Building Technology Research Institute
香港建築科技研究院
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BTRi Product Specification for Civil Engineering Works

2025 Edition

BTRi Product Specification for Civil Engineering Works (BPS-CEW)

(This Version is Continuously Updated to include Amendments issued)

This Electronic File has incorporated the following Amendments:-

Rev	Issue Date	Amendment Incorporated
First Issue	29 September 2025	-

FOREWORD

The BTRi Product Specification for Civil Engineering Works (BPS-CEW) lays down the quality of products for civil engineering works under the Construction Products Accreditation Scheme (CPAS).

The First Edition of the BPS-CEW comprises mainly the standards and requirements of construction products making reference to the General Specification for Civil Engineering Works, 2020 Edition issued by Civil Engineering and Development Department (CEDD) and particular specifications of major civil engineering projects. It was produced under the guidance of the CPAS Technical Committee comprising members from the academia and consultants in the engineering industry.

The BTRi Product Specification for Civil Engineering Works will be updated continuously. The electronic files of the sections affected by any amendment issued will be kept up-to-date on CPAS Portal.

NOTES

Clauses of the BPS-CEW generally follow the naming and numbering of the General Specification (GS) for Civil Engineering Works, 2020 Edition. BPS-CEW includes clauses that define the technical standards of construction products and excludes/ strikethrough clauses on workmanship, on-site testing or project specific requirements that would not be considered at material approval stage. Additional clauses referenced from particular specifications of public works projects are marked with "*".

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

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SECTION 1

GENERAL

SECTION 1

GENERAL

Abbreviations 1.02 (1) The following list shows the meaning of the abbreviations for the common terms used in this GS but is not intended to be exhaustive:

AASHTO	American Association of State Highway and Transportation Officials
APHA	American Public Health Association
AWWA	American Water Works Association
ANSI	American National Standards Institute
AS/NZS	Australian/New Zealand Standards
ASTM	American Society for Testing and Materials
BQ	Bills of Quantities
BS	British Standards
BS EN	European Standard adopted as British Standards
BS EN ISO	European Standards (EN) & International Organization for Standardization for (ISO)'s Standards adopted as British Standards
CBR	California Bearing Ratio
CCTV	Closed circuit television
CD	Chart Datum (0.146 m below Principal Datum)
C & D	Construction and demolition
CI	Cast iron
CIPP	Lining with cured-in-place pipes
CP	British Standard Code of Practice
CS	Construction Standard issued by Standing Committee on Concrete Technology, HKSAR
CSF	Condensed Silica Fume
CSSM	Construction Site Safety Manual
DI	Ductile iron
DDF	Disposal Delivery Form
DFT	Dry film thickness
DN	Nominal size
dn	Nominal size of tees and tapers
DRS	Daily Record Summary
EM&A	Environmental Monitoring and Audit
EPD	Environmental Protection Department
ET	Environmental Team
FGL	Finished ground level, or finished level of the permanent works
GCC	General Conditions of Contract
GEO	Geotechnical Engineering Office, Civil Engineering and Development Department
GI	Galvanized iron
GGBS	Ground Granulated Blastfurnace Slag
GS	General Specification for Civil Engineering Works
HDPE	High-density polyethylene

HKSAR	Hong Kong Special Administrative Region
HOKLAS	Hong Kong Laboratory Accreditation Scheme
HSFG	High strength friction grip
ISO	International Organisation for Standardization
JIS	Japanese Industrial Standards
LPG	Liquefied petroleum gas
PC	Portland cement
PD	Principal Datum
PE	Polyethylene
PFA	Pulverised-fuel ash
PFAC	Portland fly ash cement
PFC	Public Fill Committee
ppm	parts per million
PS	Particular Specification
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QPME	Quality Powered Mechanical Equipment
QSPSC	Quality Scheme for the Production and Supply of Concrete
RAP	Reclaimed asphalt pavement
SCC	Special Conditions of Contract
SIS	Swedish Standards
SMM	Standard Method of Measurement for Civil Engineering Works
SRPC	Sulphate resisting Portland cement
TTS	Trip-ticket system
ULSD	Ultra-low-sulphur diesel
uPVC	unplasticised polyvinyl chloride
VHS	Video Home System
VOC	Volatile Organic Compound
WIS	Water Industry Specification, Water Research Centre

(2) The following list shows the meaning of the abbreviations for the units used in this GS but is not intended to be exhaustive:

°C	degrees Celsius
dB	decibels
g	gram
g/mL	gram(s) per millilitre
g/m^2	gram(s) per square metre
ha	hectare
hr	hour
Hz	hertz
J	joule
kg	kilogram
kHz	kilohertz
kJ	kilojoule
km	kilometre
km/hr	kilometre(s) per hour
kN	kiloNewton
kPa	kiloPascal
kV	kiloVolt

kW	kiloWatt
L	litre
L/min	litre(s) per minute
L/s	litre(s) per second
m	metre
m^2	square metre
m^3	cubic metre
m/s	metre(s) per second
Mg	megagram
Mg/m^3	megagram(s) per cubic metre
min	minute
mL	millilitre
mm	millimetre
mm^2	square millimetre
mm^3	cubic millimetre
mm/s	millimetre(s) per second
MPa	megaPascal
N	Newton
N/mm	Newton(s) per millimetre
N/m^2	Newton(s) per square metre
No.	number
NTU	nephelometric turbidity units
Pa.s	Pascal(s) second
r/min	revolution(s) per minute
r/s	revolution(s) per second
s	second
t	tonne
μm	micrometer (micron)
%	percentage

Glossary of terms 1.03 (1) Words and expressions to which meanings are assigned in any section of the GS shall have the same meanings in other sections of the GS except when the context otherwise requires.

(2) Utilities are the installations (including cables, ducts and pipes) used to supply or provide electricity, lighting, traffic control, telecommunications, cable television, gas, water, drainage, sewerage and tramway, including all associated protection, supports, ancillary structures, fittings and equipment.

British Standards, European Standards adopted as British Standards, Codes of Practice and other standards 1.05 (1) Unless otherwise stated in the Contract, reference in this GS to British Standards, European Standards adopted as British Standards, British Standard Codes of Practice and similar standards shall be to that edition of the document stated in Appendix 1.1 of this Section which shall be deemed to include all amendments/corrigenda issued or published on or before the original date set for close of tender.

(2) Later editions of British Standards, European Standards adopted as British Standards, British Standard Codes of Practice and other similar standards, or standards which are considered to be equivalent, shall not apply unless approved by the Engineer. The Engineer shall not be bound to give or withhold his approval until the Contractor has provided him with a legal copy of the relevant standard for information. If approval is obtained, the Contractor shall provide two legal copies of the document for use by the Engineer.

Specifications in metric and imperial units 1.06 (1) Specifications in imperial units shall not be substituted for specifications in metric units stated in the Contract unless approved by the Engineer.

(2) Conversion of metric units to imperial units and of imperial units to metric units shall be in accordance with the Hong Kong Government Metric Reference Guidebook.

APPENDIX 1.1

STANDARDS

1.1.1 ***British Standards***

BS 144:1990	Wood preservation using coal tar creosotes
BS 373:1957 (1986)	Methods of testing small clear specimens of timber
BS 381C:1996	Specification for colours for identification, coding and special purposes
BS 416:1990	Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron
BS 434:Part 2:2006	Bitumen road emulsions. Code of practice for the use of cationic bitumen emulsions on roads and other paved areas
BS 718:1991	Specification for density hydrometers
BS 743:1970	Specification for materials for damp-proof courses
BS 864:Part 2:1983	Specification for capillary and compression fittings for copper tubes
BS 882:1992	Specification for aggregates from natural sources for concrete
BS 903	Physical testing of rubber
- BS 903:Part A18:1973 (1985)	Determination of equilibrium water vapour absorption
BS 952	Glass for glazing
- BS 952:Part 1:1995	Classification
- BS 952:Part 2:1980	Terminology for work on glass
BS 1070:1993	Specification for black paint (tar-based)
BS 1052:1980 (1999)	Specification for mild steel wire for general engineering purposes
BS 1161:1977 (1984)	Specification for aluminium alloy sections for structural purposes
BS 1203:2001	Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method
BS 1336:1971 (1988)	Specification for knotting
BS 1377 (as modified in accordance with Geospec 3, entitled "Model Specification for Soil Testing")	Methods of test for soils for civil engineering purposes
- BS 1377:Part 1:1990	General requirements and sample preparation

- BS 1377:Part 3:1990	Chemical and electrochemical tests
- BS 1377:Part 4:1990	Compaction-related tests
- BS 1377:Part 9:1990	In-situ tests
BS 1387:1985 (1990)	Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads
BS 1449:Part 1.1:1991	Steel plate, sheet and strip. Carbon and carbon-manganese plate, sheet and strip. General specification
BS 1473:1972	Specification for wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock
BS 1494:Part 2:1967	Sundry fixings
BS 1722:Part 1:1986	Specification for chain link fences
BS 1722:Part 16: 2009	Fences. Specification for powder coatings used as a plastics finish to components and mesh
BS 1740:Part 1:1971 (1990)	Specification for wrought steel pipe fittings (screwed BS 21 R-series thread)
BS 1924:Part 2:2018	Hydraulically bound and stabilized materials for civil engineering purposes. Sample preparation and testing of materials during and after treatment
BS 2015:1992	Glossary of paint and related terms
BS 2456:1990	Specification for floats (plastics) for float operated valves for cold water services
BS 2499	Hot-applied joint sealant systems for concrete pavements
- BS 2499:Part 1:1993	Specification for joint sealants
- BS 2499:Part 2:1992	Code of practice for the application and use of joint sealants
- BS 2499:Part 3:1993	Hot-applied joint sealant systems for concrete pavements. Methods of test
BS 2523:1966 (1983)	Specification for lead-based priming paints
BS 2633:1987	Specification for Class I arc welding of ferritic steel pipework for carrying fluids
BS 2648:1955	Performance requirements for electrically-heated laboratory drying ovens
BS 2782	Methods of testing plastics
- BS 2782:Part 3: Methods 320A to 320F:1976	Tensile strength, elongation and elastic modulus

- BS 2782:Part 3: Method 365A:1976 (1989)	Determination of softness number of flexible plastics materials
- BS 2782:Part 10:Method 1005:1977 (U.K. national version of European Standard EN 63:1977 with identical text)	Methods of testing plastics. Glass reinforced plastics. Determination of flexural properties. Three point method.
- BS 2782:Part 6:Method 630A:1994	Methods of testing plastics. Dimensional properties. Determination of thickness by mechanical scanning of flexible sheet
- BS 2782:Part 6:Method 631A:1993	Methods of testing plastics. Dimensional properties. Determination of gravimetric thickness and yield of flexible sheet
-BS 2846:Part 4:1976 (1985)	Techniques of estimation and tests relating to means and variances
BS 3262:Part 3:1989	Specification for application of material to road surfaces
BS 3416:1991 with AMD 7288	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 3506:1969	Specification for unplasticized PVC pipe for industrial uses
BS 3692:1967	Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units
BS 3698:1964 (1979)	Specification for calcium plumbate priming paints
BS 3900	Methods of test for paints
- BS 3900:Part G6:1989 (2000)	Assessment of resistance to fungal growth
BS 3921:1985	Specification for clay bricks
BS 3987:1974	Specification for anodic oxide coatings on wrought aluminium for external architectural applications
BS 3998:2010	Recommendations for tree work
BS 4019:1993	Rotary core drilling equipment
BS 4072:1987	Wood preservation by means of copper/chromium/ arsenic compositions
BS 4190:2014	Specification for ISO metric black hexagon bolts, screws and nuts
BS 4211:2005 + A1:2008	Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS 4254:1983	Specification for two-part polysulphide-based sealants
BS 4320:1968	Specification for metal washers for general engineering purposes. Metric series
BS 4346	Joints and fittings for use with unplasticized PVC pressure pipes

- BS 4346:Part 1:1969	Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply
BS 4449:2005	Steel for the reinforcement of concrete – Weldable reinforcing steel – Bar, coil and decoiled product - Specification
BS 4482:2005	Steel wire for the reinforcement of concrete products - Specification
BS 4483:2005	Steel fabric for the reinforcement of concrete - Specification
BS 4486:1980	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 4514:2001	Specification for unplasticized PVC soil and ventilating pipes, fittings and accessories
BS 4515:1984	Specification for welding of steel pipelines on land and offshore
BS 4515-1:2009	Specification for welding of steel pipelines on land and offshore. Carbon and carbon manganese steel pipelines
BS 4622:1970 (1983)	Specification for grey iron pipes and fittings
BS 4652:1995 Incorporating Amd No. 1	Specification for metallic zinc-rich priming paint (organic media)
BS 4660:2000	Thermoplastics ancillary fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage
BS 4756:1998	Specification for ready-mixed aluminium priming paints for woodwork
BS 4873:2016	Thermal spraying. Metallic and other inorganic coatings. Zinc, aluminium and their alloys
BS 4933:2010	Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts
BS 5154:1991	Specification for copper alloy globe, globe stop and check, check and gate valves
BS 5163:1986	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
BS 5163-1:2004	Valves for waterworks purposes. Predominantly key-operated cast iron gate valves. Code of Practice
BS 5163-2:2004	Valves for waterworks purposes. Stem caps for use on isolating valves and associated water control apparatus. Specification
BS 5252F:1976 (2004)	Framework for colour co-ordination for building purpose: colour matching fan
BS 5255:1989	Specification for thermoplastics waste pipe and fittings
BS 5262:1991	Code of practice for external renderings

BS 5270-1:1989	Bonding agents for use with gypsum plasters and cement. Specification for polyvinyl acetate (PVAC) emulsion bonding agents for indoor use with gypsum building plasters
BS 5284:1993	Methods of sampling and testing mastic asphalt used in building and civil engineering
BS 5385-1:2009	Wall and floor tiling. Design and installation of ceramic, natural stone and mosaic wall tiling in normal internal conditions. Code of practice
BS 5385-2:2015	Wall and floor tiling. Design and installation of external ceramic, natural stone and mosaic wall tiling in normal conditions. Code of practice
BS 5395:Part 1:2010	Code of practice for the design of straight stairs
BS 5493:1977	Code of practice for protective coating of iron and steel structures against corrosion
BS 5572:1994	Code of practice for sanitary pipework
BS 5589:1989	Code of practice for preservation of timber
BS 5606:1990	Guide to accuracy in building
BS 5756: 2007+A2:2017	Visual strength grading of temperature hardwood. Specification
BS 5835:Part 1:1980	Compactability test for graded aggregates.
BS 5896:2012	Specification for high tensile steel wire and strand for the prestressing of concrete
BS 5911:Part 1:2002+A2:2010	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints
BS 5911:Part 3:2002 + A1:2014	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete manholes and soakaways
BS 5911:Part 4:2002 + A2:2010	Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete inspection chambers
BS 5911:Part 6:2004+ A1:2010	Specification for road gullies and gully cover slabs
BS 5930:1981	Code of practice for site investigations
BS 5931:1980	Code of practice for machine laid in situ edge details for paved areas
BS 5980:1980	Specification for adhesive for use with ceramic tiles and mosaics
BS 61502006+A1:2014	Painting of buildings. Code of practice
BS 6349-1-4:2013	Maritime works. General. Code of practice for materials

BS 6362:1990	Specification for stainless steel tubes suitable for screwing in accordance with BS 21 `Pipe threads for tubes and fittings where pressure-tight joints are made on the threads'
BS 6398:1983	Specification for bitumen damp-proof courses for masonry
BS 6405:1984	Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: class 1 and 2
BS 6510:2010	Steel-frame windows and glazed doors. Specification
BS 6515:1984	Specification for polyethylene damp-proof courses for masonry
BS 6699:1992	Specification for ground granulated blastfurnace slag for use with Portland cement
BS 6700:1987	Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their cartilages
BS 6744:2001+A2:2009	Stainless steel bars for the reinforcement of and use in concrete. Requirements and test methods
BS 6779:Part 1:1998	Highway parapets for bridges and other structures. Specification for vehicle containment parapets of metal construction
BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water
- BS 6920:Part 1:2014	Specification
- BS 6920:Part 2	Methods of test
- BS 6920-2.1:2014	Samples for testing
- BS 6920:Section 2.2	Odour and flavour of water
- BS 6920:Subsection 2.2.1:2000+A3:2014	General method of test
- BS 6920:Subsection 2.2.2:2000+A1:2014	Method of testing odours and flavours imparted to water by multi-layered hoses and pipes
- BS 6920:Subsection 2.2.3:2000+A2:2014	Method of testing tastes imparted to water by hoses for conveying water for food and drink preparation
- BS 6920:Section 2.3:2000+A1:2014	Appearance of water
- BS 6920:Section 2.4:2000+A1:2014	Growth of aquatic micro-organisms test
- BS 6920:Section 2.5:2000+A2:2014	The extraction of substances that may be of concern to public health
- BS 6920:Section 2.6:2000+A2:2014	The extraction of metals

