movement joints shall be at least 1 mm, and not more than 3 mm, below the surrounding road surface.

APPENDIX 20.1

FRICITION TEST FOR BRIDGE BEARINGS

Scope	20.1.1	This method covers the determination of the coefficient of friction, flatness, bonding properties and resistance to mechanical damage of bridge bearings by means of a friction test.
Equipment	20.1.2	<p>The following equipment is required:</p> <ul style="list-style-type: none"> (a) Compression testing rig. (b) Test loads. (c) Equipment for measuring the loads applied, readable and accurate to within 2% of the measured load. (d) Equipment for measuring movement, readable and accurate to 0.01 mm. (e) Lubricant of the same type as will be used in service.
Procedure	20.1.3	<p>The procedure shall be as follows:</p> <ul style="list-style-type: none"> (a) The PTFE surface of the bearing shall be lubricated with the lubricant. (b) Two sets of sliding surfaces shall be mounted back to back between the platens of the compression testing rig with the stainless steel sliding surfaces in the centre. A vertical load equal to the permanent load stated in the schedule of bearings shall be applied for 1 hour. (c) A horizontal load shall then be applied steadily and without shock to the pair of stainless steel sliding surfaces and shall be increased at a rate of 0.2% of the vertical load per minute until movement occurs between the sliding surfaces. The maximum horizontal load sufficient to cause movement of at least 25 mm between the stainless steel and PTFE sliding surfaces at a rate not exceeding 50 mm/min shall be recorded. (d) The loads shall be removed. (e) The sliding surfaces shall be removed from the rig and inspected.
Calculation	20.1.4	<p>The coefficient of friction shall be calculated from the equation:</p> $\text{Coefficient of friction} = \frac{\text{maximum horizontal force}}{2 \times \text{vertical load}}$

Reporting of results

20.1.5 The following shall be reported:

- (a) Name of bearing manufacturer.
 - (b) Details of bearing and sliding surfaces.
 - (c) The vertical load applied.
 - (d) The maximum horizontal force applied.
 - (e) The total movement and rate of movement at the maximum horizontal force applied.
 - (f) The coefficient of friction to two significant figures.
 - (g) Details of any damage to the sliding surfaces.
 - (h) That the test method used was in accordance with this Specification.
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**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 21
MARINE WORKS**

SECTION 21

MARINE WORKS

GENERAL

<i>General requirements</i>	21.01	The works and materials specified in Clauses 21.02 to 21.07 shall comply with the sections stated, unless otherwise stated in this Section.
<i>Pipes and fittings</i>	21.02	Pipes and fittings, including gaskets, internal linings, external coatings and anticorrosion tape, for submarine outfalls shall comply with Section 5.
<i>Fill material</i>	21.03	Fill material for marine works shall comply with Section .
<i>Formwork</i>	21.04	Formwork and finishes to concrete shall comply with Section 14.
<i>Steel reinforcement</i>	21.05	Steel reinforcement shall comply with Section 15.
<i>Concrete</i>	21.0	Concrete shall comply with Section 1 .
<i>Joints in concrete</i>	21.07	Joints in concrete in seawalls shall comply with Section 1 .

GLOSSARY OF TERMS

<i>Reclamation</i>	21.08	Reclamation is the formation of land over an area of foreshore, sea bed, tidal inlet or river, including the adjoining areas, by the deposition of fill material to the limits stated in the Contract.
<i>Marine structures</i>	21.09	Marine structures are seawalls, revetments, breakwaters, jetties, quay walls, dolphins, docks, slipways, beacons, lighthouses, landing steps for berthing of vessels and other similar structures.
<i>Final surface of any work</i>	21.10	Final surface of any work is the surface to which the work is to be finished.

MATERIALS

<i>Fill material for marine works</i>	21.11	<p>(1) The different types of fill material for marine works shall have the particle size distributions within the ranges stated in Table 6.1 and Table 21.1.</p> <p>(2) Underwater fill material (Type 1) shall consist of natural material extracted from the sea bed or a river bed.</p> <p>(3) Underwater fill material (Type 2) shall consist of material which has a coefficient of uniformity exceeding 5 and a plasticity index not exceeding 12.</p>
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(4) Rock fill material (Grade 75) shall consist of pieces of hard, durable rock which are free from cracks, veins, discolouration and other evidence of decomposition.

(5) Rock fill material (Grade 700) shall consist of pieces of rock which are free from cracks, veins and similar defects and of which in the opinion of the Engineer not more than 30% by mass shall be discoloured or show other evidence of decomposition.

Table 21.1 : Particle size distributions of fill material

Type of fill material	Percentage by mass passing				
	Size		BS test sieve size		
	700 mm	200 mm	75 mm	20 mm	3 μ m
Underwater fill material (Type 1)	-	-	100	-	0 - 30
Underwater fill material (Type 2)	-	-	100	-	0 - 25
Rock fill material (Grade 75)	-	-	100	0	-
Rock fill material (Grade 700)	100	0 - 10	0 - 5	0	-

Rock armour

21.12 (1) The different types of rock armour shall have the maximum and minimum masses as stated in Table 21.2. At least 50% in number of the individual pieces shall have a mass exceeding the mean of the specified maximum and minimum masses.

(2) Rock armour shall consist of rock having the properties stated in Table 21.3 and shall comply with the following requirements:

- (a) The maximum size of rock shall not be greater than twice the minimum dimension.
- (b) Each piece of rock shall be free from cracks, veins and similar defects.
- (c) In the opinion of the Engineer not more than 20% in number of the individual pieces shall be discoloured or show other evidence of decomposition.

Table 21.2 : Mass of rock armour

Type of fill material	Mass of individual piece of rock (kg)	
	Maximum	Minimum
Rock armour (Type 1)	1500	750
Rock armour (Type 2)	2000	1000
Rock armour (Type 3)	2500	1500
Rock armour (Type 4)	3000	2000
Rock armour (Type 5)	4000	2500
Rock armour (Type 6)	5000	3000
Rock armour (Type 7)	500	4000

Table 21.3 : Properties of rock for rock armour

Property	Value
Specific gravity	≥ 2.6
Water absorption	$\leq 3\%$
Aggregate impact value (in dry condition)	$\leq 30\%$
Ten percent fines value (in dry condition)	≥ 100 kN
Soundness	loss in mass after five cycles not exceeding 12% for sodium sulphate and 18% for magnesium sulphate
Aggregate abrasion value	$\leq 15\%$

Facing stones

- 21.13 (1) Facing stones to seawalls and pitched slopes shall consist of pieces of hard, durable fresh granite, free from cracks, veins, and similar defects. Facing stones shall be uniform in size, shape and colour, roughly squared and hammer dressed such that they will fit together without the use of quarry spalls or surface pinning.
- (2) Facing stones for vertical concrete seawalls shall be at least 300 mm wide on the face, at least 300 mm from back to front and shall be of a height which will allow the stones to be laid in 300 mm to 400 mm courses.

<i>Bermstones</i>	21.14	<p>(1) Bermstones for seawalls and revetments shall consist of pieces of sound fresh rock, free from cracks, veins, and similar defects.</p> <p>(2) Bermstones for vertical seawalls shall be at least 1000 kg in mass and when placed in position shall be roughly rectangular on plan and between 450 mm and 750 mm thick.</p>
<i>Levelling stones</i>	21.15	Stones for levelling founding layers for marine structures shall be rock fill material (Grade 75) as stated in Clause 21.11.
<i>Joint filler for slip joints</i>	21.1	<p>(1) Joint filler for slip joints in seawalls shall consist of three plies of Type 1B fine granule surfaced bitumen felt of 1.4 kg/m² nominal mass in accordance with BS 747.</p> <p>(2) Adhesive for use with joint filler shall be a proprietary type recommended by the joint filler manufacturer and approved by the Engineer.</p>
<i>Iron and steel fittings for marine structures</i>	21.17	<p>Iron and steel fittings for marine structures shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) Cast iron for bollards, pumphouse screens and screen guides shall be Grade 150 or 180 complying with BS 1452. (b) Mild steel bolts and nuts shall comply with BS 3692. (c) Mild steel washers shall comply with BS 4320. (d) Mild steel chain shall be grade 30 steel complying with BS 405. (e) Stainless steel bolts and nuts shall comply with Grade A4 and property class 80 of BS 105. (f) Stainless steel washers shall be grade 316 austenitic steel complying with BS 1449:Part 2. The dimensions and tolerances of stainless steel washers shall comply with BS 4320. (g) Stainless steel for chains, railings, cat ladders, pumphouse screens and screen guides, mooring eyes and other marine fittings shall be grade 31 austenitic steel complying with the following: <ul style="list-style-type: none"> General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels : BS 970:Part 1 Specification for stainless and heat-resisting steel plate, sheet and strip : BS 1449:Part 2

Timber for fendering systems

- 21.18 (1) Timber for fendering systems shall be Selangan Batu species, also known as Yacal and Balau, or a similar species of hardwood visually stress graded to the HS (Hardwood Structural) grade of BS 575 . The species shall comply with the strength requirements for strength class SC8 or SC9 as stated in BS 5268:Part 2, shall be resistant to mechanical wearing and marine borer attack, and shall comply with the requirements stated in Table 21.4.
- (2) Kempas, Kapur and other hardwoods which are less resistant in a marine environment shall be pressure treated with creosote in accordance with BS 144 and BS 5589 or with copper, chrome and arsenic (CCA) salts in accordance with BS 4072. The minimum net retention for pressure creosoting shall be 130 kg/m³ and the minimum net dry salt retention for treatment with CCA shall be 30 kg/m³.

Table 21.4 : Properties of timber for fendering systems

Property	Minimum value
Oven dry density	55 kg/m ³
Static bending at rupture	5 MPa
Modulus of elasticity under bending	8700 MPa
Hardness (Janka indentation test)	3200 N
Compressive stress parallel to grain at maximum load	29 MPa
Shear stress parallel to grain at maximum load	.5 MPa

Rubber for fenders

- 21.19 Rubber for fenders shall be natural or synthetic rubber resistant to ageing, weathering and wearing and shall have the properties stated in Table 21.5. The material shall be homogeneous and free from defective impurities, pores or cracks.

Table 21.5 : Properties of rubber for fenders

Property	Value	Test method and condition Part No. of BS 903
Density	1100 kg/m ³ to 1300 kg/m ³	Part A1
Hardness (International rubber hardness degrees)	≤ 72	Part A26 Method N
Tensile strength	≥ 1 N/mm ²	Part A2
Elongation change	≥ 350%	Part A2
After accelerated air ageing test: Hardness (increase in IRHD) Reduction in tensile strength Reduction in elongation	≤ 8° ≤ 20% ≤ 20%	Part A19 Method A at 70°C x 9 hours
Oil resistance (measured by volume change percentage) Industrial gasoline Heavy oil	± 0% ± 20%	Part A1 at 23°C x 22 hours
Compression set	≤ 30%	Part A Method A at 70°C x 22 hours using Type 2 test pieces
Ozone resistance	no crack visible	Part A43 at 40°C x 100 hours
Tear resistance	≥ 0 kN/m	Part A3 Method C at 23°C
Abrasion resistance (volume loss at 3000 revolutions)	≤ 1500 mm ³	Part A9 Method C

Paint for marine works 21.20

- (1) Priming coat for temporary tide gauges shall be lead based priming paint complying with BS 2523. Undercoat and finishing coat for temporary tide gauges shall be micaceous iron oxide paint complying with BS 3981.
- (2) Primer for steel fittings for fendering systems shall be lead based primer complying with BS 2523.
- (3) Bituminous paint for fendering systems shall comply with BS 3416.
- (4) Creosote for pressure treatment of timber shall be Type 2 coal tar creosote as stated in BS 144:Part 1.

<i>Precast concrete pipes and fittings for submarine outfalls</i>	21.21	<p>(1) Precast concrete pipes for submarine outfalls shall comply with BS 5911:Part 100 and shall have gasket type flexible rebated joints with clamps and bolts.</p> <p>(2) The clamps and bolts shall be cast steel complying with BS 3100 and shall be painted with two coats of coal tar epoxy of a type approved by the Engineer to a dry film thickness of 300 µm.</p> <p>(3) Gaskets for joints in precast concrete pipes shall be type 2 rubber gaskets complying with BS 2494. The rubber gaskets shall be moulded jointless in ring moulds and shall not contain any reclaimed rubber</p> <p>(4) Epoxy resin for joints between precast concrete pipes shall be a type approved by the Engineer.</p> <p>(5) Marker buoys shall be a hard plastic type approved by the Engineer.</p>
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SUBMISSIONS

<i>Particulars of marine works</i>	21.22	<p>(1) The following particulars of the proposed marine works shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) any conditions or restrictions imposed by the Director of Marine and other authorities, including copies of applications, licences, permits and correspondence, and (b) details of methods for controlling marine traffic, <p>(2) The particulars shall be submitted to the Engineer at least 14 days before marine works start.</p>
<i>Particulars of dredging</i>	21.23	<p>(1) The following particulars of the proposed methods of dredging shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) type and capacity of dredgers, (b) methods of anchorage and positioning of dredgers, (c) sequence and rate of working, and (d) arrangements for the transportation and disposal of dredged material. <p>(2) The particulars shall be submitted to the Engineer at least 14 days before dredging starts.</p>
<i>Particulars of deposition of fill material</i>	21.24	<p>(1) The following particulars of the proposed materials and methods of deposition of fill material shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) details of Constructional Plant and transport, (b) sources and properties as required in accordance with Clauses 21.11 and 21.12, of each type of fill material,

- (c) methods of deposition and compaction of fill material,
- (d) methods of controlling the moisture content of fill material, and
- (e) sequence and rate of working.

(2) The following particulars shall also be submitted if the proposed method involves deposition of fill material by hydraulic methods:

- (a) layout plan showing the pumpline alignments and positions of the discharge points,
- (b) calculations of the rate and duration of discharge, and
- (c) details of containment bunds and tailwater drainage systems.

(3) The particulars shall be submitted to the Engineer at least 14 days before deposition of fill material starts.

***Particulars of lifting
seawall blocks, copings
and wave deflectors***

21.25

Particulars of the proposed methods and devices to be used for lifting precast concrete seawall blocks, seawall copings and wave deflectors shall be submitted to the Engineer at least 14 days before lifting starts.

***Particulars of slip
joints***

21.2

(1) The following particulars of the proposed joint filler to slip joints in seawalls shall be submitted to the Engineer:

- (a) details of joint filler, including manufacturer's literature, and
- (b) method of fixing and application of the materials.

(2) The particulars shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site.

***Particulars of timber
for fendering systems***

21.27

(1) The following particulars of the proposed timber for fendering systems shall be submitted to the Engineer:

- (a) species and grade of timber,
- (b) name and address of timber supplier, and
- (c) method of pressure treatment and amount of net retention.

(2) The particulars shall be submitted to the Engineer at least 30 days before the first delivery of the timber to the Site.

(3) Each batch of the timber delivered to the Site shall be accompanied by a certificate issued by a forestry authority approved by the Engineer or a bill of lading certifying the country of origin, method of pressure treatment, and grade and species of the timber.

<i>Particulars of rubber fenders</i>	21.28	<p>(1) The following particulars of the proposed rubber fenders shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) manufacturer's literature, including a list of physical properties of the rubber for the fenders, and (b) a report on compression load tests and characteristic load-deflection and energy-deflection curves. <p>(2) The particulars shall be submitted to the Engineer for approval of the source and type of rubber fenders at least 30 days before the first delivery of the rubber fenders to the Site.</p> <p>(3) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the rubber fenders, including the rubber used in manufacturing the fenders, comply with the requirements stated in the Contract, shall be submitted for each batch of rubber fenders delivered to the Site.</p>
<i>Particulars of submarine outfalls</i>	21.29	<p>(1) The following particulars of the proposed materials and methods of construction for submarine outfalls shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) methods of lifting, laying, jointing and testing pipes, (b) manufacturer's literature, and (c) a certificate for pipes and pipe joints showing the manufacturer's name, the date and place of manufacture and showing that the pipes comply with the requirements stated in the Contract and including the results of load tests. <p>(2) The particulars shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.</p>

HANDLING AND STORAGE OF MATERIALS

<i>Storage of fill material and dredged material</i>	21.30	Fill material and dredged material shall not be stockpiled on the foreshore, seabed or river bed within the Site unless permitted by the Engineer.
<i>Handling and storage of fill material</i>	21.31	<p>(1) Fill material shall not be handled or stored in a manner which will result in segregation, deterioration, erosion or instability of the material.</p> <p>(2) Different types of fill material shall be kept separate from each other.</p>
<i>Handling and storage of precast concrete seawall blocks, copings and wave deflectors</i>	21.32	<p>(1) Precast concrete seawall blocks, copings and wave deflectors shall be stored in such a manner that identification markings can be easily seen.</p> <p>(2) Precast concrete seawall blocks, copings and wave deflectors shall be stored on level supports and in a manner which will not result in damage or deformation to the units or in contamination of the units. The units shall be protected from damage and damaged units shall not be used in the</p>

permanent work unless permitted by the Engineer.

<i>Handling and storage of timber fenders</i>	21.33	<p>(1) Timber for fendering systems shall be stored off the ground on level supports and shall be protected from exposure to conditions which may cause reduction in the moisture content in the material.</p> <p>(2) Timber which is treated with preservatives shall not be stored on or adjacent to concrete surfaces which form part of the permanent work.</p> <p>(3) Safety precautions as recommended by the timber treatment company shall be observed in the handling of treated timber. Treated wood offcuts shall be buried in a suitable location, or burnt in an open area and the ashes buried.</p> <p>(4) Safety precautions as recommended by the supplier of wood preservatives shall be observed in the handling of the wood preservatives.</p>
<i>Handling and storage of rubber fenders and fittings</i>	21.34	<p>(1) Rubber fenders and fittings shall be left in their original packing until required for placing. All rubber surfaces shall be protected against damage.</p> <p>(2) Rubber fenders shall be handled with nylon slings of a size agreed by the Engineer or by other methods agreed by the Engineer.</p>

GENERAL MARINE WORKS REQUIREMENTS

<i>Notification of marine works</i>	21.35	Before commencing marine works, the Contractor shall provide the Engineer with evidence that the Director of Marine has been notified of the proposed works in accordance with Section 70 of the Shipping and Port Control Regulations, Chapter 313.
<i>Marking of marine works</i>	21.3	Marine works and any part of the Site in which marine works are carried out shall be marked with flags, marker buoys and lights in accordance with the International Association of Lighthouse Authorities Marine Buoyage System for Region A and in a manner agreed by the Engineer. Red flags shall be at least 0.6 m square and marker buoys shall be a type, size and colour approved by the Engineer. Lights shall be either fixed red lights or quick flashing yellow lights visible all round the horizon at a distance of at least 2 km.
<i>Marine traffic and waterfront operations</i>	21.37	<p>(1) Marine traffic and the operation of public and private concerns in areas adjacent to the Site shall not be obstructed by the activities of the Contractor.</p> <p>(2) The Contractor shall make all arrangements with and obtain the necessary approvals from the Director of Marine and any other relevant authority for temporary marine traffic arrangements and control.</p>
<i>Temporary tide gauges</i>	21.38	(1) Temporary tide gauges shall be mounted vertically and firmly on rigid supports at locations agreed by the Engineer and shall be calibrated, levelled and fixed to give tidal readings within an accuracy of 20 mm.

		(2) Temporary tide gauges shall be made of 50 mm thick hardwood and shall be at least 250 mm by 3200 mm in size. The gauges shall be painted on the marked faces with alternate 100 mm stripes in red and white and shall be marked and numbered in black at 0.5 m intervals over the tidal range from 0.0 m C.D. to +3.0 m C.D. The painting applied shall consist of one primary coat, one undercoat and one finishing coat.
Work boats	21.39	<p>(1) Work boats shall be motorised boats equipped with a rain shelter and capable of carrying at least six passengers.</p> <p>(2) Work boats shall be licensed under the Merchant Shipping (Launches and Ferry Vessels) Regulations, Chapter 281 and shall be manned and maintained in good seaworthy condition.</p> <p>(3) Work boats shall be kept available for use by the Engineer for supervision, inspection and measurement during normal working hours and at other times when the Contractor is working.</p>
Removal of floating debris	21.40	Floating debris within the Site arising from any source shall be collected and disposed of by the Contractor at regular intervals agreed by the Engineer. Floating debris shall be prevented from dispersing outside the Site.
Surveys for marine works	21.41	<p>(1) Surveys for dredging and deposition of fill material shall be carried out using echo sounders of 200 kHz to 220 kHz frequency or by other methods agreed by the Engineer.</p> <p>(2) The initial survey for dredging shall be carried out within 30 days before dredging starts.</p> <p>(3) The final survey for dredging shall be carried out within 30 days after dredging has been completed.</p> <p>(4) The initial survey for deposition of fill material shall be taken as being the same as the final survey for dredging, or the final survey for the underlying layer of fill material as appropriate, except as stated in Clause 21.41(5).</p> <p>(5) If the final survey for dredging or the final survey for the underlying layer of fill material was carried out more than 30 days before deposition of the next layer of fill material starts, the initial survey for deposition of fill material shall be carried out within 30 days before deposition of the layer of fill material starts.</p> <p>() The final survey for deposition of fill material for the first layers, intermediate layers, and final layers of underwater foundations shall be carried out within 30 days after deposition of fill material has been completed. The final survey for final layers other than those of underwater foundations shall be carried out at least 30 days and not more than 90 days after deposition of fill material has been completed.</p>
Fill material allowed to become unsuitable or to deteriorate	21.42	(1) Fill material which has been used or is required for use in the permanent work and which is allowed to become unsuitable such that in the opinion of the Engineer it no longer complies with the specified

requirements for that type of material shall be replaced or dealt with by methods agreed by the Engineer.

(2) The material which is to be replaced shall be disposed of by the Contractor.

<i>Concreting in locations affected by tides</i>	21.43	Concreting in locations affected by tides shall be carried out in dry conditions unless otherwise permitted by the Engineer. After concreting is complete, the top of the concrete shall be covered with polyethylene sheets fixed to the formwork.
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DREDGING

<i>Commencement of dredging</i>	21.44	The permission of the Engineer shall be obtained before dredging starts in any area.
<i>Dredging</i>	21.45	<p>(1) Dredging shall be carried out in such a manner and sequence that semi-fluid or disturbed seabed or foundation material will not accumulate in dredged areas.</p> <p>(2) During dredging, samples shall be taken from the dredged materials for inspection and determination of the sand content. The Contractor shall notify the Engineer if there is any sudden or significant change in the properties of dredged material.</p> <p>(3) Dredged material shall be disposed of by the Contractor in the dumping ground stated in the Contract.</p>

DEPOSITION OF FILL MATERIAL BELOW +2.5 mPD

<i>Commencement of deposition of fill material</i>	21.4	The permission of the Engineer shall be obtained before deposition of fill material starts in any area.
<i>Deposition of fill material</i>	21.47	<p>(1) Fill material shall be deposited in a manner and sequence such that minimum lateral displacement of the underlying material will be induced and such that slopes are stable at all times.</p> <p>(2) The methods and Constructional Plant used for deposition of fill material shall be such that segregation of the material does not result. Fill material shall not be deposited by end-tipping unless permitted by the Engineer.</p> <p>(3) Fill material for blanketing layers and drainage layers shall be deposited uniformly by a method agreed by the Engineer.</p>
<i>Deposition of fill material in dredged trenches</i>	21.48	(1) The first layer of fill material in dredged trenches for seawalls, revetments and breakwaters shall be deposited as soon as practicable after the dredged profile has been agreed by the Engineer. The dredged trench shall be substantially free from silt and debris before deposition of fill material starts.

<i>Deposition of rock fill material adjacent to structures and utilities</i>	21.49	<p>(2) Subsequent layers of fill material shall be deposited as soon as practicable after the profile of the underlying layer of fill material has been agreed by the Engineer.</p> <p>(1) Rock fill material deposited adjacent to or above structures, piles or pedestals shall be hand packed or placed by a method approved by the Engineer.</p> <p>(2) Rock fill material deposited around utilities, including pipes for submarine outfalls, shall be hand packed or placed by a method approved by the Engineer and shall be brought up to the specified level equally on both sides.</p> <p>(3) Rock fill material deposited directly on geotextile shall be deposited in such a manner that the geotextile is not ruptured.</p>
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DEPOSITION OF ROCK ARMOUR

<i>Deposition of rock armour</i>	21.50	<p>(1) Each piece of rock armour shall be placed individually and shall not be deposited by tipping, dumping or dropping.</p> <p>(2) Rock armour for breakwaters, revetments and similar structures shall be deposited by working from the bottom to the top of a section in such a manner and sequence that the individual rock pieces interlock and do not segregate. The interstices shall be kept free from small fragments of rock.</p> <p>(3) Rock armour deposited directly on geotextile shall be deposited in such a manner that the geotextile is not ruptured.</p>
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LEVELLING AND COMPACTION OF FILL MATERIAL

<i>Levelling of rock fill material in underwater foundations</i>	21.51	<p>The top surface of rock fill material in foundations for structures or pipes shall be thoroughly tamped with a concrete block weighing at least 10 t dropped through a height of at least 300 mm or by other methods agreed by the Engineer. The voids at the top of the foundation shall be filled with rock fill material (Grade 75).</p>
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CONSTRUCTION OF MARINE STRUCTURES

<i>Moulds for seawall blocks provided by the Employer</i>	21.52	<p>(1) Steel moulds which are provided by the Employer for standard concrete seawall blocks shall be collected from and returned to the Port Works Depot by the Contractor.</p> <p>(2) After use and before returning to the Port Works Depot, the moulds shall be cleaned and any damage repaired; the inner surfaces shall be painted with one coat of rust-inhibiting release agent of a type approved by the Engineer and outer surfaces shall be painted in accordance with the painting system stated in Clause 18.62(1).</p>
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(3) Cores for keyways and chamfer strips shall be provided and fixed by the Contractor.

Construction of seawall blocks, copings and wave deflectors

- 21.53 (1) Formwork or moulds for precast concrete seawall blocks, copings and wave deflectors shall not be loosened or removed in less than 12 hours after completion of concreting.
- (2) Precast concrete seawall blocks, copings and wave deflectors shall be marked with the date of casting, identification reference and orientation in the structure. The letters and figures used for marking shall be at least 75 mm high and shall be sufficiently durable to be legible until the unit is placed in the final position.
- (3) Key holes in precast concrete seawall blocks, copings and wave deflectors shall be kept free from soil, aggregates, concrete and other materials before and after the blocks are set in position.

Setting of seawall blocks

- 21.54 (1) Seawalls constructed with precast concrete seawall blocks shall be constructed in layers between slip joints. The blocks shall be set in close contact with each other; packing pieces shall not be used unless permitted by the Engineer.
- (2) The permission of the Engineer shall be obtained before the next layer is placed on each completed layer of blocks.

Facing stones to seawalls and revetments

- 21.55 (1) Facing stones to seawalls and revetments shall be built up one course at a time. The stones shall be thoroughly washed and cleaned with fresh water before placing and shall be set in 1:3 cement mortar. In vertical concrete seawalls there shall be at least one header stone to each square metre of facework; header stones shall be staggered in alternate courses.
- (2) Concrete backing behind facing stones shall be placed as soon as each course of facing stones has been completed.

Slip joints in seawalls

- 21.5 (1) Slip joints in seawalls shall be straight and vertical and shall be perpendicular to the face of the seawall; the joints shall extend through the seawall from the coping down to the foundation.
- (2) Joint filler shall be cut to size before fixing and shall be securely fixed in position to the existing surface with adhesive. Concrete to the adjacent section of seawall shall be placed directly against the joint filler.

Filling of channels in seawall blocks

- 21.57 The channels in precast concrete seawall blocks and backing to seawalls shall be filled with rock pieces of sizes between 20 mm to 40 mm.

Concrete copings to seawalls

- 21.58 Concrete copings to seawalls shall be constructed in lengths of at least 5 m and not more than 10 m.

Bermstones for marine structures

- 21.59 (1) Bermstones shall be placed as soon as practicable after toe blocks have been set in position or fill material has been deposited at the toe of marine structures.
- (2) Bermstones shall be set in close contact with each other and with the structure; the longitudinal axis of bermstones shall be perpendicular to the alignment of the structure on plan.

Bagged concrete

21. 0 (1) Bagged concrete shall consist of hessian or canvas bags filled to approximately 70% full with Grade 30/10 concrete.
- (2) The bags shall be filled and the open ends tied or sewn up immediately before placing.
- (3) The bags shall be placed in brick bond fashion and flattened into position. The open ends of the bags shall be directed away from the outside surface and the spaces between bags and between layers of bags shall be kept as small as practicable. Bags shall not be disturbed after placing.