- BS 6920:Part 3:2000	High temperature tests
BS 6925:1988	Specification for mastic asphalt for building and civil engineering (limestone aggregate)
BS 6949:1991	Specification for bitumen-based coatings for cold application, excluding use in contact with potable water
BS 7671:2018+A1:2020	Requirements for Electrical Installations. IET Wiring Regulations
BS 8000:1989	Workmanship on Building Sites
BS 8000-0:2014	Workmanship on construction sites. Introduction and general principles
BS 8000-7:1990	Workmanship on building sites. Code of practice for glazing
BS 8000-12:1989	Workmanship on building sites. Code of practice for decorative walkcoverings and painting
BS 8215:1991	Code of practice for design and installation of damp-proof courses in masonry construction
BS 8217:2005	Reinforced bitumen membranes for roofing. Code of practice
BS 8442:2015	Miscellaneous road traffic signs and devices. Requirements and test methods
BS 8481:2006	Design, preparation and application of internal gypsum, cement and lime plastering systems. Specification
BS 8666:2005	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification
BS 594987:2015 + A1:2017	Asphalt for roads and other paved areas. Specification for transport, laying, compaction and product type testing protocols
PD CLC/TR 50426:2004	Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio-frequency radiation. Guide

1.1.2 *American Society for Testing and Materials (ASTM) Standards*

ASTM C939 / C939M-16a	Standard Test Method of Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C 940-98a	Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C979 / C979M	Standard Specification for Pigments for Integrally Colored Concrete

ASTM C1028-89	Standard test method for determining the static coefficient of friction of ceramic tile and other like surfaces by the horizontal dynamometer pull-meter method
ASTM C1036-16	Standard Specification for Flat Glass
ASTM D5-13	Standard Test Method for Penetration of Bituminous Materials
ASTM D562-10	Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer
ASTM D113-07	Standard Test Method for Ductility of Bituminous Materials
ASTM D140-16	Standard Practice for Sampling Asphalt Materials
ASTM D242-14	Specification for mineral filler for bituminous paving mixtures
ASTM D546-17	Standard test method for sieve analysis of mineral filler for bituminous paving mixtures
ASTM D790-15e2	Measurement/Properties of internal lining for repair of pipelines and culverts: Flexural properties
ASTM D946-15	Specification for penetration-graded asphalt cement for use in pavement construction
ASTM D979-15	Methods for sampling bituminous paving mixtures
ASTM D562-10	Standard test method for consistency of paints measuring krebs unit (KU) viscosity using a stormer-type viscometer
ASTM D1754-14	Test method for effect of heat and air on asphaltic materials (thin-film over test)
ASTM D2000-12	Classification system for rubber products in automobile applications
ASTM D2027-13	Specification for cutback asphalt (medium-curing type)
ASTM D2041-11	Test method for theoretical maximum specific gravity and density of bituminous paving mixtures
ASTM D2042-15	Test method for solubility of asphalt materials in trichloroethylene
ASTM D2171-10	Test method for viscosity of asphalts by vacuum capillary viscometer
ASTM D2172-17	Test method for quantitative extraction of asphalt binderfrom asphalt mixtures
ASTM D2240	Standard test method for rubber property - durometer hardness
ASTM D2486-17	Standard test method for scrub resistance of wall paints
ASTM D2671-13	Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use

ASTM D2726-14	Test method for bulk specific gravity and density of non-absorptive compacted bituminous mixtures using saturated surface-dry specimens
ASTM D3203-17	Test method for percent air voids in compacted asphalt mixtures
ASTM D3289-17	Test method for density of semi-solid and solid bituminous materials by nickel crucible
ASTM D3359	Standard test methods for measuring adhesion by tape test
ASTM D4329	Standard practice for fluorescent UV exposure of plastics
ASTM D6307-16	Standard test method for asphalt content of asphalt mixture by ignition method
ASTM D4956-16b	Standard Specification for Retroreflective Sheeting for Traffic Control
ASTM D5444-15	Standard Test Method for Mechanical Size Analysis of Extracted Aggregate
ASTM G53-88	Practice for operating light and water-exposure apparatus (fluorescent UV-condensation type) for exposure of non-metallic materials
ASTM G154-06	Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

1.1.3 *American Association of State Highway and Transportation Officials (AASHTO) Standard*

AASHTO Designation M252-18	Standard Specification for Corrugated Polyethylene Drainage Tubing
AASHTO Designation M320-16	Standard Specification for Performance-Graded Asphalt Binder
AASHTO Designation T48-06 (2015)	Standard Method of Test for Flash and Fire Points by Cleveland Open Cup
AASHTO Designation T240-13	Standard Method of Test for Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
AASHTO Designation T315-12 (2016)	Standard Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
AASHTO Designation T316-13	Standard Method of Test for Viscosity Determination of Asphalt Binder Using Rotational Viscometer

1.1.4 *American Water Works Association (AWWA) Standards/ American National Standards Institute (ANSI)*

AWWA C 203-15	Coal-Tar Protective Coatings and Linings for Steel Water Pipes
ANSI/AWWA C210-15	Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings
ANSI/AWWA C213-15	Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipelines
ANSI A108-A118-A136.1:2019	American National Specifications for the Installation of Ceramic Tile
ANSI A118.6:1992	Ceramic tile grouts

1.1.5 *Construction Standards of the Government of the HKSAR*

CS1:2010	Testing Concrete
CS2:2012	Steel Reinforcing Bars for the Reinforcement of Concrete
CS3:2013	Aggregates for Concrete

1.1.6 *American Public Health Association (APHA) Standards*

APHA 4500-Cl-B, 21st Edition (2005)	Chloride, Argentometric method
APHA 4500-SO42-C, 21st Edition (2005)	Sulphate, gravimetric method with ignition of residue

1.1.7 *European Standards Adopted as British Standards (BS EN)*

BS EN 196-1:2005	Method of testing of Cement – Part 1: Determination of strength
BS EN 196-2:2005	Method of testing of Cement – Part 2: Chemical analysis of cement
BS EN 196-3:2005+A1:2008	Method of testing of Cement – Part 3: Determination of setting times and soundness
BS EN 196-6:2010	Method of testing of Cement – Part 6: Determination of fineness
BS EN 196-7:2007	Method of testing of Cement – Part 7: Methods of taking and preparing samples of cement
BS EN 197-1:2011	Cement – Part 1: Composition, specifications and conformity criteria for common cements

BS EN 200:2008	Sanitary tapware. Single taps and combination taps for water supply systems of type 1 and type 2. General technical specification
BS EN 295-1:2013	Vitrified clay pipe systems for drains and sewers. Requirements for pipes, fittings and joints
BS EN 295-2:2013	Vitrified clay pipe systems for drains and sewers. Evaluation of conformity and sampling
BS EN 295-3:2012	Vitrified clay pipe systems for drains and sewers. Test methods
BS EN 301:2017	Adhesives, phenolic and aminoplastic, for load-bearing timber structures. Classification and performance requirements
BS EN 302:2017	Adhesives for load-bearing timber structures
BS EN 338-2016	Structural Timber – Strength Classes
BS EN 445:2007	Grout for prestressing tendons. Test methods
BS EN 450:Part 1:2012	Fly ash for concrete. Definition, specifications and conformity criteria
BS EN 459-1:2015	Building lime. Definitions, specifications and conformity criteria
BS EN 480-12:2005	Admixtures for Concrete, Mortar and Grout – Test Methods Part 12: Determination of the Alkali Content of Admixtures
BS EN 485	Aluminium and aluminium alloys. Sheet, strip and plate
BS EN 485:Part 1:2016	Aluminium and aluminium alloys. Sheet, strip and plate. Technical conditions for inspection and delivery
BS EN 485:Part 2:2016+A1:2018	Aluminium and aluminium alloys. Sheet, strip and plate. Mechanical properties
BS EN 485:Part 3:2003	Aluminium and aluminium alloys. Sheet, strip and plate. Tolerances on dimensions and form for hot-rolled products
BS EN 485:Part 4:1994	Aluminium and aluminium alloys. Sheet, strip and plate. Tolerances on shape and dimensions for cold-rolled products
BS EN 515:2017	Aluminium and aluminium alloys. Wrought products. Temper designations
BS EN 545:2006	Ductile iron pipes, fittings, accessories and their joints for water pipelines. Requirements and test methods
BS EN 573-1:2004	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Numerical designation system
BS EN 573-2:1995	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Chemical symbol based designation system

BS EN 573-3:2019	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Chemical composition and form of products
BS EN 573-5:2007	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Codification of standardized wrought products
BS EN 598:2007+A1:2009	Ductile iron pipes, fittings, accessories and their joints for sewerage applications – Requirements and test methods
BS EN 607:2004	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing
BS EN 681-1:1996	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Vulcanized rubber
BS EN 754	Aluminium and aluminium alloys. Cold drawn rod/bar and tube
BS EN 754:Part 1:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Technical conditions for inspection and delivery
BS EN 754:Part 2:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Mechanical properties
BS EN 754:Part 3:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Round bars, tolerances on dimensions and form
BS EN 754:Part 4:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Square bars, tolerances on dimensions and form
BS EN 754:Part 5:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Rectangular bars, tolerances on dimensions and form
BS EN 754:Part 6:2008	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Hexagonal bars, tolerances on dimensions and form
BS EN 754:Part 7:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Seamless tubes, tolerances on dimensions and form
BS EN 754:Part 8:2016	Aluminium and aluminium alloys. Cold drawn rod/bar and tube. Porthole tubes, tolerances on dimensions and form
BS EN 755	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles
BS EN 755:Part 1:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Technical conditions for inspection and delivery
BS EN 755:Part 2:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Mechanical properties
BS EN 755:Part 3:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Round bars, tolerances on dimensions and form

BS EN 755:Part 4:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Square bars, tolerances on dimensions and form
BS EN 755:Part 5:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Rectangular bars, tolerances on dimensions and form
BS EN 755:Part 6:2008	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Hexagonal bars, tolerances on dimensions and form
BS EN 755:Part 7:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Seamless tubes, tolerances on dimensions and form
BS EN 755:Part 8:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Porthole tubes, tolerances on dimensions and form
BS EN 755:Part 9:2016	Aluminium and aluminium alloys. Extruded rod/bar, tube and profiles. Profiles, tolerances on dimensions and form
BS EN 816:2017	Sanitary tapware. Automatic shut-off valves PN 10
BS EN 818:Part 1:1996 + A1:2008	Short link chain for lifting purposes. Safety. General conditions of acceptance
BS EN 932-1:1997	Tests for general properites of aggregates. Methods for sampling
BS EN 932-6:1999	Tests for general properties of aggregates. Definitions of repeatability and reproducibility
BS EN 933-7:1998	Tests for geometrical properties of aggregates. Determination of shell content. Percentage of shells in coarse aggregates
BS EN 934:Part 2:2009+A1:2012	Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labeling
BS EN 934:Part 4:2009	Admixtures for concrete, mortar and grout. Admixtures for grout for prestressing tendons. Definitions, requirements, conformity, marking and labeling
BS EN 1008:2002	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
BS EN 1011-2:2001	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels
BS EN 1011:Part 4:2000	Welding. Recommendations for welding of metallic materials. Arc welding of aluminium and aluminium alloys
BS EN 1015-2:1999	Methods of test for mortar for masonry. Bulk sampling of mortars and preparation of test mortars
BS EN 1074-1:2000	Valves for water supply. Fitness for purpose requirements and appropriate verification tests. General requirements
BS EN 1074-2:2000	Valves for water supply. Fitness for purpose requirements and appropriate verification tests. Isolating valves

BS EN 1090:Part 2:2018	Execution of steel structures and aluminium structures. Technical requirements for steel structures
BS EN 1090:Part 3:2019	Execution of steel structures and aluminium structures. Technical requirements for aluminium structures
BS EN 1092-1:2018	Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated Part 1: Steel flanges
BS EN 1092-2:1997	Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated Part 2. Cast iron flanges
BS EN 1097-8: 2020	Tests for mechanical and physical properties of aggregates. Determination of the polished stone value
BS EN 1171:2015	Industrial valves — Cast iron gate valves
BS EN 1286:1999	Sanitary tapware. Low pressure mechanical mixing valves. General technical specification
BS EN 1287:2017	Sanitary tapware. Low pressure thermostatic mixing valves. General technical specification
BS EN 1329-1:2014	Plastics piping systems for soil and waste discharge (low and high temperature) within the building structure. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 1337	Structural bearings
BS EN 1337:Part 1:2000	Structural bearings. General design rules
BS EN 1337:Part 2:2004	Structural bearings. Sliding elements
BS EN 1337:Part 3:2005	Structural bearings. Elastomeric bearings
BS EN 1337:Part 4:2004	Structural bearings. Rollar bearings
BS EN 1337:Part 5:2005	Structural bearings. Pot bearings
BS EN 1337:Part 6:2004	Structural bearings. Rocker bearings
BS EN 1337:Part 7:2004	Structural bearings. Spherical and cylindrical PTFE bearings
BS EN 1337:Part 8:2007	Structural bearings. Guide bearings and restraint bearings
BS EN 1337:Part 9:1998	Structural bearings. Protection
BS EN 1337:Part 10:2003	Structural bearings. Inspection and maintenance
BS EN 1337:Part 11:1998	Structural bearings. Transport, storage and installation
BS EN 1338:2003	Concrete paving blocks. Requirements and test methods

BS EN 1339:2003	Concrete paving flags. Requirements and test methods
BS EN 1342:2012	Setts of natural stone for external paving. Requirements and test methods
BS EN 1344:2013	Clay pavers. Requirements and test methods
BS EN 1346:2007	Adhesives for tiles. Determination of open time
BS EN 1348:2007	Adhesives for tiles. Determination of tensile adhesion strength for cementitious adhesives
BS EN 1367-2:2009	Tests for thermal and weathering properties of aggregates. Magnesium sulfate test
BS EN 1401-1:2009	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 1423:2012	Road marking materials. Drop on materials. Glass beads, antiskid aggregates and mixtures of the two
BS EN 1424:1998	Road marking materials. Premix glass beads
BS EN 1427:2015	Bitumen and bituminous binders. Determination of the softening point. Ring and Ball method
BS EN 1436:2018	Road marking materials. Road marking performance for road users
BS EN 1462:2004	Brackets for eaves gutters. Requirements and testing
BS EN 1463:Part 1:2009	Road marking materials. Retroreflecting road studs. Initial performance requirements
BS EN 1463:Part 2:2000	Road marking materials. Retroreflecting road studs. Road test performance specifications
BS EN 1514-1:1997	Flanges and their joints. Dimensions of gaskets for PN-designated flanges. Non-metallic flat gaskets with or without inserts
BS EN 1561:2011	Founding. Grey cast irons
BS EN 1562:2012	Founding – Malleable cast irons
BS EN 1563:2011	Founding – Spheroidal graphite cast irons
BS EN 1774:1997	Zinc and zinc alloys. Alloys for foundry purposes. Ingot and liquid
BS EN 1871:2000	Road marking materials. Physical properties
BS EN 1916:2002	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
BS EN 1917:2002	Concrete manholes and inspection chambers, unreinforced, steel fibre and reinforced

BS EN 1982:2008	Specification for Copper and copper alloys — Ingots and castings
BS EN 1992	Eurocode 2: Design of concrete structures
BS EN 1992:Part 1-1:2004 + A1:2014	Eurocode 2: Design of concrete structures. General rules and rules for rules for buildings
BS EN 1992: Part 2:2005	Eurocode 2: Design of concrete structures. Concrete bridges. Design and detailing rules
BS EN 1993-1-1:2005	Design of Steel Structures : General rules and rules for buildings
BS EN 1993-1-5:2006	Design of Steel Structures : Plated structural elements
BS EN 1993-1-6:2007	Design of Steel Structures : Strength and stability of shell structures
BS EN 1993-1-7:2007	Design of Steel Structures : Plate structure subject to out of plane loading
BS EN 1993-1-8:2005	Design of Steel Structures : Design of joints
BS EN 1993-1-9:2005	Design of Steel Structures : Fatigue
BS EN 1993-1-10:2005	Design of Steel Structures : Material toughness and through-thickness properties
BS EN 1993-1-11:2006	Design of Steel Structures : Design of structures with tension components
BS EN 10025	Hot rolled products of structural steels
BS EN 10025:Part 1:2004	Hot rolled products of structural steels. General technical delivery conditions
BS EN 10025:Part 2:2019	Hot rolled products of structural steels. Technical delivery conditions for non-alloy structural steels
BS EN 10025:Part 3:2004	Hot rolled products of structural steels. Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
BS EN 10025:Part 4:2004	Hot rolled products of structural steels. Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
BS EN 10025:Part 5:2004	Hot rolled products of structural steels. Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
BS EN 10025:Part 6: 2004 + A1:2009	Hot rolled products of structural steels. Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition

BS EN 10029:2010	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above
BS EN 10051:2010	Continuously hot-rolled strip andplate/sheet cut from wide strip of non-alloy and alloy steels. Tolerances on dimensions and shape
BS EN 10056	Structural steel equal and unequal leg angles
BS EN 10056:Part 1:2017	Structural steel equal and unequal leg angles. Dimensions
BS EN 10056:Part 2:1993	Specification for structural steel equal and unequal angles. Tolerances on shape and dimensions
BS EN 10084:2008	Case hardening steels. Technical delivery conditions
BS EN 10085:2001	Nitriding steel. Technical delivery conditions
BS EN 10087:1999	Free cutting steels. Technical delivery conditions for semi-finished products, hot rolled bars and rods
BS EN 10088-1:2005	Stainless steels. List of stainless steels
BS EN 10088:Part 2:2014	Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
BS EN 10088:Part 4:2009	Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes
BS EN 10095:1999	Heat resisting steels and nickel alloys
BS EN 10143:2006	Continuously hot-dip coated steel sheet and strip. Tolerances on dimensions and shape
BS EN 10149:Part 3:2013	Specification for hot-rolled flat products made of high yield strength steels for cold forming. Delivery conditions for normalized or normalized rolled steels
BS EN 10160:1999	Ultrasonic testing of steel flat products made of high yield strength steels for cold forming. Delivery conditions for normalized or normalized rolled steels
BS EN 10164:2018	Steel products with improved deformation properties perpendicular to the surface of the product. Technical delivery conditions
BS EN 10210	Hot finished structural hollow sections of non-alloy and fine grain steels
BS EN 10210:Part 1:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Technical delivery requirements
BS EN 10210:Part 2:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties

BS EN 10214:2000	Steel threaded pipe fittings
BS EN 10220:2002	Seamless and welded steel tubes. Dimensions and masses per unit length
BS EN 10223:Part 2:2012	Steel wire and wire products for fencing and netting. Hexagonal steel wire netting for agricultural, insulation and fencing purposes
BS EN 10224:2002	Non-alloy steel tubes and fittings for the conveyance of water and other aqueous liquids. Technical delivery conditions
BS EN 10226	Pipe threads where pressure tight joints are made on the threads
BS EN 10226:Part 1:2004	Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation
BS EN 10226:Part 2:2005	Pipe threads where pressure tight joints are made on the threads. Taper external threads and taper internal threads. Dimensions, tolerances and designation
BS EN 10226:Part 3:2005	Pipes threads where pressure-tight joints are made on the threads. Verification by means of limit gauges
BS EN 10244-2:2009	Steel wire and wire products. Non-ferrous metallic coatings on steel wire. Zinc or zinc alloy coatings
BS EN 10250-4:2000	Open steel die forgings for general engineering purposes. Stainless steels
BS EN 10255:2004	Non-alloy steel tubes suitable for welding and threading. Technical delivery conditions
BS EN 10293:2015	Steel castings for general engineering uses
BS EN 10296-2:2005	Welded circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Stainless steel
BS EN 10297:Part 1:2003	Seamless circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Non-alloy and alloy steel tubes
BS EN 10298:2005	Steel tubes and fittings for onshore and offshore pipelines. Internal lining with cement mortar
BS EN 10300:2005	Steel tubes and fittings for onshore and offshore pipelines – bituminous hot applied materials for external coating
BS EN 10312:2002	Welded stainless steel tubes for the conveyance of aqueous liquids including water for human consumption. Technical delivery conditions
BS EN 10365:2017	Hot rolled steel channels, I and H sections. Dimensions and masses

BS EN 12004:2001	Adhesives for tiles. Definitions and specifications
BS EN 12004-1:2017	Adhesives for ceramic tiles. Requirements, assessment and verification of constancy of performance, classification and marking
BS EN 12004-2:2017	Adhesives for ceramic tiles. Test methods
BS EN 12020	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063
BS EN 12020-1:2008	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Technical conditions for inspection and delivery
BS EN 12020-2:2016	Aluminium and aluminium alloys. Extruded precision profiles in alloys EN AW-6060 and EN AW-6063. Tolerances on dimensions and form
BS EN 12163:2011	Copper and copper alloys — Rod for general purposes
BS EN 12167:2011	Copper and copper alloys — Profiles and bars for general purposes
BS EN 12200-1:2000	Plastics rainwater piping systems for above ground external use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS EN 12201-1:2011	Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 1: General
BS EN 12201-2:2011+A1:2013	Plastics piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 2 : Pipes
BS EN 12201-3:2011+A1:2012	Plastic piping systems for water supply, and for drainage and sewerage under pressure – Polyethylene (PE) – Part 3 : Fittings
BS EN 12288:2010	Industrial valves. Copper alloy gate valves
BS EN 12591:2009	Bitumen and bituminous binders. Specifications for paving grade bitumens
BS EN 12620:2002+A1:2008	Aggregates for concrete
BS EN 12878:2014	Pigments for the colouring of building materials based on cement and/or lime. Specifications and methods of test
BS EN 12899:Part 1:2007	Fixed, vertical road traffic signs - Part: 1 Fixed Signs
BS EN 13055-1:2002	Lightweight aggregates. Lightweight aggregates for concrete, mortar and grout
BS EN 13101:2002	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity
BS EN 13139:2013	Aggregates for mortar

BS EN 13263:2017	Thermoplastics piping systems for non-pressure underground drainage and sewerage. Thermoplastics fittings. Test method for impact strength
BS EN 13279-1:2008	Gypsum binders and gypsum plasters. Definitions and requirements
BS EN 13279-2:2014	Gypsum binders and gypsum plasters. Test methods
BS EN 13303:2009	Bitumen and bituminous binders. Determination of the loss in mass after heating of industrial bitumen
BS EN 13391:2004	Mechanical tests for post-tensioning systems
BS EN 13598-1:2010	Plastics piping systems for non-pressure underground drainage and sewerage – unplasticized poly(vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) Part 1: Specifications for ancillary fittings including shallow inspection chambers
BS EN 13658-1:2005	Metal lath and beads. Definitions, requirements and test methods. Internal plastering
BS EN 13658-2:2005	Metal lath and beads. Definitions, requirements and test methods. External rendering
BS EN 13707:2013	Flexible sheets for waterproofing. Reinforced bitumen sheets for roof waterproofing. Definitions and characteristics
BS EN 13808:2013	Bitumen and bituminous binders. Framework for specifying cationic bituminous emulsions
BS EN 13835:2012	Founding. Austenitic cast irons
BS EN 13914-1:2016	Design, preparation and application of external rendering and internal plastering. External rendering
BS EN 13914-2:2016	Design, preparation and application of external rendering and internal plastering. Internal plastering
BS EN 13924-1:2015	Bitumen and bituminous binders. Specification framework for special paving grade bitumen. Hard paving grade bitumens
BS EN 13986:2004+A1:2005	Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking
BS EN 14188:Part 2:2004	Joint fillers and sealants. Specifications for cold applied sealants
BS EN 14399:Part 3:2015	High-strength structural bolting assemblies for preloading. System HR. Hexagon bolt and nut assemblies
BS EN 14411:2016	Ceramic tiles. Definition, classification, characteristics, assessment and verification of constancy of performance and marking
BS EN 14814:2016	Adhesives for thermoplastic piping systems for fluids under pressure – Specifications

BS EN 14901-1:2014+A1:2019	Ductile iron pipes, fittings and accessories. Requirements and test methods for organic coatings of ductile iron fittings and accessories. Epoxy coating (heavy duty)
BS EN 14901-2:2019	Ductile iron pipes, fittings and accessories. Requirements and test methods for organic coatings of ductile iron fittings and accessories. Thermoplastic acid modified polyolefin coating (TMPO)
BS EN 15091:2013	Sanitary tapware. Electronic opening and closing sanitary tapware
BS EN 15167-1:2006	Ground granulated blast furnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria
BS EN 15167-2:2006	Ground granulated blast furnace slag for use in concrete, mortar and grout. Conformity evaluation
BS EN 15322:2013	Bitumen and bituminous binders. Framework for specifying cut-back and fluxed bituminous binders
BS EN 16228	Drilling and foundation equipment. Safety
BS EN 16228:Part 1:2014	Drilling and foundation equipment. Safety. Common requirements
BS EN 16228:Part 2:2014	Drilling and foundation equipment. Safety. Mobile drill rigs for civil and geotechnical engineering, quarrying and mining
BS EN 16228:Part 4:2014	Drilling and foundation equipment. Safety. Foundation equipment
BS EN 16228:Part 5:2014	Drilling and foundation equipment. Safety. Diaphragm walling equipment
BS EN 16228:Part 7:2014	Drilling and foundation equipment. Safety. Interchangeable auxiliary equipment
BS EN 16737:2016	Structural timber: Visual strength grading of tropical hardwood
EN 63:1977 (same as BS 2782:Part 10:Method 1005:1977)	Glass reinforced plastics. Determination of flexural properties. Three point method.
PD 970:2005	Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels
PD 6695-1-10	Recommendations for the design of structures to BS EN 1993-1-10
PD/CEN/TR 15123:2005	Design, preparation and application of internal polymer plastering systems

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1.1.8 *European Standards (EN) and/or International Organization for Standardization (ISO) Standards Adopted as British Standards (BS EN ISO)*

BS EN ISO 62:2008	Plastics - Determination of water absorption

BS EN ISO 148:Part 1:2016	Metallic materials. Charpy pendulum impact test. Test method
BS EN ISO 178:2010+A1:2013	Plastics – Determination of flexural properties
BS EN ISO 527-1:2019	Plastics. Determination of tensile properties. General principles
BS EN ISO 1183-1:2012	Plastics - Methods for determining the density of non-cellular plastics, Part 1: Immersion method, liquid pyknometer
BS EN ISO 1452 – 1:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). General
BS EN ISO 1452 – 2:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). Pipes
BS EN ISO 1452 – 3: 2010	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure – Unplasticized poly (vinyl chloride) (PVC-U) Part 3: Fittings
BS EN ISO 1452 – 5:2009	Plastics piping systems for water supply and for buried and above–ground drainage and sewerage under pressure. Unplasticized poly (vinyl chloride) (PVC U). Fitness for purpose of the system
BS EN ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN ISO 1513:2010	Paint and varnishes. Examination and preparation of test samples
BS EN ISO 1518-1:2011	Paints and varnishes. Determination of scratch resistance. Constant-loading method
BS EN ISO 1519:2011	Paints and varnishes. Bend test (cylindrical mandrel)
BS EN ISO 1524:2013	Paints, varnishes and printing inks. Determination of fineness of grind
BS EN ISO 2063:2005	Thermal spraying – Metallic and other inorganic coatings. Zinc, aluminium and their alloys
BS EN ISO 2431: 2011	Paints and varnishes. Determination of flow time by use of flow cups
BS EN ISO 2808:2007	Paints and varnishes. Determination of film thickness
BS EN ISO 2813:2014	Paints and varnishes. Determination of gloss value at 20 degrees, 60 degrees and 85 degrees
BS EN ISO 2814:2006, BS 3900-D4:2006	Paints and varnishes. Comparison of contrast ratio (hiding power) of paints of the same type and colour
BS EN ISO 3231:1998, BS 3900-F8:1993	Paints and varnishes. Determination of resistance to humid atmospheres containing sulfur dioxide
BS EN ISO 3269:2019	Fasteners. Acceptance inspection

BS EN ISO 3452:Part 1:2013	Non-destructive testing. Penetrant testing. General principles
BS EN ISO 3506-1:2020	Mechanical properties of corrosion-resistant stainless-steel fasteners. Bolts, screw and studs
BS EN ISO 3506-2:2009	Mechanical properties of corrosion-resistant stainless-steel fasteners. Nuts
BS EN ISO 4016:2011	Hexagon head bolts. Product grade C.
BS EN ISO 4034:2012	Hexagon regular nuts (stle 1). Product grade C.
BS EN ISO 4042:2018	Fasteners. Electroplated coatings
BS EN ISO 4618:2014	Paints and varnishes. Terms and definitions
BS EN ISO 4624:2016	Paints and varnishes. Pull-off test for adhesion
BS EN ISO 6892:Part 1:2019	Metallic materials. Tensile testing. Method of test at room temperature
BS EN ISO 7089:2000	Plain washers. Normal series. Product grade A
BS EN ISO 7090:2000	Plain washers, chamfered. Normal series. Product grade A
BS EN ISO 7092:2000	Plain washers. Small series. Product grade A
BS EN ISO 7093:Part 1:2000	Plain washers. Large series. Product grade A
BS EN ISO 7500-1:2018	Metallic materials. Calibration and verification of static uniaxial testing machines. Tension/compression testing machines. Calibration and verification of the force-measuring system
BS EN ISO 7599:2018	Anodizing of aluminium and its alloys. General specifications for anodic oxidation coatings on aluminium
BS EN ISO 8501	Preparation of steel substrates before application of paints and related products
BS EN ISO 8501-1:Part 1: 2007	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
BS EN ISO 8501:Part 3:2007	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Preparation grades of welds, edges and other areas with surface imperfections
BS EN ISO 8502:Part 3:2017	Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness. Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)

BS EN ISO 8502:Part 6:2006	Preparation of steel substrates before application of paints and related products -- Tests for the assessment of surface cleanliness. Extraction of soluble contaminants for analysis -- The Bresle method
BS EN ISO 8503:Part 1:2012	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces
BS EN ISO 8503-2:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the grading of surface profile of abrasive blast-cleaned steel. Comparator procedure
BS EN ISO 8503-3:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the calibration of ISO surface profile comparators and for the determination of surface profile. Focusing microscope procedure
BS EN ISO 8503-4:1995	Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Method for the calibration of ISO surface profile comparators and for the determination of surface profile. Stylus instrument procedure
BS EN ISO 9117-1:2009	Paints and varnishes. Drying tests. Determination of through-dry state and through-dry time
BS EN ISO 9117-3:2010	Paints and varnishes. Drying tests. Surface-drying test using ballotini
BS EN ISO 9445-1:2010	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Narrow strip and cut lengths
BS EN ISO 9445-2:2010	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Wide strip and plate/sheet
BS EN ISO 9606:Part 1:2017	Qualification testing of welders. Fusion welding. Steels
BS EN ISO 10601:2008	Micaceous iron oxide pigments for paints. Specifications and test methods
BS EN ISO 10545:Part 2:2018	Ceramic tiles. Determination of dimensions and surface quality
BS EN ISO 10545: Part 3:2018	Ceramic tiles. Determination of water absorption, apparent porosity, apparent relative density and bulk density
BS EN ISO 10545: Part 4:2019	Ceramic tiles. Determination of modulus of rupture and breaking strength
BS EN ISO 10545: Part 6:2012	Ceramic tiles. Determination of resistance to deep abrasion for unglazed tiles
BS EN ISO 10545: Part 7:1999	Ceramic tiles. Determination of resistance to surface abrasion for

	glazed tiles
BS EN ISO 10545:Part 8:2014	Ceramic tiles. Determination of linear thermal expansion
BS EN ISO 10545:Part 11:1996	Ceramic tiles. Determination of crazing resistance for glazed tiles
BS EN ISO 10545:Part 13:2016	Ceramic tiles. Determination of chemical resistance
BS EN ISO 10545:Part 14:1997	Ceramic tiles. Determination of resistance to stains
BS EN ISO 10684:2004	Fasteners. Hot dip galvanized coatings
BS EN ISO 11124	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives
BS EN ISO 11124-1:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. General introduction and classification
BS EN ISO 11124-2:2018	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Chilled-iron grit
BS EN ISO 11124-3:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. High-carbon cast-steel shot and grit
BS EN ISO 11124-4:1997	Preparation of steel substrates before application of paints and related products. Specifications for metallic blast-cleaning abrasives. Low-carbon cast-steel shot
BS EN ISO 11126	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives.
BS EN ISO 11126:Part 1:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. General introduction and classification
BS EN ISO 11126:Part 3:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Copper refinery slag
BS EN ISO 11126:Part 4:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Coal furnace slag
BS EN ISO 11126:Part 5:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Nickel refinery slag
BS EN ISO 11126:Part 6:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Iron furnace slag
BS EN ISO 11126:Part 7:2018	Preparation of steel substrates before application of paints and

	related products. Specifications for non-metallic blast-cleaning abrasives. Specification for fused aluminium oxide
BS EN ISO 11126:Part 8:2018	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Olivine sand
BS EN ISO 11126:Part 9:2004	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Staurolite
BS EN ISO 11126:Part 10:2017	Preparation of steel substrates before application of paints and related products. Specifications for non-metallic blast-cleaning abrasives. Almandite garnet
BS EN ISO 11296:Part 4:2018	Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks. Lining with cured-in-place pipes
BS EN ISO 11600:2003+A1:2011	Building construction. Jointing products. Classification and requirements for sealants
BS EN ISO 12567-1:2010	Thermal performance of windows and doors — Determination of thermal transmittance by the hot-box method. Complete windows and doors
BS EN ISO 12944	Paints and varnishes. Corrosion protection of steel structures by protective paint systems.
BS EN ISO 12944:Part 3:2017	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Design considerations
BS EN ISO 12944:Part 5:2019	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Protective paint systems
BS EN ISO 13918:2018	Welding. Studs and ceramic ferrules for arc stud welding
BS EN ISO 14555:2017	Welding. Arc stud welding of metallic materials
BS EN ISO 14713	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures
BS EN ISO 14713:Part 1:2017	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. General principles of design and corrosion resistance
BS EN ISO 14713:Part 2:2020	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Hot dip galvanizing
BS EN ISO 14713:Part 3:2017	Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Sherardizing
BS EN ISO 15613:2004	Specification and qualification of welding procedures for metallic materials. Qualification based on pre-production welding test
BS EN ISO 15614	Specification and qualification of welding procedures for metallic materials. Welding procedure test

BS EN ISO 15614:Part 1:2017+A1:2019	Specification and qualification of welding procedures for metallic materials. Welding procedure test. Arc and gas welding of steels and arc welding of nickel and nickel alloys
BS EN ISO 17636	Non-destructive testing of welds. Radiographic testing.
BS EN ISO 17636:Part 1:2013	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film
BS EN ISO 17636:Part 2:2013	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors
BS EN ISO 17637: 2016	Non-destructive testing of welds. Visual testing of fusion-welded joints
BS EN ISO 17638:2016	Non-destructive testing of welds. Magnetic particle testing
BS EN ISO 17640:2018	Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment
BS EN ISO 22282-3	Geotechnical investigation and testing. Geohydraulic testing. Water pressure tests in rock
BS ISO 34-1:2004	Rubber, vulcanized or thermoplastic. Determination of tear strength. Trouser, angle and crescent test pieces
BS ISO 37:2011	Rubber, vulcanized or thermoplastic. Determination of tensile stress-strain properties
BS ISO 48:2010	Rubber, vulcanized or thermoplastic. Determination of hardness (hardness between 10 IRHD and 100 IRHD)
BS ISO 188:2007	Rubber, vulcanized or thermoplastic. Accelerated ageing and heat resistance tests
BS ISO 815:Part 1:2019	Rubber, vulcanized or thermoplastic. Determination of compression set. At ambient or elevated temperatures
BS ISO 974:2000	Plastics. Determination of the brittleness temperature by impact
BS ISO 1051:1999	Rivet shank diameters
BS ISO 1431:2004	Rubber, vulcanized or thermoplastic. Resistance to ozone cracking. Static and dynamic strain testing
BS ISO 1817:2005	Rubber, vulcanized. Determination of the effect of liquids
BS ISO 2285:2007	Rubber, vulcanized or thermoplastic - Determination of tension set under constant elongation, and of tension set, elongation and creep under constant tensile load
BS ISO 2781:2008	Rubber, vulcanized or thermoplastic - Determination of density
BS ISO 3310	Test sieves. Technical requirements and testing

BS ISO 3310:Part 1:2016	Test sieves. Technical requirements and testing. Test sieves of metal wire cloth
BS ISO 3310:Part 2:2013	Test sieves. Technical requirements and testing. Test sieves of perforated metal plate
BS ISO 4587:2003	Adhesives. Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies
BS ISO 4649:2017	Rubber, vulcanized or thermoplastic. Determination of abrasion resistance using a rotating cylindrical drum device
BS ISO 14654:1999	Epoxy-coated steel for the reinforcement of concrete
BS ISO 14656:1999	Epoxy powder and sealing material for the coating of steel for the reinforcement of concrete
BS ISO 16132:2016	Ductile iron pipes and fittings. Seal coats for cement mortar linings
BS ISO 16269:Part 6:2014	Statistical interpretation of data. Determination of statistical tolerance intervals

1.1.9 *Japanese Industrial Standards (JIS)*

JIS Z 1902:2000	Petrolatum tapes for corrosion protection
JIS A 6910 – 1988	Quality tests for multi-layer acrylic paint

1.1.10 *International Organization For Standardization (ISO) Standards*

ISO 4591:1992	Plastics - Film and sheeting - Determination of average thickness of a sample, and average thickness and yield of a roll, by gravimetric techniques (gravimetric thickness)
ISO 4593:1993	Plastics - Film and sheeting - Determination of thickness by mechanical scanning
ISO 9001:2000	Quality management systems – Requirements

1.1.11 *Water Industry Specification, Water Research Centre*

WIS 4-52-01:1992	Polymeric anti-corrosion (barrier) coatings
WIS 4-32-08:2016 issue 4	Specification for the fusion jointing of polyethylene pressure pipeline systems using PE80 and PE100 materials

1.1.12 ***National Water Council, UK***

Manual of Sewer Condition Classification, 5th Edition, 2013	Coding system for recording of results

1.1.13 ***Australian/New Zealand Standards (AS/NZS)***

AS/NZS 4456.2:2003	Masonry units and segmental pavers – Methods of test. Method 2: Assessment of mean and standard deviation
AS/NZS 4456.14:2003	Masonry units and segmental pavers - Methods of test. Method 14: Determining water absorption properties

1.1.14 ***中華人民共和國行業標準***

JTG F40-2004	公路瀝青路面施工技術規範 (Technical Specifications for Construction of Highway Asphalt Pavements)

1.1.15 ***Canadian Standard***

CSA-A3000-2018	Cementitious Materials Compendium

1.1.11 ***Publicly Available Specification***

PAS 1075:2009-04	Pipes made from Polyethylene for alternative installation techniques – Dimension, Technical Requirements and Testing

1.1.11 ***Geo Publication***

GEO Publication No. 1/2006	Foundation design and construction

1.1.11 ***Design Manual Published By Highways Department***

Structures Design Manual for Highways and Railways 2013 Edition	Structures Design Manual for Highways and Railways

1.1.19 ***IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE)***

IEC 61386-1:2008/AMD1:2017 CSV	Conduit systems for cable management – Part 1: General requirements
IEC 61386-21:2002	Conduit systems for cable management – Part 21: Particular requirements – Rigid conduit systems
IEC 60670-1:2015	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations – Part 1: General requirements

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 4

FENCING

SECTION 4

FENCING

Wire 4.10 (1) Wire for fencing, including plastic coated wire, shall be galvanized mild steel complying with BS 4102.

(2) Barbed wire shall consist of two line wires and point wire formed in accordance with BS 4102, Clause 4.1.

(3) Galvanized coating to steel wire shall comply with BS EN 10244-2:2009.

(4) Plastic coating to steel wire shall be green and shall comply with BS 4102, Section 6.

Chain link fence 4.11 Chain link fence shall comply with BS 1722:Part 1 unless otherwise stated in this Section.

Steel 4.13 Steel for fencing shall comply with the following:

Hot rolled sections	: BS EN 10365
Hot rolled structural steel sections	
- Equal and unequal angles	: BS EN 10056
- Hollow sections	: BS EN 10210
- Weldable structural steel	: BS EN 10025

Bolts, nuts, washers and fittings 4.14 (1) Bolts, nuts and washers for fencing shall comply with the following:

ISO metric black hexagon bolts, screws and nuts	: BS 4190
ISO metric black cup and countersunk head, bolts and screws with hexagon nuts	: BS 4933
Metal washers for general engineering purposes	: BS 4320

(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) Fittings, including eye bolt strainers, cleats, winding brackets, stretcher bars, extension arms, hook bolts and base plates, shall be galvanized mild steel.

(4) Bolts, nuts, washers and fittings for fixing to concrete and timber shall be galvanized. Bolts, nuts, washers and fittings for fixing to steel shall have the same protective treatment as the steel.

(5) Staples shall be D-section galvanized wire.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 5

DRAINAGE WORKS

SECTION 5

DRAINAGE WORKS

Precast concrete pipes and fittings

5.11 (1) Precast concrete pipes and fittings shall comply with BS EN 1916 and BS 5911:Part 1.

(2) Precast concrete pipes and fittings shall have flexible spigot and socket joints.

5.11A* (1) All cast in-situ or precast concrete pipes and fittings for sewerage (and drainage) works shall be coated or lined with polyvinyl chloride (PVC), high density polyethylene (HDPE) or any other accepted lining or coating to protect the concrete surface from internal attack by sewage. The minimum thickness of the PVC/HDPE lining shall be 1.5 mm and be provided with locking extensions on one side for embedment in the concrete; these extensions shall be extruded integrally with the sheet during manufacture. Any jointing of the lining shall be to manufacturers' specifications and shall be free from any wobble, defect or irregularity.

(2) Chemical resistant mortar protection shall be provided to exposed benching formed in concrete.

Vitrified clay pipes and fittings

5.12 (1) Vitrified clay pipes and fittings shall comply with BS EN 295. The pipes and fittings shall be glazed and shall be the normal chemical resistant type.

(2) Vitrified clay pipes and fittings shall have flexible mechanical joints.

DI pipes and fittings

5.13 (1) DI pipes and fittings shall comply with BS EN 545 and BS EN 598. Pipes and fittings shall be lined internally with cement mortar and shall be coated externally with bituminous coating.

(2) Flexible joints in DI pipes and fittings shall be the push-in type and shall be capable of withstanding the required minimum angular deflection. Flexible joints shall also be capable of withstanding axial movements and shall allow a minimum withdrawal of 38 mm when there is no deflection of the joint.

(3) Flanged joints in DI pipes and fittings shall be PN 16 rating complying with BS EN 1092-1.

(4) Pipes that are to be built in to structures shall have puddle flanges welded on.

5.13A* (1) (a) Externally, all pipes and fittings shall be coated with metallic zinc before the bitumen coating is applied. The zinc coating shall be in accordance with clause 4.4.2 of BS EN 598.

(b) Internally, all pipes and fittings shall be lined with sulphate resisting high alumina cement mortar in accordance with clause 4.4.3 of BS EN 598, and with an epoxy coating in accordance with clause 4.5 of BS EN 598.

(c) Externally, the buried sections of the jointed pipeline shall be continuously protected by polyethylene sleeving.

(2) All DI pipes and fittings with nominal size of DN100 or above shall be of Class K9 and Class K12 respectively.

Grey iron pipes and fittings 5.14 Grey iron pipes and fittings shall comply with BS 4622.

uPVC pipes and fittings 5.15 (1) uPVC pipes and fittings shall comply with the relevant British Standard stated in Table 5.1.

(2) uPVC pipes and fittings above ground shall have solvent welded spigot and socket joints. uPVC pipes and fittings below ground shall have either solvent welded spigot and socket joints or flexible spigot and socket joints with elastomeric joint rings.

(3) Fittings for uPVC pressure pipes complying with BS 3506 shall comply with the following:

Injection moulded uPVC fittings for solvent welding	: BS 4346:Part 1
Fittings for uPVC pressure pipes	: BS EN ISO 1452-3

(4) Adhesives for uPVC pressure pipes shall comply with BS EN 14814.

(5) The Class of uPVC pressure pipes complying with BS 3506 shall depend on the pressure rating.

5.15A* (1) uPVC classification by area of installation shall be :

(a) Class K3 for areas without vehicular traffic.

(b) Class M125 for areas with vehicular traffic.

(2) All uPVC pipes and fittings, below ground, with nominal size of DN 150 to DN 500, shall be rib reinforced and UPONOR ULTRA-RIB or equivalent accepted.

(3) All uPVC pipes and fittings shall contain at least 30% by weight of waste plastic, and shall not contain phthalates and heavy metals including cadmium, lead, mercury, tin.

GI pipes and fittings 5.16 (1) GI pipes and fittings shall comply with the following:

Steel tubes and tubular suitable for screwing to BS 21 pipe threads	: BS EN 10255
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

(2) GI pipes and fittings shall be medium class thickness and shall be galvanized in accordance with BS EN ISO 1461.

Table 5.1: uPVC pipes and fittings

Use	Nominal size (mm)	Standard
Gravity sewage pipes and fittings above ground	32 - 50	BS 5255 BS EN 1329-1
	82 - 160	BS 4514 BS EN 1329-1
Gravity surface water pipes and fittings above ground	50 - 160	BS EN 12200-1 BS EN 607 BS EN 1462
Gravity sewage and storm water pipes and fittings below ground	110 - 1000	BS EN 1401-1 (Fittings also refer to BS 4660 and BS EN 13598-1)
Pressure pipes and fittings above and below ground	10 - 600	BS 3506

PE pipes and fittings 5.16A (1) PE compounds used for manufacturing PE pipes and fittings shall conform to BS EN 12201-1 and meet the requirements of PE 100-RC as defined in Clause 3.1 of PAS 1075. PE compounds shall also be 100% virgin, pre-coloured compounds. No reprocessed, recycled or own reprocessed materials shall be used in the manufacturer of any pipes or fittings.

(2) PE pipes shall comply with BS EN 12201-2.

(3) PE fittings shall comply with BS EN 12201-3 and have a material designation of PE 100.

Bolts, nuts and washers 5.17 (1) Bolts, nuts and washers for flanged joints, detachable couplings and flange adapters shall comply with the following:

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

Metal washers for general engineering purposes : BS 4320

The bolts, nuts and washers shall be hot-dip galvanised in accordance with BS EN ISO 1461 or treated with other suitable coating approved by the Engineer.

(2) Stainless steel bolts and nuts shall comply with BS EN ISO 3506-1 and BS EN ISO 3506-2, steel Grade A4 and property Class 80. Washers shall be Grade A4 to the standards stated in Clause 5.6.9.1 of BS EN 1090:Part 2.

(3) Spheroidal graphite cast iron bolts shall be Grade EN-GJS-500-7 complying with BS EN 1563.

(4) Bolts, nuts and washers shall be insulated from electrochemically dissimilar metal by non-metallic washers and sleeves.

(5) 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.

Elastomeric joint rings

5.18 (1) Elastomeric joint rings shall be Type WC complying with BS EN 681-1. 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.

(2) Elastomeric gaskets for flanged pipes shall be the inside bolt circle type. The gaskets shall be natural rubber with a thickness of 3 mm and with other dimensions complying with BS EN 1514-1.

5.18A* (1) Rubber joint rings for drainage purposes shall be Type D complying with relevant requirements of BS EN 681-1.

(2) Rubber joint rings shall be manufactured from synthetic rubber as detailed below and shall be obtained from the manufacturers of the pipes to be joined.

(3) Rubber rings for drainage purposes including sewers and sewage pumping mains shall be made from EPDM, SBR or Nitrile Rubber (NBR).

(4) Joint lubricants for sliding joints shall have no deleterious effects on either the joint rings or pipes and shall be unaffected by the liquid to be conveyed.

(5) Each gasket shall be legibly and durably marked with the following information :

(i) the manufacturer's name or trademark

(ii) the nominal diameter of the pipe for which the gasket is to be used

(iii) the pressure rating in MPa (gauge).

Detachable couplings and flange adapters

5.19 (1) Detachable couplings and flange adapters shall be of a proprietary type approved by the Engineer.

(2) Detachable couplings and flange adapters shall accommodate the angular deflection and straight draw stated in Table 5.2 for the different nominal diameters of pipes connected.

5.19A* (1) Dimensions and tolerances shall be in accordance with BS 5163 type B and BS 5150 where appropriate.

Table 5.2: Angular deflection and straight draw

Nominal diameter of pipe	Detachable coupling		Flange adapter	
	Angular deflection	**Straight draw**	**Angular deflection**	**Straight draw**
Not exceeding 450 mm	± 6°	± 10 mm	± 3°	± 5 mm
exceeding 450 mm and not exceeding 600 mm	± 5°		± 2.5°	
exceeding 600 mm and not exceeding 750 mm	± 4		± 2°	
exceeding 750 mm and not exceeding 1200 mm	± 3°		± 1.5°	
exceeding 1200 mm and not exceeding 1800 mm	± 2°		± 1°	
exceeding 1800 mm	± 1°		± 0.5°	

Anticorrosion tape 5.20 (1) Anticorrosion tape shall be a proprietary type approved by the Engineer. The tape shall be a rubber/bitumen compound with fabric reinforcement and shall be backed with PVC film. The tape shall have a high resistance to cathodic disbonding, acids and alkalis and shall have the minimum properties stated in Table 5.3.

(2) Anticorrosion tape shall be applied to valves, flanged joints, slip-on couplings and flange adapters. Type 1 shall be used for pipes smaller than 700 mm diameter and Type 2 shall be used for pipes 700 mm diameter 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 5.3: Properties of anticorrosion tape
(except where stated the values shown are minimum values)

Property	Value	
	Type 1	**Type 2**
Thickness of PVC backing (μm)	85	500
Tensile strength (N/mm)	8	10
Elongation (%)	≤ 26	≤ 26
Tear strength (N)	20	36
Adhesion strength (N/mm)	2	2
Holiday test voltage (kV)		
- single layer	10	10
- double layer	15	15
Impact strength (J)	3.5	8
Temperature range (°C)	5 - 60	8 - 60
Total thickness (mm)	1.6	2.0
Mass (kg/m^2)	1.8	2.4

Bituminous coatings 5.21 (1) Bituminous coatings shall comply with the following:

Bitumen-based hot-applied coating for corrosion protection of steel pipes and fittings : BS EN 10300

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 coatings.

Aggregates for granular bed and granular fill 5.22 (1) Granular bed shall be Type A material and granular fill shall be Type B material.

(2) Type A or Type B material shall consist of hard, clean, crushed slag, gravel, crushed rock, crushed concrete or crushed inert demolition material having a grading within the limits of Table 5.4. The ten per cent fines values shall be at least 50 kN. The material passing the 425 μm BS test sieve shall be non-plastic when tested in accordance with Geospec 3.

(3) Type A and Type B materials shall be obtained from a source approved by the Engineer.

(4) Aggregates for granular bed shall have the compacting fraction values stated in Clause 5.88.

Table 5.4: Range of grading of Type A and Type B materials

BS test sieve	Percentage by mass passing	
Metric	**Type A**	**Type B**
63 mm	-	100
37.5 mm	100	85 - 100
20 mm	-	0 - 20
10 mm	45 - 100	0 - 5
3.35 mm	25 - 80	-
600 μm	8 - 45	-
75 μm	0 - 10	-

Table 5.5: 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

Joint filler and compressible padding 5.23 (1) Joint filler for joints in concrete bed, haunch and surround shall be a firm, compressible, single thickness, non-rotting filler. The thickness of the filler shall be as stated in Table 5.5.

(2) Compressible padding between pipes and supports shall be bitumen damp-proof sheeting complying with BS 743.

Polyethylene sheeting 5.24 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

Precast concrete manholes 5.25 Precast concrete manhole units shall comply with BS EN 1917 & BS 5911:Part 3. Cover slabs and reducing slabs shall be reinforced as required to comply with the load test requirements stated in BS 5911:Part 3.

Chambers and gullies 5.26 (1) Precast concrete chambers shall comply with BS EN 1917 and BS 5911:Part 4. Cover slabs shall be reinforced as required to comply with the load test requirements stated in BS EN 1917 and BS 5911:Part 4. The types of cement for the manufacture of precast concrete chambers and gullies, and cover slabs shall be as stated in BS EN 1917 and BS 5911:Part 4, or a combination of PFA and PC or PFAC complying with BS EN 197-1. The PFA content shall not exceed 40% by mass of the cementitious content.

(2) Vitrified clay gullies shall comply with BS EN 295.