Cutting and jointing timber for fendering systems

21. 1 (1) The finished surfaces of timber for fendering systems shall be free from irregularities; the timber shall not be cut by force splitting.
- (2) Timber which is to be pressure treated with preservatives shall be machined to the specified dimensions, sizes and shapes before treatment.
- (3) Drilling of holes and cutting of notches and recesses in timber shall be completed before painting and installation starts.
- (4) Pieces of timber shall not be jointed to form a member for the fendering system unless otherwise stated in the Contract.
- (5) Unless otherwise permitted by the Engineer pressure treated timber shall not be cut or drilled for holes after the treatment process; if cutting or drilling is permitted, surfaces exposed by cutting or drilling shall be field-treated as stated in Clauses 21.61(6) and 21.61(7).
- () Exposed surfaces of timber treated with creosote shall be field-treated by brushing, spraying or dipping with hot creosote.
- (7) Exposed surfaces of timber treated with CCA salts shall be field-treated by brushing or dipping with either a 100 g/L solution of the wood preservative or a solution suitable for after-fabrication treatment as recommended in BS 4072.

Painting to timber fendering systems

21. 2 (1) Timber members in fendering systems shall be painted with two coats of bituminous paint before installation.
- (2) Steel fittings for fendering systems, other than the threaded portions of bolts, nuts and other fittings, shall be painted with one coat of primer and two coats of bituminous paint before installation. The minimum thickness of each coat shall be 300 µm.
- (3) Bolt heads, shanks and nuts on the outer face of timber fendering systems shall be recessed into notches at a distance of 25 mm below the surface of the fenders. The notches shall be filled flush with the surface with a sealant composed of one part bitumen and two parts cement.

Installation of rubber fenders

21. 3 Timber or steel base templates shall be used to position anchor bolts for rubber fenders.

TRIALS FOR SUBMARINE OUTFALLS

<i>Trials for submarine outfalls</i>	21. 4	(1) A trial shall be carried out to demonstrate that the proposed methods of lifting, laying and jointing pipes for submarine outfalls, including jointing of riser pipes to the diffuser pipes, comply with the specified requirements. The trial shall include a demonstration by a method agreed by the Engineer that the joints between the riser pipes and the diffuser pipes are sufficiently strong to withstand the forces which will be applied during construction of the submarine outfall. (2) The trial shall be carried out at least 14 days before pipelaying starts.
<i>Results of trials for submarine outfalls</i>	21. 5	If in the opinion of the Engineer the proposed methods of lifting, laying and jointing pipes as demonstrated by the submarine outfall trial do not comply with the specified requirements, particulars of proposed changes shall be submitted to the Engineer; further trials shall be carried out until in the opinion of the Engineer the methods are satisfactory.
<i>Commencement of pipelaying for submarine outfalls</i>	21.	Pipelaying for submarine outfalls shall not start until in the opinion of the Engineer the methods of lifting, laying and jointing pipes as demonstrated by the submarine outfall trial are satisfactory.

CONSTRUCTION OF SUBMARINE OUTFALLS

<i>Laying of submarine outfall pipes</i>	21. 7	(1) Pipes for submarine outfalls shall be marked with fluorescent paint such that the sequence of laying will be seen on underwater photographs. The letters and numbers used for marking shall be at least 100 mm high and shall be painted in orange on a white background. (2) Before submarine outfall pipes are laid, a guide rail of mild steel channel or other material agreed by the Engineer, painted with fluorescent paint, shall be laid on the levelling stones to provide a visible aid for laying pipes. (3) During construction of submarine outfalls, the open ends of the outfall pipes and riser pipes shall be temporarily capped by a method agreed by the Engineer to prevent the entry of silt or fill material.
<i>Marker blocks for submarine outfalls</i>	21. 8	(1) Concrete marker blocks for submarine outfalls shall be placed on top of the fill material along the alignment of the pipeline as soon as deposition of fill material has been completed. (2) Concrete marker blocks shall be marked with fluorescent paint. The letters and numbers used for marking shall be at least 100 mm high and shall be painted in orange on a white background. (3) Concrete marker blocks shall be linked by coloured nylon ropes of at least 25 mm diameter.
<i>Diffuser pipes for submarine outfalls</i>	21. 9	Epoxy resin joints between riser pipes and diffuser pipes shall be made in dry conditions.

Diffuser caps for submarine outfalls

- 21.70 (1) Diffuser caps shall be placed on top of the open ends of riser pipes and precast end plates shall be placed on the open end of the outfall within 7 days after the pipeline has been tested.
- (2) Marker buoys shall be tied to the diffuser caps with 1 m long nylon ropes of mm diameter.

TOLERANCES***Tolerances: dredging***

- 21.71 The final surface of dredging shall be within 300 mm of the specified surface.

Tolerances: deposition of fill material

- 21.72 (1) The final surface of deposition and compaction of fill material, measured perpendicular to the specified surface, shall comply with the following requirements:
- (a) Top surfaces to receive levelling stones shall be not more than 75 mm above, and not more than 250 mm below, the specified surface.
 - (b) Top surfaces of levelling stones shall be within 25 mm of the specified surface for foundations of structures and shall be within 50 mm of the specified surface for submarine outfalls.
 - (c) Other top surfaces shall be within 250 mm of the specified surface.
- (2) There shall be no abrupt change in level of the finished surface of reclamation and levelling stones.

Tolerances: precast concrete seawall blocks and copings

- 21.73 Precast concrete seawall blocks and copings shall be within 25 mm of the specified position. The gaps between adjacent blocks and between successive layers of blocks shall not exceed 20 mm.

Tolerances: timber fendering systems

- 21.74 (1) The dimensions of members of timber fendering systems shall be within 5 mm of the specified dimensions.
- (2) The levels and positions of timber fendering systems shall comply with the following requirements:
- (a) The top level of blocks for landings and steps shall be within 5 mm of the specified level.
 - (b) The top level of other members shall be within 10 mm of the specified level.
 - (c) The horizontal position perpendicular to the berthing face of the fendering system shall be within 10 mm of the specified position.
 - (d) The horizontal position parallel to the berthing face of the fendering system shall be within 25 mm of the specified

position.

***Tolerances:
rubber fenders***

- 21.75 (1) The dimensions of rubber fenders and bolt holes shall comply with the following requirements:
- (a) The bolt hole diameter shall be within 2 mm of the specified diameter.
 - (b) The bolt pitch shall be within 4 mm of the specified pitch.
 - (c) The height, length and width of rubber fenders shall be within +4% and -2% of the specified dimensions.
 - (d) The thickness of fender sections shall be within +8% and -5% of the specified thickness.
- (2) The positions of rubber fenders shall comply with the following requirements:
- (a) The centrelines shall be within 25 mm of the specified positions on the face of the supporting structures.
 - (b) The inclination shall not deviate by more than 1 in 50 from the specified inclination.

***Tolerances: submarine
outfalls***

- 21.7 (1) The horizontal alignment of submarine pipelines shall be within 250 mm of the specified alignment.
- (2) The invert level of submarine outfalls shall be within 50 mm of the specified level.
- (3) There shall be no abrupt change in alignment or level of the submarine outfall.

TESTING : DREDGED MATERIAL

***Samples: dredged
material***

- 21.77 (1) Areas being dredged shall be divided into a grid at 15 m intervals. One sample of dredged material shall be provided from each point on the grid at 2 m depth intervals. Additional samples shall be provided from positions instructed by the Engineer if there appears to be any change in the quality of the dredged material.
- (2) The mass of each sample shall be at least 1 kg. The method of sampling shall be as agreed by the Engineer.

***Testing: dredged
material***

- 21.78 Each sample of dredged material shall be tested as stated in the Contract.

TESTING : PARTICLE SIZE DISTRIBUTION, PLASTICITY INDEX AND COEFFICIENT OF UNIFORMITY OF FILL MATERIAL FOR MARINE WORKS

<i>Batch: fill material for marine works</i>	21.79	A batch of fill material for marine works is any quantity of fill material for marine works of the same type and which in the opinion of the Engineer has similar properties throughout.						
<i>Samples: fill material for marine works</i>	21.80	<p>(1) One sample of each type of fill material for marine works shall be provided at the same time as particulars of the material are submitted to the Engineer. Unless otherwise agreed by the Engineer, one sample of each type of fill material for marine works shall be provided from each batch.</p> <p>(2) The size of samples and the method of sampling shall be as stated in Clause .58.</p>						
<i>Testing: fill material for marine works</i>	21.81	<p>(1) Each sample of fill material shall be tested to determine the particle size distribution, plasticity index and coefficient of uniformity.</p> <p>(2) The method of testing shall be in accordance with the following:</p> <table><tr><td>Particle size distribution</td><td>: Clause .59(3)</td></tr><tr><td>Plasticity index</td><td>: BS 1377, test 4</td></tr><tr><td>Coefficient of uniformity</td><td>: Clause 6.59(4).</td></tr></table>	Particle size distribution	: Clause .59(3)	Plasticity index	: BS 1377, test 4	Coefficient of uniformity	: Clause 6.59(4).
Particle size distribution	: Clause .59(3)							
Plasticity index	: BS 1377, test 4							
Coefficient of uniformity	: Clause 6.59(4).							
<i>Non-compliance: fill material for marine works</i>	21.82	<p>(1) If the result of any test for particle size distribution, plasticity index or coefficient of uniformity of fill material for marine works does not comply with the specified requirements for the property, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.</p> <p>(2) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with such requirements.</p>						

TESTING : RELATIVE DENSITY, WATER ABSORPTION, AGGREGATE IMPACT VALUE, TEN PERCENT FINES VALUE, AGGREGATE ABRASION VALUE, SOUNDNESS AND RESISTANCE TO FRACTURE OF ROCK ARMOUR

<i>Batch: rock armour</i>	21.83	A batch of rock armour is any quantity of rock armour of the same type and which in the opinion of the Engineer has similar properties throughout.
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- Samples: rock for rock armour*** 21.84 (1) One sample of each proposed type of rock for rock armour shall be provided at the same time as particulars of the material are submitted to the Engineer.
- (2) If instructed by the Engineer, a representative sample of each type of rock for rock armour, broken down into appropriate sizes, shall be provided for testing under Clause 21.85.
- Testing: rock for rock armour*** 21.85 (1) Each sample of rock for rock armour taken as stated in Clause 21.84(2) shall be tested to determine the specific gravity, water absorption, aggregate impact value, ten percent fines value, aggregate abrasion value and soundness.
- (2) The method of testing shall be in accordance with the following:
- | | |
|--------------------------|-----------------------------|
| Relative density | : BS 812:Part 2 |
| Water absorption | : BS 812:Part 2 |
| Aggregate impact value | : BS 812:Part 112 |
| Ten percent fines value | : BS 812:Part 111 |
| Aggregate abrasion value | : BS 812:Part 113 |
| Soundness | : BS 349:Part 1, Appendix B |
- Samples: rock armour*** 21.8 (1) One sample piece of each type of rock armour shall be provided for the dropping test from each 100 pieces or part thereof of that type delivered to the Site.
- (2) One sample piece of each type of rock armour of the specified minimum size and one piece of the specified maximum size shall be provided for checking the sizes of material.
- (3) The sample pieces of the specified minimum and maximum sizes shall be mounted on individual plinths at locations agreed by the Engineer. The design and details of the plinths shall be prepared by the Contractor and agreed by the Engineer.
- Testing: rock armour*** 21.87 (1) Each sample piece of rock armour taken as stated in Clause 21.8 (1) shall be tested by the dropping test to determine the resistance to fracture.
- (2) The dropping test shall be carried out with the largest cross-section of the specimen horizontal. The specimen shall be dropped from a vertical height to the underside of the specimen of 1.5 m, onto a steel plate. The steel plate shall be at least 20 mm thick and shall be firmly bedded on a level concrete base.

No-compliance: rock for rock armour	21.88	<p>(1) If the result of any test for specific gravity, water absorption, aggregate impact value, ten percent fines value, aggregate abrasion value or soundness of rock for rock armour does not comply with the specified requirements for the property, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.</p> <p>(2) The batch shall be considered as not complying with specified requirements for the property if the result of any additional test does not comply with such requirements.</p>
Non-compliance: dropping test	21.89	<p>(1) If a sample piece of rock armour fractures as a result of the dropping test, nine additional sample pieces of rock armour from the same group of 100 pieces or part thereof shall be tested. If any one of these sample pieces fracture as a result of the dropping test, every piece of rock armour in the same group shall be tested. Only those pieces of rock armour passing the dropping test shall be used.</p> <p>(2) A specimen is deemed to fracture if:</p> <ul style="list-style-type: none"> (a) cracking occurs after dropping, or (b) the difference in masses of the original specimen and the largest single piece after dropping exceeds 1% of the mass of the original specimen.

TESTING : TIMBER FOR FENDERING SYSTEMS

Batch: timber for fendering systems	21.90	A batch of timber for fendering systems is any quantity of timber for fendering systems of the same grade and species and from the same source, covered by the same test certificates and bills of lading.
Samples: timber for fendering systems	21.91	One sample of timber for fendering systems shall be provided at the same time as particulars of the material are submitted to the Engineer. Unless otherwise permitted by the Engineer, six samples shall be provided from each batch of timber for fendering systems delivered to the Site.
Testing: timber for fendering systems	21.92	<p>(1) For fendering systems delivered to the site, the samples shall be provided in pairs taken from three separate barks of timber. Each sample shall be 1000 mm x 50 mm x 50 mm and shall be cut with the longest dimension parallel to the grain and the two shorter dimensions tangential and radial to the growth rings.</p> <p>(2) Each sample of timber for fendering systems shall be tested to determine the oven dry density, static bending at rupture, modulus of elasticity under bending, hardness, compressive stress parallel to grain at maximum load and shear stress parallel to grain at maximum load.</p> <p>(3) The method of testing, including the Janka indentation test for hardness, shall be in accordance with BS 373 except that the specimens shall be tested at a moisture content of at least 25%.</p>

Compliance criteria: Janka indentation test, test for shear stress parallel to grain at maximum load	21.93	<p>The results of Janka indentation tests and tests for maximum shear parallel to grain of timber for fendering systems shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) Each of the results of Janka indentation tests on the end face, radial face and tangential face shall comply with the requirements stated in Table 21.4. (b) Each of the results of tests for shear parallel to grain on the radial face and tangential face shall comply with the requirements stated in Table 21.4.
Non-compliance: timber for fendering systems	21.94	<p>(1) If the result of any test for oven dry density, static bending at rupture, modulus of elasticity under bending, hardness, compressive stress parallel to grain at maximum load or shear stress parallel to grain at maximum load, of timber for fendering systems does not comply with the specified requirements for the property, three additional pairs of samples shall be provided from the same batch and additional tests for the property shall be carried out.</p> <p>(2) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.</p>

TESTING : RUBBER FENDERS

Batch: rubber fenders	21.95	A batch of rubber fenders is any quantity of rubber fenders of the same type and from the same source, covered by the same test certificates.
Samples: rubber fenders	21.9	Unless otherwise permitted by the Engineer, one sample shall be provided from each 50 rubber fenders or part thereof delivered to the Site.
Testing: rubber fenders	21.97	<p>(1) Each sample of rubber fenders shall be compression load tested either at a laboratory approved by the Engineer or at the manufacturer's workshop in the presence of the representative of a Government body or other organisation approved by the Engineer.</p> <p>(2) Each sample of rubber fenders shall be subjected to three complete load cycles at a rate of 200 mm ± 20 mm per minute to 50% deflection. The results of the test shall be shown on a load-deflection curve and on an energy-deflection curve.</p>
Compliance criteria: rubber fenders	21.98	<p>The result of compression load tests on rubber fenders shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) The sample shall not show any visible sign of cracks or permanent deformation in shape. (b) The height of each sample one minute after releasing the third compression load shall be at least 95% of the original height. (c) The recovery in height shall be as stated in Clause 21.98(b) for the repeated compression test.

- (d) For each loading cycle, the deflection as measured from the load-deflection curve and the energy-deflection curve shall not deviate by more than 10% from the deflection at the same load on the characteristic curves provided by the manufacturer.

***Non-compliance:
rubber fenders***

- 21.99 (1) If the result of any compression load test on rubber fenders does not comply with the specified requirements stated in Clause 21.98, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.
- (2) The batch shall be considered as not complying with specified requirements for the property if the result of any additional test does not comply with such requirements.

TESTING : SUBMARINE OUTFALLS

***Testing:
submarine outfalls***

- 21.100 (1) Submarine outfalls shall be tested to determine if there is any blockage or leakage.
- (2) Precast end plates and diffuser caps shall be removed before the outfall is tested.
- (3) The outfall shall be cleaned by high velocity water jets or by other electromechanical methods agreed by the Engineer; riser pipes and diffuser pipes shall be cleaned by high capacity grit suction pumps or by other methods agreed by the Engineer.
- (4) The outfall shall be tested for blockages by pulling a mandrel approved by the Engineer through the outfall between manholes and between manholes and the end of the outfall. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.
- (5) Riser pipes and diffuser pipes shall be tested for blockages and leakage by pumping dyed water through the outfall and inspecting the discharge plume at each riser pipe; precast end plates shall be replaced before the test is carried out.

***Compliance criteria:
submarine outfalls***

- 21.101 There shall be no blockage or leakage in submarine outfalls, including riser pipes and diffuser pipes.

***Non-compliance:
submarine outfalls***

- 21.102 If the result of any test for blockage or leakage of submarine outfalls does not comply with the specified requirements for the test, the blockage shall be removed, or the leakage shall be repaired, by methods approved by the Engineer, or the outfall or diffuser pipes shall be repaired or replaced by methods approved by the Engineer; the submarine outfall shall be re-tested for blockage or leakage.

**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 22
RAILWAY WORKS**

SECTION 22

RAILWAY WORKS

GENERAL

General requirements	22.01	The works and materials specified in Clauses 22.02 to 22.04 shall comply with the section stated, unless otherwise stated in this Section.
Formwork	22.02	Formwork and finishes to concrete for continuously paved track shall comply with Section 14.
Reinforcement	22.03	Steel reinforcement for continuously paved track shall comply with Section 15.
Concrete	22.04	Concrete for continuously paved track shall comply with Section 16.

GLOSSARY OF TERMS

Ballasted track	22.05	Ballasted track is track in which the various components are supported on a trackbed of sleepers and ballast.
Cant	22.06	Cant is the raising of the rail on the outside of the curve above the inner rail.
Chinese material	22.07	Chinese material is permanent way material manufactured to Chinese Standards.
Continuously paved track	22.08	Continuously paved track is track in which the various components are supported on a trackbed of mass or reinforced in-situ or precast concrete.
Loading gauge	22.09	Loading gauge is the limit stated in the Contract beyond which materials or goods loaded on a wagon shall not project.
Structure gauge	22.10	Structure gauge is the limit stated in the Contract within which nothing shall project.
Track	22.11	Track is the components supported on the trackbed, including rails, fastenings, shoulders, resilient pads and base-plates.
Trackbed	22.12	Trackbed is the supporting medium directly below the track.
Track gauge	22.13	Track gauge is the minimum distance between the running edges of the two rails measured perpendicular to the centreline of the track.
Trackwork	22.14	Trackwork is all work necessary to assemble and adjust the track on the trackbed.
UIC 54 material	22.15	UIC 54 material is permanent way material manufactured to the Standards of the Union International Chemin de Fer for use on tracks with rails weighing 54 kg/m.
Corporation	22.16	Corporation is the railway corporation as defined in the Special Conditions

of Contract.

MATERIALS

Ballast

- 22.17 (1) Except as stated in Clause 22.17(2) ballast shall be hard, durable stone which is angular in shape and shall have the particle size distribution stated in Table 22.1.
- (2) Ballast for use with 550 mm wide concrete sleepers shall be uniform in grading with 100% passing a 15 mm BS test sieve and 100% retained on a 5 mm BS test sieve.
- (3) Ballast shall be clean and free from earth, weathered overburden, stone dust and vegetable matter and other deleterious material; the combined free mica, clay and silt content shall be less than 5%.
- (4) Ballast shall have the properties stated in Table 22.2.

Table 22.1 : Particle size distribution of ballast

BS test sieve (mm)	Percentage by mass passing (%)
50	100
37.5	85 – 90
28	35 – 70
20	0 – 25
10	0 - 5

Table 22.2 : Properties of ballast

Property	Value (%)
Crushing value	≤ 30
Flakiness index	≤ 40
Elongation index	≤ 40
Los Angeles wet attrition test	≤ 40

Sulphur fixings

- 22.18 Materials for sulphur fixings shall comply with the following:

OPC	: BS 12
Sand	: BS 1199
Paraffin	: BS 2869:Part 2, Class C1

<i>Rail clips for continuously paved track</i>	22.19	Rail clips for continuously paved track shall be Pandrol type PR429A clips with glass reinforced nylon insulators or an equivalent type approved by the Engineer.
<i>Rail pads for continuously paved track</i>	22.20	<p>(1) Rail pads for continuously paved track shall be 140 mm wide, 10 mm thick and at least 2100 mm long.</p> <p>(2) The hardness, minimum tensile strength, minimum elongation at break, maximum compression set and resistance to heat and ageing of the rail pads shall be as stated in BS 1155, for a T 60 material.</p> <p>(3) The minimum electrical resistance of the rail pads measured between the contacting areas and expressed as a value of specific or volume resistance shall be 400,000 ohms per pad.</p> <p>(4) The rail pads shall be resistant to attack by brine, animal urine and excreta, or petroleum products as demonstrated by testing pads immersed in such liquids in accordance with BS 903:Part A16 for a period of 72 hours at a temperature of 70°C ± 1°C.</p>
<i>Adhesive for railway works</i>	22.21	Adhesive for railway works shall be a proprietary type approved by the Engineer.
<i>Galvanizing to rail clips and rail pads</i>	22.22	<p>(1) Shoulders shall be galvanized before installation. Galvanizing shall comply with BS 729.</p> <p>(2) Metal parts of rail clips shall be sheradised in accordance with BS 4921, Table 1, Class 1</p> <p>(3) Metallic zinc-rich priming paint for repairs to galvanized metal shall comply with BS 4652.</p>

MATERIALS PROVIDED BY THE EMPLOYER

<i>Materials provided by the Employer</i>	22.23	<p>(1) The following materials will be provided by the Employer:</p> <ul style="list-style-type: none"> (a) track components stated in Clauses 22.24 to 22.26, (b) portions, igniters and moulds for forming joints for UIC 54 material, (c) portions, igniters and material for manufacturing moulds for forming welded joints for Chinese material, and (d) turnout complete, insulated joints, expansion joints and lubricants. <p>(2) The materials shall be obtained from the Corporation stores in Shatin.</p>
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<i>Chinese material</i>	22.24	<p>The following track components will be provided for each 25 m of track using Chinese material:</p> <ul style="list-style-type: none"> (a) 50 m of 50 kg/m rail, (b) 36 No. 2500 mm x 268 mm x 195 mm prestressed concrete sleepers, (c) 144 No. rail fastenings, (d) 144 No. insulators, and (e) 72 No. rubber pads.
<i>UIC 54 material</i>	22.25	<p>(1) The following track components will be provided for each 25 m of track using UIC 54 material:</p> <ul style="list-style-type: none"> (a) 50 m of UIC 54 kg/m rail, (b) 36 No. 2515 mm x 265 mm x 212 mm prestressed concrete sleepers, (c) 144 No. Pandrol rail fastenings, (d) 144 No. nylon insulators, and (e) 72 No. rubber bonded cork pads. <p>(2) The following additional track components will be provided for each 25 m of track using UIC 54 material on curves of less than 2000 m radius:</p> <ul style="list-style-type: none"> (a) 3 No. 2515 mm x 265 mm x 212 mm prestressed concrete sleepers, (b) 12 No. Pandrol rail fastenings, (c) 12 No. nylon insulators, and (d) 6 No. rubber bonded cork pads.
<i>Wide sleepere materia</i>	22.26	<p>The following track components will be provided for each 25 m of track using 550 mm wide sleepers:</p> <ul style="list-style-type: none"> (a) 50 m of 50 kg/m rail, (b) 43 No. 2500 mm x 550 mm x 170 mm concrete sleepers, (c) 172 No. rail fastenings, (d) 172 No. insulators, and (e) 86 No. rubber pads.

DESIGN OF CONTINUOUSLY PAVED TRACK

<i>Design of continuously</i>	22.27	(1) Continuously paved track shall be designed by the Contractor to
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paved track

comply with the requirements stated in Clause 22.27(2) to (6).

(2) The methods of installation and replacement of fastenings for continuously paved track shall be such that the fastenings can be completed by one man using manual tools. The method of installing the shoulders shall ensure electrical insulation between the rails. Only one type of fastening shall be used on plain track. The fastenings shall be installed at a nominal spacing of 700 mm centre to centre; minor alterations to this spacing may be necessary to ensure that all rail joints occur midway between fastenings.

(3) The design loading for continuously paved track shall comply with BS 5400:Part 2, Type RU loading.

(4) The rails for continuously paved track shall be inclined inward at 1:20 to the vertical and the track gauge on straight and curved track shall be 1435 mm. Allowance shall be made for turnouts as stated in Clause 22.62; allowance for curves is not necessary. The cant shall be achieved by the inner rail being held at the grade line and the outer rail being raised.

(5) Drainage for continuously paved track shall be such that:

- (a) the track structure shall span the drains without interfering with the drains, and
- (b) liquid spilled from passing wagons shall be carried away from the rails and fastenings.

(6) Running-on boxes for continuously paved track shall comply with the outline design stated in the Contract.

SUBMISSIONS

Particulars of employees

22.28 The following particulars of the proposed foreman and welders for tracklaying work shall be submitted to the Engineer at least 14 days before the relevant work starts:

- (a) name,
- (b) copy of Hong Kong Identity Card, and
- (c) details of previous experience.

Particulars of welding

22.29 The following particulars of the proposed welding procedures shall be submitted to the Engineer at least 14 days before welding starts:

- (a) details of format of records,
- (b) details of welding procedures, and

		(c) valid certificate of competency in Alumino-thermic welding for each welder issued by an authority approved by the Engineer.
<i>Particulars of continuously paved track</i>	22.30	<p>(1) The following particulars of the proposed materials and methods of construction for continuously paved track shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) details of design, including drawings, (b) details of rail clips, including manufacturer's literature, (c) manufacturer's literature and a certificate for rail pads showing the manufacturer's name, the date and place of manufacture and showing that the rail pads comply with the requirements stated in the Contract and including results of tests for: <ul style="list-style-type: none"> - thickness and width - mean deflection - hardness, tensile strength, elongation, compression, and set - electrical resistance - resistance to ageing - resistance to brine, pig urine and petroleum products, and (d) methods and sequence of construction. <p>(2) The particulars, including certificates, shall be submitted to the Engineer at least 28 days before construction of continuously paved track starts. Certificates shall be submitted for each batch of rail pads delivered to the Site.</p>
<i>Particulars of destressing</i>	22.31	<p>The following particulars of the proposed destressing procedures shall be submitted to the Engineer for approval at least 14 days before destressing starts:</p> <ul style="list-style-type: none"> (a) details of format of records, and (b) turnouts or other sections of track which will be used as anchors.

HANDLING AND STORAGE OF MATERIALS

<i>Handling and storage of welding portions and igniters</i>	22.32	Welding portions and igniters are classified as Dangerous Goods and shall be handled and stored as such; welding portions shall be protected and kept dry.
<i>Handling and storage of sleepers</i>	22.33	<p>(1) Sleepers shall be handled by the rail seats and shall not be subjected to rough handling, shock loading or dropping.</p> <p>(2) Sleepers shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the sleepers. Sleepers shall be protected from damage and damaged sleepers shall not be</p>

used unless permitted by the Engineer.

PRELIMINARY WORK

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| <i>Preparation of formation</i> | 22.34 | <p>(1) Construction of ballasted track shall start as soon as practicable after the formation has been completed. The formation shall be protected as stated in Clause 6.52.</p> <p>(2) The permission of the Engineer shall be obtained before construction of the trackbed starts.</p> |
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CONSTRUCTION OF BALLASTED TRACK

- | | | | | | | | | |
|-----------------------------------------------------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|-----------------------------------------------------------------------------|-------------|----------|---------------------------------|----------|
| <i>Laying bottom ballast</i> | 22.35 | <p>(1) The minimum depth of ballast below the underside of the sleepers shall comply with the following:</p> <table border="0" style="margin-left: 40px;"> <tr> <td>(a) Main lines and running lines</td> <td style="text-align: right;">: 300 mm</td> </tr> <tr> <td>(b) Sidings</td> <td style="text-align: right;">: 150 mm</td> </tr> <tr> <td>(c) Tracks with 550 mm sleepers</td> <td style="text-align: right;">: 75 mm.</td> </tr> </table> <p>(2) Bottom ballast shall be laid in layers not exceeding 150 mm. Each layer shall be compacted by at least four passes of a vibrating roller having a static load per 100 mm width of roll of at least 3.5 kN.</p> | (a) Main lines and running lines | : 300 mm | (b) Sidings | : 150 mm | (c) Tracks with 550 mm sleepers | : 75 mm. |
| (a) Main lines and running lines | : 300 mm | | | | | | | |
| (b) Sidings | : 150 mm | | | | | | | |
| (c) Tracks with 550 mm sleepers | : 75 mm. | | | | | | | |
| <i>Fixing bolts in sleepers</i> | 22.36 | <p>Bolts used with Chinese material shall be fixed in the sleepers using sulphur fixings. The ingredients shall be mixed and heated to a temperature not exceeding 160°C until all of the sulphur becomes liquid. The mixture shall then be poured into the bolt holes and the bolts inserted using a jig to locate them in position. The sleepers and jig shall not be moved until the mixture has reached the ambient temperature.</p> | | | | | | |
| <i>Canting track</i> | 22.37 | <p>The track shall be canted in accordance with the following requirements:</p> <table border="0" style="margin-left: 40px;"> <tr> <td>(a) The inner rail on a curve shall remain at the grade line.</td> </tr> <tr> <td>(b) The cant shall be evenly run off in the length of the transition curve.</td> </tr> </table> | (a) The inner rail on a curve shall remain at the grade line. | (b) The cant shall be evenly run off in the length of the transition curve. | | | | |
| (a) The inner rail on a curve shall remain at the grade line. | | | | | | | | |
| (b) The cant shall be evenly run off in the length of the transition curve. | | | | | | | | |
| <i>Placing ballast</i> | 22.38 | <p>(1) After the track has been laid and temporarily jointed, it shall be lifted by jacks or crowbars to a level of 25 mm below the specified final level and packed as stated in Clause 22.38(2).</p> <p>(2) Ballast shall be placed and compacted under the lifted sleepers for a distance of 230 mm on each side of the centre lines of the rails. The ballast shall be packed using a plate laying beater or ballast tamper; packing shall be continued until ballast refuses to penetrate under the sleepers near the rail seats. Large stones shall not be forced under the sleepers. Ballast shall be lightly packed under the sleeper ends and centres.</p> | | | | | | |

- (3) The alignment of the track shall be corrected after packing.
- (4) After initial lifting and packing have been completed, the voids between the sleepers shall be boxed up, except for portions within 115 mm on each side of the centreline of the rails, and placing and compaction of ballast to the shoulders shall be completed. The 230 mm slots may be omitted if a rail mounted ballast tamper is used.
- (5) After the permanent joints have been completed, the track shall be lifted and packed to the specified line and level by the procedure stated in Clause 22.38(1) to (3).
- (6) After the track has been lifted and packed to the specified line and level, boxing up shall be completed. Ballast shall be stopped flush with the top of the sleepers.

Laying turnouts

22.39

- (1) Turnouts shall be laid as stated in Clause 22.39(2) to (8).
- (2) The bearers under the switches and in the lead shall be laid perpendicular to the centreline of the main line. The bearers under the crossing shall be laid perpendicular to the main line such that they are symmetrical with the check rails.
- (3) Timber bearers shall be set out and vertical holes shall be bored in the bearers to suit the fastenings; boring shall be carried out before the track is laid in position.
- (4) Base plates or cast-in shoulders shall be used on concrete slabs and on concrete bearers. Base plates shall be fastened to the slab or bearer by medium tensile studs or bolts. Studs, bolts or shoulders shall be fixed into preformed or drilled holes in the slab or bearer using adhesive. Studs, bolts and shoulders shall be cleaned and the inside face of the holes shall be roughened before installation. The adhesive shall be applied in accordance with the manufacturer's recommendations.
- (5) The rails shall be laid perpendicular to the bearers.
- (6) Base plates and slide chairs shall be secured to timbers with coach screws and turned plumb with a box spanner until the entire overlap firmly grips the sole plate or slide chair.
- (7) Joints between rails shall be made as for bolted track using fish-plates except that the rails shall be butted together.
- (8) The rails shall be cut with a rail saw to accommodate turnouts and holes shall be drilled for the bolted fishplate connection. Rails less than 3700 mm long shall not be used in closures.

Marking cant

22.40

The cant shall be marked on concrete sleepers at curves and transitions by painting yellow numerals on a black background.

Fouling marks

22.41

A painted concrete fouling mark shall be placed at locations where the distance between the running edges of converging tracks is 2140 mm.

CONSTRUCTION OF CONTINUOUSLY PAVED TRACK

<i>Fixing shoulders</i>	22.42	Shoulders shall be cast into the structure of continuously paved track or fixed into preformed or drilled holes in the structure using adhesive. The shoulder shall be cleaned before installation. If the shoulders are fixed by adhesive, the holes shall be at least 45 mm diameter and the inside face of the holes shall be roughened; the adhesive shall be applied in accordance with the manufacturer's recommendations.
<i>Repairs to galvanized coatings</i>	22.43	Damage to galvanised coatings shall be repaired by applying two coats of metallic zinc-rich priming paint. Sufficient paint shall be applied to provide a zinc coating of at least the same thickness as the galvanised coating. Repairs to galvanised coatings shall be carried out within 8 hours of damage. Traces of rust shall be removed from the surface of the metal before the repair is carried out.
<i>Rectification to continuously paved trackbed</i>	22.44	If the continuously paved trackbed does not comply with the tolerances stated in Clause 22.69, the rail seating areas shall be ground down or built up using materials approved by the Engineer and applied in accordance with the manufacturer's recommendations.

WELDING, CUTTING, DRILLING AND JOINTING RAILS

<i>Welding rails</i>	22.45	<p>(1) Rails shall be welded using the Thermit or Boutet process or using other processes approved by the Engineer.</p> <p>(2) Welds shall be free from cracks and gross intrusions. Fusion shall be complete and the total area of internal defects, including pores and slag intrusions, shall not exceed 60 mm². The largest single defect shall not exceed 5 mm in diameter.</p> <p>(3) The ends of rails shall be free from chemical compounds and shall be cleaned with a wire brush before welding. Preheat shall be applied before welding if recommended by the manufacturer of the welding portions.</p> <p>(4) Welding gaps shall be in accordance with the manufacturer's recommendations for the type of weld being used. Rails shall be aligned such that a flat running surface is provided; the running edges shall be flush.</p> <p>(5) Welds shall be finished by grinding after the rail temperature has fallen below 400°C. The equipment used shall be such that local overheating of the rail is avoided.</p> <p>(6) Rails which are to be cut to length and which will be welded within 12 hours of cutting may be flame cut to form a square and vertical cut; the cut end shall be cleaned before welding.</p> <p>(7) Lengths of rail shall be cut out for at least 700 mm on each side of condemned welds unless the Engineer permits a wide gap weld to be used.</p>
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Joints shall not be closer together than 5 m.

<i>Records of welding operations</i>	22.46	Records of welding operations shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer. Records shall contain the following details: <ul style="list-style-type: none"> (a) date, (b) names of welders, (c) location of welding operation, and (d) batch of portion used in making each weld.
<i>Closure rails</i>	22.47	Closure rails of at least 5 m length shall be cut at connections to fish-plated track and at insulated joints.
<i>Cutting rails</i>	22.48	Except as stated in Clause 22.45(6), rails shall be cut using a cold saw technique. The cut shall be square and vertical to within 1 mm. Burrs shall be removed from the cut ends and the cut ends shall be smoothed.
<i>Drilling rails</i>	22.49	Holes in rails shall be drilled and completed to the final diameter in one pass using a rail drill. Holes shall not be cut by using a torch.
<i>Fish-plated joints</i>	22.50	<p>(1) The butt ends of the rails shall be cleaned with a wire brush before fish-plated joints are made. The fishing surfaces of the rails and fish-plates shall be cleaned with a wire brush and lubricated with a 1:1 graphite/grease mixture. The bolts shall be cleaned and oiled before insertion.</p> <p>(2) Metal shims shall be inserted at fish-plated joints to form expansion gaps and shall be retained in position until the track is packed and lined. Metal shims shall be 6 mm thick if the temperature of the rail is less than 40°C at the time of insertion and shall be 3 mm thick if the temperature of the rail is 40°C or greater at the time of insertion.</p> <p>(3) Bolts to fish-plated joints shall be tightened using a 600 mm long spanner. The two bolts nearest the butt shall be tightened first. The length of the spanner shall not be extended.</p>
<i>Insulated rail joints</i>	22.51	Insulated rail joints shall be installed in accordance with the manufacturer's recommendations.

DESTRESSING

<i>Notice of destressing operations</i>	22.52	The Contractor shall make arrangements, through the Engineer, at least 14 days before destressing operations start for representatives of the Corporation's Permanent Way Staff to be present during the operation.
<i>Destressing requirements</i>	22.53	(1) Continuous welded track which is clipped down when the rail temperature is between 30°C and 35°C shall be considered to be stress free. The stress free temperature used for calculating extensions for destressing operations when using rail tensors shall be 35°C.

- (2) Destressing shall be carried out using hydraulic tensors. Two sets of equipment shall be used simultaneously to enable both rails to be pulled together.
- Preparations for destressing*** 22.54 (1) The rails shall be free to move during destressing operations.
- (2) Turnouts or other sections of track which will be used as anchors in destressing operations shall be as agreed by the Engineer.
- (3) Tell-tale points shall be marked, including one at each end of each anchor length, to monitor rail movements and the effectiveness of the anchors during destressing operations. The tell-tale points shall be established by freeing the rails from a well bedded sleeper and marking each rail in line with a reference mark.
- (4) Fastenings shall be released before destressing operations start, commencing from the cut or free end. The rails shall be lifted free from all obstructions and shall be placed on solid rollers positioned at intervals of 10 to 11 sleepers with the rail pads removed. Side rollers shall be used on curved track. Rails shall be vibrated or shaken by bars under the rail to ensure that the rails are free to move during tensioning.
- (5) Reference points shall be established on each rail length at approximately 50 m intervals to check that the calculated extension is obtained throughout the length of the free rail in destressing operations.
- Temperature of rails*** 22.55 (1) Rail temperatures shall be measured using magnetic rail thermometers. The thermometers shall be placed on the rail foot or on the web on the shaded side of each rail and shall be protected from damage and exposure to conditions which may affect the readings. At least three thermometers shall be used on each rail, one located adjacent to the pulling point, the second located at the midpoint of the free rail and the third located adjacent to the anchors. Additional thermometers shall be used if the spacing exceeds 200 m.
- (2) The initial reading shall not be taken until at least 10 minutes after placing the thermometer. The readings used to calculate the extension shall be taken at the last possible moment before marking the reference points.
- (3) The average temperature shall be taken after the readings of all thermometers have stabilised.
- Extensions of rails*** 22.56 The required extension of each rail to be tensioned shall be calculated in accordance with Table 22.3. The full extension shall then be marked at the free end and the proportional movement marked at intermediate reference points such that rail movements can be monitored during tensioning.

Table 22.3 : Required extension of continuous welded rail

Rail temperature	Required extension (mm) for rail lengths (km)
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°C	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	1	2	3	5	6	7	8	9	10	12	13	14	15	16	17	18	20	21	22	23
33	2	5	7	9	12	14	16	18	21	23	25	28	30	32	35	37	39	41	44	46
32	3	7	10	14	17	21	24	28	31	35	38	41	45	48	52	55	59	62	66	69
31	5	9	14	18	23	28	32	37	41	46	51	55	60	64	69	74	78	83	87	92
30	6	12	17	23	29	35	40	46	52	58	63	69	75	81	86	92	98	104	109	115
29	7	14	21	28	35	41	48	55	62	69	76	83	90	97	104	110	117	124	131	138
28	8	16	24	32	40	48	56	64	72	81	89	97	105	113	121	129	137	145	153	161
27	9	18	28	37	46	55	64	74	83	92	101	110	120	129	138	147	156	166	175	184
26	10	21	31	41	52	62	72	83	93	104	114	124	135	145	155	166	176	186	197	207
25	12	23	35	46	58	69	81	92	104	115	127	138	150	161	173	184	196	207	219	230
24	13	25	38	51	63	76	89	101	114	127	139	152	164	177	190	202	215	228	240	253
23	14	28	41	55	69	83	97	110	124	138	152	166	179	193	207	221	235	248	262	276
22	15	30	45	60	75	90	105	120	135	150	164	179	194	209	224	239	254	269	284	299
21	16	32	48	64	81	97	113	129	145	161	177	193	209	225	242	258	274	290		
20	17	35	52	69	86	104	121	138	155	173	190	207	224	242	259	276	293			
19	18	37	55	74	92	110	129	147	166	184	202	221	239	258	276	294				
18	20	39	59	78	98	117	137	156	176	196	215	235	254	274	293					
17	21	41	62	83	104	124	145	166	186	207	228	248	269	290						
16	22	44	66	87	109	131	153	175	197	219	240	262	284							
15	23	46	69	92	115	138	161	184	207	230	253	276	299							
14	24	48	72	97	121	145	169	193	217	242	266	290								
13	25	51	76	101	127	152	177	202	228	253	278									
12	26	53	79	106	132	159	185	212	238	265	291									
11	28	55	83	110	138	166	193	221	248	276										
10	29	58	86	115	144	173	201	230	259	288										
9	30	60	90	120	150	179	209	239	269	299										
8	31	62	93	124	155	186	217	248	279											
7	32	64	97	129	161	193	225	258	290											
6	33	67	100	133	167	200	233	267	300											
5	35	69	104	138	173	207	242	276												
4	36	71	107	143	178	214	250	285												
3	37	74	110	147	184	221	258	294												
2	38	76	114	152	190	228	266													
1	39	78	117	156	196	235	274													
0	40	81	121	161	201	242	282													

- Destressing operations** 22.57 (1) Destressing operations shall be carried out in accordance with the procedure stated in Clause 22.57(2) to (10).
- (2) The calculated extension in the rail plus an allowance for the welding gap shall be marked on the rail and the necessary cuts shall be made.
- (3) The rail tensors shall be positioned in accordance with the manufacturer's recommendations on both rails to be tensioned. The longitudinal separation of the tensors shall not exceed 15 m.
- (4) The rail tensors shall be used in accordance with the manufacturer's recommendations. During tensioning the rail shall be extended to the reference mark at the pulling point and the movement checked at the tell-tale points and at each intermediate reference point. The force applied by the tensors shall be monitored during tensioning to ensure that it is related to the required extension.
- (5) The length of straight track to be tensioned in one direction shall not exceed 900 m. The length of curved rail to be tensioned in one direction shall not exceed 150 m.
- (6) The required extension may be obtained over the whole length by pulling in both directions from a central pulling point provided that the overall length of track to be tensioned does not exceed:

- (a) 300 m for curved track, or
 - (b) 1800 m for straight track.
- (7) At least 10 m of rail on each side of the weld shall be fastened down before welding.
- (8) Rollers shall be removed and the track shall be fastened down commencing at the pulling point and working towards the anchor point. Fastening down shall stop at least 36 m from the anchoring point to allow stress equalisation into the anchor. Side rollers shall not be removed on curves until the rail has been refastened to within a distance of 30 m from the side roller.
- (9) The rail tensors shall remain in position under pressure for 20 minutes after welding.
- (10) The fastenings for 36 m on the anchor side of the inner tell-tale point shall be released after tensioning. The rails shall be lifted and shaken or vibrated and all fastenings shall be replaced.

<i>Records of distressing operations</i>	22.58	<p>Records of distressing operations shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer. Records shall contain the following details:</p> <ul style="list-style-type: none"> (a) date, (b) location of distressing operation, (c) temperatures of the rails at the times when the rails are clipped down, and (d) movements of the rail which occur at the tell-tale points when the fastenings are released.
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TOLERANCES

<i>Tolerances: vertical alignment of track</i>	22.59	<p>The vertical alignment of the track shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) The level shall be within 10 mm of the specified level. (b) The deviation from the specified gradient over any 3 m length shall not exceed 0.1%. (c) The maximum deviation from the design profile at summits or sags shall not exceed 4 mm on any 10 m chord or 6 mm on any 20 m chord.
<i>Tolerances: horizontal alignment of</i>	22.60	<p>The horizontal alignment of the track shall comply with the following requirements:</p>

track

- (a) The alignment shall be within 10 mm of the specified alignment.
- (b) The versine on any 20 m chord shall be within 5 mm of the specified value and the versine on any 10 m chord shall be within 2 mm of the specified value.
- (c) There shall be no negative versines on curved tracks.
- (d) The deviation of successive versines from each other taken at 10 m intervals over a 20 m chord shall not exceed 5 mm. The deviation of successive versines from each other taken at 5 m intervals over a 10 m chord shall not exceed 2 mm.

Tolerances: cant of track

- 22.61 (1) The cant of the track shall be within 3 mm of the specified cant. The cant shall not be of the opposite hand to the specified cant at any point.
- (2) The rate of change of cant on any 2 m length shall not exceed 4 mm on straights and circular curves and shall not exceed 5 mm on transition curves.

Tolerances: track gauge

- 22.62 The track gauge shall be within 2 mm of the value stated in Table 22.4. The rate of change of gauge shall not exceed 3 mm in any 3 m length.

Table 22.4 : Track gauge

Type of track	Track gauge
Chinese turnouts : straight road	1435 mm
Chinese turnouts : turnout road <ul style="list-style-type: none"> - toe of the switch - over the lead 	1435 mm 1438 mm
Other tracks	1435 mm

Tolerances: cyclic changes

- 22.63 There shall be no cyclic changes in vertical alignment, horizontal alignment, cant or gauge of the track.

Tolerances: insulated joints

- 22.64 Insulated joints shall be within 350 mm of the specified position.

Tolerances: welded joints

- 22.65 The maximum bump or hollow across welded joints, measured with a 1 m long straight edge, shall not exceed 2 mm.

Tolerances: level of bottom ballast

- 22.66 The finished level of compacted bottom ballast shall be not more than 50 mm, and not less than 25 mm, below the specified level of the underside of the sleepers or turnout bearers.

Tolerances: sleepers

- 22.67 Sleepers shall be within 30 mm of the specified spacing. Sleepers shall be perpendicular to the track to within 10 mm on straights and to within 25 mm on curves, measured over the length of the sleeper.

Tolerances: coping slabs

- 22.68 (1) The centre of coping slabs shall be within - 5 mm, + 10 mm of the specified position measured from the centreline of the track.

- (2) The sides of coping slabs shall be parallel and the maximum bump or hollow on the surface shall not exceed 5 mm measured across the diagonal.

***Tolerances:
continuously paved
track***

- 22.69 Continuously paved track shall comply with the following requirements:
- (a) The rail pads shall be with 3 mm of the centreline of the rail.
 - (b) The maximum bump or hollow of the rail seats shall not exceed 1.5 mm over a 1.5 m length in the longitudinal direction.
 - (c) The maximum bump or hollow of the rail seats shall not exceed 1.5 mm over a length equal to the width of the rail flange plus 25 mm in the transverse direction.

TESTING : BALLAST

Batch: ballast

- 22.70 A batch of ballast is any quantity of ballast of the same type, produced at the same time in the same place, covered by the same certificates and delivered to the Site at any one time.

Samples: ballast

- 22.71 (1) Unless otherwise permitted by the Engineer, one sample of ballast shall be provided from each batch of ballast delivered to the Site.
- (2) The size of each sample shall be 30 kg. The method of sampling shall be in accordance with BS 812:Part 102.

Testing: ballast

- 22.72 (1) Each sample of ballast shall be tested to determine the properties stated in Table 22.5.
- (2) The method of testing shall be as stated in Table 22.5.

Table 22.5 : Testing ballast

Property	Method of testing
Particle size distribution	BS 1377, test 7(A)
Crushing value	BS 812:Part 110
Flakiness index	BS 812:Part 105.2
Elongation index	BS 812:Part 105.1
Los Angeles wet attrition test	ASTM C 131

TESTING : SULPHUR FIXINGS

Batch: sulphur fixings	22.73	A batch of sulphur fixings is any quantity of sulphur fixings produced in one day.
Testing: sulphur fixings	22.74	<p>(1) Each batch of sulphur fixings shall be tested to determine the resistance to movement of the shoulder and the resistance to cracking of the compound in the sulphur fixings.</p> <p>(2) Tests shall be carried out on 1% of the sulphur fixings in each batch; at least one test shall be carried out on each day that sulphur fixings are installed.</p> <p>(3) A pull-out load of 60 kN shall be applied to the sulphur fixing and maintained for at least two minutes.</p>
Compliance criteria: sulphur fixings	22.75	The sulphur fixing shall withstand the load test without movement of the shoulder and without cracking of the compound in the sulphur fixing.
Non-compliance: sulphur fixings	22.76	<p>(1) If the result of any test for resistance to movement of the shoulder or resistance to cracking of the compound in the sulphur fixings does not comply with the specified requirements for the test, additional tests shall be carried out on the same batch. Additional tests shall be carried out on 10% of the sulphur fixings in the batch.</p> <p>(2) If the result of any additional test does not comply with the specified requirements for the test, every sulphur fixing in the batch shall be tested.</p> <p>(3) If the result of any test on any sulphur fixing does not comply with the specified requirements for the test, the bolts shall be removed from the sleeper and refixed and the sulphur fixing shall be tested.</p>

TESTING : RAIL PADS FOR CONTINUOUSLY PAVED TRACK

Batch: rail pads	22.77	A batch of rail pads for continuously paved track is any quantity of rail pads of the same material and produced by the same process in one week, covered by the same certificates and delivered to the Site at any one time.
Samples: rail pads	22.78	Unless otherwise permitted by the Engineer one sample shall be provided from each batch of 1000 rail pads or part thereof delivered to the Site.
Testing: rail pads	22.79	<p>(1) Each sample of rail pads shall be tested to determine dimensional accuracy, mechanical properties and volume resistivity; one set of tests shall be performed on specimens under normal working conditions and another set of tests shall be performed on specimens which have been subjected to accelerated ageing. The accelerated ageing process shall be carried out by air-oven methods for a 72 hours duration at a temperature of $70 \pm 1^{\circ}\text{C}$.</p> <p>(2) The methods of testing mechanical properties shall comply with the following:</p>

Hardness	: BS 903:Part A26
Minimum tensile strength	: BS 903:Part A2
Minimum elongation at break	: BS 903:Part A3
Maximum compression set	: BS 903:Part A6
Accelerated ageing and heat resistance	: BS 903:Part A19
Static load test	: Clause 22.79(4)

(3) The thickness of rail pads shall be measured at five places evenly spaced along the length of the specimen with the gauge specified in BS 903:Part A4. The width and length of rail pads shall be measured at five places evenly spaced along the length of the specimen.

(4) The method of determining the compression strain of rail pads in the static load test shall be in accordance with BS 903:Part A4 and the following:

- (a) the test piece shall be 200 mm in length cut from one pad and shall not contain the end 50 mm of the pad,
- (b) a compressive force of 30 kN shall be applied and removed in two successive cycles for the purpose of conditioning the test piece, and
- (c) after the conditioning an initial force of 10 kN shall be applied and the deformation gauge set to zero; the force shall then be steadily increased to 30 kN and the gauge reading taken to determine the deflection, and
- (d) the force shall then be removed and the thickness of the test piece measured at two places 10 minutes after the removal of the load.

(5) The method to determine the volume resistivity of rail pads shall be in accordance with BS 903:Part C2 and the following:

- (a) The diameter of the electrodes (D₁) shall be 50 mm.
- (b) Graphite electrodes shall be applied.
- (c) One specimen shall be tested in a dry condition. The other specimen shall be immersed in a bath of distilled water for 48 hours and dried with blotting paper to remove all surface water before testing.
- (d) Both faces of each specimen shall be lightly rubbed with a clean cloth. If there is any evidence of surface products which may affect the electrical resistance the surfaces shall be lightly rubbed with a fine emery cloth.
- (e) The voltage applied shall be 100 ± 10 volts direct current.

Compliance criteria: rail pads	22.80	<p>(1) The dimensions of rail pads shall comply with the following:</p> <ul style="list-style-type: none"> (a) The thickness shall be within 0.2 mm of the specified thickness. (b) The width shall be within 2 mm of the specified width. (c) The length shall be within 20 mm of the specified length. <p>(2) The results of static load tests shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) The mean deflection measured in Clause 22.79(4) shall be between 0.8 mm and 1.2 mm. (b) The difference between the means of the two sets of thickness measurements before and after the static load test shall be no more than 0.1 mm. <p>(3) The results of tests for volume resistivity shall comply with the requirements stated in Clause 22.20(3).</p> <p>(4) The results of all tests on specimens which have been subjected to ageing in accordance with Clause 22.79(1) shall comply with the same requirements as stated in Clause 22.80(1), (2) and (3).</p>
Non-compliance: rail pad	22.81	<p>(1) If the result of any test on the rail pads does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out.</p> <p>(2) If the result of any tests for mean deflection does not comply with the requirements of Clause 22.80(2), additional tests may be performed on four specimens cut from four different pads in the batch. The mean deflection of the four specimens shall be between 0.9 mm and 1.1 mm.</p> <p>(3) The batch shall be considered as not complying with the specified requirements for the property if the result of any additional test does not comply with the specified requirements for the property.</p>

TESTING : SHOULDERS

Testing: shoulders	22.82	<p>(1) Twenty four samples of shoulders shall be selected by the Engineer from each batch of 600 shoulders or part thereof installed in position. Each of the selected shoulders shall be tested to determine the resistance to movement and failure under a test load of 40 kN.</p> <p>(2) Testing shall be carried out by a method agreed by the Engineer and using equipment agreed by the Engineer.</p>
Compliance criteria: shoulders	22.83	The shoulder shall withstand the test load without movement or failure.

***Non-compliance:
shoulders***

- 22.84 (1) If the result of any test for resistance to movement or failure of shoulders does not comply with the specified requirements, 24 additional shoulders from the same batch shall be tested.
- (2) If the result of any additional test does not comply with the specified requirements, every shoulder in the batch shall be tested.
- (3) If the result of any test on any shoulder does not comply with the specified requirements, the shoulder shall be replaced and tested.
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**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 23
WATER SUPPLY PIPEWORKS**

SECTION 23

WATER SUPPLY PIPEWORKS

GENERAL

<i>General requirements</i>	23.01	The works and materials specified in Clauses 23.02 to 23.05 shall comply with the sections stated, unless otherwise stated in this Section.
<i>Drainage works</i>	23.02	Drainage works shall comply with Section 5.
<i>Earthworks</i>	23.03	Earthworks shall comply with Section 6.
<i>Formwork</i>	23.04	Formwork and finishes to concrete shall comply with Section 14.
<i>Concrete</i>	23.05	Concrete shall comply with Section 16.

GLOSSARY OF TERMS

<i>Fitting</i>	23.06	Fitting is a component fitted to a pipe for jointing or connecting or for changing the direction or bore of a pipe.
<i>Flexible joint</i>	23.07	Flexible joint is a connection between pipes and fittings which provides angular deflection or axial movement or a combination of both in service without impairing the efficiency of the connection.
<i>Mechanical joint</i>	23.08	Mechanical joint is a flexible joint in which an elastomeric joint ring is located in the socket and the joint sealed by applying pressure to the joint ring by means of a gland bolted to the socket.
<i>Nominal size</i>	23.09	Nominal size is a numerical designation of size which is common to all components in a pipework system. The nominal size is stated as a convenient round number in millimetres and is related to, but not normally the same as, the actual internal diameter of the pipework; dn designates the nominal size of tees and tapers which are less than DN.
<i>Push-in joint</i>	23.10	Push-in joint is a flexible joint in which an elastomeric joint ring is located in the socket and the joint is effected by entering the spigot through the joint ring into the socket.
<i>Special fitting</i>	23.11	Special fitting is a fitting which is made from a manipulated or fabricated pipe.
<i>Thin walled pipe</i>	23.12	Thin walled pipe is a pipe, including pipes of DN 1200 or greater, which has a ratio of nominal size to wall thickness, excluding linings and coatings, exceeding 125.