(3) Precast concrete gullies shall comply with BS 5911:Part 6.

Step irons 5.27 Step irons shall comply with BS EN 13101. Step irons shall be malleable cast iron complying with BS EN 1562 and shall be hot-dip galvanized in accordance with BS EN ISO 1461.

Manhole covers, gully gratings and kerb overflow weirs made of 5.28 (1) ~~Manhole covers,~~ gully gratings and kerb overflow weirs made of cast iron shall be of Grade EN-GJL-150 complying with BS EN 1561. Bolts and nuts shall comply with BS 4190.

cast iron

(2) Covers, gratings and weirs shall be cleanly cast, free of air holes, sand holes, cold shuts and chill and shall be neatly dressed and fettled. Castings shall be free of voids whether due to shrinkage, gas inclusions or other causes. Bolts and nuts shall not be over-tightened.

(3) The dimensions of the different types of covers, gratings and weirs shall be as stated in the Contract. The test loads which the covers and gratings are required to withstand, and the minimum masses of covers gratings and weirs, shall be as stated in Tables 5.6, 5.7 and 5.8.

(4) Covers, gratings and weirs shall have the manufacturer's name cast integrally with the unit in a raised form and shall be protected with bituminous coating. Covers shall have a raised design on the top surface as stated in the Contract.

5.28A* (1) Manhole covers shall be of ductile iron complying with BS EN 124.

(2) Except for ductile iron covers or recessed manhole covers, covers and frames shall be manufactured from Flake Graphite Iron to BS 1452:1990 to a minimum grade of 180.

(a) Ductile iron covers and frames shall be supplied with frames and shall conform to the requirements of BS EN 124 to Class E600.

(b) Recessed manhole covers and frames shall be manufactured from Grade 43 steel to BS EN 10029:2010, BS EN 10025:2019, Parts 1 to 3 and BS EN 10210:2019. The covers and frames shall be manufactured in accordance with the requirements of BS EN ISO 1461. Recessed manhole covers and frames shall be used whenever manhole covers are located on footpath and carriageway with paving blocks.

(3) U-channel grating for U-channel at carriageway shall refer to latest version of Highways Department Standard Drawing No. H3155. Compound material channel grating should be used.

Gully gratings and channel gratings made of compound material

5.28A (1) Gully gratings and channel gratings made of compound material essentially shall comprise of non-metallic components with strength and properties complying with the conditions stated in this clause. Embedded steel reinforcement bars are permitted on condition that there is a minimum 10 mm cover.

(2) Gratings shall be cleanly cast and free of any holes or voids. The outer surface shall be smooth, regular and with no observable damage.

(3) Gratings shall have the manufacturer’s name cast integrally with the unit in a raised form.

(4) Gratings shall be stored off the ground on level supports in a manner which will not result in damage or deformation of the units. The units shall be protected from direct sunshine.

Table 5.6: Details of manhole covers and frames

Type of manhole cover and frame	Minimum mass (kg)	Grade	Test requirements	
			Diameter of block (mm)	Test load (t)
Double triangular manhole cover and frame	180	Medium duty	100	5
Double triangular manhole cover for sewers	130	Heavy duty	300	30
Frame	105	Heavy duty	300	30
Double triangular desilting manhole cover for sewers	290	Heavy duty	300	30
Frame	165	Heavy duty	300	30
Double seal terminal manhole cover for sewers				
- Type MA2-29/29A & B	-	Heavy duty	300	20
- Type MA2-45/45A & B	-	Heavy duty	300	20
- Type MC2-29/29A & B	-	Medium duty	100	5
- Type MC2-45/45A & B	-	Medium duty	100	5

Table 5.7: Details of gully gratings and frames

Type of gully grating and frame	Minimum mass (kg)	Grade	Test requirements	
			Diameter of block (mm)	Test load (t)
Grating for hinged gully grating Type GA2-325	28.0	Heavy duty	300	20
Frame	24.5	Heavy duty	300	20
Grating for double triangular gully grating Type GA1-450	57.5	Heavy duty	300	20
Shallow frame				
- adjacent to kerb	33.5	Heavy duty	300	20
- away from kerb	36.5	Heavy duty	300	20
Deep frame				
- adjacent to kerb	40.5	Heavy duty	300	20
- away from kerb	44.0	Heavy duty	300	20
Grating for hinged gully grating Type GA2-450	61.5	Heavy duty	300	20
Frame	37.0	Heavy duty	300	20

Table 5.8: Details of kerb overflow weirs

Type of kerb overflow weir	Minimum mass (kg)
Type 1-325	39.5
Type 3-325	31.5
Type 1-450	44.0
Type 3-450	36.5
Type 4-450	33.0

Penstocks 5.29 (1) Penstocks shall comply with the following requirements:

(a) Frames and gates shall be cast iron complying with BS EN 1561, Grade EN-GJL-250.

(b) Stems shall be stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970, Grade 1.4401.

(c) Operating nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(d) Sealing faces shall be phosphor bronze complying with BS EN12163 & BS EN12167, Grade CW452K.

(e) Sealing strips at inverts of flush invert penstocks shall be elastomer complying with ASTM D 2000.

(f) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.17(2).

(g) Adjustable wedges shall be phosphor bronze complying with BS EN12163 & BS EN12167, Grade CW452K or stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970, Grade 1.4401.

(2) Penstocks shall be designed for on-seating pressure or off-seating pressure or both on-seating and off-seating pressures as stated in the Contract.

(3) Sealing faces shall be of rectangular sections and shall be fixed to the frames and gates using taperhead screws of the same material as the sealing faces.

(4) Adjustable wedges shall have sufficient contact areas with the gates to minimise wear.

(5) Frames shall include guide rails or guide faces for gates. Clearance within guides shall be as small as practicable such that the gates will not vibrate under flow conditions.

(6) Penstocks shall have rising stems unless otherwise stated in the Contract. Rising stems shall have perspex protection tubes with open/close indicators.

Gate valves 5.30 (1) Gate valves shall comply with BS EN 1171 and with the following requirements:

(a) Bodies and wedges shall be cast iron complying with BS EN 1561, Grade EN-GJL-250 and shall have renewable gunmetal seat rings.

(b) Gunmetal for renewable seat rings shall be Grade CC491K complying with BS EN 1982.

(c) Stem nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(d) Stems shall be aluminium bronze complying with BS EN12163 & BS EN12167, Grade CW307G.

(e) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.17(2).

(2) Gate valves shall be double flange-ended solid wedge type with nominal pressure designation PN 16. Flanges shall be PN 16 complying with BS EN 1092-1.

~~(3)~~ Gate valves shall have outside screw rising stems unless otherwise stated in the Contract. Rising stems shall have perspex protection tubes with open/close indicators~~.~~

~~(4) Gate valves shall be fitted with a plate showing the operating position of the valve in the closed, quarter closed, half closed, three quarters closed and open positions.~~

(5) Chains for chain operated gate valves shall be mild steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088-1, BS EN 10095, BS EN 10250-4 and PD 970 and hot-dip galvanized in accordance with BS EN ISO 1461. The chains shall be continuous.

Flap valves 5.31A* (1) Flap valves, except those specified otherwise, shall comply with the following :

(a) Frames shall be an inner sealing frame welded into an outer fixing frame to produce a sloping surface to guarantee closure in balance or dry conditions.

(b) Frame shall be of stainless steel to BS EN 10088 Grade 316 supplied in natural finish. Plastic material will not be accepted.

(c) Frame seal shall be EPDM (Ethylene Propylene) wiper type seal having an angled lip seal or equivalent. The seal shall be fixed with corrosion resistant retaining strip and stainless steel grade 316 fasteners.

(d) Door shall be manufactured as a composite sandwich construction comprising a lightweight, rigid cellular core with fully welded mild steel box section matrix, sandwiched between two outer skins of ultra violet stabilized and non-toxic rigid compressed composite plastic. Door shall be internally chemically bonded and sealed.

(e) Hinge links shall be of stainless steel to BS EN 10088 Grade 316 with bronze bushes.

(2) Square or rectangular flap valves shall be wall mounted double hung double hinge flap valves.

(3) Circular flap valves used for pipes 600mm diameter or below shall be connected to pipes with socket and of rigid plastic construction.

(4) Flap valve shall be a proprietary brand flap valves with equivalent functions or performance.

Sludge valves 5.32 (1) Sludge valves shall comply with the following requirements:

(a) Bodies and valve sections shall be cast iron complying with BS EN 1561, Grade EN-GJL-250.

(b) Sealing faces and stem nuts shall be gunmetal complying with BS EN 1982, Grade CC491K.

(c) Stems shall be aluminium bronze complying with BS EN12163 & BS EN12167, Grade CW307G.

(2) The stems of sludge valves shall operate through non-rising stem nuts housed in bridges bolted over the body sections.

(3) Outlet flanges of sludge valves shall be PN 16 complying with BS EN 1092-1.

Air valves 5.33 (1) Air valves shall be of the elongated body type and shall have a pressure rating of 3 bars unless otherwise stated in the Contract.

(2) Dual orifice air valves shall have:

(a) A small orifice valve for releasing air at working pressure, and

(b) A large orifice valve for allowing air to pass at atmospheric pressure during emptying and filling of pipework.

(3) The bodies and covers of small and large orifice valves shall be cast iron complying with BS EN 1561, Grade EN-GJL-250. The trim and float shall be stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10095, BS EN 10088-1, BS EN 10250-4 and PD 970, Grade 1.4401.

(4) Small orifice valves shall have an adjustable Vitron orifice button to ensure positive sealing. Large orifice valves shall have a Buna-N seat.

(5) The valve inlet of small orifice valves shall be 75 mm diameter and the valve outlet shall be 25 mm diameter. The venting orifice shall be 5 mm diameter. The valve inlet and the valve outlet of large orifice valves shall be 75 mm diameter.

(6) Air valves shall be provided with isolating gate valves.

Fittings for penstocks and valves 5.34 (1) Handwheels and tee keys for penstocks and valves shall turn in a clockwise direction for closing. Handwheels shall have smooth rims and the direction of opening and closing shall be clearly cast on the handwheel. The

opening effort required at any point on the handwheel rim shall not exceed 250 N when operated against the full unbalanced pressure.

(2) Extension stems for penstocks and valves shall be stainless steel of the same grade as the stems. Extension stems shall be connected with muff couplings.

(3) Handwheels, tee keys, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings for penstocks and valves shall be cast iron complying with BS EN 1561.

(4) Bolts and nuts for fixing penstocks and valves to structures shall be stainless steel complying with Clause 5.17(2). Bolts shall be indented foundation bolts.

(5) Grout for filling rebates and box-outs shall be of a proprietary type approved by the Engineer and shall contain a non-shrink admixture.

Filling abandoned pipes and manholes 5.35 (1) Foam concrete for filling abandoned pipes, culverts, manholes and voids shall be composed of PC (or PFAC), fine aggregate (from natural or recycled aggregate), water, admixtures for accelerating or retarding the setting time and foam to reduce the density and to produce a flowing self levelling material.

(2) As an alternative to foam concrete when permitted by the Engineer, a grout of PC/PFA and water may be used. Sand and admixtures may not be used in the PC/PFA grout unless approved in writing by the Engineer.

(3) The PC/PFA grout shall consist of 15 parts of PFA to 1 part of PC by mass together with the minimum amount of water necessary to achieve a consistency suitable for flowing into the pipes, culverts, manholes and voids.

JOINTING PIPES

Flanged joints 5.57A* (1) The flanges shall be to BS EN598:2007 PN 16.

MANHOLES, CHAMBERS, GULLIES AND CHANNELS

Manholes, chambers and gullies 5.73 (1) Bases, inverts and benching for precast concrete manholes shall be constructed in-situ using Grade 20 concrete~~,~~ unless otherwise stated in the Contract.

(2) Precast concrete units for manholes and chambers shall be set vertically with step irons staggered and vertically aligned above each other. Joints between precast units shall be the rebated type and shall be sealed with cement mortar. Lifting holes shall be filled with cement mortar. Surplus cement mortar shall be removed and joints shall be pointed.

(3) Concrete surround to manholes, chambers and gullies shall be Grade 20 concrete. Joints in concrete surround shall be staggered by at least 150 mm from joints in the precast units. Concrete surround to gullies shall be placed up to the sides of the excavation.

(4) The frames for manhole covers and gully gratings shall be set to the same levels as the surrounding surface, allowing for falls and cambers, using brickwork and/or concrete as specified in the Contract. The number of courses

of brickwork used below frames shall not exceed three and the minimum grade for concrete shall be Grade 20.

(5) Cement mortar for fixing manhole covers and gully gratings in position and bonding brickwork shall consist of cement and sand in the proportions 1:3 by mass.

(6) Excavations around manholes and chambers in carriageways shall be filled using Grade 10 concrete up to the carriageway formation level. Fill material for excavations around other manholes and chambers shall be fine fill material.

5.73A* (1) Both shaft and chamber cover slabs shall be of heavy duty type complying with Appendix G of BS 5911 Part I.

(2) Epoxy sealed protective lining shall be provided for all sewage concrete surfaces for epoxy-lined manhole.

(3) Epoxy lining applied to the concrete surfaces of manhole shall fulfil the requirements as:

(a) Epoxy lining shall be applied on all concrete surfaces of concrete manhole or water retaining structures for protection against sewage acidic corrosion. It shall be either paint or spray type.

(b) The composition of the lining shall be solvent free epoxy resin containing coal tar, acid resistant fillers and wetting agents.

(c) It shall be suitable for application to concrete structure under immersed conditions, primerless, waterproof, VOC free.

MISCELLANEOUS

Safety chains and fittings

5.114* (1) Stainless steel safety chain shall be manufactured from Grade 316S31 steel complying with BS970: Part 1.

MULTI-PART COVERS

Materials for covers and frames

5.115* (1) Covers and frames shall be manufactured from ductile iron to ISO 1083 / BS EN 1563:2018. Steel components shall comply with BS EN 10083 / ISO 630.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 7

GEOTECHNICAL WORKS

SECTION 7

GEOTECHNICAL WORKS

PART 1: GENERAL REQUIREMENTS

GENERAL

General requirements 7.01 The works and materials specified in Clauses 7.02 to 7.05 shall comply with the sections stated, unless otherwise stated in this Section.

PART 3: SLOPE TREATMENT WORKS

Cement mortar 7.84 (1) Cement mortar for in-filling joints in rock faces, for bedding rock for masonry infilling and for surfacing slopes shall consist of Portland Cement (PC) and sand in the proportions 1:3 by mass.

(2) PC shall comply with BS EN 197-1.

(3) Sand shall be natural sand or crushed natural stone complying with BS 1200.

Rock for masonry infilling 7.85 Rock for masonry infilling shall not exceed 300 mm in size and shall be obtained from a source approved by the Engineer.

Soil-cement 7.86 (1) Soil-cement shall consist of PC, sand and inorganic soil in the proportions 1:3:12 by mass unless otherwise stated. The mix proportion of soil-cement is 1:3:40 by mass when it is applied to the top layer (maximum 300 mm thick) or other areas as directed or agreed by the Engineer.

(2) PC shall comply with BS EN 197-1.

(3) Sand shall be natural sand or crushed natural stone complying with BS 1200.

(4) Inorganic soil shall be free of organic matter and shall contain not more than 30% of soil particles passing a 63 μm BS test sieve.

Aggregates for sprayed concrete 7.87 The nominal maximum aggregate size of aggregates for sprayed concrete shall not exceed 10 mm.

Reinforcement for sprayed concrete 7.88 Unless otherwise approved by the Engineer fabric reinforcement including A393 and A252 for sprayed concrete shall comply with GS Section 15 except that the 50 mm x 50 mm x 2.7 mm (wire diameter) hot-dip galvanized steel welded mesh shall have tensile strength not less than 275N/mm^2.

Protective mesh and fixings 7.89 (1) Protective mesh for slopes shall be PVC coated galvanized steel wire woven into a double twist hexagonal mesh. Each hexagon shall be 80 mm x 60 mm. The steel wire shall be at least 2.2 mm diameter and the PVC coating shall be at least 0.4 mm thick. PVC coating on steel wire shall comply with BS 1722-16 or equivalent. The colour of PVC coating is to be approved by the Engineer. Wire for protective mesh shall comply with BS 1052. Galvanized

coating on wires shall comply with BS EN 10244-2. The tolerance on the opening of mesh shall comply with BS EN 10223-2.

(2) Tying wire for protective mesh shall be 2.2 mm diameter PVC coated galvanized soft annealed steel wire.

(3) Bolts for fastening protective mesh to rock or structure shall be galvanized mild steel hooks as stated in the Contract.

(4) Stainless steel anchor bolts and accessories for fastening protective mesh to soil nail heads shall be as stated in the Contract.

(5) Hooks, fixing pins, steel plates and washers for fixing the protective mesh to slope face shall be as shown on the Drawings and shall be galvanized to BS EN ISO 1461.

(6) Galvanizing shall comply with BS EN ISO 1461.

Rock bolts 7.90 (1) Rock bolts shall be a proprietary type approved by the Engineer. Rock bolts shall comply with CS2 and shall be mild steel or high yield deformed steel as stated in the Contract. Rock bolts shall be galvanized to BS EN ISO 1461. Rock bolts shall have non-corrodible centralizers capable of ensuring an even annulus of grout as approved by the Engineer.

(2) The rated working load of rock bolts shall not exceed 50% of the ultimate tensile strength. A reduction of 4 mm in the diameter of the bolt shall be taken into account for corrosion when calculating the ultimate tensile strength.