MATERIALS

- | | | |
|----------------------------------------------------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Materials for water supply pipeworks</i> | 23.13 | Materials for water supply pipeworks for potable water shall be non-toxic, shall not promote microbial growth and shall not impart a taste, odour, cloudiness or discolouration to the water after disinfection and washing out of the pipelines as stated in Clause 23.73. |
| <i>Steel pipes and fittings</i> | 23.14 | <p>(1) Steel pipes and fittings shall comply with the following:</p> <p style="margin-left: 40px;">Steel pipes and specials for water and sewage : BS 534</p> <p style="margin-left: 40px;">Dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes : BS 3600</p> <p style="margin-left: 40px;">Steel pipes and tubes for pressure purposes: carbon steel with specified room temperature properties : BS 3601.</p> <p>(2) Steel pipes and fittings shall be manufactured by the electric-resistance welded and induction-welded process or by the submerged- arc welded process; the tensile strength of the steel used shall be at least 410 N/mm².</p> <p>(3) Steel pipes and fittings shall be coated or lined internally and externally as stated in Table 23.1.</p> <p>(4) Gusseted steel bends and tees shall be fabricated in accordance with BS 534, BS 2633 and BS 4515.</p> |
| <i>DI pipes and fittings</i> | 23.15 | <p>(1) DI pipes and fittings shall comply with BS 4772. Pipes and fittings other than collars, caps and blank flanges shall be lined internally with cement mortar in accordance with BS 4772, Clause 3.2. Linings shall be made with sulphate-resisting Portland cement complying with BS 4027.</p> <p>(2) Pipes shall be externally coated with metallic zinc in accordance with BS 4772, Clause 3.1. Fittings shall be externally coated with zinc rich paint in accordance with BS 4772, Clause 3.1.5(b). After zinc coating pipes and fittings shall be externally coated with a finishing coat of one of the following materials as stated in BS 4772, Clause 3.3:</p> <p style="margin-left: 40px;">(a) bitumen based hot applied coating material complying with Clause 23.22 and BS 4147 : Type I, Grade C, or</p> <p style="margin-left: 40px;">(b) bitumen based cold applied coating material complying with Clause 23.22 and BS 3416 : Type II.</p> |

Table 23.1 : Protection to steel pipes and fittings

Type of pipe or fitting	Internal coating	External coating
Pipes for fresh water	Bitumen lining complying with Clause 23.22 and BS 534 : Clause 31.2	Reinforced bitumen sheathing complying with BS 534 : Clause 30.3, or bitumen enamel wrapping (filled bitumen with glass tissue) to BS 534 : Clause 30.4 or Clause 30.5, with bitumen-based coating materials complying with Clause 23.22 and BS 4147: Type 2.
Fittings for fresh water other than slip-on type couplings and flange adapters	Bitumen lining complying with Clause 23.22 and BS 534 : Clause 31.3	
Pipes exceeding DN 600 for salt water	Sulphate-resisting concrete lining complying with BS 534 : Clause 33.1	
Fittings exceeding DN 600 for salt water other than slip-on type couplings and flange adapters	Sulphate-resisting concrete lining complying with BS 534 : Clause 33.2	
Pipes not exceeding DN 600 for salt water	Sulphate-resisting concrete lining complying with BS 534 : Clause 33.1 or sulphate-resisting cement mortar lining complying with BS 534 : Clause 33.3	
Fittings not exceeding DN 600 for salt water other than slip-on type couplings and flange adapters	Sulphate-resisting concrete lining complying with BS 534 : Clause 33.2 or sulphate-resisting cement mortar lining complying with BS 534 : Clause 33.3	
Slip-on type couplings and flange adapters	Bitumen coating complying with Clause 23.22 and BS 534 : Clause 29.1	

UPVC pipes and fittings

- 23.16 UPVC pipes and fittings shall be Class D and shall comply with following:
- UPVC pipe for cold water services : BS 3505
 - Joints and fittings for use with UPVC pressure pipes
 - injection moulded UPVC fittings for solvent welding for use with pressure pipes, including potable water supply : BS 4346:Part 1
 - mechanical joints and fittings principally of UPVC : BS 4346:Part 2
 - solvent cement : BS 4346:Part 3.

GI pipes and fittings

- 23.17 GI pipes and fittings shall comply with the following:
- Steel tubes and tubulars suitable for screwing to BS 21 pipe threads : BS 1387, medium grade
 - Pipe threads for tubes and fittings where pressure-tight joints are made on the threads : BS 21
 - Wrought steel pipe fittings (screwed BSP thread) : BS 1740:Part 1

Flanges

- 23.18
- (1) Steel flanges shall comply with BS 4504:Section 3.1, and shall be either steel plate for welding type or steel plate blank flange type. The dimensions and drilling of flanges shall comply with BS 4504:Section 3.1, Table 11, as appropriate regardless of the nominal pressure rating.
 - (2) Steel ring flanges shall be machined in the bore to a diameter of $4 \text{ mm} \pm 1 \text{ mm}$ larger than the outside diameter of the pipe to which the flange is to be welded.
 - (3) Steel puddle flanges shall be separated into 180° segments.
 - (4) DI flanges shall be cast-on standard flanges complying with BS 4772.

Bolts and nuts

- 23.19
- (1) Bolts and nuts for flanged joints shall comply with BS 4504:Section 3.1, Section 6.
 - (2) Bolts and nuts shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

(3) Bolts shall be sufficiently long and shall be suitably threaded for jointing the relevant flanges.

Elastomeric joint rings 23.20 Elastomeric joint rings shall comply with BS 2494, Type 1 for water. Elastomeric joint rings for DI pipes and fittings shall comply with BS 4772, Clause 2.3.4. The dimensions of rings for use with flanged joints shall comply with BS 4865:Part 1. The rings shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

Anticorrosion tape 23.21 (1) Anticorrosion tape shall be a proprietary type approved by the Engineer. The tape shall be a petrolatum compound with fabric reinforcement and or rubber/bitumen compound with fabric reinforcement and PVC backing. The tape shall have a high resistance to cathodic disbonding, acids and alkalis. Petrolatum anticorrosion tape and bituminous anticorrosion tape shall have the minimum properties stated in Table 23.2.

(2) Petrolatum anticorrosion tape shall be used for valves, flanged joints, slip-on type couplings and flange adapters. Bituminous anticorrosion tape Type 1 shall be used for pipes below DN 700; Type 2 shall be used for pipes DN 700 and above.

(3) Primer and mastic filler for use with anticorrosion tape shall be compatible with the tape and shall be a type recommended by the manufacturer of the tape and approved by the Engineer.

Table 23.2 : Properties of anticorrosion tape

Property	Petrolatum Tape	Bituminous Tape	
		Type 1	Type 2
Thickness of PVC backing (µm)	-	85	500
Tensile strength (N/mm)	4	8	10
Tear strength (N)	-	20	36
Adhesion strength (N/mm)	0.5	2	2
Holiday test voltage (kV)			
- single layer	-	10	10
- double layer	16	15	15
Impact strength (J)	-	3.5	8
Temperature range (°C)	-5 to 45	5 to 60	8 to 60
Total thickness (mm)	1.1	1.6	2.0
Mass (kg/m ²)	1.4	1.8	2.4

- Bituminous coatings** 23.22 (1) Bituminous coatings shall comply with the following:
- Bitumen based hot applied coating material for protecting iron and steel including suitable primers where required : BS 4147, Type I, Grade C
- Black bitumen coating solutions for cold application : BS 3416, Type II.
- (2) Bituminous coatings used for repairing joints and coatings shall be compatible with the adjacent coating.
- (3) Bituminous coatings shall be made from petroleum or asphaltic bitumen.
- Whitewash** 23.23 Whitewash shall comply with AWWA C 203.
- Zinc-based paint** 23.24 (1) Zinc-based paint shall be a proprietary type approved by the Engineer.
- (2) Primers for zinc-based paint shall comply with BS 4652.
- (3) Rust inhibitor shall be a chemical agent which is capable of converting rust into iron phosphate.
- Joint filler and compressible padding** 23.25 (1) Joint filler for joints in concrete bed, haunch and surround shall be a proprietary type approved by the Engineer and shall be a firm, compressible, single thickness, non-rotting filler. The thickness of the filler shall be as stated in Table 23.3.
- (2) Compressible padding between pipes and supports shall be bitumen damp-proof sheeting complying with BS 743.

Table 23.3 : Joint filler for concrete bed, haunch and surround

Nominal diameter of pipe	Thickness of joint filler (mm)
less than 450 mm	18
450 mm - 1200 mm	36
exceeding 1200 mm	54

<i>Polyethylene sheeting</i>	23.26	Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.
<i>Extension keys</i>	23.27	Extension keys and clamps for valves shall be Grade 43A steel complying with BS 4360 and shall be hot-dip galvanised in accordance with BS 729 after fabrication.

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

<i>Materials provided by the Employer</i>	23.28	<p>(1) The following materials for water supply pipeworks included in Contracts entered into with Water Supplies Department will be provided by the Employer and shall be used in the permanent works:</p> <ul style="list-style-type: none"> (a) full, half and quarter length pipes with plain, flanged and spigot and socket ends, (b) ring flanges, puddle flanges, slip-on type couplings, flange adapters, collars, expansion joints, detachable joints, elastomeric joint rings, nuts and bolts, (c) blank flanges and caps other than those required for pressure tests, (d) bends, tees and tapers, (e) steel pipes for the fabrication of gusseted steel bends and tees, (f) primer, bitumen based composition and woven glass cloth for repairs to joints in steel pipes with bitumen coating provided by the Employer other than materials for protection of steel flanged joints, slip-on type couplings and flange adapters, and (g) gate valves, air relief valves, butterfly valves and non-return valves, including all winding gear, operating motors and control equipment. <p>(2) The materials shall be obtained from the locations and at the times stated in the Contract.</p> <p>(3) Water and sterilising chemicals for cleaning, sterilising and testing pipelines as stated in Clauses 23.73 and 23.77 will be provided by the Employer for one set of tests. The water and sterilising chemicals shall be obtained from the locations stated in the Contract or from other locations agreed by the Engineer and shall be mixed by the Contractor.</p>
<i>Equipment loaned by the Employer</i>	23.29	<p>(1) The purpose made moulding box for repairs to external coatings of steel pipes as stated in Clause 23.65 will be loaned by the Employer.</p> <p>(2) The continuous pressure recorder and purpose made charts for pressure tests on pipelines for water supply pipeworks as stated in Appendix 23.1 will be loaned by the Employer.</p>

INSPECTION OF MANUFACTURE

Inspection of manufacture and testing

- 23.30 (1) The manufacture and testing of pipes, joints, fitting and valves for water supply pipeworks other than materials provided by the Employer shall be inspected by an independent inspection authority approved by the Engineer.
- (2) The inspections shall be carried out at the manufacturer's works or at other locations stated in the Contract or instructed by the Engineer. The facilities and equipment required for inspections shall be provided by the Contractor.

SUBMISSIONS

Particulars of independent inspection authority

- 23.31 Particulars of the proposed independent inspection authority for pipes, joints, fittings and valves for water supply pipeworks, including name and address, previous experience, and names of inspectors, shall be submitted to the Engineer at least 28 days before manufacture of the materials starts.

Particulars of pipes, joints and fittings

- 23.32 (1) The following particulars of the proposed pipes, joints and fittings for water supply pipeworks shall be submitted to the Engineer:
- (a) manufacturer's literature, including details of:
 - manufacturing process
 - pressure and temperature ratings
 - permissible values of straight draws and angular deflection of flexible joints
 - recommendations for handling, storage, laying, jointing and repair
 - drilling and tapping equipment for connections to pipes,
 - (b) a certificate for each material showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests required in accordance with the relevant British Standard,
 - (c) three copies of drawings showing details of the pipes, joints and fittings, including the materials used and the mass of each item, and
 - (d) a certificate of inspection of the manufacture and testing signed by the approved independent inspection authority.
- (2) The particulars, including certificates other than certificates of inspection, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Particulars of welding

- 23.33 (1) The following particulars of the proposed materials and methods of construction for welding joints in steel pipes for water supply pipeworks shall be submitted to the Engineer:

- (a) details of welders, including names, copies of Hong Kong Identity Cards and details of previous experience,
- (b) details of format of records,
- (c) details of welding procedures, including welding plant, method of welding, materials, manufacturer and size of electrodes, number of runs and current strength,
- (d) procedures for nitrogen gas tests on joints, and
- (e) valid certificate of competency in accordance with BS 2633, Clause 11 for each welder, issued by an authority approved by the Engineer.

(2) The particulars shall be submitted to the Engineer at least 14 days before welding starts.

Particulars of pressure tests 23.34

(1) The following particulars of the proposed procedures for pressure tests on pipelines for water supply pipeworks shall be submitted to the Engineer:

- (a) test equipment and method of setting up the equipment,
- (b) calibration certificates for pressure gauges,
- (c) procedure for carrying out the test, and
- (d) programme for testing.

(2) The particulars shall be submitted to the Engineer at least 14 days before the test starts.

TRIALS

Welding trials

23.35

(1) Unless otherwise permitted by the Engineer, trials shall be carried out to demonstrate the competency of each proposed welder who will be employed to weld joints in steel pipes for water supply pipeworks.

(2) Trials shall be carried out at least 7 days before welding starts.

(3) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before carrying out welding trials.

(4) The trials shall be carried out using the welding procedures submitted to the Engineer.

(5) Trials shall be carried out under similar conditions as those which will be encountered on the Site. Each trial shall consist of fillet welding two steel plates using at least two electrodes to complete one run of weld; the thickness of the steel plates shall be the same as the thickness of the steel pipe which will be welded.

(6) A 150 mm length of the plate which contains what in the opinion of the Engineer is the worst welding shall be cut from the steel plates and broken in a vice.

(7) The Engineer shall determine the competency or otherwise of each welder on the basis of the results of the welding trials.

Pipe jointing trials

23.36

(1) Trials shall be carried out to demonstrate that the pipes, joints and fittings for water supply pipeworks fit correctly.

(2) The trials shall be carried out at least 6 weeks, or such shorter period agreed by the Engineer, before the materials are to be incorporated in the permanent work.

(3) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by Engineer, before carrying out trials.

(4) The Contractor shall immediately inform the Engineer of any pipes, joints or fittings which do not fit correctly. Modifications shall be made to pipes, joints and fittings which do not fit correctly or replacements shall be provided as instructed by the Engineer.

Trials for drilling and tapping

23.37

(1) Trials shall be carried out to demonstrate that the proposed equipment and methods of drilling and tapping pipes for water supply pipeworks will produce connections which comply with the specified requirements.

(2) The trials shall be carried out at least 14 days before drilling and tapping starts.

(3) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before carrying out trials.

TRANSPORT, HANDLING AND STORAGE OF MATERIALS

Transport, handling and storage of pipes, joints and fittings

23.38

(1) Pipes, joints and fittings for water supply pipeworks shall be transported, handled and stored in accordance with the manufacturers' recommendations and in a manner which will not result in damage or deformation to the pipes, joints and fittings or in contamination of the pipes, joints and fittings.

(2) Pipes, joints and fittings shall be protected from damage and damaged pipes, joints and fittings shall not be used in the permanent work unless permitted by the Engineer. Pipes, joints and fittings shall be securely packed and supported to prevent movement when being transported.

(3) UPVC pipes, joints and fittings shall be protected from exposure to conditions which may affect the material.

(4) Bolts and nuts shall be packed in sealed metal containers.

(5) Elastomeric joint rings shall be packed in bags and lubricant for joints shall be stored in sealed containers marked to identify the contents. The rings and lubricant shall be protected from exposure to conditions which may affect the material.

(6) Boxed or crated materials or those in sealed containers shall remain in their original boxes, crates or containers.

Handling o pipes and fittings

23.39

(1) Pipes and fittings other than thin walled pipes shall be handled by manual methods or by using lifting appliances or chains, wire rope or canvas slings of a type recommended by the pipe manufacturer and agreed by the Engineer; hooks shall not be used.

(2) Slings shall be placed around the pipes and fittings and padding shall be provided at points of contact between pipes and fittings and metal lifting appliances or slings. Pipes and fittings shall not be handled by means of metal slings passed through the pipes.

(3) Pipes and fittings shall not be subjected to rough handling, shock loading or dropping and shall not be rolled down ramps unless permitted by the Engineer; if permitted, the ramps shall be padded.

Storage o pipes

23.40

(1) Pipes other than thin walled pipes shall be stored horizontally at least 75 mm above the ground on wedged timber bearers. The bottom layers and the outer pipes in each layer shall be securely wedged to prevent sideways movement.

(2) Socket and spigot pipes shall be stored with the sockets alternating and in such a manner that loads are not applied to the sockets.

(3) The height of stacks of pipes other than thin walled pipes shall not exceed 2 m unless recommended by the manufacturer and permitted by the Engineer.

(4) Pipes shall not be strung out along the route of the pipeline unless permitted by the Engineer.

Transport o thin walled pipes

23.41

When being transported, thin walled pipes shall be supported on three rubber covered saddles shaped such that the pipes are supported over at least one-quarter of the circumference. The pipes shall be securely fixed in position at each saddle by straps tightened by turnbuckles. One saddle shall be placed at the mid-point of the length of the pipe and the other two saddles shall be placed at distances of one-fifth of the length of the pipe from each end of the pipe.

Handling and storage o thin walled pipes

23.42

(1) When being handled and stored, thin walled pipes shall be protected from deformation by means of at least two screw jack cruciform struts with rubber padded ends shaped to fit the circumference of the pipes. The struts shall be fitted inside the pipes; any temporary struts fixed by the manufacturer shall be left in position until the cruciform struts have been fixed.

(2) Thin walled pipes shall be handled by using two reinforced canvas slings at least 300 mm wide. The slings shall be suspended from a lifting beam and shall be placed at a distance of one-fifth of the length of the pipe from each end of the pipe.

(3) Thin walled pipes shall not be rolled.

(4) Thin walled pipes shall be stored on timber bearers padded with hessian or straw to provide continuous support over at least one-third of the circumference of the pipe. The pipes shall be securely fixed in position with wedges placed at a distance of one-fifth of the length of the pipe from each end of the pipe.

(5) Thin walled pipes shall not be stacked on top of each other.

Storage of valves

23.43 Valves, including power operated valves and associated electrical and control equipment, shall be stored in accordance with the manufacturer's recommendations in a weatherproof store.

ACCESS TO PIPELINES ACCESS TO PIPELINES

Access to pipelines

23.44 (1) Rubber wheeled trolleys shall be provided to obtain access inside pipelines exceeding DN 500 for water supply pipeworks in order to joint pipes, repair joints, coatings and linings and inspect the pipeline. Persons entering pipelines shall wear clean soft-soled footwear.

(2) Mechanical fans shall be provided to ensure that an adequate air supply is available to those entering pipelines for inspection. Engine driven fans shall be fitted with a flexible exhaust or other methods of keeping exhaust fumes clear of the fresh air intake.

LAYING AND BEDDING PIPES

Laying pipes

23.45 (1) The Engineer shall be allowed to inspect trenches, bedding, pipes, joints, fittings and valves before pipelaying for water supply pipeworks starts. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before pipelaying starts in any part of the permanent work.

(2) The permission of the Engineer shall be obtained before pipelaying starts in any part of the permanent work.

(3) The Contractor shall inspect pipes, joints, fittings and valves, including internal and external coatings, immediately before and after pipelaying; valves shall be inspected to ensure that they are in working order and are capable of being fully opened and closed. Deleterious material shall be removed and damage shall be repaired immediately before and after pipelaying; potable water shall be used for washing.

(4) The inside of pipelines shall be kept clean and free from water, dirt, stones, debris and deleterious material. Except when pipes are being jointed, the open ends of pipelines shall be sealed with a wooden plug or stopper or by other methods agreed by the Engineer.

(5) Measures shall be taken to prevent flotation of pipes.

(6) Pipelaying shall follow closely on excavation of the trench. Lengths of trench which in the opinion of the Engineer are excessive shall not be left open.

(7) Unless otherwise permitted by the Engineer, pipelines with a gradient steeper than 1 in 20 shall be laid in an uphill direction with sockets facing uphill.

(8) Pipes shall be laid in such a manner that water will not pond in locations with zero and shallow gradients and such that the line and level of pipes will comply with the specified tolerances.

<i>Laying steel pipes</i>	23.46	Steel pipes with welded joints for water supply pipeworks shall be spot welded to the adjacent pipe to which they will be jointed immediately after laying. Steel pipes manufactured with longitudinal or spiral welds shall be aligned in such a manner that the welds are staggered from pipe to pipe by at least 15° of arc.
<i>Laying pipes with flexible joints</i>	23.47	The degree of the curve of pipes for water supply pipeworks with flexible joints which are to be laid to a curve shall be equally distributed over all joints within the curved section. The deflection at a completed joint shall not exceed 3° or three-quarters of the maximum deflection recommended by the manufacturer whichever is less.
<i>Installation of valves</i>	23.48	<p>(1) Operating gear and associated fittings shall be installed and fixed at the same time as valves for water supply pipeworks are installed. After installation, valves shall be cleaned inside and outside and left in a closed position.</p> <p>(2) Extension keys and clamps shall be fixed to valves in valve chambers if the vertical distance between the top of the valve spindle and the finished ground level exceeds 600 mm. The length of extension keys shall be such that the top of the extension key is not more than 300 mm below the finished ground level.</p>
<i>Bedding pipes</i>	23.49	<p>(1) Surfaces on which pipes for water supply pipeworks will be laid shall be cleaned and objects which may damage the pipes shall be removed before pipes are laid.</p> <p>(2) The bottom of trenches on which pipes will be laid directly shall be shaped to support the pipes uniformly along the length of the barrel; holes shall be dug to prevent pipes resting on the sockets and to allow the pipes to be jointed.</p>

CUTTING AND DRILLING PIPES

<i>Cutting pipes</i>	23.50	(1) Pipes for water supply pipeworks shall be cut and the ends shall be prepared in accordance with the manufacturer's recommendations; purpose made equipment recommended by the manufacturer and agreed by the Engineer shall be used for cutting the pipes.
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(2) Cut ends of pipes shall be square and even, without damage to the pipe or coating. Cut ends, including cut ends of the piece not immediately required, shall be trimmed and chamfered to suit the type of joint and in such a manner that elastomeric joint rings will not be damaged by the cut end.

(3) Pipes requiring to be cut to form closing lengths shall not be cut until adjacent pipes have been laid and jointed and the length to be cut can be accurately measured.

(4) The permission of the Engineer shall be obtained before pipes provided by the Employer are cut. Only those pipes which in the opinion of the Engineer are suitable for cutting on Site shall be cut. All off-cuts shall be used for the permanent work unless in the opinion of the Engineer this is not practicable.

Drilling pipes

23.51

(1) Pipes for water supply pipeworks shall be drilled for small diameter connections using purpose made drilling and tapping equipment.

(2) The threads of screw joints shall be painted before assembly with two coats of bituminous paint and shall be wrapped with three turns of spun yarn or other material approved by the Engineer.

JOINTING PIPE

Jointing pipes

23.52

(1) Pipes for water supply pipeworks shall be jointed in accordance with the manufacturer's recommendations and using jointing equipment and jointing materials recommended by the manufacturer and agreed by the Engineer.

(2) The Contractor shall inspect pipes, joints, fittings and valves, including internal and external coatings, immediately before and after jointing. Deleterious material shall be removed and damage shall be repaired immediately before and after jointing; potable water shall be used for washing. Surfaces which are to be jointed and jointing materials shall be cleaned immediately before jointing.

(3) All joints in pipelines shall be watertight.

(4) The widths of gaps at joints shall be in accordance with the manufacturer's recommendations and shall be achieved by marking the outside of the pipe, by using metal feelers or by other methods agreed by the Engineer. The position of elastomeric joint rings shall be checked by using metal feelers after jointing.

(5) Gaps at joints in pipes shall be protected after jointing by methods agreed by the Engineer to prevent dirt, stones or other material entering the joint.

(6) Bolts holes in flanged joints and joints incorporating bolted components shall be correctly orientated before the bolts are tightened. The correct size of bolts and nuts shall be used. Bolt threads shall be lubricated and bolts shall be tightened using the correct size of spanner. Bolts shall be tightened in diametrically opposite pairs working around the bolt circle until all bolts are tightened to the torque recommended by the manufacturer.

(7) Bolt holes in flanged joints shall be orientated symmetrically about the vertical diameter with no bolt holes on the vertical diameter. Elastomeric joint rings shall be the correct size and shall not protrude into the bore of the pipe. The rings may be temporarily fixed to the face of the flange using a minimum amount of adhesive of a type recommended by the manufacturer; jointing compound or paste shall not be used.

DI pipes with push-in joints 23.53 DI pipes with push-in joints for water supply pipeworks shall be jointed by smearing the spigot end of the pipe with lubricant and placing the elastomeric joint ring in position inside the groove of the socket end of the laid pipe. The spigot end of the pipe shall be placed in the socket end of the laid pipe and pushed home.

DI pipes with mechanical joints 23.54 (1) DI pipes with mechanical joints for water supply pipeworks shall be jointed as stated in Clauses 23.54(2) to (4).

(2) The elastomeric joint ring and the ends of the pipe shall be smeared with lubricant over a distance recommended by the manufacturer.

(3) The gland and the elastomeric joint ring shall be placed in position on the spigot end of the pipe.

(4) The spigot end of the pipe shall be placed in the socket end of the laid pipe before the bolts are tightened.

Welding joints in steel pipes 23.55 (1) Welding of joints in steel pipes for water supply pipeworks shall be carried out by the metal-arc process in accordance with BS 2633 and BS 4515.

(2) Butt welding shall not be used for jointing plain ended pipes other than for gusseted bends unless approved by the Engineer; if approved, the ends of the pipes shall be prepared in accordance with BS 534 and BS 2633 and welding shall be carried out in accordance with BS 4515.

(3) Records of welding operations shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. Records shall contain the following details:

- (a) date,
- (b) names of welders,
- (c) location of welding operation, and
- (d) electrodes used in making each weld.

Steel pipes with spigot and socket joints 23.56 (1) Steel pipes with spigot and socket joints for water supply pipeworks shall be jointed as stated in Clause 23.56(2) to (6).

(2) Pipes not exceeding DN 700 shall be welded externally. Pipes exceeding DN 700 shall be welded internally and shall then be welded externally with a sealing weld.

(3) Loose scale, slag, rust, paint and other deleterious material shall be removed from parts of pipes to be welded by wire brushing or by other methods agreed by the Engineer; the parts shall be kept clean and dry before welding.

(4) A double-run convex fillet weld shall be used for pipes not exceeding DN 900 and a triple-run convex fillet weld shall be used for pipes exceeding DN 900. The leg length of the fillet as deposited shall be at least the same as the full thickness of the pipe wall. The actual throat depth shall not be less than seven-tenths, and shall not exceed nine-tenths, of the minimum leg length as deposited.

(5) Deposition of the weld metal shall be carried out in such a manner that all welds have adequate root fusion and are of good, clean metal, free from cracks, gas holes, slag intrusion and other impurities. The surface of the weld shall have an even contour with a regular finish and shall indicate proper fusion with the parent metal. Slag shall be removed from each weld by light hammering with a chipping hammer and by wire brushing.

(6) Welds which contain cracks or other cavities or defects or in which the weld metal overlaps on to the parent metal without proper fusion shall be cut out and the joints shall be rewelded.

Steel pipes with welded steel collar joints 23.57

Steel pipes with welded steel collar joints for water supply pipeworks shall be jointed by leaving a gap not exceeding 75 mm between the ends of the pipes to be jointed. A split steel collar shall be placed centrally around the ends of the pipes; the collar shall be at least the same thickness as the pipe wall and shall be approximately 300 mm long. The end of each pipe shall be fillet welded to the collar as stated in Clause 23.56.

Steel pipes with couplings and flange adapters 23.58

(1) Steel pipes with slip-on type couplings and flange adapters for water supply pipeworks shall be jointed as stated in Clause 23.58(2) to (4).

(2) Protective wrappings shall be removed from the ends of plain ended pipes to be jointed and shall be replaced by:

- (a) bitumen coating complying with Clause 23.22 and BS 534 : Clause 29.1, or
- (b) epoxy or plastics based coating of a proprietary type approved by the Engineer.

(3) The pipe shall be finished to an even, smooth surface free from distortion to allow the components of the coupling or flange adapter to be correctly positioned and jointed.

(4) The coupling or flange adapter shall be placed in position on the plain end before the bolts are tightened.

UPVC pipes with push-in joints 23.59

UPVC pipes with push-in joints for water supply pipeworks shall be jointed as stated in Clause 23.53.

<i>UPVC pipes with solvent welded joints</i>	23.60	UPVC pipes with solvent welded joints for water supply pipeworks shall be jointed by applying solvent cement to the pipes to be jointed and pushing the pipes home. Excess solvent shall not be applied and surplus solvent shall be removed after jointing. Solvent welded pipes jointed outside the trench shall not be placed in the trench until the solvent setting period recommended by the manufacturer has elapsed.
<i>GI pipe joints</i>	23.61	GI pipes for water supply pipeworks shall be screw jointed using a threaded coupler. The surface of the pipe and coupler shall be cleaned and the threads shall be painted with two coats of bituminous paint. The pipe thread shall be wrapped with three turns of spun yarn or other material approved by the Engineer and the joint tightened using purpose made tools. Coal tar compounds or lead-based paint shall not be used. Locking nuts to branch connections shall be tightened. Branch connections shall not protrude inside the pipe.