(3) Nuts for rock bolts shall be of grade 4 steel and comply with BS 4190. Connectors shall comply with Section 15 of this GS. Bearing plates shall be of grade S275 steel plate and comply with BS EN 10025:Part 1 and BS EN 10025:Part 3. Holes in steel plates for rock bolt heads shall be drilled perpendicular to the face of the steel plate and the centre of the hole shall be at a position of within 2 mm from the centroid of the plate. The clearance between the steel bar and the hole of the steel plate shall not be more than 2 mm. All nuts, connectors and bearing plates shall be galvanized to BS EN ISO 1461. Rock bolts shall have non-corrodible centralizers capable of ensuring an even annulus of grout as approved by the Engineer. Grease shall comply with Table 1 of Geospec 1.

Grout for rock bolts 7.91 Grout for rock bolts shall be as stated in Clauses 7.174 and 7.182 except that the water cement ratio shall not exceed 0.45.

Rock dowels 7.92 Rock dowels shall comply with CS2 and shall be galvanized to BS EN ISO 1461. Rock dowels shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the steel bar as approved by the Engineer.

Grout for rock dowels 7.93 Grout for rock dowels shall be as stated in Clauses 7.160 and 7.168 except that the water cement ratio shall not exceed 0.45.

Soil nails 7.94 (1) Soil nail bars shall be of high yield deformed bars. Dimensions, mass per metre and permissible deviation of soil nail bars shall refer to CS2 Cl. 1.4. Chemical composition of soil nail bars shall refer to CS2 Cl. 1.5 and mechanical properties shall refer to CS2 Cl. 1.6. Definition of relevant terms such as stockist, manufacturer, etc. in the clauses in relation to soil nails shall be referred to CS2 Cl. 1.2. Nuts shall be of Grade 4 steel and comply with BS

4190. Connectors shall comply with this Section. Bearing plates shall be of Grade S275 steel plate and comply with BS EN 10025:Part 1 and BS EN 10025:Part 3. Permanent casings shall comply with BS 4019-3. Holes in steel plates for soil nail heads shall be drilled perpendicularly to the face of the steel plate and the centre of the hole shall be at a position of within 2 mm from the centroid of the plate. The clearance between the steel bar and the hole of the steel plate shall not be more than 2 mm. All steel components for soil nails shall be galvanized to BS EN ISO 1461. Materials for repair to hot dip galvanized coating shall comply with BS EN ISO 1461.

(2) Soil nails shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the soil nail bars. The nominal diameter of the centralizers shall not differ from the specified diameter of the drillhole by more than 10 mm. Wires and ties for fixing and anchoring packers, centralizers and grout pipes etc. shall be made of non-corrodible materials. The spacing of the centralizers and the suitability of the method of fixing the centralizers, grout pipes and corrugated sheathing where required shall be determined by carrying out trials on site until no damage, deformation and displacement of the centralizers, grout pipes and corrugated sheathing are observed on completion of assembling all components, during inserting and withdrawing the soil nails. Once approval is given, no change to the type, method and arrangement of fixing of the centralizers, grout pipe and corrugated sheathing shall be made without the prior approval of the Engineer.

(3) Connectors for soil nail bars shall be of a proprietary type approved by the Engineer. Connectors shall be a cold swaged or threaded type. The connectors shall be capable of developing the full tensile strength of the parent bar and shall comprise high tensile steel studs and seamless steel tubes fitted with protective plastic caps. For soil nails using threaded type connectors but without galvanized coating on either the threads inside the connectors or the threads at the ends of soil nail bars, heat-shrinkable sleeve of a proprietary type as approved by the Engineer shall be used as an alternative to galvanization as a corrosion protection measure to the connections. Any rust on the threads of soil nail bars and connectors shall be thoroughly cleaned before being connected together.

(4) Unless otherwise specified by the manufacturer and approved by the Engineer, the heat-shrinkable sleeve for soil nail bars connectors shall be made of a layer of radiation cross-linked polyethylene and a layer of anti-corrosion mastic sealant material. The properties of polyethylene and mastic sealant materials shall comply with the following requirements:

Property	Test Method	Unit	Acceptance
Properties of polyethylene			
Tensile strength at 23˚C (Cross head speed: 50mm/min)	BS EN ISO 527-1	MPa	≥ 17
Ultimate elongation at 23˚C (Cross head speed: 50mm/min)	BS EN ISO 527-1	%	≥ 350
Impact brittleness	BS ISO 974	°C	≤ -40
Water absorption at 23˚C, 24 hrs	BS EN ISO 62	% increase in weight	≤ 0.1
Properties of mastic sealant material			
Corrosion effect	ASTM		No corrosion

	D2671 (Procedure A)		
Peel strength to steel at 23˚C (Cross head speed : 100mm/min)	DIN 30672	N/cm	≥ 4
Shear strength at 23˚C (Cross head speed : 50mm/min)	BS ISO 4587	N/cm^2	≥ 10
Softening point	ASTM E28	°C	≥ 70

Soil nails with double-corrosion protection 7.95 (1) Materials for soil nails with double-corrosion protection shall comply with Clause 7.94 unless otherwise specified in the following sub-clauses.

(2) Corrugated sheathing for the double corrosion protection shall be a proprietary type approved by the Engineer and shall be made of high density thermoplastic materials which shall be homogeneous, thermally stable, chemically inert and resistant to chemical, bacterial and fungal attack. The wall thickness of the sheathing shall be at least 1.0 mm. Plastic sheathing and all associated components shall comply with the requirements as stipulated in Table 2 of the Model Specification for Prestressed Ground Anchors (GEOSPEC 1).

(3) Finished internal and external surfaces of the sheathing shall be smooth, clean and free of flaws, pin-holes, bubbles, cracks and other defects. Sheathing and all associated components shall be used in accordance with the manufacturer's instructions.

(4) Sheathing and other plastic protective components shall:

(a) Not contain any substances that will promote corrosion;

(b) be covered to prevent exposure to ultra-violet light from direct or indirect sunlight;

(c) be resistant to slip; and

(d) be capable of withstanding the applied handling stresses, the hydrostatic and grouting pressures.

(5) Centralizers shall be provided on the soil nail bars and the sheathing at suitable intervals to meet the following requirements:

(a) The soil nail bars shall be positioned in the sheathing so that a minimum grout cover to the bar of 10 mm is maintained; and

(b) There shall be minimum clearance of 15 mm between the sheathing and the sides of the drillholes or casing.

(6) Corrugated sheathing shall be embedded at least 50 mm into soil nail head.

Grout for soil nails 7.96 Grout for soil nails shall be as stated in Clauses 7.174 and 7.182 except that the water cement ratio shall not exceed 0.45 and PFA shall not be used unless agreed by the Engineer.

Non-biodegradable mats for erosion control 7.97

(1) Non-biodegradable mats for erosion control shall be woven and ultraviolet stabilized mats. The mats shall have the material properties stated in the Contract.

(2) The mats must be produced by proprietary manufacturers and specifically designed for the erosion control of sloping ground.

(3) The colour of the mats shall be black or dark green or other colour as directed or approved by the Engineer.

Biodegradable mats for erosion control 7.98

(1) Biodegradable mats for erosion control shall be woven coir mesh mats or woven jute mats. The mats shall have the material properties stated in the Contract.

(2) The mats must be produced by proprietary manufacturers and specifically designed for the erosion control of sloping ground.

Wire mesh for erosion control 7.99

Wire mesh for erosion control shall comply with Clause 7.89(1). Unless otherwise specified in the Drawings, the wire mesh shall be fixed onto the slope surface by means of anchor bolts and/or fixing pins. The fixing pins, steel plates and washers for fixing the wire mesh to slope face shall comply with Clause 7.89. Galvanized coating on wires shall comply with BS EN 10244-2. The anchor bolts, nuts and washers for fixing the wire mesh to soil nail heads shall be stainless steel complying with Section 5. Details of the anchor bolts and fixing pins shall be submitted to the Engineer for approval. Anchor bolts and accessories shall have the following properties:

(a) The minimum size of the anchor bolts shall be M8.

(b) The components of the anchor bolts shall include:

(i) Hexagonal bolt or threaded rod with hexagonal nut.

(ii) Washer with minimum diameter of 20 mm.

(c) The length and diameter of the drillholes and the minimum size and embedment depth of the anchor bolts shall be ~~as~~ stated in the Contract-or otherwise approved by the Engineer.

(d) The mean ultimate tensile resistance and mean ultimate shear resistance of the anchor bolts shall be 31 kN and 47 kN respectively in non-crack concrete with concrete strength at 30 N/mm^2.

SPRAYED CONCRETE

Spraying concrete 7.122

~~(1) The surface temperature and moisture content of the soil shall be measured, and the results submitted to the Engineer, immediately before sprayed concrete is applied.~~

~~(2) For the dry mix process, the aggregate and sand for sprayed concrete shall be kept dry before mixing. Sand shall be natural sand or crushed natural stone. The water shall be added at the nozzle at the instant of application. The air and water supply, the rate of application and all other factors affecting the quality of the work shall be adjusted to produce dense concrete with no sloughing. For the wet mix process, the ready mixed concrete shall comply with Section 16 of GS unless otherwise approved by the Engineer. For both the dry mix process and the wet mix process, rebound material shall not be~~

~~reused and shall be removed within 8 hours of spraying.~~

~~(3) Sprayed concrete shall be applied in layers not exceeding 50 mm thick to the total thickness stated in the Contract. The maximum panel dimension shall not exceed 15 m^2.~~

~~(4) Sprayed concrete shall be applied perpendicularly to the surface to be sprayed and the nozzle shall not be positioned farther than 1.5 metres from the surface during spraying.~~

~~(5) Colour pigment approved by the Engineer shall be mixed thoroughly with the sprayed concrete mix. A layer of 25 mm thick of the coloured sprayed concrete shall be applied to form the total thickness of sprayed concrete stated in the Contract.~~

~~(6) Details of the colour pigments (e.g. specification and colour samples etc.) and the method statement shall be submitted for the Engineer's approval prior to application.~~ The pigment shall comply with ASTM C979/C979M and shall have the characterization of light fast, lime proof, weather resistance and durable like concrete. Colour to be employed shall be directed by the Engineer.

SOIL NAILS

Soil-nail head 7.145 ~~(1) Soil nail heads shall be constructed in accordance with the details as specified in the Contract. A method statement for the construction of soil nail heads shall be submitted for the Engineer's agreement.~~

~~(2) The threads at the top end of soil nail bars shall be thoroughly cleaned, properly treated with galvanized coating or protected with approved zinc rich paint prior to construction of soil nail heads.~~

(3) Steel reinforcement for soil nail heads shall be of Grade 500B steel and comply with CS2 requirements. Concrete for soil nail heads shall be Grade 30/20 concrete or 30 MPa sprayed concrete and comply with GS Section 16 requirements.

~~(4) Concreting of soil nail heads shall be carried out in a manner which ensures that the placed concrete is adequately compacted. Unless agreed otherwise by the Engineer, concreting of soil nail heads using sprayed concrete shall be applied in two stages, allowing the bearing plate to be positioned firmly against the first stage concrete. The method statement as referred to in sub-clause (1) of this Clause shall include proposal for the construction sequence of 2 stage sprayed concrete soil nail heads. Trial runs shall also be conducted to demonstrate to the Engineer that the proposed method statement will produce satisfactory results and the rebound of sprayed concrete material is minimal.~~

~~(5) Any temporary excavation for constructing soil nail heads, including overbreaks shall be backfilled with Grade 30/20 concrete, 30 MPa sprayed concrete or other material as agreed by the Engineer.~~

~~(6) Where instructed by the Engineer, a maximum of 3 concreted soil nail heads shall be uncovered from the batch of soil nail heads constructed on any one day at any site for examination of the quality of soil nail heads. If defective workmanship is identified in any one of the uncovered soil nail heads, the whole batch of soil nail heads constructed on the same day at that site shall be deemed to be defective. All the remaining soil nail heads constructed on the~~

~~same day at that site shall be broken up for the Engineer's examination. The soil nail heads shall be re-constructed and re-examined to the satisfaction of the Engineer.~~

Installation of anchor bar for pull-out tests 7.145A* (1) Anchor bars shall comprise high yield steel bar with minimum characteristic strength 460 MPa conforming to C.S.2, 1995; Or, GEWI bars with Ys = 500MPa; Or, Wire rope anchor Ys = 1770 MPa.

PART 4: GROUTING FOR GEOTECHNICAL WORKS

Materials for grout 7.173 Materials for grout shall comply with Section 16 except as stated in this Section.

Grout for geotechnical works 7.174 (1) Cement grout for geotechnical works consists of PC, PFA, sand and water. Admixtures shall not be used unless permitted by the Engineer. The use of PFA in cement grout shall follow the same requirements of PFA in concrete as specified in Section 16.

(2) Sand for grout shall be clean dry sand complying with BS 1200 and shall have a particle size distribution such that 100% passes a 2 mm BS test sieve and not more than 30% passes a 0.2 mm BS test sieve.

(3) Water for grout shall be clean fresh water having a temperature not exceeding 30°C or less than 5°C.

(4) Cement grout shall have a minimum crushing strength of 30 MPa at 28 days.

(5) The amount of bleeding of grout shall not exceed 0.5% by volume 3 hours after mixing or 1.0% maximum when measured at 23±1.7°C in a covered glass or metal cylinder of 100 mm internal diameter and with a grout depth of approximately 100mm. In addition, the water shall be reabsorbed by the grout within 24 hours.

(6) The flow cone efflux time of grout shall not be less than 15 seconds.

Standpipes 7.175 Unless otherwise approved by the Engineer standpipes for grouting shall be standard black metal pipe complying with BS 1387. With the permission of the Engineer, non-metallic grout pipe may be used for grouting rock dowels, rock bolts and soil nails. Where metal standpipes are used for grouting rock dowels, rock bolts and soil nails, they shall be extracted from drillholes as grouting proceeds.

PART 5: GROUNDWATER DRAINAGE AND CONTROL

Granular filter material 7.209 (1) Granular filter material for granular filter, trench drains and caisson drains shall consist of durable, inert, natural material free of clay, organic material and other impurities.

~~(2) Granular filter material shall have the particle size distribution stated in~~

~~the Contract.~~

7.209A* (1) Granular filter material shall be designed in accordance with the guidance contained in GEO Publication No. 1/93.

Geotextile filter

7.210A* (1) Geotextile filter shall compose of resistant synthetic polymer with the following properties: -

(a) resistant to all naturally occurring soil acids and alkalis;

(b) resistant to biological attack;

(c) resistant to deterioration caused by the effects of exposure to weather and burial; the base polymer of the geotextile fibres shall contain suitable additives such as UV stabilizers and antioxidants;

(d) stable over the temperature range 0°C to 60°C; and

(e) strong enough to withstand the forces imposed upon it during construction. A guarantee to this effect must be given by the supplier of the geotextile.

(2) Type 1 geotextile shall be an approved proprietary brand of non-woven, synthetic fibre fabric complying with the following criteria: -

(a) Pore size O90 (Hydrodynamic sieving) no smaller than 100 microns and equal to or less than 2 x D85, where D85 is the 85% size of the subgrade material.

(b) Tensile strength (plane strain tensile test ASTM D4595) not less than 8 kN/m.

(3) Type 2 geotextile shall be an approved proprietary brand of non-woven, synthetic fibre fabric complying with the following criteria: -

(a) Pore size O90 (Hydrodynamic sieving) no smaller than 50 microns and equal to or less than 2 x D85, where D85 is the 85% size of the subgrade material.

(b) Tensile strength (plane strain tensile test ASTM D4595) not less than 8kN/m, with elongation at half maximum load less than 10% and elongation at maximum load not greater than 40%.

(c) Burst strength (ASTM D3786) of not less than 2500 kPa.

(d) Permeability (10cm constant head test) shall be no smaller than 30 litre/m²/s.

(4) All geotextile filters shall meet the filter design criteria given in GEO Publication No 1/93.

Filter pipes

7.211 (1) Filter pipes shall comply with the following:

Precast concrete pipes	: BS 5911:Part 1 and BS EN 1916
Vitrified clay pipes	: BS EN 295
DI pipes	: BS EN 545

Steel pipes	:	BS EN 10224
Perforated concrete pipes	:	BS 5911:Part 1 and BS EN 1916
uPVC pipes	:	BS EN 1401-1 (Fittings also refer to BS 4660 and BS EN 13598-1) or BS 3506
Corrugated polyethylene tubing	:	AASHTO M252-18

(2) Class O uPVC pipes shall not be used.

(3) The perforations in perforated pipes shall be cleanly cut and shall be uniformly spaced along the length and circumference of the pipe.

(4) uPVC plastic pipes shall be jointed by couplers.

Raking drains 7.212 (1) Type O raking drains shall be unlined raking drains. Drain holes shall be at least 40 mm diameter.

(2) Type 1 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert.

(3) Type 2 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert and enclosed within a geotextile filter sheath.

(4) Type 3 raking drains shall be double pipe raking drains consisting of an outer permanent pipe and an inner removable pipe enclosed within a geotextile filter sheath. The outer and inner pipes shall be perforated pipes with a non-perforated invert.