PROTECTION TO STEEL FLANGED JOINTS, SLIP-ON TYPE COUPLINGS AND FLANGE ADAPTERS

<i>Protection to steel flanged joints, slip-on type couplings and flange adapters</i>	23.62	<p>(1) Steel flanged joints, slip-on type couplings and flange adapters in steel pipes for water supply pipeworks shall be protected as stated in Clause 23.62(2) to (4). Protection shall be carried out after jointing is complete.</p> <p>(2) The joint, including bolts and nuts, shall be cleaned to remove all moisture, dirt, oil, grease and deleterious material. Bolts and nuts shall be painted with two coats of bituminous paint and the joint shall be coated with primer. Mastic filler shall be applied in such a manner that all depressions, corners and voids between the bolts and nuts are filled and a smooth surface is available on which to apply the anticorrosion tape.</p> <p>(3) At least two layers of anticorrosion tape shall be applied to all parts of the joint and to the adjacent pipe for at least 200 mm beyond each end of the joint. The tape shall be applied in accordance with the manufacturer's recommendations and shall be wrapped spirally around the joint and pipe with at least 55% overlap per spiral.</p> <p>(4) The tape shall be moulded manually after application to take up the contours of the parts being protected.</p>
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REPAIRS TO JOINTS, COATINGS AND LININGS

<i>Repairs to joints, coatings and linings</i>	23.63	<p>(1) Joints and damage to coatings and linings of pipes, joints and fittings for water supply pipeworks shall be repaired as stated in Clauses 23.63 to 23.69.</p> <p>(2) Unless otherwise approved by the Engineer, repairs to joints, coatings and linings shall be carried out using materials of the same type and grade as in the pipe, joint or fitting.</p> <p>(3) External repairs shall be completed before internal repairs are carried out.</p>
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(4) Internal repairs and adjacent areas shall be washed with potable water after the repair is complete.

Internal repairs to steel pipes with bitumen coatings

23.64

(1) Internal repairs to joints and coatings of steel pipes with bitumen coatings shall be carried out as stated in Clause 23.64(2) to (5).

(2) Dirt, mill scale, rust and other deleterious material shall be removed from the areas to be repaired by wire brushing to leave dry, clean, bright metal. All damaged material shall be removed and the area shall be cleaned and dried.

(3) Primer shall be applied to the metal surface by brushing, avoiding bare spots, floods and sags.

(4) The area surrounding the area to be repaired shall be gently heated with a blow lamp or hot iron until the adjacent coating is molten.

(5) Bitumen shall be heated to 200°C and shall be stirred from time to time to prevent overheating. The bitumen shall be worked into the area to be repaired with a heated trowel to the same thickness as the adjacent coating; the bitumen shall be finished to a smooth, uniform surface.

External repairs to steel pipes with bitumen coatings

23.65

(1) External repairs to joints other than flanged joints, slip-on type couplings and flange adapters of steel pipes with bitumen coatings shall be carried out as stated in Clause 23.64 except as stated in Clause 23.65(2) to (5).

(2) External repairs shall not start until any specified electrical continuity has been provided and any individual test to each joint has been carried out.

(3) A purpose made moulding box shall be cleaned and coated internally with whitewash. After the whitewash has dried, the box shall be fitted centrally around the joint and bolted together. Gaps between the pipe and the box shall be sealed with yarn or other material agreed by the Engineer to prevent leakage.

(4) The heated bitumen shall be poured into the box in one operation. After the bitumen has solidified, the box shall be removed, cleaned and stored for re-use.

(5) The affected area of bitumen coating shall be painted with whitewash after cooling.

(6) External repairs to coatings of steel pipes with bitumen coatings shall be carried out as stated in Clause 23.64 except that the heated bitumen together with woven glass cloth shall be worked into the area to be repaired. The affected area of bitumen coating shall be painted with whitewash after coating.

Internal repairs to steel pipes with concrete or cement mortar lining

23.66

(1) Internal repairs to joints and linings of steel pipes with concrete or cement mortar linings shall be carried out as stated in Clause 23.66(2) to (4).

(2) The area to be repaired shall be cut back to leave clean, bright metal. The area surrounding the area to be repaired shall be wetted.

(3) The concrete or cement mortar shall be worked into the area to be repaired and compacted to the same thickness as the adjacent lining; the concrete or cement mortar shall be finished to a smooth uniform surface. The compressive strength and density of the compacted concrete or cement mortar shall be in accordance with BS 534, Clause 33.5. The repaired area shall be cured by using curing compound as stated in Clause 16.11.

(4) Samples of the concrete or cement mortar shall be provided and test cubes shall be made and tested as stated in Clauses 16.58 to 16.62.

***Repairs to DI pipes
with bitumen coatings***

23.67

Internal and external repairs to joints and coatings of DI pipes with bitumen coatings shall be carried out using bituminous paint. The area to be repaired shall be cleaned to bare metal and dried. The area to be repaired shall be painted with bituminous paint to the same thickness as the adjacent coating; the paint shall be finished to a smooth uniform surface.

***Internal repairs to DI
pipes with cement
mortar lining***

23.68

(1) Internal repairs to joints and linings of DI pipes with cement mortar linings shall be carried out as stated in Clause 23.68(2) to (4).

(2) The area to be repaired shall be cut back to leave clean, bright metal. The area surrounding the area to be repaired shall be wetted.

(3) The cement mortar shall be worked into the area to be repaired and compacted to the same thickness as the adjacent lining; the cement mortar shall be finished to a smooth uniform surface. The repaired area shall be cured with curing compound as stated in Clause 16.11.

(4) The inside of pipe sockets and the faces of flanges shall be kept free from cement mortar.

Repairs to GI pipes

23.69

Internal and external repairs to joints and coatings of GI pipes shall be carried out using zinc-based paint. The area to be repaired shall be cleaned to bare metal and dried. The area to be repaired shall be painted with a rust inhibitor, primer and two coats of zinc-based paint.

THRUST AND ANCHOR BLOCKS

***Thrust and anchor
blocks***

23.70

(1) The bearing face, and other faces stated in the Contract, of concrete thrust and anchor blocks for water supply pipeworks shall be cast directly against undisturbed ground; the faces of excavations shall be trimmed to remove loose material before concreting. Excess excavation and working space shall be filled with concrete of the same Grade as the block.

(2) Internal pressure shall not be applied to the pipeline until thrust and anchor blocks have developed the specified grade strength.

BED, HAUNCH AND SURROUND

***Concrete bed, haunch
and surround***

23.71

(1) Concrete bed, haunch and surround to pipelines for water supply pipeworks shall be constructed as stated in Clause 23.71(2) to (5).

(2) Pipes shall be supported at the required level by Grade 20 precast concrete wedges, blocks or cradles or by other methods agreed by the Engineer. One support shall be placed adjacent to each end of each pipe and the spacing between supports shall not exceed 3 m. Compressible sheeting shall be placed between the pipes and supports.

(3) Flexible joints shall be formed in concrete bed, haunch and surround at flexible joints in pipelines. Joint filler shall be placed next to the flexible joint in the pipeline and shall extend for the complete thickness of the bed, haunch and surround.

(4) Polyethylene sheeting shall be placed on the trench bottom before concreting.

(5) Concrete shall be placed evenly over the complete width of the bed and over the complete length of the pipe being concreted up to a level of 25 mm below the underside of the pipe. Concrete shall then be placed on one side of the pipe only and worked under the pipe until the concrete spreads under the pipe. Concrete shall then be placed equally on both sides of the pipe to the specified level.

TOLERANCES

<i>Tolerances : pipelines</i>	23.72	The line and level of pipelines for water supply pipeworks shall be within 25 mm of the specified line and level.
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CLEANING AND STERILISATION OF PIPELINES

<i>Cleaning and sterilisation o pipelines</i>	23.73	<p>(1) Fresh water and potable water pipelines for water supply pipeworks shall be cleaned and flushed through with potable water. Cleaning and flushing shall be carried out after:</p> <ul style="list-style-type: none"> (a) the complete pipeline, or parts of the pipelines permitted by the Engineer, has been tested, (b) Temporary Works required for testing have been removed, and (c) parts of the pipeline removed for testing have been reconnected. <p>(2) The pipeline shall be completely filled with water that has been dosed with a homogeneous solution of sterilising chemicals such that the final concentration of free chlorine in the water is at least 30 ppm. The water shall be left in the pipeline for at least 24 hours.</p> <p>(3) After the 24 hour period, the pipeline shall be drained down and the sterilising water shall be flushed out using potable water until the concentration of the remaining chlorine is less than 1 ppm.</p>
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- (4) Unless otherwise permitted by the Engineer, pipelines shall be cleaned and sterilised not more than 7 days before the pipeline is handed over.

TESTING : JOINTS IN STEEL PIPES

Testing: joints in steel pipes	23.74	<p>(1) Spigot and socket joints in steel pipes exceeding DN 700 for water supply pipeworks shall be tested after welding by the nitrogen gas test.</p> <p>(2) A tapped hole of approximately 6 mm diameter shall be made in the socket end of each pipe to be tested and a non-return valve shall be fixed in the hole. The nitrogen gas test shall be carried out by pumping nitrogen to a pressure of 400 kPa into the annular space between the spigot and socket. The pump shall be disconnected and the pressure shall be recorded for 30 minutes.</p>
Compliance criteria: joints in steel pipes	23.75	There shall be no drop in pressure in the joint during the 30 minute period of the nitrogen gas test.
Non-compliance: joints in steel pipes	23.76	If the result of any nitrogen gas test does not comply with the specified requirement for the test, the weld at the joint shall be cut out and the joint shall be rewelded and tested.

TESTING : PRESSURE PIPELINES FOR WATER SUPPLY PIPEWORKS

Testing: pressure pipelines for water supply pipeworks	23.77	<p>(1) Pressure pipelines for water supply pipeworks shall be tested as stated in Clause 23.77(2) to (6).</p> <p>(2) The pipeline shall be tested in sections as stated in the Contract unless otherwise permitted by the Engineer; if testing in sections other than those stated in the Contract is permitted, the section to be tested shall be as long as practicable provided that the specified test pressure will not be exceeded. Final tests on complete pipelines which have been tested in sections shall not be carried out unless stated in the Contract.</p> <p>(3) The test pressure shall be as stated in the Contract. If the test pressure is not stated in the Contract, the test pressure shall be:</p> <ul style="list-style-type: none"> (a) 1.5 times the maximum working pressure if the maximum working pressure does not exceed 1.5 MPa, or (b) 1.3 times the maximum working pressure if the maximum working pressure exceeds 1.5 MPa. <p>(4) Unless otherwise permitted by the Engineer, pressure tests shall not be carried out until the fill material has been deposited and compacted over the complete length of the pipeline to be tested; if permitted, sufficient fill material shall be deposited to restrain the pipeline in position during the test.</p>
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(5) Tests shall not be carried out simultaneously on pipelines in the same trench.

(6) The method of testing shall be in accordance with Appendix 23.1.

(7) Unless otherwise permitted by the Engineer, the pipeline shall be left charged with water at a head of at least 15 m after testing and until the pipeline has been sterilised or handed over to the Employer.

***Compliance criteria:
pressure pipelines for
water supply pipeworks***

23.78 The results of tests on pressure pipelines for water supply pipeworks shall comply with the following requirements:

- (a) The leakage of water from the pipeline determined by the pressure test shall not exceed the permitted leakage calculated in accordance with Clause 23.1.4 in Appendix 23.1.
- (b) There shall be no discernable leakage of water from the pipeline or from any joint during the pressure test.

***Non-compliance:
pressure pipelines for
water supply pipeworks***

23.79 If the result of any test on pressure pipelines for water supply pipeworks does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the pipeline shall be retested.

TESTING WATER STERILISATION

***Testing: water
sterilisation***

23.80 After the pressure test on fresh water and potable water pipelines for water supply pipelines has been completed, samples of the water in the pipeline will be taken by the Engineer. The number of samples and locations of sampling shall be as instructed by the Engineer. Testing shall be carried out as stated in Clauses 24.35 and 24.36 for water sterilisation of water retaining structures.

APPENDIX 23.1

PRESSURE TESTS ON PIPELINES

<i>Scop</i>	23.1.1	This method covers the determination of the leakage of water from pipelines for water supply pipeworks by means of a pressure test.
<i>Equipment</i>	23.1.2	<p>The following equipment is required:</p> <ul style="list-style-type: none"> (a) Blank flanges or caps. (b) Struts and wedges. (c) Temporary concrete blocks or other anchors. (d) Force pump and pump feed tank. (e) Pressure gauge, readable and accurate to 0.01 m head. (f) Continuous pressure recorder and purpose made charts.
<i>Procedure</i>	23.1.3	<p>The procedure shall be as follows:</p> <ul style="list-style-type: none"> (a) Pipes and valves shall be checked for cleanliness and the operation of valves shall be checked. (b) Blank flanges or caps shall be fixed to the ends of the pipeline, or section of the pipeline, to be tested. Tests shall not be made against valve gates. (c) The blank flanges and caps shall be secured with struts and wedges against temporary concrete blocks or other anchors. The blocks and anchors shall be completed and shall have hardened sufficiently before testing starts. (d) Thrust and anchor blocks, pipe straps and other devices required to prevent movement of pipes and fittings shall be completed before testing starts. (e) The pipeline shall be filled with water and all air shall be removed. (f) Unless otherwise permitted by the Engineer, the pipeline shall remain filled for 3 days before testing starts to allow absorption to take place and to achieve conditions which are as stable as practicable. (g) The pressure in the pipeline shall be increased slowly to the specified test pressure by pumping water into the pipeline using a force pump. (h) The pressure in the pipeline shall be maintained within +0% and -5% of the specified test pressure for a test period of at least 2 hours.

- (i) At the beginning and end of the test period and at 30 minute intervals during the test period, readings shall be taken from the pressure gauge and the pressures (p) shall be recorded. The pressure shall be adjusted to the specified test pressure each time a reading is taken.
- (j) The pressure shall be adjusted to within the specified tolerances for the test pressure at any time during the test period when the pressure falls outside the specified tolerances.
- (k) The pressure shall be monitored during the test by means of a continuous pressure recorder with purpose made charts.
- (l) The leakage of water from the pipeline shall be measured as the amount of water required to maintain the specified test pressure in the pipeline; the amount of water shall be determined from the fall in level of water in the pump feed tank.

Calculation

- 23.1.4 (1) The average test pressure (P) shall be calculated as the average of the pressures (p) recorded during the test.
- (2) The permitted leakage of water from the pipeline during the pressure test shall be calculated from the equation:

$$\text{Permitted leakage} = 0.02 \times d \times l \times \frac{t}{24} \times \frac{P}{10} \text{ litre}$$

where:

- d is the nominal diameter of the pipe (mm)
- l is the length of pipeline tested (km)
- t is the test period (hr)
- P is the average test pressure (m)

Reporting o results

- 23.1.5 The following shall be reported:
- (a) The internal diameter of the pipe to the nearest 1 mm.
 - (b) The length of pipeline tested to the nearest 1 m.
 - (c) The test period to the nearest 0.01 hr.
 - (d) The pressures recorded during the test to the nearest 0.01 m.
 - (e) The average test pressure to the nearest 0.01 m.
 - (f) The leakage and permitted leakage of water to the nearest 0.1 litre.
 - (g) Details of any discernable leakage of water from the pipeline during the test.
 - (h) Charts obtained from the continuous pressure recorder.
 - (i) That the test method used was in accordance with this Specification

**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 24
WATER RETAINING STRUCTURES**

SECTION 24

WATER RETAINING STRUCTURES

GENERAL

<i>General requirements</i>	24.01	The works and materials specified in Clauses 24.02 to 24.07 shall comply with the sections stated, unless otherwise stated in this Section.
<i>Earthworks</i>	24.02	Earthworks shall comply with Section 6.
<i>Formwork</i>	24.03	Formwork and finishes to concrete shall comply with Section 14.
<i>Reinforcement</i>	24.04	Steel reinforcement shall comply with Section 15.
<i>Concrete</i>	24.05	Concrete shall comply with Section 16.
<i>Joints in concrete</i>	24.06	Joints in concrete shall comply with Section 16.
<i>Drainage systems</i>	24.07	Drainage systems shall comply with Section 5.

GLOSSARY OF TERMS

<i>Water retaining structure</i>	24.08	Water retaining structure is a structure, or part of a structure, including walls, floors, roofs, columns and footings, which is stated in the Contract to be constructed for storing, conveying or excluding water, sewage or other aqueous liquids.
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MATERIALS

<i>Sliding layers</i>	24.09	Sliding layers below floor slabs of water retaining structures shall be a proprietary type of polyethylene sheeting approved by the Engineer. Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 1.1 mm.
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MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

<i>Materials provided by the Employer</i>	24.10	Water and sterilising chemicals for cleaning, sterilising and testing water retaining structures as stated in Clauses 24.24 and 24.31 will be provided by the Employer for one set of tests. The water and sterilising chemicals shall be obtained from the locations stated in the Contract or from other locations agreed by the Engineer and shall be mixed by the Contractor.
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<i>Equipment loaned by the Employer</i>	24.11	The equipment for recording water levels in tests on water retaining structures as stated in Clause 24.31(4) that is to be included in Contracts entered into with the Water Supplies Department will be loaned by the Employer.
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SUBMISSIONS

<i>Particulars of sliding layers</i>	24.12	Particulars of the source and type of proposed sliding layers for water retaining structures shall be submitted to the Engineer for approval at least 14 days before the first delivery of the sliding layer to the Site.
<i>Particulars of materials and methods of construction for water retaining structures</i>	24.13	<p>(1) The following particulars of the proposed materials and methods of construction for water retaining structures shall be submitted to the Engineer:</p> <ul style="list-style-type: none"> (a) sequence and method of concreting bays in floor slabs, walls and roof slabs and in columns and footings, (b) details of alternative locations of construction joints if required, (c) details of type and size of waterstops at construction joints and box-outs, (d) sequence and method of testing roofs for watertightness, and (e) details of method of testing water retaining structures for watertightness including: <ul style="list-style-type: none"> - arrangement of pumps and equipment, - source of water, - equipment for measuring fall in water level, - device for dampening the oscillatory motion of the water surface, - filling rate, - method of correction for evaporation and rainfall. <p>(2) The particulars shall be submitted to the Engineer at least 28 days before the relevant work starts.</p>
<i>Samples of sliding layers</i>	24.14	Samples of the proposed sliding layers for water retaining structures shall be submitted to the Engineer at the same time as particulars of the sliding layer are submitted.

STORAGE OF MATERIALS

<i>Storage of sliding layers</i>	24.15	Sliding layers for water retaining structures shall be stored in accordance with the manufacturer's recommendations in a dry weatherproof store.
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DRAINAGE SYSTEMS

<i>Drainage systems</i>	24.16	Measures shall be taken to prevent concrete and deleterious material from being deposited in drainage systems under floors and on roofs of water retaining structures. After construction and before testing, the drainage system shall be thoroughly cleaned by rodding and flushing to remove any deleterious material which may impede the flow of water into or through the drainage system. The lines and levels of drainage systems shall be within 20 mm of the specified horizontal alignment and within 10 mm of the specified vertical alignment.
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CONSTRUCTION OF WATER RETAINING STRUCTURES

<i>Laying sliding layers</i>	24.17	Polyethylene sheeting in sliding layers below floor slabs of water retaining structures shall be laid flat without creases. Laps shall be at least 225 mm and there shall be no gaps at the edges of bays.
<i>Floor slabs of water retaining structures</i>	24.18	If reinforcement is continuous across the joint between bays in the floor slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.
<i>Walls of water retaining structures</i>	24.19	<p>(1) If reinforcement is continuous across the joint between bays in the wall of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 72 hours between the completion of concreting the lift in one bay and commencement of concreting the adjacent lift in the adjacent bay.</p> <p>(2) Unless otherwise permitted by the Engineer the first lift in each bay in the walls of water retaining structures shall be concreted within seven days after completion of concreting the adjacent base of the wall. Individual lifts shall be concreted in one continuous operation without cold joints, whether or not the full height of the wall is concreted in one lift. If the full height of the wall is not placed in one lift, succeeding lifts shall be concreted within seven days from concreting of the adjacent lift unless otherwise permitted by the Engineer.</p>
<i>Roof slabs of water retaining structures</i>	24.20	If reinforcement is continuous across the joint between bays in the roof slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.
<i>Built-in pipes in water retaining structures</i>	24.21	Puddle flanges on built in pipes in water retaining structures shall be located centrally within the formwork. Waterstops shall be fixed around the perimeter of box outs to the built in pipes.

PROTECTION OF WATER RETAINING STRUCTURES

Protection of water retaining structures

- 24.22 (1) Immediately after the roof slab of water retaining structures has been tested, the slab shall be protected with damp sacks or by other methods agreed by the Engineer from exposure to conditions which may affect the slab; the protection shall be continued until the roof drainage system has been constructed or the fill material has been deposited and compacted.
- (2) Materials shall not be stockpiled on roof slabs of water retaining structures. Constructional Plant or other vehicles shall not stand or run on floor slabs or roof slabs of water retaining structures unless permitted by the Engineer.
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DEPOSITION OF FILL MATERIAL

Deposition of fill material

- 24.23 (1) Fill material shall not be deposited behind sections of walls of water retaining structures until at least seven days after completion of concreting to the section of wall.
- (2) Fill material shall be spread out evenly and shall not be stockpiled on roofs to water retaining structures. Weed killer or other chemicals shall not be applied to fill material on the roofs of water retaining structures for potable or fresh water.
- (3) Deposition of fill material on or adjacent to water retaining structures shall be carried out after the watertightness test on the structure has been completed, unless otherwise permitted by the Engineer.
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CLEANING AND STERILISATION OF WATER RETAINING STRUCTURES

Cleaning and sterilisation of water retaining structures

- 24.24 (1) Immediately before water retaining structures are tested for watertightness, all dust, debris, unused materials and equipment shall be removed from the structure and the interior of the structure shall be washed and brushed down with water.
- (2) Water for washing water retaining structures for potable or fresh water shall be fresh, potable water incorporating a mixture of sterilising chemicals added before the structure is washed at a concentration instructed by the Engineer. The structure shall be maintained in a clean condition after cleaning.
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TESTING : DRAINAGE SYSTEMS FOR WATER RETAINING STRUCTURES

Testing: drainage systems for water retaining structures	24.25	<p>Drainage systems under floors and on roofs of water retaining structures shall be tested in accordance with the following requirements:</p> <ul style="list-style-type: none"> (a) Water shall be poured at different locations agreed by the Engineer along the drainage system and the flow of water observed at junction pits, outfalls and other discharge points. (b) A mandrel shall be pulled through each completed section of pipeline of 300 mm diameter or less. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.
Compliance criteria: drainage systems for water retaining structures	24.26	<p>The results of tests on drainage systems for water retaining structures shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) The water shall in the opinion of the Engineer be freely discharged by the drainage system. (b) The bore, linearity and jointing of pipes shall comply with the specified requirements.
Non-compliance: drainage systems for water retaining structures	24.27	<p>If the result of any test on the drainage system for water retaining structures does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the drainage system shall be retested.</p>

TESTING : WATERTIGHTNESS OF ROOFS

Testing: watertightness of roofs	24.28	<ul style="list-style-type: none"> (1) The roofs of water retaining structures shall be tested for watertightness over the complete area of the roof, including perimeter joints; roofs shall not be tested in sections unless permitted by the Engineer. (2) Water shall be ponded on the roof for a period of three days and topped up to maintain a depth of at least 75 mm. The test shall be carried out before fill material is deposited or drainage systems are constructed on the roof.
Compliance criteria: watertightness of roofs	24.29	<p>There shall be no leaks or damp patches visible on the soffits of roofs of water retaining structures during or at the end of the test for watertightness.</p>
Non-compliance: watertightness of roofs	24.30	<p>If the result of any test for watertightness of the roof of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the roof shall be retested.</p>

TESTING : WATERTIGHTNESS OF STRUCTURES

Testing: watertightness of structures 24.31

(1) Water retaining structures shall be tested for watertightness as stated in Clause 24.31(2) to (7). Each compartment of structures which incorporate division walls shall be tested separately with adjoining compartments empty; the complete structure shall also be tested.

(2) The structure shall be filled with water at an approximately uniform rate not exceeding 2 m depth in 24 hours to the levels stated in Table 24.1. The water used for testing water retaining structures for potable or fresh water shall be fresh potable water. The permission of the Engineer shall be obtained before filling starts. The structure or each compartment of the structure being tested shall be kept full for 7 days before testing allow for absorption.

(3) After the period for absorption, the water shall be topped up to the specified level and the test shall begin. During testing, the oscillatory motion of the water surface shall be dampened. The test period shall be 7 days.

(4) The equipment for recording water levels shall be installed in a temporary enclosure of minimum dimensions 2 m x 2 m x 2.5 m high with a lockable door; the enclosure shall be located over stilling wells, manhole openings or other points of recording water levels. The temporary enclosure shall be removed on completion of the test. The equipment shall be calibrated before testing starts and at regular intervals agreed by the Engineer and shall be readable and accurate to 0.5 mm.

(5) The fall in water level in water retaining structures shall be measured at hourly intervals between 8 a.m. and 5 p.m. each day; the total fall shall be measured at the end of the test period.

(6) Except as stated in Clause 24.31(7), structures shall be emptied after completion of testing and maintained in a clean and dry condition. The water shall be removed at an approximately uniform rate not exceeding 2 m depth in 24 hours. The permission of the Engineer shall be obtained before emptying starts.

(7) Unless otherwise instructed by the Engineer, the water used for the final tests on water retaining structures for potable or fresh water shall be retained in the structure and shall not be wasted or contaminated.

Compliance criteria: watertightness of structures 24.32

The results of tests for watertightness of water retaining structures shall comply with the following requirements:

- (a) The total fall in water level at the end of the test period, after adjustment for evaporation and rainfall, shall not exceed 1/500 times the maximum specified depth of water in the test or 10 mm, whichever is less.
- (b) There shall be no leaks or damp patches visible on the surface of the structure, including any division walls, during or at the end of the test.

Non-compliance: watertightness of structures	24.33	If the result of any test for watertightness of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the structure shall be retested.
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Table 24.1 : Tests on water retaining structures

Type of structure	Part of structure tested	Test water level
Water retaining structures other than for sewage	Structure with division wall each compartment of structure	100 mm below top of division wall
	Structure with division wall complete structure	Top water level of structure
	Structure without division wall	
Water retaining structures for sewage	Structure with division wall each compartment of structure	Top water level of structure
	Structure with division wall complete structure	
	Structure without division wall	

TESTING : WATER STERILITY

Samples: water sterilisation	24.34	After the test for watertightness of a water retaining structure for potable or fresh water has been completed, samples of the water in the structure shall be taken by the Engineer. The number of samples and location of sampling shall be as instructed by the Engineer.
Testing: water sterilisation	24.35	Each sample of water shall be tested to determine the bacteriological content.
Compliance criteria: water sterilisation	24.36	The results of tests for bacteriological content of the water shall demonstrate that in the opinion of the Engineer the structure has been adequately sterilised .

**GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS**

**SECTION 25
BUILDING WORKS**

SECTION 25

BUILDING WORKS

PART 1 : ASPHALT ROOFING

MATERIALS

<i>Mastic asphalt</i>	25.01	Mastic asphalt for asphalt roofing shall comply with BS 6925, Type R988 or BS 6577, Type R1162.
<i>Isolating membrane</i>	25.02	Isolating membrane for asphalt roofing shall be black sheathing felt complying with BS 747, Class 4A(i) and shall weigh at least 17 kg per 810 mm wide by 25 m long roll.
<i>Bitumen dressing compound</i>	25.03	Bitumen dressing compound for asphalt roofing shall be cut-back bitumen, Grade 25 sec or other grade approved by the Engineer and shall comply with the following: <div style="margin-left: 100px;"> Bitumens for road purposes : BS 3690:Part 1 Bitumens for industrial purposes : BS 3690:Part 2. </div>
<i>Bituminous paint</i>	25.04	Bituminous paint for asphalt roofing shall comply with BS 6949.
<i>Sand</i>	25.05	Sand for finishing the surface of asphalt roofing shall be fine, clean sand and shall be graded such that 100% passes a 600 µm BS test sieve and 100% is retained on a 300 µm BS test sieve.
<i>Stone chippings</i>	25.06	Stone chippings for asphalt roofing shall be white stone (Baak Shek) chippings and shall be graded such that 100% passes a 5 mm BS test sieve and 100% is retained on a 2.36 mm BS test sieve.
<i>Reflective paint</i>	25.07	Reflective paint for asphalt roofing shall be a proprietary type approved by the Engineer and shall be a bituminous based aluminium paint or a paint compatible with bituminous surfaces.
<i>Metal lathing</i>	25.08	Metal lathing for asphalt roofing shall be zinc coated or stainless steel expanded metal lathing complying with BS 1369:Part 1. The reinforcement shall be at least 10 mm short way of mesh and shall be at least 0.46 mm thick.

SUBMISSIONS

<i>Particulars of asphalt roofing</i>	25.09	(1) The following particulars of the proposed materials and methods of construction for asphalt roofing shall be submitted to the Engineer: <div style="margin-left: 40px;"> (a) name of specialist sub-contractor, </div>
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- (b) a certificate for each material for asphalt roofing showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests on mastic asphalt for
 - hardness number, and
 - binder content and grading of mineral aggregate.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before asphalt roofing work starts. Certificates for mastic asphalt shall be submitted for each batch of mastic asphalt delivered to the Site.

<i>Samples of materials</i>	25.10	<p>Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are provided:</p> <ul style="list-style-type: none"> (a) mastic asphalt, (b) sand, and (c) stone chippings.
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STORAGE OF MATERIALS

<i>Storage of isolating membrane, bitumen dressing compound, bituminous paint, sand, stone chippings, reflective paint and metal lathing</i>	25.11	<p>Isolating membrane, bitumen dressing compound, bituminous paint, sand, stone chippings, reflective paint and metal lathing shall be stored in a dry weatherproof store.</p>
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ASPHALT ROOFING WORK

<i>Heating asphalt</i>	25.12	<p>(1) Mastic asphalt for asphalt roofing shall be gradually heated in a purpose made mixer to a temperature until it flows but not exceeding 230°C. The asphalt shall be continuously agitated such that local overheating is prevented during heating and until it has been discharged for use.</p> <p>(2) The molten asphalt shall be transported in buckets which has been coated with cement; ashes or oil shall not be used for coating buckets and other equipment.</p>
<i>Laying mastic asphalt</i>	25.13	<p>(1) Asphalt work for asphalt roofing shall be carried out in accordance with CP 144:Part 4.</p> <p>(2) Mastic asphalt shall be laid on a clean dry surface using wood or metal gauges to ensure the correct thickness of each coat. Two coats of equal thickness to a total thickness of at least 20 mm shall be laid on horizontal roof surfaces and on slopes not exceeding 30°. Two coats of</p>

equal thickness to a total thickness of at least 13 mm shall be laid to skirtings, upstands and drips and on slopes exceeding 30°.

(3) Joints in successive coats shall be staggered by at least 150 mm.

(4) If blows due to entrapment of moisture or air are formed during laying, the affected parts shall be pierced and made good while the surrounding asphalt is warm.

<i>Laying isolating membrane</i>	25.14	Black sheathing felt for asphalt roofing shall be laid on a dry surface and shall not be sealed to the structure on slopes less than 30° to the horizontal; laps of at least 75 mm shall be formed at joints.
<i>Forming angles</i>	25.15	<p>(1) Internal angles between horizontal and vertical surfaces on asphalt roofing shall be formed with stout asphalt fillets; the fillets shall be at least 50 mm on face and shall be continuous with the surfaces.</p> <p>(2) The specified total thickness of asphalt shall be maintained at external angles between horizontal and vertical surfaces or between sloping surfaces.</p>
<i>Forming skirtings</i>	25.16	Skirtings shall be formed in asphalt roofing and shall be at least 150 mm high above roof finishes; the top edge shall be splayed and tucked into a groove at least 25 mm deep and 25 mm wide.
<i>Dressing to rainwater outlets</i>	25.17	Asphalt roofing shall be neatly dressed into rainwater outlets and sealed. Metal surfaces in contact with the asphalt roofing shall be cleaned and primed with one coat of bituminous paint before the asphalt is laid. Flashings to rainwater outlets shall be embedded in the first coat of the asphalt and then the second coat shall be applied.
<i>Dressing to pipes through roofs</i>	25.18	Asphalt roofing and isolating membrane shall be neatly dressed around sleeves to pipes passing through roofs; the dressing shall be at least 150 mm high and shall have a stout asphalt angle fillet at the bottom. Metal surfaces in contact with the asphalt roofing shall be cleaned and primed with one coat of bituminous paint before the asphalt is laid.
<i>Finishing roof surfaces</i>	25.19	Immediately after asphalt laying to asphalt roofing is complete, the roof surfaces shall be well rubbed with a clean wood float and fine clean sand.
<i>Solar protection</i>	25.20	<p>(1) Roof surfaces to which stone chippings are to be applied shall be dressed with bitumen dressing compound applied at a rate of 3 kg/m². The surfaces shall be dressed immediately with stone chippings lightly rolled in at a rate of 15 kg/m²; loose chippings shall be removed.</p> <p>(2) Reflective paint to asphalt roofing shall be applied in two coats at the rate recommended by the manufacturer.</p>

TESTING : ASPHALT ROOFING

Batch: <i>mastic asphalt</i>	25.21	A batch of mastic asphalt is any quantity of mastic asphalt of the same type, manufactured at the same time in the same place and delivered to the Site at any one time and which, for the purpose of testing laid mastic asphalt, is laid on the same day.
Samples: mastic asphalt	25.22	<p>(1) Samples of mastic asphalt shall be provided from each batch of mastic asphalt delivered to the Site. The samples shall be provided at least 14 days before asphalt roofing work starts.</p> <p>(2) Samples of mastic asphalt shall be provided from each batch of laid mastic asphalt. Holes formed by taking samples of laid mastic asphalt shall be reinstated using mastic asphalt.</p> <p>(3) The number and size of samples and the method of sampling shall be in accordance with BS 5284.</p>
Testing: <i>mastic asphalt</i>	25.23	<p>(1) Each sample of mastic asphalt shall be tested to determine the hardness number, binder content and grading of mineral aggregate.</p> <p>(2) The method of testing shall be in accordance with BS 5284.</p>
Compliance criteria: <i>mastic asphalt</i>	25.24	The results of tests on mastic asphalt shall comply with BS 6925.

PART 2 : CARPENTRY AND JOINERY

MATERIALS

Timber for carpentry and joinery

25.25

(1) Timber for carpentry and joinery shall be of mature growth and shall be seasoned and free from large, loose or dead knots, wood wasp holes, infestation, splits and other defects which will reduce the strength or produce blemishes. The moisture content in timber at the time of fabrication shall not exceed the following:

- (a) Internal timber for use in air conditioned premises : 12%
- (b) Other internal timber : 16%
- (c) Timber with one face to the exterior of the building and one face to the interior : 18%
- (d) External timber : 20%.

(2) Hardwood shall be San Cheung (Kapore), white seraya, red seraya, teak or other hardwood approved by the Engineer. The density of hardwood other than teak shall be at least 720 kg/m^3 at 15% moisture content. The density of teak shall be at least 650 kg/m^3 at 15% moisture content.

(3) Softwood shall be cedar, spruce or China fir.

(4) Plywood shall comply with BS 6566:Parts 1 to 8. Grade 1 veneer plywood shall be used for natural finishes and shall be hardwood faced as stated in the Contract. Grade 2 veneer plywood shall be used for painted finishes and shall be luan faced.

Nails, screws and plugs

25.26

(1) Nails for carpentry and joinery shall be steel nails with a 'bright' finish.

(2) Screws shall be brass, stainless steel, alloy or other non-corroding metal approved by the Engineer and shall have countersunk heads.

(3) Plugs for fixing to hard materials shall be a proprietary type approved by the Engineer and shall be plastic, soft metal, fibre or similar material.

Wood preservative

25.27

Wood preservative for carpentry and joinery shall be a proprietary type approved by the Engineer. Wood preservative which will be completely concealed or not decorated shall be an exterior grade and colourless; wood preservative which is likely to be exposed to or in contact with painted finishes shall be coloured and suitable for overpainting.

<i>Adhesive</i>	25.28	<p>(1) Adhesive for timber for internal use shall be synthetic resin adhesive classified as moisture resistant and moderately weather-resistant in accordance with BS 1204:Part 1. Adhesive for timber for internal use under very damp conditions or for external use shall be synthetic resin adhesive classified as weather-proof and boil-proof in accordance with BS 1204:Part 1.</p> <p>(2) Adhesive for plywood for external use or in areas of high humidity shall be phenol formaldehyde resin adhesive classified as weather-proof and boil-proof in accordance with BS 1203. Adhesive for plywood for other uses shall be resin adhesive classified as moisture resistant and weather resistant in accordance with BS 1203.</p>
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SUBMISSIONS

<i>Particulars of timber</i>	25.29	<p>(1) The following particulars of the proposed timber for carpentry and joinery shall be submitted to the Engineer:</p> <p>(a) a certificate for each type of timber showing the source of the timber and showing that the timber complies with the requirements stated in the Contract and including results of tests for</p> <ul style="list-style-type: none"> - density, and - moisture content. <p>(2) The particulars shall be submitted to the Engineer at least 14 days before the first delivery of the timber to the Site. The particulars shall be submitted for each batch of the timber delivered to the Site.</p>
<i>Samples of materials</i>	25.30	<p>Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the timber are submitted:</p> <p>(a) hardwood, softwood and plywood, and</p> <p>(b) nails, screws and plugs.</p>

STORAGE OF MATERIALS

<i>Storage of timber</i>	25.31	Timber shall be stored in a dry, weatherproof and well ventilated store with a raised floor.
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CARPENTRY AND JOINERY WORK

<i>Treatment to timber</i>	25.32	<p>(1) Unexposed surfaces of timber doors and windows, including backing, fillets, backs of door and window frames, shall be treated with two coats of wood preservative before fixing or bedding in. Door and window frames shall be knotted and shall receive at least one coat of primer before being fixed in position.</p>
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		(2) Hidden faces of built-in timber shall be treated with two coats of wood preservative before being assembled and fixed in position.
<i>Finish to timber</i>	25.33	Planed timber shall be used for all surfaces of carpentry and joinery. Exposed surfaces shall have a fine glasspapered finish and arrises shall be rounded to a radius of 1 mm.
<i>Framed timber</i>	25.34	(1) Faces of framed joints of timber shall be square and shall be driven together to give a close accurate fit. (2) Timber shall be prepared and framed up with dry joints and stored until required for fixing in position. Before fixing, all joints shall be opened up, put back together with white lead and wedged up; sections which have warped or developed shakes or other defects shall be replaced.
<i>Running bonded joints</i>	25.35	Running bonded joints in timber shall be cross-tongued using teak tongues; double tongues shall be used for work exceeding 40 mm thick.
<i>Building-in timber</i>	25.36	Timber sections shall be screwed or nailed to the backing which shall be plugged. The location of concealed services shall be checked before fixing timber sections to walls and other surfaces.
<i>Nailing</i>	25.37	Timber sections which are split when nailing shall be replaced. Nail heads shall be punched below timber surfaces.
<i>Fixing screws</i>	25.38	(1) Timber sections shall be screwed in drilled pilot holes. (2) Screws shall be inserted to their full depth with a screwdriver; hammers shall not be used. (3) Screw heads shall be countersunk at least 5 mm below timber surfaces; colour and grain matched pellets cut from similar timber shall be fixed in with adhesive and finished off flush with the surrounding surface.

TESTING : TIMBER

<i>Batch: timber</i>	25.39	A batch of timber is any quantity of timber of the same type and grade, from the same source, covered by the same certificates and delivered to the Site at any one time.
<i>Samples timber</i>	25.40	(1) 1 sample of timber shall be provided from each batch of timber. (2) The size of each sample shall be 1000 mm x 50 mm x 50 mm.
<i>Testing: timber</i>	25.41	(1) Each sample of timber shall be tested to determine the moisture content at the time of fabrication.

(2) The moisture content at the time of fabrication shall be calculated from the equation:

$$\text{Moisture content} = (m_w - m_d)/m_d \quad \%$$

where

- m_w is the wet or supplied mass, and
- m_d is the dry mass.

(3) The dry mass shall be determined by drying the sample in an oven at a temperature of $103^\circ\text{C} \pm 2^\circ\text{C}$ until the mass is constant and weighing the sample.

PART 3 : GLAZING

MATERIALS

<i>Glass</i>	25.42	<p>(1) Glass shall comply with BS 952 and be of a proprietary type approved by the Engineer. Glass shall be free from bubbles, smoke wanes, air holes, scratches and other defects and shall be cut to the required size with clean undamaged edges and surfaces which are not disfigured.</p> <p>(2) Clear float glass shall be used for glazing unless otherwise stated in the Contract.</p> <p>(3) Sheet glass shall be clear sheet glass and shall be at least 3 mm thick.</p> <p>(4) Reinforced glass shall be Georgian wired cast or hexagonal wired cast glass of standard quality; the glass shall have a nominal thickness of 6 mm and shall have square wire mesh electrically welded at each intersection.</p> <p>(5) Hollow pressed glass blocks shall have a pattern approved by the Engineer and shall have radius corner blocks to match.</p> <p>(6) Glass blades for fixed and adjustable louvres shall have a nominal thickness of 6 mm; the edges shall be parallel and shall be ground to remove sharp arrises.</p>
<i>Putty</i>	25.43	Putty for glazing to metal, hardwood and softwood shall be a proprietary type approved by the Engineer.
<i>Bituminous paint</i>	25.44	Bituminous paint for cut edges of wired glass shall comply with BS 6949.

SUBMISSIONS

<i>Samples of materials</i>	25.45	Samples of each proposed type of glass shall be submitted to the Engineer at least 14 days before glazing starts.
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STORAGE OF MATERIALS

<i>Storage of glass and putty</i>	25.46	<p>(1) Glass shall be stored vertically in a dry weatherproof store with a raised floor. Glass shall be kept clean and dry and shall be protected from exposure to condensation and moisture.</p> <p>(2) Putty shall be stored in sealed containers which shall be marked to identify the contents and protected from exposure to conditions which may adversely affect the putty all in accordance with the manufacturer's recommendations. The putty shall not be used after the recommended shelf life has been exceeded.</p>
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GLAZING WORK

Glazing work

- 25.47 (1) Glazing work shall be carried out in accordance with BS 6262. External glazing shall be weather-tight on completion.
- (2) Frames and beading shall be cleaned and primed before glazing as stated in Part 6 of this section.
- (3) Directionally patterned or wired glass shall be set with the pattern or wires parallel to the surround and aligned with adjacent panes. Cut edges of wired glass shall be painted with one coat of bituminous paint.
- (4) Edge clearances shall be at least 3 mm and shall be equally spaced around each pane.
- (5) Putty edge covers shall be as stated in Table 25.1.
- (6) Setting and location blocks shall be used for panes of glass exceeding 0.2 m². The blocks shall be located in accordance with BS 6262 and shall be at least 30 mm from the corners of the frame.
- (7) Back putty shall be finished flush with the frame on top edges and sides, and at 45° on bottom edges. There shall be no metal-glass or wood-glass contact, and no voids or spaces in the putty.
- (8) Glass shall be secured to wood surrounds by glazing sprigs at a maximum spacing of 450 mm and shall be secured to metal surrounds by spring clips; glazing sprigs and spring clips shall be provided by the manufacturer of the surround.
- (9) Back putty shall be of regular thickness and at least 2 mm thick. Front putty shall be formed to a triangular fillet stopping 2 mm short of sight lines. Opening lights shall be kept closed until the putty has hardened.
- (10) Putty shall be primed and painted as soon as it has hardened.
- (11) Timber beading shall be bedded in putty and secured with countersunk brass screws and cups; screws and cups shall be at a maximum spacing of 200 mm and shall not be more than 75 mm from each corner.
- (12) Metal beading shall be supplied with the frames and shall be fixed in accordance with the manufacturer's recommendations.
- (13) Gaps between glass and beading shall be sealed with putty.

Table 25.1 : Edge covers for glazing

Area of glass (m ²)	Edge cover (mm)
not exceeding 0.5	5
exceeding 0.5 and not exceeding 1.5	9
exceeding 1.5 and not exceeding 4.0	12

PART 4 : PLUMBING

GENERAL

<i>Licensed plumber</i>	25.48	Plumbing shall be carried out by a licensed plumber.
<i>Taps, valves and fittings</i>	25.49	Taps, valves and fittings shall be a proprietary type approved by Water Supplies Department. Red lead jointing materials shall not be used.

MATERIALS

<i>Pipework for plumbing</i>	25.50	<p>(1) Cast iron waste and ventilating pipes and fittings shall comply with BS 416 and shall have Type A or Type B sockets without ears. Holderbats shall be cast iron with 8 mm brass bolts and nuts or galvanized mild steel with cadmium plated bolts.</p> <p>(2) Plastic rainwater pipes not exceeding 80 mm diameter, gutters and fittings shall comply with BS 4576:Part 1. Internal pipework, external pipes exceeding 80 mm diameter and fittings shall comply with BS 4514. Plastic roof outlets shall be a proprietary type approved by the Engineer and shall be provided with a sealing flange and screw fixed flat or domed grating.</p> <p>(3) Plastic soil and ventilating pipes and fittings shall comply with BS 4514. Plastic waste pipes shall comply with BS 5255.</p> <p>(4) Plastic pipes for cold water shall be unplasticized PVC pipes complying with BS 3505 and shall have a pressure rating of Class D, or higher, as stated in the Contract; fittings shall comply with BS 4346:Part 1, BS 4346 Part 2 and BS 4346:Part 3.</p> <p>(5) Copper pipes shall comply with BS 2871:Part 1, Table X in half hard condition. Fittings for copper pipes shall comply with BS 864:Part 2, Table 6 symbol reference 864.1, 864.2 or 864.4.</p> <p>(6) Adapters for pipework shall be a proprietary type approved by the Engineer.</p> <p>(7) Jointing compound for waste outlets shall be a proprietary type approved by the Engineer.</p>
<i>Cisterns, tanks and cylinders</i>	25.51	Cisterns and covers, tanks and cylinders shall be galvanized mild steel complying with BS 417:Part 2, Grade A thickness or other materials approved by the Engineer. Joints between sections of cistern covers shall have weatherproof standing welt type laps.
<i>Draw-off taps and stop valve</i>	25.52	<p>(1) Screw-down type draw-off taps and stop valves not exceeding 50 mm shall comply with BS 1010:Part 2. Stop valves in flushing water systems shall be diaphragm or ball type valves approved by the Engineer.</p> <p>(2) Copper alloy gate valves and check valves shall comply with BS 5154.</p>

(3) Gate valves exceeding 50 mm diameter shall be double flanged cast iron wedge gate valves complying with BS 5150. Gate valves for flushing water systems shall have zinc free bronze trim and a rising stem. Gate valves at incoming water mains shall comply with BS 5163.

Float operated valves

25.53

(1) Float operated valves not exceeding 50 mm diameter for tanks shall be bronze and shall comply with BS 1212:Part 1 or BS 1212:Part 2 and shall have the pressure rating stated in the Contract. The bronze shall be zinc free for flushing water systems. The float shall be plastic and comply with BS 2456.

(2) Float operated valves exceeding 50 mm diameter for tanks shall be cast iron with gunmetal trim and shall have the pressure rating stated in the Contract. For flushing water systems, the trim shall be zinc free bronze and the float shall be epoxy coated copper or other material approved by the Engineer.

(3) Float operated valves for cisterns shall be diaphragm type plastic bodied valves complying with BS 1212:Part 3. The valves shall have rubber or plastic diaphragms and shall have the pressure rating stated in the Contract. Metal parts of the valves shall be coated with two coats of bituminous paint.

Sanitary appliances

25.54

(1) Sanitary appliances shall be a proprietary type approved by the Engineer and shall be white and complete with all necessary fittings.

(2) Wastes, chains, stays, taps and combination tap assemblies shall be chromium plated brass.

(3) Lavatory basins shall be vitreous china size 635 mm x 455 mm and shall have a back skirting not exceeding 75 mm high or other type approved by the Engineer. Basins shall be supported on brackets to suit the basin; the brackets shall be a proprietary type approved by the Engineer.

(4) Sinks shall be at least 0.9 mm thick satin finish stainless steel Grade 18/8. Overflow and sound deadening pads shall be provided under the sink and drainers.

(5) WC pans shall be pedestal type vitreous china washdown with a horizontal outlet. Flushing cisterns shall be provided with valveless syphonic flushing apparatus, discharge pipes, float operated valves and overflows. Flushing cisterns shall be:

- (a) low level plastic,
- (b) high level plastic,
- (c) low level vitreous china, or
- (d) close coupled vitreous china

as stated in the Contract. Seats and covers for WC pan shall be a proprietary type approved by the Engineer. WC pan connectors shall be PVC.

(6) Urinals shall be a vitreous china bowl type and shall be provided with vitreous china flushing cistern, UPVC flush pipes and spreaders to suit the number of appliances in the following range:

- (a) 4.5 litres to serve a single bowl,
- (b) 9 litres to serve two bowls, and
- (c) 13.5 litres to serve three bowls.

(7) Traps shall be a proprietary type approved by the Engineer and shall be provided with a 75 mm deep seal.

Pipe brackets and fixings

25.55

(1) Pipe brackets for plumbing shall suit the type of pipe and the surface to which they are to be fixed and shall be a proprietary type approved by the Engineer.

(2) Pipe brackets shall include as appropriate:

- (a) fanged ends for building into concrete, brickwork and similar materials,
- (b) plain round ends for fixing in drilled holes with adhesive,
- (c) expanding bolts or stud anchors for fixing to concrete, brickwork and similar materials,
- (d) threaded ends for fixing to steelwork and timber, and
- (e) holed face plates for screwing to timber or plugs.

(3) Bolts for fixing pipe brackets shall be brass, cadmium plated steel or other non-corrodible metal approved by the Engineer. Expanding bolts and stud anchors shall be a proprietary type approved by the Engineer.

(4) Adhesive for fixing pipe brackets shall be a proprietary type approved by the Engineer.

SUBMISSIONS

Particulars of plumbing work

25.56

(1) The following particulars of the proposed plumber and materials for plumbing work shall be submitted to the Engineer:

- (a) name and registration number of plumber, and
- (b) manufacturer's literature for pipework, cisterns, tanks and cylinders, draw-off taps and valves, float operated valves, sanitary appliances and pipe brackets.

(2) The particulars of materials for plumbing shall be submitted to the Engineer at least 14 days before plumbing work starts

<i>Samples of materials</i>	25.57	Unless otherwise permitted by the Engineer, samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are submitted: <ul style="list-style-type: none"> (a) pipework, (b) taps and valves, and (c) pipe brackets.
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STORAGE OF MATERIALS

<i>Storage of pipes, gutters and fittings</i>	25.58	Pipes, gutters and fittings shall be stored in a dry weatherproof store and in such a manner that they are clear of the ground without resting on their sockets. Rubber jointing rings shall be stored in sealed plastic bags and shall be protected from exposure to conditions which may adversely affect the rings. The rings shall be stored in a manner which will not result in deformation of the rings.
<i>Storage of sanitary appliances</i>	25.59	Sanitary appliances shall be stored in a dry weatherproof store. Metal sinks and similar appliances shall be stored on a level surface and in a manner which will not result in contamination by cement or lime.

PLUMBING WORK

<i>Plumbing work</i>	25.60	<p>(1) The ends of pipes and gutters shall be cut clean and square and shall be chamfered internally or externally as required; cutting and chamfering shall be carried out using purpose-made equipment.</p> <p>(2) Measures shall be taken to prevent deleterious material entering pipework, by temporarily sealing the ends of pipes and openings and by fitting access covers and cleaning eyes as plumbing work proceeds. Jointing material shall not project into the bore of pipes or fittings.</p> <p>(3) Pipes passing through walls or floors shall be contained in a plastic pipe sleeve with 5 mm clearance. Pipes passing through fire rated walls or floors shall be contained in a galvanized mild steel pipe sleeve with 20 mm clearance; the clearance shall be caulked for the full depth with mineral wool or other material approved by the Engineer. Sleeves shall be finished flush with walls and ceilings and shall project 100 mm above the finished floor levels. Masking plates shall be provided on both sides of walls and ceilings and shall be sealed against the weather.</p> <p>(4) Above ground foul water drainage shall be carried out in accordance with BS 5572. Bolted access doors or inspection units shall be provided to all branches and bends other than ventilating and anti-syphon pipes.</p>
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(5) Cast iron pipes shall be jointed with gaskin and caulked lead or a cold caulking compound. Flexible joints shall be made in accordance with the manufacturer's recommendations. Cast iron pipes shall be jointed to clay spigot and socket pipes with gaskin and a mixture of cement and sand in the proportions 1:2 by volume.

(6) Plastic pipes shall be fixed and jointed in accordance with the manufacturer's recommendations. Plastic pipes shall be jointed to pipes of other materials using adapters.

(7) Copper pipes shall be jointed with non-manipulative compression fittings or capillary fittings. Copper pipes shall be jointed to cast iron sockets with copper alloy caulking bushes and with gaskin and lead or a cold caulking compound. Copper pipes shall be jointed to tapped bosses on cast iron pipes with copper alloy threaded connectors.

(8) Water supply installations shall be carried out in accordance with BS 6700. Pipes shall be laid to a gradient of at least 1 in 100 to prevent air locks. Tanks, cisterns and pipework shall be cleaned out and flushed through with potable water after completion.

(9) Waste outlets to wash basins, sinks and toilets shall be jointed with a proprietary type of jointing compound approved by the Engineer.

(10) WC pans on concrete floors shall be bedded in white lead putty or other non-hardening compound approved by the Engineer and shall be fixed with No. 14 SG round headed brass screws 70 mm long with domed plastic inserts. WC pans shall be jointed to drain pipes with WC pan connectors or other fittings approved by the Engineer.

TESTING : PLUMBING - FOUL DRAINS

*Testing: plumbing –
foul drains*

25.61

(1) Foul drains shall be tested by plugging the lower end of the pipe and filling the pipe with water up to the flood level of the lowest sanitary appliance. Drainage above the flood level of the lowest sanitary appliance shall be tested by visual inspection.

(2) The lengths of foul drains tested in each test shall be as instructed by the Engineer.

*Compliance criteria:
plumbing - foul drains*

25.62

The level of water in tests on foul drains shall remain constant for a 30 minute period without visible leakage.

TESTING : PLUMBING - WATER PIPES

*Testing: plumbing -
water pipes*

25.63

Water pipes inside buildings shall be visually inspected for leaks and shall be tested as follows:

- (a) All systems, including cisterns, tanks and cylinders, shall be filled slowly with water to expel all air.

- (b) Service pipes connected to mains shall be tested at 1.5 times mains pressure for 1 hour.
- (c) Distribution pipes fed from storage tanks shall be tested at 1.5 times working pressure for 1 hour.
- (d) Each tap shall be opened and checked for a satisfactory rate of flow.

Compliance criteria:
plumbing - water pipes

25.64

Water pipes inside buildings shall show no loss of water or visual evidence of leakage.

PART 5 : PLASTERWORK AND OTHER FINISHES

MATERIALS

Cement, water and sand 25.65

- (1) Cement for plasterwork and other finishes shall be OPC complying with BS 12.
- (2) Water for plasterwork and other finishes shall be as stated in Clause 16.09.
- (3) Sand for mixes for plasterwork and other finishes which do not incorporate lime shall be clean, hard, durable crushed rock or clean sand and shall have the particle size distribution stated in Table 25.2. Sand for mixes which incorporate lime shall be clean natural sand and shall have the particle size distribution stated in Table 25.3.
- (4) The quantity of clay, fine silt and fine dust present in the sand shall not exceed 10% by mass when determined in accordance with BS 812:Part 101, BS 812:Part 102, BS 812:Part 103 and BS 812:Section 105.1. The chloride content of sand or crushed rock shall not exceed 0.03 % by mass when determined in accordance with BS 812:Part 4.

Table 25.2 : Particle size distribution of sand for mixes which do not incorporate lime

BS test sieve size	Percentage by mass passing
5.00 mm	100
2.36 mm	90 – 100
1.18 mm	70 – 100
600 µm	40 – 80
300 µm	5 – 40
150 µm	0 – 10

Table 25.3 : Particle size distribution of sand for mixes incorporating lime

BS test sieve size	Percentage by mass passing
2.36 mm	100
1.18 mm	90 - 100
600 µm	55 - 100
300 µm	5 - 50
150 µm	0 - 10

<i>Gypsum plaster</i>	25.66	Gypsum plaster for plastering shall comply with BS 1191:Part 1, Grade B.
<i>Lime</i>	25.67	Lime for plastering shall be hydrated lime or quicklime complying with BS 890.
<i>Stone chippings</i>	25.68	Stone chippings for Shanghai plaster shall be granite, white stone or marble chippings; the chippings shall be free from dust and shall be graded such that 100% passes a 5 mm BS test sieve and 100% is retained on a 2.36 mm BS test sieve.
<i>Metal lathing</i>	25.69	<p>Metal lathing for plastering shall comply with BS 1369:Part 1 and shall be one of the following types:</p> <ul style="list-style-type: none"> (a) zinc coated or stainless steel expanded metal lathing 6 mm short way of mesh and weighing at least 1.6 kg/m², or (b) zinc coated or stainless steel ribbed metal lathing weighing at least 2.25 kg/m².
<i>Aggregates for lightweight screeds</i>	25.70	Aggregates for lightweight screeds shall be 5 mm exfoliated vermiculite or a proprietary type of lightweight beads or granules approved by the Engineer.
<i>Vapour barrier</i>	25.71	Vapour barrier for lightweight roof screeds shall be polyethylene sheeting and shall have a nominal thickness of 80 µm.
<i>Aggregates for terrazzo</i>	25.72	Aggregates for terrazzo shall be angular crushed marble of a colour compatible with surrounding finishes. Aggregate shall be free from dust and shall be graded such that 100% passes a 10 mm BS test sieve and 100% is retained on a 5 mm BS test sieve.
<i>Aggregates for granolithic concrete</i>	25.73	Aggregates for granolithic concrete shall be crushed grey granite or white stone complying with BS 882. Aggregate shall be free from dust and shall be graded such that 100% passes a 10 mm BS test sieve and 100% is retained on a 2.36 mm BS test sieve.