(5) Pipes for raking drains shall be perforated pipes with non-perforated invert as approved by the Engineer. The portion of openings in the perforated pipe shall cover between approximately two-thirds 50% and 70% of the circumference of the pipe. The percentage of opening areas to overall surface area of the pipe shall not be less than 14% for 40 mm diameter pipe, nor less than 8% for 65 mm or above diameter pipe. The pipe material shall have the following physical properties or having equivalent functions:

(a) Material: non-metallic

(b) Minimum tensile strength: 21,300 kN/m^2

(c) Minimum compressive strength: 22,000 kN/m^2

(d) Minimum flexural strength: 6,800 kN/m^2

(6) Couplers for filter pipes shall also have non-perforated invert and shall be of similar strength and durability of the pipe materials. The lapped length of coupler and each end of the filter pipes shall be at least 100 mm. The elongation at the pipe connection shall be less than 5 mm under a 45 kg pulling force.

(7) Geotextile filter sheaths for raking drains shall be formed of non-woven geotextile filter robust enough to prevent tearing and shall have the following

physical properties or materials having equivalent functions or performance as approved by the Engineer:

(a) Material: non-metallic

(b) Minimum tensile strength: 17 kN/m

(c) Apparent opening size: 140 μm

(d) Coefficient of permeability under 2 kN/m^2: 5×10^{-3} m/s

(e) Flow rate at 100 mm head under 2 kN/m^2: 195 L/m^2s

(8) Tying wires for jointing pipes and stitching filter sheath shall be non-metallic wires of minimum breaking load 400 N or equivalent as approved by the Engineer.

7.212A* Geotextile filter sheaths for raking drains shall be formed of non-woven geotextile filter robust enough to prevent tearing and shall have the following physical properties or materials having equivalent functions:

(a) The minimum thickness of geotextile filter sheaths shall be 0.5 mm. Tanfnel grade U-40.

Relief drains

7.213 Relief drains shall be drain mats with multi-layer porous fabric wrapped in filter fabric and covered with an impermeable fabric or products having equivalent functions or performance as approved by the Engineer. PVC flanges for connecting relief drains to outlet pipes shall be directed by the Engineer.

7.213A* Relief drains shall be of Netlon 20-100FC or 30-200FC type. PVC flanges for connecting relief drains to outlet pipes shall be as shown on CEDD Standard Drawing No. C2404.

Fill material for trench drains

7.214 (1) Fill material to be used with geotextile filter in trench drains shall be clean crushed rock. Type A and Type B fill material shall have the particle size distributions stated in Table 7.3.

(2) Fill material passing a 425μm BS test sieve shall be non-plastic.

(3) The D15 particle size of Type A fill material for use with perforated pipes shall be at least 15% larger than twice the maximum dimension of the perforations, where D15 is the equivalent sieve size in millimetres, interpolated from the particle size distribution curve, through which 15% of the fill material would pass.

Table 7.3: Particle size distribution of fill material for trench drains

Type of fill material	**Percentage by mass passing BS test sieve**						
	63 mm	37.5 mm	20 mm	10 mm	3.35mm	600 μm	63 μm
Type A	-	100	-	45-100	25-80	8-25	0-5
Type B	100	85-100	0-20	0-5	-	-	-

Caisson liners

7.215 Caisson liners shall be concrete tapered rings at least 100 mm thick and not exceeding 1 m deep. The liners shall be constructed with well-compacted concrete of Grade 20/20 or greater.

Prefabricated band drains

7.216A* (1) Prefabricated band drains shall consist of a plastic core and a filter. The drain shall have a minimum of 100mm nominal width (+5mm) and 5mm thickness. The drains may be manufactured as a single unit or the filter may be wrapped around the core, and overlapped and sealed to contain the core. The core shall be made of a continuously extruded material with channels, waffles, studs or other means, to allow continuous flow along the length of the drain. The filter shall be a non-woven geotextile. The drains shall be made from chemically treated paper, polyethylene, polyester or other polyolefine or other synthetic materials or combination of such materials.

(2) The filter jacket for the prefabricated band shall prevent excessive migration of soil particles into the core, that would adversely affect their performance, previously proved effective under similar soil and pressure conditions, and have a permeability greater than the surrounding soil.

(3) The prefabricated band drains shall also comply with the following requirements:

Table 7.1: Requirements of prefabricated band drains

Component	**Property**	**Test Method (Note 1)**	**Requirements**
Drain	Width	ASTM D 3774-(2016)	100mm ± 5mm
	Thickness	ASTM D 5199-12	5mm
	Discharge Capacity, q_w (Note 2) - straight (Note 3) - folded (Note 4)	ASTM D 4716M-14	 $> 90 \times 10^{-3}$ l/s $> 60 \times 10^{-3}$ l/s
	Tensile Strength (Note 5)	ASTM D 4632M-15a	> 2.0 kN
	Elongation at break	ASTM D 4632M-15a	>10%
	Elongation at 1kN	ASTM D 4632M-15a	<10%
Filter	Apparent Opening Size (O_{95})	ASTM D 4751-16	< 75μm
	Permeability	ASTM D 4491M-17	$> 1 \times 10^{-4}$ l/s
	Permittivity	ASTM D 4491M-17	$> 0.20\ s^{-1}$
	Grab Tensile Strength	ASTM D 4632M-15a	> 0.35 kN

Note 1: All testing methods refer to American Society for Testing and Materials
Note 2: qw = qi/i where qi is the flow rate at hydraulic gradient i
Note 3: For i = 0.50 at 280 kPa in compacted clay, sample straight.
Note 4: For i = 0.50 at 280 kPa in compacted clay, sample "S" folded (r = 3.2mm).

PART 8: PAINTING TO CONCRETE/ SPRAYED CONCRETE SURFACES

Paint for concrete/ sprayed concrete surfaces

7.282 Paint for concrete/sprayed concrete surfaces shall be water-based paint for external use. The components of paint shall not be toxic or hazardous to health.

Particulars of paint

7.283 Details of paint products (e.g. specification and colour samples etc.) and method statement shall be submitted for the Engineer's approval prior to painting. The colour of paint shall be "Antique" to BS 5252F colour code 10B25 or other colour as directed by the Engineer.

PART 9: FLEXIBLE BARRIER SYSTEM

Structural steel 7.284* (1) All structural steel shall be not inferior than Grade 43 and to comply with BS 4360 or equivalent.

(2) All hot-dip galvanized steelwork to comply with BS EN ISO 1461:1999.

Ring net 7.285* Ring net shall be of high grade steel wire with strength of at least 1770 N/mm^2 and zinc/aluminum coated. The minimum diameter of wires shall be 3 mm. The maximum diameter of rings shall be 300 mm.

Wire mesh 7.286* The diagonal steel wire mesh shall be chain link type with wire at least 2.4 mm in diameter and with maximum mesh size 50x50 mm. The wire shall be zinc/aluminum coated at minimum of 240g/m^2.

Shackles 7.287* Shackles shall be galvanized high grade steel in accordance with DIN 1142.

Wire rope anchor 7.288* The wire rope anchor shall be with high strength wires of 1770 N/mm^2 tensile grade, stranded into two spiral rope with minimum diameter of 22.5 mm each and provide minimum admissible load of 470kN. Each single wire shall be hot dip galvanized. The wire rope anchor shall be firmly anchored into the ground.

Wire ropes 7.289* All wire ropes (including retaining ropes and lateral anchor ropes except support ropes) shall be composed of high grade steel wires with minimum tensile strength of 1960 N/mm^2 while that of support ropes shall be of minimum tensile strength of 1770 N/mm^2. They shall be of 22mm in diameter and be zinc/aluminum coated.

Posts and ground plates 7.290* Posts shall be anchored with a ground plates that firmly sit on the ground surface. Posts and ground plates shall be hot dip galvanized to 0.08 mm minimum thickness.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 8

PILING WORKS

SECTION 8

PILING WORKS

Steel piles 8.17 (1) Steel bearing piles and steel sheet piles shall comply with BS EN 1090:Part 2.

(2) Steel sheet piles shall be of a proprietary section approved by the Engineer.

Pile shoes 8.18 (1) Cast iron pile shoes for precast concrete piles shall be manufactured from chill hardened iron as used for making grey iron castings complying with BS EN 1561, Grade EN-GJL-150. The chilled iron point of the shoe shall be free of major blow-holes and other surface defects.

(2) Steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR.

(3) Cast steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10293, Grade GE.

(4) Straps and fastenings for cast pile shoes for precast concrete piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR and shall be cast into the point of the shoe to form an integral part of the shoe.

(5) Pile shoes for driven cast-in-place piles shall be manufactured from durable materials approved by the Engineer and capable of withstanding driving stresses without damage. The shoes shall be designed to provide a watertight joint with permanent casings.

(6) Cast steel pile shoes for steel bearing piles shall be manufactured from steel complying with BS EN 10293, Grade GE.

(7) Welded fabricated pile shoes for steel bearing piles shall be manufactured from steel complying with BS EN 10025:Part 2, Grade S275JR.

Epoxy paint 8.19 Epoxy based paint for epoxy coatings to steel piles shall be a proprietary type approved by the Engineer.

Bituminous coating material 8.20 Bituminous coating material for steel piles shall be hot-applied filled or unfilled bituminous material complying with BS EN 10300.

Grout for piling works 8.21 (1) Grout for piling works shall consist of Portand cement (PC) and water. Sand, PFA and admixtures may be used with the approval of the Engineer.

(2) The minimum cementitious content of grout shall be 600 kg/m^3, unless otherwise permitted by the Engineer.

(3) Grout used to fill core holes shall have a minimum crushing strength of not less than the specified grade strength of the concrete surrounding the core hole.

(4) Grout used in minipiles shall have a minimum crushing strength of 30

MPa at 28 days.

(5) The amount of bleeding of grout shall not exceed 2% in the first 3 hours and shall not exceed 4% in total. The water shall be reabsorbed by the grout during the 24 hours after mixing.

(6) Free expansion of grout shall not exceed 10% at the ambient temperature.

(7) The chloride ion content of admixtures for concrete containing embedded metal or for concrete made with SRPC shall not exceed 2% by mass of the admixture or 0.03% by mass of the cementitious content, whichever is less.

(8) The maximum total chloride content of grout, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the grout, shall not exceed 0.1%.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 9

CARRIAGEWAYS: SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

SECTION 9

CARRIAGEWAYS: SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

Sub-base material using virgin material

9.02 Sub-base material shall be crushed rock and shall have the properties stated in Table 9.1. Sub-base material passing the 425 μm BS test sieve, when tested in accordance with Clause 9.46(4) shall be non-plastic.

Recycled sub-base material in lieu of virgin material

9.03 (1) Recycled sub-base material shall be crushed rock, crushed concrete or clean crushed inert demolition material and may contain up to 12.5 % by mass of natural sand which passes the 5mm BS test sieve. The material shall lie within the grading limits of Table 9.1, and not be gap graded.

(2) The material shall have a ten per cent fines value of 50 KN or more when tested in accordance with Clause 9.47(3).

(3) The material passing the 425μm BS test sieve shall be non-plastic when tested in accordance with Clause 9.47(4).

(4) The aggregate shall be considered suitable if it has a soundness value greater than 65%.

(5) The material shall have a water-soluble sulphate content of less than 1.9g of sulphate (expressed as SO_3) per litre, if used within 500mm of cement-bound material, concrete pavements, concrete structures or concrete products.

(6) The material shall have a minimum laboratory California Bearing Ratio (CBR) value of 30% or such other higher value as specified by the Engineer.

(7) The material shall not contain quantities of contaminants in excess of the percentages given in Table 9.2 unless otherwise approved by the Engineer.

~~(8) Notwithstanding the above sub-clauses, the Contractor may propose for the Engineer's approval the use of virgin aggregates in lieu of recycled aggregates in the sub-base material when there is a shortage of supply of recycled aggregates.~~

Table 9.1: Properties of sub-base material

Properties	BS test sieve	Percentage by mass passing
Particle size distribution	75 mm 37.5 mm 20 mm 10 mm 5 mm 600 μm 75 μm	100 85 - 100 60 - 85 40 - 70 25 - 45 8 - 22 0 - 10
Ten per cent fines value		> 50 kN

Table 9.2: Allowable contamination of recycled sub-base material

Sub-base type	Type of contamination			
	Maximum sulphate content by mass	Maximum metals content by mass	Maximum foreign material content e.g. glass, soft material, etc. by mass	Maximum organic material content by mass
Recycled sub-base	1%	1%	1%	0.5%

Aggregates for bituminous materials

9.04 (1) Coarse aggregate for bituminous materials shall be crushed rock all retained on a 5 mm BS test sieve and shall have the properties stated in Table 9.3.

(2) Fine aggregate for bituminous materials shall be crushed rock all passing 5 mm BS test sieve. The water absorption of fine aggregate shall not exceed 2.0%.

(3) For the purpose of mix design, the combined grading of aggregates for bituminous materials shall be such that the particle size distribution lies within the limits stated in Table 9.4 for the relevant bituminous material.

Table 9.3: Properties of coarse aggregate for bituminous materials

Properties	**Nominal maximum aggregate size (mm)**			
	37.5	**28**	**20**	**10**
Flakiness index	≤ 25.0%	≤ 26.0%	≤ 27.0%	≤ 30.0%
Ten per cent fines value	> 100 kN			
Water absorption	≤ 2.0%			

Table 9.4: Design limits for particle size distribution and bitumen content for bituminous materials

Properties		Type of bituminous material					
		Roadbase (recipe mix)	**Base course**		**Wearing course**		**Polymer modified friction course**
Nominal maximum Aggregate size (mm)		37.5	37.5	28	20	10	10
	BS test sieve	Percentage by mass passing					
Particle size distribution	50 mm	100	100	-	-	-	-
	37.5 mm	90 - 100	91 - 100	100	-	-	-
	28 mm	70 - 94	70 - 94	91 - 100	100	-	-
	20 mm	62 - 84	62 - 84	85 - 95	91 - 100	-	-
	14 mm	-	55 - 76	72 - 87	78 - 90	100	100
	10 mm	49 - 67	49 - 67	55 - 75	68 - 84	87 - 100	85 - 100
	5 mm	37 - 55	37 - 55	35 - 53	54 - 72	62 - 80	20 - 40
	2.36 mm	27 - 43	27 - 43	25 - 40	42 - 58	42 - 58	5 - 15
	1.18 mm	-	20 - 35	15 - 30	34 - 48	34 - 48	-
	600 μm	13 - 28	13 - 28	12 - 24	24 - 38	24 - 38	-
	300 μm	7 - 21	7 - 21	8 - 18	16 - 28	16 - 28	-
	150 μm	-	4 - 14	5 - 12	8 - 18	8 - 18	-
	75 μm	2 - 8	2 - 8	3 - 6	4 - 8	4 - 8	2 - 6
Bitumen content as percentage of total mass including binder	min.	3.0	4.0	4.5	5.0	6.0	5.5
	max.	4.0	4.5	5.0	5.5	7.0	7.0

Filler for bituminous materials

9.05 (1) Filler for bituminous materials shall be crushed rock filler, PC, PFAC, PFA or hydrated lime. Filler shall be free-flowing and dry before addition to the bituminous mixture.

(2) Filler for polymer modified friction course material shall contain hydrated lime. The amount of hydrated lime, expressed as a percentage by mass of the total aggregates, shall be at least 1.5%.

(3) PC and PFAC shall comply with BS EN 197:Part 1.

(4) PFA shall comply with BS EN 450:Part 1 except that the criterion for maximum water requirement shall not apply.

(5) Crushed rock filler and hydrated lime shall comply with ASTM D 242.

Bitumen 9.06 (1) Bitumen for bituminous materials other than polymer modified friction course material shall comply with ASTM D 946, Grade 60-70 and shall have a softening point exceeding 44°C and less than 55°C. The wax content of the bitumen shall comply with requirements for Grade A specified in JTG F40-2004. Unless otherwise permitted by the Engineer, blending or mixing of bitumen shall be carried out at a refinery approved by the Engineer.

(2) Bitumen for polymer modified friction course material shall be polymer modified bitumen that shall be a pre-blended type bitumen with Styrene-Butadiene-Styrene (SBS) polymer manufactured by the wet mix method unless otherwise approved by the Engineer. Dry mix method for mixing the bitumen and polymer in the batching plant shall not be allowed. The polymer modified bitumen shall have a performance grade not lower than PG 76 of the Performance Graded Asphalt Binder Specification specified by the AASHTO Designation M320.

Bituminous emulsion 9.07 Bituminous emulsion shall be cationic bituminous emulsion complying with BS EN 13808, Class C40B4.

Bituminous priming material 9.08 Bituminous priming material shall be medium curing-grade cutback bitumen complying with ASTM D 2027, Table 1, Class MC-30.

Pavement reinforcement mesh 9.08A* The pavement reinforcement mesh shall be Glasgrid 8502 or products having equivalent functions or performance. The mesh shall have minimum weight of 560g/m^2, coated with modified polymer coating and specially formulated pressure-sensitive adhesive with effective working temperature from 5°C - 60°C and meet with the minimum value of:

Physical Properties	Min. value
Tensile strength across width	⩾200kN/m
Tensile strength across length	⩾100kN/m
Modulus of Elasticity	⩾69,000,000kPa

DESIGN OF SUB-BASE MATERIAL AND BITUMINOUS MATERIALS

Design of bituminous materials 9.10 (1) Bituminous materials shall consist of coarse and fine aggregates complying with Clause 9.04, filler complying with Clause 9.05 and bitumen complying with Clause 9.06. The different types of bituminous materials shall have particle size distributions and bitumen contents within the limits stated in Table 9.4.