<i>Tiles</i>	25.74	Each type of tile and fitting shall be obtained from the same manufacturer and shall match in colour and texture.
<i>Floor tiles</i>	25.75	Clay floor tiles and fittings shall comply with BS 6431:Part 1, BS 6431:Part 2, BS 6431:Section 3.1, BS 6431:Section 3.2, BS 6431:Section 4.1 and BS 6431:Section 4.2. Ceramic floor tiles shall be vitrified and shall have a water absorption not exceeding 3%. Clay floor quarry tiles shall be Group II and shall have a water absorption not exceeding 10%. Anti-slip tiles shall be embossed or treated with carborundum or similar grit to provide an anti-slip surface.
<i>Ceramic wall tiles</i>	25.76	Glazed ceramic wall tiles and fittings shall comply with BS 6431:Part 1, BS 6431:Part 2, BS 6431:Section 3.1, BS 6431:Section 3.2, BS 6431:Section 4.1 and BS 6431:Section 4.2 and shall be eggshell glazed. The tiles shall be 100 mm x 100 mm or 152 mm x 152 mm and shall be at least 5.5 mm thick; the tiles shall have cushion edges.
<i>Mosaic tiles</i>	25.77	<p>(1) Glass mosaic tiles shall be fully vitrified glass tiles free from cracks or sharp edges and shall be uniform in colour and texture. The tiles shall be 20 mm x 20 mm x 4 mm thick and shall be regular in shape.</p> <p>(2) Glazed ceramic mosaic tiles shall be free from cracks or sharp edges and shall be uniform in colour and texture. The tiles shall be 18 mm x 18 mm x 5 mm thick or 25 mm x 25 mm x 5 mm thick and shall be regular in shape with square edges.</p> <p>(3) Unglazed vitreous mosaic tiles shall have a water absorption not exceeding 3% and shall be 18 mm x 18 mm or 18 mm x 38 mm and shall be 4 mm or 5 mm thick with matching coved tiles.</p>
<i>Concrete roof tiles</i>	25.78	Concrete roof tiles shall be precast and shall be manufactured using Grade 20/10 concrete. The tiles shall be flat and shall be 300 mm x 300 mm x 30 mm thick or 400 mm x 400 mm x 35 mm thick.
<i>Adhesive</i>	25.79	Adhesive for tiles shall be a proprietary type recommended by the tile manufacturer and approved by the Engineer.
<i>Bitumen</i>	25.80	Bitumen for tiles shall be as stated in Clause 25.03.

SUBMISSIONS

<i>Particulars of plasterwork and other finishes</i>	25.81	<p>(1) The following particulars of the proposed materials for plasterwork and other finishes shall be submitted to the Engineer:</p> <p>(a) a certificate for cement, gypsum plaster and lime showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract,</p>
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- (b) a certificate for sand, stone chippings and each type of aggregate showing the source of the material and showing that the material complies with the requirements stated in the Contract, and including results of tests as appropriate, for
 - grading
 - silt content, and
- (c) manufacturer's literature and a certificate for each type of tile and fittings showing the manufacturer's name, the date and place of manufacture and showing that the tiles comply with the requirements stated in the Contract.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

<i>Samples of materials</i>	25.82	<p>Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are submitted:</p> <ul style="list-style-type: none"> (a) sand, stone chippings and aggregates, and (b) tiles and fittings.
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DELIVERY AND STORAGE OF MATERIALS

<i>Delivery and storage of cement, gypsum plaster and lime</i>	25.83	Cement, gypsum plaster and lime shall be delivered in sealed bags or containers bearing the manufacturer's name. The bags and containers shall be stored in a dry weatherproof store with a raised floor.
<i>Storage of adhesive for tiles</i>	25.84	Adhesive for tiles shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions which may adversely affect the adhesive. The adhesive shall be stored in accordance with the manufacturer's recommendations and shall not be used after the recommended shelf life has been exceeded.

TRIAL PANELS

<i>Trial panels</i>	25.85	<p>(1) A trial panel shall be constructed for each type of plastering and rendering, each textured finish to screeds, terrazzo, granolithic concrete and each type of tile to demonstrate that the proposed materials will produce a finish which complies with the specified requirements.</p> <p>(2) Trial panels shall be constructed at least 7 days before the relevant work starts.</p> <p>(3) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before constructing trial panels.</p> <p>(4) Trial panels shall be constructed using the materials submitted to the Engineer.</p>
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(5) Each trial panel shall be 1 m x 1 m and shall be constructed at a location agreed by the Engineer.

(6) Trial panels shall be used as a means of comparison against which the Engineer shall determine the compliance or otherwise of the finish in the permanent work. Trial panels shall be protected from damage and shall be left in position until the Engineer instructs their removal.

<i>Non-compliance: trial panels</i>	25.86	If in the opinion of the Engineer the specified finish has not been produced in the trial panel, particulars of proposed changes to the materials and methods of construction shall be submitted to the Engineer; further trial panels shall be constructed until the specified finish is produced in the trial panel.
<i>Commencement of plasterwork and other finishes</i>	25.87	Plasterwork and other finishes shall not commence until in the opinion of the Engineer the specified finish has been produced in the trial panel.
<i>Changes in materials</i>	25.88	Unless permitted by the Engineer, the materials used to produce the specified finish in trial panels shall not be changed.

PLASTERING AND RENDERING

<i>Preparation for plastering and rendering</i>	25.89	<p>(1) Concrete surfaces which are to be plastered or rendered shall be spatterdashed immediately after the formwork has been removed or shall be treated with a proprietary type of bonding agent approved by the Engineer. Existing concrete surfaces shall be hacked uniformly over the complete area to expose the aggregate over at least 50% of the area. The joints in brickwork surfaces shall be raked out to a depth of at least 10 mm.</p> <p>(2) The surfaces shall be cleaned to remove dirt, dust, oil and other deleterious material.</p> <p>(3) Spatterdash shall consist of cement and coarse sand or granite fines in the proportions 1:2 by volume mixed with the minimum amount of water necessary to achieve the consistency of a thick slurry. Spatterdash shall be thrown with a hand trowel onto the surface to a thickness not exceeding 6 mm and shall cover at least 60% of the area which is to be plastered or rendered. Spatterdash shall be wetted one hour after application and shall be allowed to cure and harden before undercoats are applied.</p> <p>(4) Exposed external arrises of plastering or rendering shall be formed at right angles made with galvanized steel corner beads.</p> <p>(5) Junctions between dissimilar solid backgrounds in the same plane which are to be plastered or rendered shall be jointed with a strip of metal lathing. The largest dimension of the mesh shall be perpendicular to the direction of the supports. The lathing shall extend at least 150 mm along each side of the junction and shall be fixed at 100 mm centres with galvanized steel staples, nails or tying wire as appropriate to the nature of the background. Laps shall be at least 50 mm where end laps occur between supports and shall be at least 25 mm at other locations. Laps</p>
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shall be secured with tying wire at 75 mm centres. Cut ends of lathing shall be painted with one coat of bituminous paint complying with Clause 25.111.

(6) Base coats and first coats of plastering and rendering shall be cross scratched to provide a key for the next coat.

<i>Mixing plaster and render</i>	25.90	Plaster and render shall be mixed using the minimum amount of water necessary to achieve the required consistency and shall be used within one hour after mixing. Unless otherwise permitted by the Engineer, the materials shall be mixed by mechanical methods.
<i>Cement render</i>	25.91	<p>(1) Cement render shall consist of cement and sand or granite fines in the proportions 1:3 by volume.</p> <p>(2) Cement render with a specified finished thickness of 10 mm or less shall be applied in one layer. Cement render with a specified finished thickness exceeding 10 mm but not exceeding 20 mm shall be applied in two layers of equal thickness.</p>
<i>Gypsum plaster</i>	25.92	<p>(1) Gypsum plaster shall be applied in two coats on solid backgrounds. The first coat shall consist of Browning plaster and sand in the proportions 1:2 by volume and the finishing coat shall consist of neat finish plaster to give a total thickness not exceeding 10 mm.</p> <p>(2) Gypsum plaster shall be applied in three coats on metal lathing. The first coat shall consist of metal lathing plaster and sand in the proportions 1:1½ by volume. The second coat and the finishing coat shall be as stated in Clause 25.92(1) for the first coat and the finishing coat respectively. The total thickness shall not exceed 13 mm measured from the outer face of the metal lathing.</p>
<i>Lime plaster</i>	25.93	<p>(1) Lime plaster for internal use shall be applied in two coats on solid backgrounds. The first coat shall consist of cement, lime and sand in the proportions 1:4:16 by volume and shall not exceed 10 mm thick on walls and 5 mm thick on soffits. The second coat shall consist of cement, lime and sand in the proportions 1:12:30 by volume and shall be 5 mm thick. The total thickness shall not exceed 15 mm on walls and 10 mm on soffits.</p> <p>(2) Lime plaster for internal use shall be applied in three coats on metal lathing. The first coat and the second coat shall consist of cement, lime and sand in the proportions 1:2:6 by volume. The finishing coat shall consist of cement, lime and sand in the proportions 1:12:30 by volume and shall be 5 mm thick. The total thickness shall not exceed 13 mm measured from the outer face of the metal lathing.</p>
<i>Shanghai plaster</i>	25.94	<p>(1) Shanghai plaster shall be applied in two coats, each 10 mm thick. The base coat shall consist of cement and sand in the proportions 1:3 by volume. The finishing coat shall consist of cement and stone chippings or marble chippings in the proportions 1:1 by volume; the chippings shall be mixed in one of the proportions stated in Table 25.4.</p> <p>(2) After the finishing coat has set, the surface shall be scrubbed to expose the aggregate.</p>

Table 25.4 : Proportions of chippings in Shanghai plaster

Colour of Shanghai plaster	Cement	Proportions of chippings by mass (%)				
		Stone chippings			Marble chippings	
		Dark grey	Light grey	White	Black	White
Dark	Ordinary	70	-	20	10	-
Medium	White	60	20	20	-	-
Light	White	5	75	-	-	20
White	White	-	-	-	-	100

SCREEDS, TERRAZZO AND GRANOLITHIC CONCRETE

Preparation for screeds, terrazzo and granolithic concrete

- 25.95 (1) Concrete surfaces which are to receive screeds, terrazzo or granolithic concrete shall be hacked uniformly over the complete area to expose the coarse aggregate. Laitance shall be removed from fresh concrete by using stiff brushes or other methods agreed by the Engineer.
- (2) The surfaces shall be cleaned to remove dirt, dust, oil and other deleterious material; the surfaces shall be dampened for 12 hours before applying the finish in such a manner that surplus water will not be left. Neat cement slurry shall be brushed onto the existing surface immediately before applying the finish; a proprietary type of bonding agent approved by the Engineer may be used instead of cement slurry.

Mixing screeds, terrazzo and granolithic concrete

- 25.96 Screeds, terrazzo and granolithic concrete shall be mixed as stated in Clause 25.90 for plaster and render.

Screeds

- 25.97 (1) Floor screeds exceeding 40 mm thick shall consist of cement, sand or granite fines and coarse aggregate in the proportions 1:1½:3 by volume; the coarse aggregate shall be graded such that 100% passes a 10 mm BS test sieve and 75% is retained on a 5 mm BS test sieve.
- (2) Lightweight screeds shall consist of cement and lightweight aggregate in the proportions 1:8 by volume for roofs and 1:6 by volume for floors unless otherwise approved by the Engineer. The screed shall be finished with cement and sand or granite fines in the proportions 1:4 by volume.
- (3) Other screeds shall consist of cement and sand or granite fines in the proportion 1:3 by volume.

- (4) Wall screeds shall be at least 10 mm thick; the surface shall be lightly scratched to form a key.
- (5) Floor screeds which are to be laid monolithically with the base shall be at least 15 mm thick and shall be applied within 3 hours after laying the base. Floor screeds which are to be bonded to a hardened concrete base shall be at least 20 mm thick.
- (6) Lightweight screeds shall be at least 50 mm thick excluding the topping; the topping shall be at least 15 mm thick and shall be laid monolithically with the screed.
- (7) Vapour barriers for lightweight roof screeds shall be laid flat without creases; laps shall be at least 150 mm.
- (8) Screeds shall be laid between timber battens and in bays not exceeding 15 m²; the length of each bay shall not exceed 1½ times the width of the bay and the top surface of the batten shall be set to the required level. Screeds shall be compacted to a uniform density throughout.
- (9) Screeds shall be completed with one of the following surface finishes as stated in the Contract:
 - (a) a smooth untextured finish using a steel trowel or power float,
 - (b) an even textured finish using a wood float, or
 - (c) a slightly roughened textured finish using a stiff brush.

Terrazzo

25.98

- (1) Terrazzo shall be applied in two coats; the minimum thickness of each coat shall be as stated in Table 25.5. The first coat shall consist of cement and sand or granite fines in the proportions 1:3 by volume. The finishing coat shall consist of white or coloured cement and marble aggregate in the proportions 1:2½ by volume. The finishing coat shall be applied before the first coat has set.
- (2) Terrazzo shall be laid in bays not exceeding 1 m²; the length of each bay shall not exceed 1½ times the width of the bay. Bays shall be laid in a chequer board pattern and 24 hours shall be allowed between laying adjacent bays. Bays shall be separated from other bays and from adjacent finishes to the complete depth of both coats by 3 mm thick brass strips. Terrazzo shall be compacted to a uniform density throughout.
- (3) After curing has been completed as stated in Clause 25.103, the surface of terrazzo shall be ground to a smooth finish and to expose the aggregate; voids in the surface shall be filled with matching cement.
- (4) One coat of wax polish shall be applied to the surface of wall finishes. Floor finishes shall not be highly polished or wax polished.

Table 25.5 : Thickness of finish of Terrazzo

Location	First coat	Finishing coat
Floors	10 mm	15 mm
Walls and dadoes	10 mm	10 mm
Treads	-	20 mm
Risers	-	15 mm

- Granolithic concrete** 25.99 (1) The proportions and surface finish of the different types of granolithic concrete shall be as stated Table 25.6.
- (2) Granolithic concrete which is to be laid monolithically with the base shall be at least 20 mm thick and shall be applied within 3 hours after laying the base. Granolithic concrete which is to be bonded to a hardened concrete base shall be at least 40 mm thick.
- (3) Granolithic concrete shall be laid and compacted as stated in Clause 25.97(8) for screeds and 24 hours shall be allowed between laying adjacent bays.
- (4) Trowelled surface finishes to granolithic concrete shall be formed by trowelling the surface with a steel trowel at least 3 times over a period of 6 hours to 10 hours after compaction to give a smooth finish; cement shall not be used to absorb surplus water. Laitance produced by trowelling shall be removed and shall not be worked into the surface.
- (5) Rubbed surface finishes to granolithic concrete shall be formed by rubbing down a trowelled surface finish after it has set with fine carborundum stone to form a smooth finish and to expose the aggregate.
- (6) Washed surface finishes to granolithic concrete shall be formed by brushing off a trowelled surface finish before it has set to expose the aggregate.

Table 25.6 : Proportions and surface finish of granolithic concrete

Type of granolithic concrete	Proportions by volume				Type of surface finish
	Cement	Granite fines	Granite aggregate	White stone	
A	2	1	4	-	Trowelled or rubbed
B	2	1	-	4	
C	1	-	2	-	Washed
D	1	-	-	2	

TILING

Floor tiles

- 25.100 (1) Floor tiles on concrete bases shall be laid by the semi-dry method as stated in Clause 25.100(2) to (4).
- (2) The tiles shall be laid on a bed of cement and sand in the proportions 1:4 by volume. The bed shall be mixed semi-dry and shall be at least 20 mm thick. The concrete base which is to receive the tiles and bed shall be prepared and cleaned as stated in Clause 25.95.
- (3) The tiles shall be immersed in water for 30 minutes and shall be allowed to drain immediately before laying. The cement and sand bed shall be compacted and finished to the required level. A slurry of cement and sand in the proportions 1:1 by volume shall be mixed with the minimum amount of water necessary to achieve a creamy consistency and shall be spread and trowelled over the bed to a nominal thickness of 3 mm. The tiles shall be firmly bedded into the slurry to leave straight and even joints. Tiles with minor variation in colour shall be placed at random locations.
- (4) After the bed has set, the tiles shall be grouted with a mix of cement and sand in the proportions 1:1 by volume together with the minimum amount of water necessary to achieve the required workability; surplus grout shall be cleaned from the face of tiles as work proceeds.
- (5) Floor tiles on floor screeds shall be laid by the thick bed method as stated in Clause 25.100(6) to (8).
- (6) The tiles shall be laid on a bed of cement and sand or granite fines in the proportions 1:3 by volume; the bed shall be approximately 15 mm thick and shall not be thicker than the tiles. The screed shall be dampened with clean water to prevent water being absorbed from the bed.

(7) Before laying, the tiles shall be immersed in water for 30 minutes and allowed to drain and the back of tiles shall be coated with a slurry of cement together with the minimum amount of water necessary to achieve a creamy consistency. The tiles shall be firmly tamped into the bed to leave straight and even joints. Tiles with minor variations in colour shall be placed at random locations.

(8) After the bed has set, the tiles shall be grouted with a mix of cement and sand in the proportions 1:1 by volume together with the minimum amount of water necessary to achieve the required workability; surplus grout shall be cleaned from the face of tiles as work proceeds.

(9) After laying floor tiles, no traffic shall be allowed on the floor for the first four days and after that only light traffic as approved by the Engineer is allowed for the next ten days.

Wall tiles

25.101 (1) Wall tiles shall be fixed to wall screeds as stated in Clause 25.100(5) to (8) except as stated in Clause 25.101(2) to (6).

(2) Glazed wall tiles shall be laid on a bed of cement and sand or granite fines in the proportions 1:3 by volume; the bed shall be at least 5 mm, and shall not exceed 15 mm, thick. Mosaic tiles shall be laid on a bed of cement and granite fines in the proportions 1:3 by volume; the bed shall be 10 mm thick. Tiles with minor variations in colour shall be placed at random locations.

(3) Glazed wall tiles shall be soaked in clean water for at least 30 minutes before laying; mosaic tiles shall not be soaked.

(4) The backs of glazed wall tiles shall be coated with a mortar of cement and sand or granite fines in the proportions 1:3 by volume. The backs of sheets of mosaic tiles shall be coated with a slurry of cement of the same colour as the final grout.

(5) The backing paper of mosaic tiles shall be removed and final straightening of the tiles shall be carried out as the sheets are fixed firmly into position.

(6) Glazed wall tiles and mosaic tiles shall be grouted with a final grout of white cement and powdered limestone in the proportions 1:3 by volume.

Roof tiles

25.102 (1) Roof tiles shall be laid on a bed of cement and sand in the proportions 1:4 by volume.

(2) Roof tiles shall be laid loose and hot bitumen shall be poured between the joints and pointed.

(3) 25 mm wide joints shall be formed for each 3 m of roof tiles, and 75 mm wide joints shall be formed around the perimeter of roof tiles, to allow for expansion.

PROTECTION OF PLASTERWORK AND OTHER FINISHES

<i>Protection of plasterwork and other finishes</i>	25.103	Completed and partially completed surfaces of plasterwork and other finishes shall be protected from rapid or localised drying out for at least 7 days by covering with polythene sheeting, damp hessian, or a layer of damp sand at least 50 mm thick, or by other methods agreed by the Engineer.
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TOLERANCES

<i>Tolerances: plasterwork and other finishes</i>	25.104	There shall be no abrupt irregularities in the surface of plasterwork and other finishes and there shall be no gradual irregularities exceeding 5 mm in a 2 m length.
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PART 6 : PAINTING

MATERIALS

<i>Paint and associated materials</i>	25.105	(1) Unless otherwise approved by the Engineer, paint and associated materials in a coating system shall be obtained from the same manufacturer and shall be supplied in sealed containers marked to identify the contents, the manufacturer's brand label and recommendations for use.
		(2) Paint and associated materials for general use shall be a proprietary type approved by the Engineer and shall be obtained from manufacturers approved by the Engineer.
		(3) Paint and associated materials which will be applied to surfaces which may come into contact with potable or fresh water shall be a proprietary type approved by the Engineer which is listed in the current version of the 'Water Fittings and Materials Directory' issued by the United Kingdom Water Research Council as being suitable for such use.
		(4) Undercoats and finishing coats shall be compatible with the primer and with each other and shall be obtained from the same manufacturer. Undercoats and primary finishing coats shall be of slightly different tints to each other and to the finishing coat.
		(5) Flat finish undercoats shall be used for hard gloss finishes.
<i>Aluminium primer</i>	25.106	Aluminium primer shall comply with BS 4756, Type 1.
<i>Zinc chromate primer</i>	25.107	Zinc chromate primer and metallic zinc-rich primer Type 2 shall comply with BS 4652.
<i>Lead primer</i>	25.108	Lead primer shall comply with BS 2523.
<i>Calcium plumbate primer</i>	25.109	Calcium plumbate primer shall comply with BS 3698.
<i>Bitumastic paint</i>	25.110	Bitumastic paint shall be quick drying Type B complying with BS 1070.
<i>Bituminous paint</i>	25.111	Bituminous paint shall comply with BS 6949.
<i>Knotting</i>	25.112	Knotting shall comply with BS 1336.
<i>Stopping</i>	25.113	Stopping shall comply with BS 544.
<i>Rust inhibitor</i>	25.114	Rust inhibitor shall be a chemical agent which is capable of converting rust into iron phosphate.
<i>Sealers</i>	25.115	Sealers for plaster, masonry and similar materials shall be a stabilising solution or oil based plaster sealer.
<i>Wood preservative</i>	25.116	Wood preservative shall be as stated in Clause 25.27.
<i>Polyurethane paint</i>	25.117	Polyurethane paint shall be a two-pack type.
<i>Epoxy paint</i>	25.118	Cold cure epoxy paint shall be a two-pack type.

<i>Textured paint</i>	25.119	Textured paint for external use shall be a heavy duty masonry paint incorporating a fine aggregate filler.
<i>Plastic emulsion paint</i>	25.120	Plastic emulsion paint shall be a vinyl or acrylic based emulsion incorporating a fungicide.
<i>Cement paint</i>	25.121	Cement paint shall be a waterproof cement based paint supplied in drums and shall not be mixed with lime or similar materials.
<i>Gloss paint</i>	25.122	Synthetic gloss paint for internal and external use shall have an alkyd resin base combined with drying oils and pigments.
<i>Selection of colours for paintwork</i>	25.123	<p>(1) The colours of paintwork shall be provisionally selected by the Engineer from a catalogue showing the range of colours offered by the manufacturers; the catalogue shall be submitted to the Engineer at least 14 days before painting starts.</p> <p>(2) Trial panels shall be painted in each of the colours provisionally selected by the Engineer. Each trial panel shall be 1 m x 1 m and shall be painted with the complete paintwork system.</p> <p>(3) The Engineer shall select the final colour of paintwork from the trial panel.</p> <p>(4) Trial panels shall be used as a means of comparison for the colour of the finished paintwork. Trial panels shall be protected from damage and shall be left in position until the Engineer instructs their removal.</p>

STORAGE OF MATERIALS

<i>Storage of paint and associated materials</i>	25.124	<p>(1) Paint and associated materials shall be stored in a dry weatherproof store; the store shall be maintained in a cool, well ventilated condition.</p> <p>(2) Tins of paint shall be labelled as being for external use, internal use, undercoating and finishing, as appropriate, and shall be protected from exposure to conditions which may adversely affect the material. Paint and associated materials shall be stored in accordance with the manufacturers' recommendations and shall not be used after the recommended shelf life has been exceeded.</p>
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PAINTWORK

<i>Preparation of surfaces for painting</i>	25.125	<p>(1) Surfaces which are to be painted shall be dry and clean, and deleterious and loose material shall be removed.</p> <p>(2) Absorbent surfaces which are to be painted with cement paint shall be thoroughly dampened to provide even suction.</p> <p>(3) Knotting shall be applied to knots in timber.</p>
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(4) Screws and nails in timber and building board surfaces shall be recessed or punched below the finished surface and the whole surface shall be stopped.

(5) Plaster, cement render, masonry, concrete and similar surfaces shall be stopped and sealed.

(6) Scale and rust shall be removed from non-galvanized steel and ironwork; the surface shall be painted with rust inhibitor at least 12 hours before priming or shall be blast-cleaned in accordance with the paint manufacturer's recommendations.

(7) Surfaces adjacent to paintwork shall be temporarily masked to prevent contamination during painting.

Type and number of coats for painting system

25.126 The type and number of coats applied to different surfaces for each painting system shall be as stated in Table 25.7.

Application of paint and associated materials

25.127 (1) Paint and associated materials shall be applied in accordance with BS 6150 and shall be mixed and applied in accordance with the manufacturers' recommendations.

(2) Painting shall not be carried out in wet or misty weather, in direct strong sunlight, or if in the opinion of the Engineer there is excessive dust in the atmosphere.

(3) Paint and associated materials shall be applied with bristle brushes or rollers. If mechanical spraying is permitted by the Engineer the primer coat, or the first undercoat if a primer coat is not required, shall be applied by brush.

(4) Primer coats shall be thoroughly brushed into all surfaces including joints, angles and sawn ends. Primer coats shall be applied to surfaces which will be inaccessible before fittings are fixed in position.

(5) Paint and associated materials shall not be applied until the underlying surface has been rubbed down with fine glass paper and is clean and dry.

(6) Undercoats and finishing coats shall be applied in an even film free from brush marks, sags and runs. If two hard gloss finishing coats are to be applied, the second coat shall be applied within 48 hours after the first coat.

(7) Cement paint shall be applied within 1 hour after mixing; a minimum of 12 hours drying time shall be allowed between coats.

(8) "Wet Paint" signs in English and Chinese shall be prominently displayed adjacent to newly painted surfaces.

Table 25.7 : Type and number of coats for painting systems

Painting system	Surface type	Primer		No. of under-coats	Finishing coat	
		Type	No. of coats		Type	No. of coats
A	Internal woodwork	Aluminium primer	1	1	Hard gloss	1
B	Internal woodwork natural finish	Polyurethane primer	1	1	Polyurethane paint	1
C	External woodwork	Aluminium primer	1	2	Hard gloss	1
D	Hidden surfaces of woodwork and rough sawn timbering	-	-	-	Wood preservative	2
E	Non-structural internal bright steel	Zinc chromate metallic zinc-rich or lead primer	1	1	Hard gloss	1
F	Non-structural external bright steel	as for E above	1	1	Hard gloss	2
G	Internal galvanized steel	Calcium plumbate primer	1	1	Hard gloss	1
H	External galvanized steel	as for G above	1	1	Hard gloss	2
I	Galvanized steel adjacent to the coast or in sewage treatment works	Epoxy red oxide chromate primer	1	1	Cold cure epoxy paint	1
J	Ironwork	-	-	1 before fixing	Bitumastic paint	2
K	Internal walls and ceilings	Alkali resistant primer	1	-	Semi-gloss plastic emulsion paint	2
L	External walls without tile or similar finishes	-	-	-	Cement paint	2
M	Structural steelwork	as stated in Section 18				

PART 7 : BRICKWORK AND BLOCKWORK

MATERIALS

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| <i>Clay bricks</i> | 25.128 | <p>(1) Clay bricks shall be a brand approved by the Engineer and shall be well burnt, hard, sound, square and clean.</p> <p>(2) The nominal dimensions of clay bricks shall be 225 mm x 112.5 mm x 75 mm, 200 mm x 100 mm x 75 mm, and special sizes and shapes in accordance with the requirements stated in the Contract.</p> <p>(3) Clay bricks for fair faced work shall be selected for evenness, texture, sharpness of arrises and uniformity of colour.</p> <p>(4) The compressive strength of the clay bricks shall be at least 7.0 MPa.</p> |
| <i>Concrete bricks and blocks</i> | 25.129 | <p>(1) Concrete bricks and blocks shall be obtained from a manufacturer approved by the Engineer. The compressive strength of the concrete bricks shall be at least 7.0 MPa and for blocks and fixing bricks at least 2.8 MPa.</p> <p>(2) The nominal dimensions of concrete bricks shall be 225 mm x 105 mm x 70 mm. The size of concrete blocks shall be as approved by the Engineer.</p> <p>(3) Concrete bricks and blocks for fair faced work shall be selected for evenness, texture and sharpness of arrises.</p> |
| <i>Concrete hollow blocks</i> | 25.130 | The compressive strength of the concrete hollow blocks shall be at least 2.8 MPa over the gross area. |
| <i>Brickwork reinforcement</i> | 25.131 | Brickwork reinforcement shall be expanded metal or mild steel rods and shall be galvanized or painted with two coats of bituminous paint complying with Clause 25.111. |
| <i>Damp proof course</i> | 25.132 | Damp proof course shall be two layers of 2-ply bituminous paper or other types complying with BS 743; hessian based types of bitumen damp proof course shall not be used. |
| <i>Wall ties</i> | 25.133 | <p>(1) Wall ties between the ends of walls and concrete shall be:</p> <ul style="list-style-type: none"> (a) 6 mm diameter steel rods 350 mm long galvanized or painted with two coats of bituminous paint complying with Clause 25.111, or (b) 20 mm x 3 mm galvanized mild steel flats 350 mm long and fanged at both ends. <p>(2) Wall ties for walls built against the face of concrete structures shall be 20 mm x 3 mm galvanized mild steel flats 150 mm long and fanged at both ends.</p> |

(3) The length of mild steel flat ties which are fixed by shot firing into concrete walls may be reduced if permitted by the Engineer.

Mortar for brickwork and blockwork

25.134 (1) Cement, water and sand for mortar for brickwork and blockwork shall be as stated in Clause 25.65.

(2) Lime putty shall be prepared by mixing hydrated lime with the minimum amount of water necessary to achieve a thick creamy consistency; the putty shall be left undisturbed for at least 16 hours before use.

(3) Cement mortar shall consist of cement and sand in the proportions 1:3 by volume. Cement lime mortar shall consist of cement, lime putty and sand in the proportions 1:1:6 by volume for external walls and in the proportions 1:2:9 by volume for internal walls.

SUBMISSIONS

Particulars of brickwork and blockwork

25.135 (1) The following particulars of the proposed materials for brickwork and blockwork shall be submitted to the Engineer:

- (a) a certificate showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests for crushing strength of clay bricks, concrete bricks and blocks and concrete hollow blocks,
- (b) details of brickwork reinforcement, damp proof course and wall ties, and
- (c) details of materials for mortar.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Samples of materials

25.136 Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are submitted:

- (a) each type of brick and block, and
- (b) brickwork reinforcement, damp proof course and wall ties.

TRIAL PANELS

Trial panels

25.137 (1) A trial panel shall be constructed for each type of faced and fair faced brickwork or blockwork to demonstrate that the proposed materials will produce brickwork or blockwork which complies with the specified requirements.

(2) Trial panels shall be constructed at least 14 days before the relevant work starts.

(3) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before constructing trial panels.

(4) Trial panels shall be constructed using the materials submitted to the Engineer.

(5) Each trial panel shall be 1 m x 1 m and shall be constructed at a location agreed by the Engineer.

(6) Trial panels shall be used as a means of comparison against which the Engineer shall determine the compliance or otherwise of the brickwork or blockwork in the permanent work. Trial panels shall be protected from damage and shall be left in position until the Engineer instructs their removal.

***Non-compliance:
brickwork and
blockwork***

25.138 If in the opinion of the Engineer the brickwork or blockwork in the trial panel does not comply with the specified requirements for brickwork or blockwork, particulars of proposed changes to the materials and methods of construction shall be submitted to the Engineer; further trial panels shall be constructed until the trial panel complies with the specified requirements.

***Commencement of
brickwork and
blockwork***

25.139 Brickwork and blockwork shall not commence until in the opinion of the Engineer the trial panel complies with the specified requirements.

Changes in materials

25.140 Unless permitted by the Engineer, the materials used to produce a trial panel which complies with the specified requirements shall not be changed.

HANDLING AND STORAGE OF MATERIALS

***Handling and storage
of bricks and blocks***

25.141 Bricks and blocks shall be unloaded and handled in a manner which will not result in soiling, chipping or other damage to the bricks and blocks. Bricks and blocks shall be stacked on a dry, level base and in a manner which will not result in damage to the bricks or blocks or in contamination of the bricks or blocks. Bricks and blocks shall be protected from damage and damaged bricks and blocks shall not be used in the permanent work unless permitted by the Engineer.

LAYING BRICKS AND BLOCKS

Type of mortar

- 25.142 (1) Cement mortar shall be used for brickwork and blockwork:
- (a) below the damp proof course, including basement walls,
 - (b) for brickwork and blockwork not exceeding 150 mm thick,
 - (c) in load-bearing walls, and

- (d) for pointing where the bed is cement mortar or where stated in the Contract.

(2) Cement lime mortar shall be used for brickwork and blockwork other than those stated in Clause 25.124(1).

(3) Mortar shall be mixed using the minimum amount of water necessary to achieve the required consistency and shall be used within one hour after mixing. Unless otherwise permitted by the Engineer, the materials shall be mixed by a mechanical method.

***Bond and gauge of
brickwork and
blockwork***

25.143 (1) Stretcher bond shall be used for half brick walls and English bond shall be used for brick walls exceeding half brick thick. Stretcher bond shall be used for blockwork.

(2) Brick courses shall be gauged with four courses to 300 mm including joints.

(3) Bricks and blocks shall be laid on a full bed of mortar and the joints shall be filled solid to a thickness of 10 mm.

(4) Single frog bricks in load-bearing walls shall be laid with the frog facing upward and filled with mortar.

(5) Courses shall be kept level and perpends shall be kept in line vertically. Quoins and other angles shall be plumbed as the work proceeds and shall be constructed in advance of the remainder of the wall, but not exceeding five courses, and shall be racked back between levels.

(6) Bricks and blocks shall be wetted before laying during dry weather using the minimum amount of water necessary to prevent premature drying out of the mortar.

***Laying damp proof
courses***

25.144 (1) Brickwork shall be flushed up with cement mortar to form a level and even bed to receive the horizontal damp proof course.

(2) Damp proof courses shall be laid in a continuous strip with 150 mm laps at the end of the length and at returns. The mortar joint shall be completed to the normal thickness.

Fixing wall ties

25.145 (1) At junctions of walls and concrete, wall ties shall be fixed at 300 mm centres vertically and shall project 250 mm into the wall.

(2) Wall ties shall be fixed for walls built against the face of concrete structures and shall be spaced at intervals of 900 mm horizontally and 300 mm vertically in a staggered pattern; the ties shall project 75 mm into the wall.

***Finishing of joints in
brickwork and
blockwork***

25.146 Joints which will not be visible in the finished brickwork and blockwork shall be struck off as the work proceeds. Joints which will be exposed shall be struck flush and weather pointed as the work proceeds. Joints in brickwork to which plaster or other wet applied finishes will be applied shall be raked out to a depth of 10 mm.

TOLERANCES

<i>Tolerances: brickwork and blockwork</i>	25.147	Brickwork and blockwork shall comply with the following requirements: <ol style="list-style-type: none"> (a) The position on plan shall be within 15 mm of the specified position. (b) The length shall be within 15 mm of the specified length. (c) The height shall be within 10 mm of the specified height. (d) The level of bed joints shall be within 10 mm of the specified level in any 5 m length. (e) The brickwork and blockwork shall be straight to within 15 mm in any 5 m length. (f) The brickwork and blockwork shall be vertical to within 15 mm in any 3 m height.
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TESTING : BRICKS AND BLOCK

<i>Batch: bricks and blocks</i>	25.148	A batch of bricks or blocks is any quantity of bricks or blocks of the same type, manufactured or produced at the same time in the same place, covered by the same certificates and delivered to the Site at any one time.
<i>Samples: bricks and blocks</i>	25.149	<ol style="list-style-type: none"> (1) Unless otherwise permitted by the Engineer, one sample of each type of bricks or blocks shall be provided at the same time as particulars of the material are submitted to the Engineer and one sample of each type of bricks or blocks shall be provided from each batch of the material delivered to the Site. (2) The number of bricks or blocks in the sample shall be 10 for each batch of 15,000 bricks or blocks or part thereof. (3) The method of sampling shall be in accordance with BS 3921.
<i>Testing: bricks and blocks</i>	25.150	<ol style="list-style-type: none"> (1) Each brick or block in the sample shall be tested to determine the crushing strength of the brick or block. (2) The method of testing shall be in accordance with BS 3921. (3) The average of the 10 crushing strengths of the bricks or blocks shall be calculated and referred to as the compressive strength.
<i>Compliance criteria: bricks and blocks</i>	25.151	The compressive strength of bricks and blocks shall be as stated in Clauses 25.128(4), 25.129(1) and 25.130, or as stated elsewhere in the Contract.

PART 8 : METAL WINDOWS AND DOORS

MATERIALS

Materials for metal windows and doors

- 25.152 (1) Materials for metal windows and doors shall be as stated in Clause 25.152(2) to (9).
- (2) Steel shall be weldable structural steel complying with BS 4360. Hot dipped galvanized plain steel sheet and coil shall comply with BS 2989. Steel tubing shall comply with BS 1387 medium grade and shall be galvanized. Slotted steel angles shall be self-finished angles complying with BS 4345 and shall have cadmium plated steel fittings.
- (3) Aluminium alloy plate, sheet and strip shall comply with BS 1470 and shall be of the specified alloy designation. Aluminium alloy bars, extruded tube sections and hollow sections shall comply with BS 1474, alloy designation 6063. Aluminium sections for structural purposes shall comply with BS 1161. Aluminium alloy drawn tubes shall comply with BS 1471, alloy designation 6063.
- (4) Brass rods and sections shall comply with BS 2874, designation CZ 106, condition M.
- (5) Stainless steel shall be of the 18/9 chromium nickel group. Stainless steel plate, sheet and strip shall comply with BS 1449:Part 2 and shall be Finish No. 2B for mill finish and Finish No. 4 for polished finish. Stainless steel tubes for structural and general engineering purposes shall comply with BS 6323:Parts 1 and 8, and shall have the same finish as for plate, sheet and strip.
- (6) Fixings shall be the same material and shall have the same finish as the material to be fixed.
- (7) Stud anchors and fixing bolts shall be a proprietary type of expanding bolt approved by the Engineer.
- (8) Polysulphide-based sealant shall be a one-pack gun-grade type complying with BS 5215.
- (9) Adhesive for bonding metal to wood or metal to metal shall be a proprietary type approved by the Engineer.
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DESIGN AND FABRICATION OF METAL WINDOWS AND DOORS

Steel windows and doors

- 25.153 (1) Steel windows and doors shall be designed and fabricated by the Contractor in accordance with BS 6510 and as stated in Clauses 25.153(2) to (12).

(2) Sections shall be 32 mm universal steel rolled medium or equivalent W20 sections, dovetail grooved for a weatherstrip when specified, and shall be hot rolled, cold straightened and free from rolling defects. Manufacturer's fabrication holes shall be sealed by welding before delivery to the Site.

(3) Frames shall be square and flat with mitred, welded corners and with glazing bars machine-tenoned or welded to frames.

(4) Water bars shall be welded to frames for the complete width of the window or door.

(5) Weather bars shall be welded to the heading of frames for the complete width of the window or door.

(6) Slotted adjustable lugs for building in windows and doors shall project at least 60 mm beyond the metal frames.

(7) Loose mullions and transoms to suit window or door openings shall have an additional 75 mm length at each end for building-in purposes.

(8) Mastic and bolts shall be used for assembly of composite units; mullions and transoms shall be bedded in mastic with all interstices completely filled.

(9) Windows shall be suitable for external glazing. Rolled steel heavy channel section glazing beading shall be 13 mm x 10 mm for windows and 20 mm x 10 mm for doors; the beading shall be mitred at corners and fixed with galvanized mild steel flat headed countersunk screws at centres not exceeding 225 mm. Frames shall be tapped to receive screws.

(10) Members shall be hot-dip galvanized in accordance with BS 729 or zinc sprayed to 0.2 mm nominal thickness in accordance with BS 2569:Part 1.

(11) Chloroprene rubber or polyvinyl chloride weatherstrips of a proprietary type approved by the Engineer shall be securely fixed into the dovetail groove in the window or door section to provide continuous contact between the opening casement and the fixed frame.

(12) Temporary steel clamps shall be provided at the top and bottom of opening lights of casements before transportation from the factory and shall be left in position until installation is complete.

***Fittings and furniture
to steel windows and
doors***

25.154 (1) Fittings and furniture to steel windows and doors shall be a proprietary type approved by the Engineer and shall comply with the requirements stated in Clause 25.154(2) to (13).

(2) Hinges shall be steel with brass pins and shall be welded or riveted to frames.

- (3) Fittings, including friction grip pivots, casement fasteners, spring catches, brackets, slide arms, shoes, slip bolts, cabin hooks and eyes, and handles shall be manganese brass with bronze finish and shall be capable of retaining the opening parts rigidly in both the open and closed positions.
- (4) Handle plates and round headed stay brackets shall be welded to the fixed frames and shall have interchangeable handles and stays.
- (5) Windows and doors which are to be hung to open shall be fitted with the fittings and furniture stated in Clause 25.154(6) to (11).
- (6) Side-hung casements and vertically centre-hung ventilators shall be fitted with a two-point nose fastener or a two throw casement fastener with mild steel adjustable connecting rod and a 250 mm peg stay or bronze sliding stay as stated in the Contract.
- (7) Projecting casements shall be fitted with bronze sliding shoes, pivots and friction side arms and one spring catch with a ring for hand or pole operation and two square-shank barrel bolts.
- (8) Top-hung ventilators shall be fitted with a 200 mm peg stay with a round-headed stay bracket welded to the fixed frame and with a second peg to secure the stay firmly and horizontally against the first peg when the ventilator is closed.
- (9) Bottom-hung ventilators shall be fitted with a spring catch and fanlight roller stay to limit opening and to permit the ventilator to swing free for cleaning.
- (10) Horizontally centre-hung ventilators shall be fitted with a spring catch with ring and eye for cord or pole operation.
- (11) Doors shall be fitted with sliding bolts of suitable length, striking plates at top and bottom, magnetic catch, panic bolt, three-lever mortice lock with two keys, lever or knob handles and escutcheon plates as stated in the Contract.
- (12) Flyscreens shall be extruded aluminium with plastic covered fibre-glass mosquito gauze with 7 x 7 mesh per 10 mm square. Side-hung casements for use with flyscreens shall have a locking handle and an opening and closing mechanism consisting of a bronze cam handle and bronze roto operator. Top-hung casements for use with flyscreens shall have bronze through-the-frame type stays.
- (13) Window poles shall be 25 mm diameter teak with a strong brass hook at one end suitable for opening and closing high windows.

***Aluminium windows
and doors***

- 25.155 (1) Aluminium windows and doors shall be designed and fabricated by the Contractor in accordance with BS 4873 and as stated in Clauses 25.155(2) to (13) and 25.156.

(2) Fixed windows and doors shall be capable of withstanding a wind load calculated in accordance with the 'Code of Practice on Wind Effects Hong Kong' with a minimum of 3 kPa with a permissible maximum deflection of less than $1/180^{\text{th}}$ of the length of the particular member. Mild steel cores, anchors, brackets and similar fittings shall be used as stiffeners where necessary.

(3) Sections shall be extruded aluminium alloy complying with BS 1470 and BS 1474, British alloy designation 6063; the sections shall have a wall thickness of at least 1.6 mm and shall be dovetail grooved for a weatherstrip.

(4) Aluminium sections shall be:

- (a) clear anodised in accordance with BS 1615, AA/20,
- (b) colour anodised in accordance with BS 3987, average 25 μm thick, or
- (c) treated with a proprietary type of hardcoat anodic finish approved by the Engineer with wearing qualities better than those stated in Clause 25.155(4)(a) and (b).

(5) Frames shall be mechanically jointed of mortice and tenon construction to provide rigid and secure connections. Sash members shall develop the full strength of other members using solid block angle pieces and shall provide a neat weathertight joint with adequate drainage in bottom members.

(6) Galvanized steel fixing lugs shall be provided at centres not exceeding 300 mm for outer frames of each unit. Lugs shall be fixed with rag-bolts or with proprietary stud anchors or fixing bolts of a type approved by the Engineer.

(7) Galvanized steel water bars shall be provided for the complete width of the window or door where the design requires.

(8) Mullions, transoms and corner posts in composite units shall have an additional 75 mm length at each end for building-in purposes. Mullions and transoms exceeding 1.5 m in length shall be reinforced with galvanized steel with extended ends for building-in purposes.

(9) Composite units shall be assembled on Site using all necessary bolts, screws and other fixings; joints shall be sealed with a proprietary type of sealant approved by the Engineer.

(10) Chloroprene rubber, plasticized PVC or nylon pile weatherstrips of a type approved by the Engineer shall be securely fixed into the dovetail groove in the window or door section to provide continuous contact between each opening part and its fixed frame.

(11) Windows and doors shall be suitable for internal glazing with a glazing system and aluminium beading of a type approved by the Engineer. Beading shall either form an integral part of the frame or shall be securely fixed to the frame.

(12) Aluminium alloy, stainless steel or nylon matching the surrounding finish shall be used for exposed fixings including screws, nuts, bolts, washers and rivets. Concealed fastening devices shall be galvanized or cadmium plated steel.

(13) Window and door units and other associated materials shall be wrapped in strong waterproof paper or polythene sheeting to protect against damp and scratching before transportation from the factory; the wrapping shall not be removed until installation starts.

***Fittings and furniture
to aluminium windows
and doors***

25.156 (1) Fittings and furniture to aluminium windows and doors shall be a proprietary type approved by the Engineer and shall comply with the requirements stated in Clause 25.156(2) to (14).

(2) Friction pivots and sliding stays shall be stainless steel capable of providing a maximum opening of 100° and with a minimum clearance of 100 mm between the frame and window for cleaning purposes.

(3) Casement fasteners, locking handles, spring catches, casement stays, brackets, slipbolts and similar fittings and furniture shall be either diecast zinc alloy complying with BS 1004 suitably coloured to match the anodised window or door metal or moulded stainless steel with satin finish.

(4) Locks shall be cadmium plated steel with stainless steel or brass parts.

(5) Pull handles shall be anodized aluminium.

(6) Rollers, guides and similar fittings shall be cadmium plated steel with nylon or brass rollers to suit the weight of the door or window and shall be adjustable after installation.

(7) Windows and doors which are to be hung to open shall be fitted with fittings and furniture as stated in Clause 25.156(8) to (11).

(8) Side and top hung windows shall be fitted with friction pivots, sliding stays, casement fastener or pull handle, and locking handle; casement fasteners and locking handles shall be dual where required.

(9) Sliding windows shall be fitted with rollers, guides and similar fittings, pull handle and stops and sliding bolts or locking mechanism. The window shall be constructed such that it cannot be lifted off its rollers without the removal of a safety device.

(10) Side hung doors shall be fitted with floor springs and adjustable top pivots, single or double action to stand open or not as stated in the Contract, mortice dead lock, top and bottom flush lever bolts and push plates and pull handles as required.

(11) Sliding doors shall be fitted with heavy duty rollers, guides and similar fittings, pull handle and stops, hook bolt locking latch and four bolts.

(12) Flyscreens shall be fitted on the inside surface with frames of extruded aluminium and plastic covered mosquito gauze of 7 x 7 mesh per 10 mm square. Screens shall be fixed to window frames by wing nuts. The windows shall be fitted with locking handles and an opening and closing mechanism comprising a cam handle and roto operator.

(13) All steel framework, cores, anchors and brackets shall be primed with zinc chromate primer complying with Clause 25.106 and painted with two coats of bituminous paint complying with Clause 25.111.

(14) Concealed aluminium or stainless steel surfaces which may come into contact with wet mortar, cement, plaster or similar materials shall be painted with one coat of bituminous paint complying with Clause 25.111. Exposed aluminium or stainless steel surfaces shall be protected with a strippable coating or masking tape which shall not be removed until instructed by the Engineer.

Roller shutters and doors

25.157 The design of roller shutters and doors, including boxes, hoods, guides and all other parts shall be carried out by the Contractor in accordance with the requirements stated in the Contract.

SUBMISSIONS

Particulars of metal windows and doors

25.158 (1) The following particulars of the proposed materials and methods of construction for metal windows and doors shall be submitted to the Engineer:

- (a) name and address of manufacturer,
- (b) manufacturer's literature, and
- (c) three sets of working drawings.

(2) The particulars shall be submitted to the Engineer at least 14 days before fabrication of the window or door starts.

Samples of materials

25.159 Samples of materials for metal windows and doors, including fittings and furniture, shall be submitted to the Engineer at the same time as particulars of the windows or doors are submitted. Details of the samples to be provided shall be as agreed by the Engineer.

Instruction manuals

25.160 Two copies of instruction manuals shall be provided for motorised roller shutters and doors. The manuals shall include detailed operating and maintenance instructions, including wiring and schematic drawings, a schedule of component parts and a priced list of recommended spares. The manuals shall be provided at the same time as the particulars of the roller shutters and doors are submitted.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of metal windows and doors

- 25.161 (1) Metal windows and doors shall be handled and stored in a manner which will not result in damage or distortion. Opening lights shall be kept closed.
- (2) Temporary steel clamps in steel windows and doors shall be left in position until installation is complete. Wrapping to aluminium windows and doors shall not be removed until installation starts.
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FIXING METAL WINDOWS AND DOORS

Fixing metal windows and doors

- 25.162 (1) Metal windows and doors which consist of composite units shall be assembled using all necessary bolts, screws and other fixings; joints shall be sealed using polysulphide-based sealant.
- (2) Windows and doors shall be positioned plumb, level and square.
- (3) Pockets shall be formed in heads, jambs, cills and other parts of structures to receive fixing lugs; the pockets shall be made good after building in the lugs and screws to frames. Frames shall be screwed using packing pieces where necessary.
- (4) Steel frames shall be bedded in mortar to form a waterproof seal.
- (5) Aluminium frames shall be bedded in a proprietary type of butyl mastic bedding compound approved by the Engineer to form a waterproof seal.
- (6) Joints around external edges of steel frames shall be raked out and pointed with a proprietary type of oil based mastic sealant approved by the Engineer to form a smooth, flat joint.
- (7) Joints around external edge of aluminium frames shall be raked out and pointed with polysulphide-based sealant to form a smooth, flat joint.
- (8) Adjoining surfaces to joints shall be temporarily masked to prevent contamination during pointing.
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PART 9 : MASONRY

MATERIALS

<i>Stone</i>	25.163	Stone for masonry shall be local granite and shall be free from defects which will adversely affect the strength or appearance of the masonry.
<i>Mortar</i>	25.164	Cement mortar for masonry shall be as stated in Clause 25.134.
<i>Wall ties</i>	25.165	Wall ties between masonry walls and concrete shall be galvanized mild steel flats; the ties shall be at least 40 mm wide, 3 mm thick and 150 mm long and shall be fanged at both ends.
<i>Damp proof course</i>	25.166	Damp proof course for masonry shall be as stated in Clause 25.132.

SUBMISSIONS

<i>Samples of materials</i>	25.167	Samples of the following proposed materials for masonry shall be submitted to the Engineer for approval of the source and type of each material at least 14 days before the masonry work starts: <ul style="list-style-type: none"> (a) each type of stone, (b) wall ties, and (c) damp proof course.
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TRIAL PANELS

<i>Trial panels</i>	25.168	A trial panel shall be constructed for each type of masonry as stated in Clauses 25.137 to 25.140 for brickwork and blockwork.
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HANDLING AND STORAGE OF MATERIALS

<i>Handling and storage of stone</i>	25.169	Stone for ashlar stone walling shall be transported with the minimum amount of handling and shall be stacked in the vehicle using packing pieces to prevent damage. The stone shall be stored in stacks on battens and protected from exposure to rain.
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RUBBLE STONE WALLING

<i>Preparation of stone for rubble stone walling</i>	25.170	(1) Stones for random rubble walling shall be irregular in shape and roughly cut to between 75 mm and 300 mm high, at least 75 mm deep and between 75 mm and 600 mm long on bed. The length or depth on bed of each stone shall be greater than the height.
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(2) Stones for squared rubble walling shall be trimmed roughly square to between 75 mm and 300 mm high, varying in 75 mm stages. Each stone shall be between 100 mm and 150 mm deep and between 100 mm and 600 mm long on bed. The length or depth on bed of each stone shall be greater than the height.

(3) Stones for square coursed rubble walling shall be trimmed roughly square as stated in Clause 25.170(2) to suit courses of regular height varying from 150 mm to 250 mm.

***Laying and jointing
rubble stone walling***

25.171 (1) Stones in rubble stone walling shall be laid dry on a full even bed of cement mortar; all joints shall be filled and shall be between 5 mm and 15 mm wide.

(2) Stones of random shapes and sizes in random rubble walling shall be bonded together over each face of the wall. Stones shall be selected and rough dressed to keep joint widths to a minimum. At least one bonding stone of minimum size 450 mm x 150 mm shall be provided and carried through the full thickness of the wall per square metre. Not more than 3 stones shall be provided adjacent to a vertical joint.

(3) Roughly squared stones of random sizes in square rubble walling shall be bonded together with continuous straight horizontal joints. The number of vertical joints shall be kept to a minimum.

(4) Roughly squared stones in square coursed walling shall be laid as stated in Clause 25.171(3) but brought up to courses at centres not exceeding 750 mm to line up with quoin and jamb stones.

(5) Squared rubble walling exceeding 300 mm thick and faced one side shall be constructed in accordance with the following requirements:

(a) Roughly squared stone at least 300 mm thick shall be provided with a backing of random rubble.

(b) At least two bonding stones per square metre shall be regularly spaced and carried through the full thickness of the wall or at least 450 mm into the backing, whichever is less.

(6) Squared rubble walling exceeding 300 mm thick and faced both sides shall be constructed in accordance with the following requirements:

(a) Roughly squared stone at least 150 mm thick shall be provided with a core of random rubble.

(b) Bonding stones shall be provided as stated in Clause 25.171(5) but shall be carried through the full thickness of the wall or 450 mm into the core.

***Pointing rubble stone
walling***

25.172 Joints in rubble stone walling shall be raked out to a depth of 15 mm as the work proceeds. The joints shall be pointed in cement mortar on completion with a flush, weathered or recessed joint as required.

ASHLAR STONE WALLING

<i>Preparation of stone for ashlar stone walling</i>	25.173	The exposed faces and joint faces of each stone for ashlar stone walling shall be dressed square and true, free from hollows or rough areas. Exposed faces shall be finished to a finely squared dressed surface. Stones shall be at least 300 mm high. Each stone shall be clearly marked to indicate its position in the finished work.
<i>Laying and jointing ashlar stone walling</i>	25.174	Stones in ashlar stone walling shall be laid on a full, even bed of mortar consisting of cement and fine crushed stone in the proportions 1:3 by volume. All joints shall be filled and shall be 5 mm wide. Stones shall be laid to bond together throughout the wall, and to the backing, using projecting bonding stones.
<i>Pointing ashlar stone walling</i>	25.175	Joints in ashlar stone walling shall be raked to a depth of 15 mm as the work proceeds and shall be pointed with a flush joint on completion using bedding mortar.

PROTECTION OF MASONRY

<i>Protection of masonry</i>	25.176	Newly erected masonry shall be protected from exposure to conditions which may adversely affect the masonry. Arrises, projections and similar features shall be covered with protective sheeting lapped and securely held in position. Facework shall be kept clean at all times.
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WALL TIES FOR MASONRY

<i>Wall ties for masonry</i>	25.177	<p>(1) Wall ties in masonry which is to face an existing or newly constructed wall shall be fixed at a rate of 5 per m². Ties shall be fixed 100 mm into the wall and 75 mm into the masonry.</p> <p>(2) Wall ties shall be fixed between the ends of walls and concrete or brickwork at centres of at least 450 mm vertically and shall project 250 mm into the masonry.</p>
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TOLERANCES

<i>Tolerances masonry</i>	25.178	<p>(1) Rubble stone walling shall comply with the following requirements:</p> <ul style="list-style-type: none"> (a) The position on plan shall be within 25 mm of the specified position. (b) The length shall be within 25 mm of the specified length. (c) The height shall be within 25 mm of the specified height. (d) The level of bed joints shall be within 25 mm of the specified level in any 5 m length.
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- (e) The walling shall be straight to within 25 mm in any 5 m length.
 - (f) The walling shall be vertical to within 20 mm in any 3 m height.
- (2) Ashlar stone walling shall comply with the following requirements:
- (a) The position on plan shall be within 15 mm of the specified position.
 - (b) The length shall be within 15 mm of the specified length.
 - (c) The height shall be within 10 mm of the specified height.
 - (d) The level of bed joints shall be within 10 mm of the specified level in any 5 m length.
 - (e) The walling shall be straight to within 15 mm in any 5 m length.
 - (f) The walling shall be vertical to within 15 mm in any 3 m height.
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