(2) The Contractor shall use bituminous wearing course and base course materials incorporating reclaimed asphalt pavement (RAP) for carriageway works. The RAP and production of bituminous materials incorporating RAP shall comply with Clauses 9.09 (4) and (5). The specific requirements are as follows:-

(a) Wearing course and base course materials incorporating RAP shall be designed, manufactured, laid and tested in accordance with the requirements for these materials using non-recycled materials or otherwise specified by the Engineer. Failure in designing and manufacturing a mix satisfying such requirements shall not be accepted as a valid reason for not incorporating RAP in bituminous wearing course and base course materials.

(b) The RAP shall comply with the following:

(i) RAP shall be obtained from milling or excavation of existing bituminous pavements, and return loads from site and offcuts from bituminous layer joint preparation. Return load can include bituminous materials rejected from site. RAP shall be crushed and screened as necessary such that the maximum particle size is not greater than the nominal maximum aggregate size of the type of bituminous materials being produced and a reasonably well-graded and consistent mixture can be produced.

(ii) RAP shall be free of foreign materials such as unbound granular sub-base, broken concrete, or other contaminants.

(iii) RAP shall be stored in separate stockpiles before use. RAP that has been stockpiled for some time shall be reprocessed, where necessary, to ensure that it is in a free-flowing state at the time of use.

(iv) The amount of RAP allowable in the bituminous wearing course or base course materials shall be in the range of 20% to 30% by mass of the total mix. Separate mix designs shall be required for these materials incorporating RAP.

~~(c) Notwithstanding the above clauses, the Contractor may propose for the Engineer's approval for using bituminous wearing course or base course materials without RAP when there is a shortage of supply of RAP in the market.~~

(3) The properties of the different types of bituminous materials shall be as stated in Table 9.5.

~~(4) Bituminous materials of all aggregate sizes, other than bituminous roadbase material, shall be designed in accordance with the Marshall Method of Mix Design stated in The Asphalt Institute Handbook 'MS-2 Mix Design Methods for Asphalt Concrete and other Hot-mix Types, Sixth Edition (1997)' with modifications only if agreed by the Engineer. The compaction standard shall be 75 blows per side. For design of polymer modified friction course materials, the compaction standard shall be 50 blows per side unless otherwise agreed by the Engineer. The mixing and compaction temperatures for the mixes shall follow the recommendations of the manufacturer of the polymer modified bitumen.~~

~~(5) For polymer modified friction course material, binder drainage tests in accordance with BS 594987, Annex K shall be carried out on the proposed aggregate/modified binder combination to determine the maximum target binder content (T_{max}) of the mix. The proposed mix will be acceptable if the maximum target binder content (T_{max}) is equal to or greater than the proposed binder content.~~

Table 9.5: Properties of designed bituminous materials

Properties	Type of bituminous material				
	Base course		Wearing course		Polymer modified friction course
	Nominal maximum aggregate size (mm)				
	37.5	28	20	10	10
Minimum Marshall stability (kN)	10.0		10.0		-
Maximum flow value (mm)	4.0		4.0		-
Minimum voids in mineral aggregate as a percentage of total bulk volume	12.5	13.0	14.0	16.0	-
Air voids in mix as a percentage of total bulk volume	3.0 - 5.0		3.0 - 5.0		min. 20.0

Bituminous materials 9.10A* (1) Bituminous materials of all aggregate sizes, other than bituminous roadbase material, shall be designed in accordance with the Marshall Method of Mix Design stated in The Asphalt Institute Handbook 'MS-2 Mix Design Methods for Asphalt Concrete and other Hot-mix Types, Sixth Edition (1997)'. For design of bituminous wearing course and base course materials, the compaction standard shall be 75 blows per side. The amount of RAP allowable in the bituminous wearing course or base course materials shall be in the range of 10% to 15% by mass of the total mix. Separate mix designs shall be required for these materials incorporating RAP. For design of polymer modified friction course and highly modified friction course material, the compaction standard shall be 50 blows per side. The mixing and compaction temperatures for the mixes shall follow the recommendations of the manufacturer of the polymer modified bitumen and highly modified bitumen.

(2) For polymer modified friction course and highly modified friction course material, binder drainage tests in accordance with BS 5949-87, Annex K shall be carried out on the proposed aggregate/modified binder combination to determine the maximum target binder content (T_{max}) of the mix. The proposed mix will be acceptable if the maximum target binder content (T_{max}) is equal to or greater than the proposed binder content.

(3) For the avoidance of doubt, Clauses 9.10 (1) to (5) are applicable to bituminous wearing course and base course materials without RAP.

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 10

CONCRETE CARRIAGEWAYS

SECTION 10

CONCRETE CARRIAGEWAYS

GENERAL

General requirements 10.01 ~~(1) The works and materials specified in Clauses 10.02 to 10.06 shall comply with the sections stated, unless otherwise stated in this Section.~~

(2) All adhesives and sealants shall contain not more than 0.01% and 0.5% by wet weight of formaldehyde and total aromatic compounds (including benzene, toluene, xylenes, ethylbenzene, etc.) respectively.

Concrete 10.04 Concrete for concrete carriageways shall comply with Section 16. In addition, the abrasion resistance in Los Angeles value for coarse aggregates in concrete shall not exceed 30% loss in accordance with CS3.

MATERIALS

Reinforcement 10.07 Dowel bars, tie bars, cradles and tie bars for cradles shall be Grade 250 plain round steel bars complying with Section 15. Dowel bars and tie bars shall be straight. Both ends of dowel bars and one end of tie bars shall be sawn square with all burrs removed.

Cement mortar for cradles 10.08 Cement mortar for supporting cradles shall consist of 1 part of cement to 3 parts of fine aggregate together with the minimum amount of water necessary to achieve a consistency suitable for the required work. Fine aggregates shall be sand or crushed rock to BS EN 13139 and shall be less than or equal to 4mm.

Fine aggregate 10.09 Fine aggregate for concrete shall be clean, hard and durable crushed rock in accordance with Section 16.

Polyethylene sheeting 10.10 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

Joint filler 10.11 Joint filler shall be of a proprietary type approved by the Engineer and shall be a firm, compressible, single thickness, non-rotting filler.

Joint sealant 10.12 (1) Joint sealant shall be of a grade suited to the climatic conditions of Hong Kong and shall perform effectively over a temperature range of 0°C to 60ºC.

(2) Joint sealant shall be a cold poured two-part polymer-based sealant complying with BS EN 14188:Part 2, Class A.

(3) Primers and caulking material for use with joint sealant shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer.

Bond breaker tape 10.13 Bond breaker tape shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer. The tape shall be a polyethylene film with adhesive applied on one side and shall be the full width of the groove.

Groove forming strip 10.14 (1) Groove forming strip shall be of a proprietary type approved by the Engineer. The strip shall be a firm compressible strip of either ethylene vinyl acetate foam with a density of at least 90 kg/m^3 or synthetic rubber. The strip shall be 25 mm deep and 5 mm thick and shall be sufficiently rigid to remain in position during concreting without deforming or stretching.

(2) Adhesive for groove forming strip shall be of a proprietary type recommended by the groove forming strip manufacturer and approved by the Engineer.

Sleeves for dowel bars and tie bars 10.15 Sleeves for dowel bars and tie bars shall be uPVC and shall have a nominal wall thickness not exceeding 1.5 mm. The sleeves shall fit tightly to the bars.

Epoxy resin grout 10.16 Epoxy resin grout shall be of a proprietary type approved by the Engineer.

CONCRETE

Concrete mix 10.17 Concrete for concrete carriageways shall comply with the following requirements:

(a) Concrete shall be Grade 40/20 and shall be a designed mix.

(b) The concrete mix shall contain either PFAC or a minimum of 265 kg of PC plus a minimum of 85 kg of PFA per m^3 of compacted concrete.

(c) The percentage by mass of fine aggregate to total aggregate shall be at least 30%.

(d) The workability in terms of designed slump value shall not exceed 75 mm.

Cementitious content of concrete 10.18 The minimum cementitious content of concrete for concrete carriageways shall be 350 kg/m^3.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 11

MISCELLANEOUS ROADWORKS

SECTION 11

MISCELLANEOUS ROADWORKS

PART 1: GENERAL REQUIREMENTS

Cement mortar 11.09 Cement mortar shall consist of one part of cement to three parts of fine aggregate by volume together with the minimum amount of water necessary to achieve a consistency suitable for the required work. Fine aggregates shall be sand or crushed rock to BS EN 13139 and shall be less than or equal to 4mm.

Polyethylene sheeting 11.10 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

PART 2: CONCRETE PROFILE BARRIERS

Concrete mix 11.11 Concrete for concrete profile barriers shall be Grade 30/20.

PART 3: PEDESTRIAN GUARD-RAILING

Steel 11.28 Steel for pedestrian guard-railing shall comply with the following:

Hot finished seamless tubes	: BS EN 10297:Part 1
Steel tubes and tubular suitable for screwing to BS EN 10226 pipe threads	: BS EN 10255
Hot rolled sections	: BS EN 10365
Hot rolled structural steel sections - equal and unequal angles	: BS EN 10056
Weldable structural steels	: BS EN 10025

Stainless steel 11.29 Stainless steel for pedestrian guard-railing shall be Grade 1.4401 and shall comply with the following:

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes	: BS EN 10088:Part 2
Stainless steel tubes suitable for threading in accordance with BS EN 10226	: BS 6362

Aluminium 11.30 (1) Aluminium for pedestrian guard-railing shall be 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, screws, washers and rivets

11.31 (1) Bolts, nuts, screws, washers and rivets for pedestrian guard-railing shall comply with the following:

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

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

Metal washers for general engineering purposes : BS 4320

Rivets for general engineering Purposes : BS ISO 1051

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

(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 and expansion bolts and resin bonded bolts shall be of proprietary types approved by the Engineer and shall be capable of withstanding the design loading.

(4) Galvanized bolts, nuts, screws, washers and rivets shall be used with galvanized pedestrian guard-railing. Aluminium materials shall be insulated from ferrous materials by a non-conductive insulator at least 2 mm thick of a type approved by the Engineer.

Mesh infill

11.32 Mesh infill for pedestrian guard-railing shall comply with BS 4483. The mesh infill shall be free of surface defects, surface irregularities and mesh misalignment.

PART 4: UNTENSIONED BEAM BARRIERS

Beams

11.39 (1) Beams for untensioned beam barriers shall be formed from steel plates complying with BS 1449:Part 1.1, type BHR, and BS EN 10149:Part 3, Grade S315NC.

(2) The beams shall be capable of withstanding a tensile force of at least 300 kN and shall not deflect by more than 40 mm when loaded centrally with a point load of 1 t over a simply supported span of 3 m.

(3) Beams shall comply with the following requirements:

(a) The base metal thickness shall be within 0.2 mm of the specified thickness.

(b) The strip width shall be within + 2.5 mm and - 0 mm of the specified width.

(c) The camber of the strip length shall be within 8 mm of the specified camber.

(d) The beam shall be straight to within 1.5 mm in a 1.5 m length.

(e) Angles at bends shall be within 2° of the specified angle.

(4) Bolt slots in beams for connection to posts shall be prepared in the workshop by cold saw-cutting. The spacing of the slots shall be such that posts will be spaced at either 4 m or 2 m.

(5) Beams shall be hot-dip galvanized to BS EN ISO 1461.

Welds for end beam sections shall be full-penetration butt welds.

Posts 11.40 (1) Posts for untensioned beam barriers shall be formed from Grade 275JR steel complying with BS EN 10025:Part 2.

~~(2) Posts shall be hot-dip galvanized in accordance with BS EN ISO 1461.~~

(3) Posts fabricated from hollow sections shall be sealed by welding mild steel sealing plates over the open ends. The plates shall be at least 3 mm thick.

(4) Posts shall be within the tolerances stated in BS EN 10365.

11.40A* (1) Posts and blocking-out pieces shall be hot-dip galvanized in accordance with BS EN ISO 1461 to a coating thickness of at least 610 g/m^2.

Cleats and struts 11.41 (1) Cleats and struts for untensioned beam barriers shall be fabricated from angle sections complying with BS EN 10056 and shall be weldable structural steel complying with BS EN 10025:Part 2, Grade 275JR.

(2) Cleats and struts shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(3) The dimensional tolerances of steel angles for cleats and struts shall comply with BS EN 10056.

Bolts and nuts 11.42 (1) Bolts for untensioned beam barriers shall be M 16 size and strength Grade 4.6 complying with BS 4190. Bolts for beam splicing, bolts for connecting beams to posts and bolts for connecting beams to cleats shall be round or button-headed with oval shoulders. Other bolts shall be ISO metric black hexagon type.

(2) Nuts for untensioned beam barriers shall be strength Grade 4 or 5 complying with BS 4190.

(3) Bolts and nuts shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(4) Nuts shall be tapped 0.4 mm oversize to accommodate the galvanized coating.

(5) 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.

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

Washers 11.43 (1) Washers for untensioned beam barriers shall be black mild steel and shall comply with BS 4320, Form E, F or G. Washers shall be manufactured from steel complying with BS 1449:Part 1.1 and BS EN 10149:Part 3, Grade S315NC.

(2) Plain washers shall be 2 mm thick and shall be of dimensions suitable for use with M 16 bolts and nuts.

(3) Plain washers shall be hot-dip galvanized in accordance with BS EN ISO 1461.

(4) Shaped washers shall have a thickness of at least 5 mm and shall be cast iron complying with BS EN 13835. The washers shall be shaped to fit the curvature of circular hollow sections used as posts.

PART 5: KERBS, EDGINGS AND QUADRANTS

Concrete kerbs, edgings and quadrants 11.51 (1) Concrete for kerbs, edgings and quadrants shall be Grade 30/20. Concrete for foundations and backings to kerbs, edgings and quadrants shall be Grade 20/20.

(2) Precast concrete kerbs, edgings and quadrants shall comply with BS EN 1339 except that the requirement for testing of weathering resistance, abrasion resistance, slip/skid resistance shall not be applied. The nominal length of kerbs shall be 1 m and the nominal length of edgings shall be 750 mm.

PART 6: FOOTWAYS, CYCLETRACKS AND PAVED AREAS

Concrete for footways, cycletracks and paved areas 11.56 Concrete for footways, cycletracks and paved areas shall be Grade 30/20.

PART 7: PRECAST CONCRETE UNITS FOR PAVING

Units 11.61 (1) The dimensions of units shall be within 3 mm of the specified

dimensions unless otherwise stated. Chamfers shall not exceed 5 mm in width and depth or shall be round unless otherwise approved by the Engineer.

(2) Units may incorporate integral spacer nibs to aid the laying but these spacer nibs shall not be included in the size of the units.

(3) Units shall come in wide ranges of colours to facilitate pavement design by the Engineer. The colours of units shall be consistent over the area to be paved, stable and fade resistant under any outdoor climate situations.

(4) Units shall not exhibit defects such as cracking or flaking.

(5) Units shall be free of any surface sealant unless otherwise directed by the Engineer.

Precast concrete paving slabs 11.62 (1) Paving slabs shall be square or rectangular of metric size 200 mm x 300 mm or 300 mm x 300 mm.

~~(2) Paving slabs shall be 60 mm thick for footpaths. Paving slabs of other thickness may be used if approved by the Engineer.~~

11.62A* (1) Paving slabs shall be 60mm thick for footways and 80mm thick for carriageways and vehicular accesses.

Precast concrete paving blocks 11.63 (1) Paving blocks shall be as shown in relevant Highways Department Standard Drawings, unless otherwise specified by the Engineer. 200 x 200 x 60 mm paving units shall be considered as paving blocks.

(2) Paving blocks shall be 60 mm thick for footpaths and 80 mm thick for carriageways and vehicular accesses. Paving blocks of other thickness may be used if approved by the Engineer.

Precast concrete paving setts 11.64 (1) Paving setts shall be square of metric size 100 mm x 100 mm unless otherwise specified by the Engineer.

(2) Paving setts shall be 60 mm thick for footpaths and 80 mm thick for carriageways and vehicular accesses. Paving setts of other thickness may be used if approved by the Engineer.

Concrete 11.65 (1) Concrete for units in footways and cycle tracks shall be Grade 30. Concrete for units in carriageways or areas to which vehicles will have access shall be Grade 45.

The nominal maximum aggregate size for concrete in precast units shall be 10 mm.

Concrete & use of recycled aggregates 11.65A* (1) Concrete for paving units in footways and cycle tracks shall be Grade 30; concrete for paving units in carriageways or areas to which vehicles will have access shall be Grade 45.

(2) Aggregates for concrete shall comply with the following requirements:

(a) The aggregates shall contain not less than 70% by weight of recycled aggregates.

(b) The recycled fine aggregates shall constitute not less than 40% by weight

of the total recycled aggregates. The recycled glass cullet shall be included as recycled fine aggregates and shall constitute 20% to 25% by weight of the total aggregates.

(c) The nominal maximum size of the aggregates shall be 10 mm.

(d) The recycled coarse aggregates shall be retained on a 5 mm BS test sieve.

(e) The recycled fine aggregates shall all pass a 5 mm BS test sieve.

(f) The recycled glass cullet shall all pass a 3.35 mm BS test sieve and shall be integrated with other constituents in such a manner that there is no sharp edge nor burr exposed to put the pedestrians at risk when the paving unit surface is eroded.

(g) The recycled aggregates shall contain no more than 0.5% of wood and other materials less dense than water by using the manual sorting test method in accordance with BRE Digest 433.

(h) The recycled aggregates shall contain no more than 1% of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, glass, etc.) by using the manual sorting test method in accordance with BRE Digest 433.

(i) The recycled aggregates, except recycled glass cullet, shall be the crushed inert construction and demolition materials produced from the crushing plant of the Civil Engineering and Development Department.

(j) The recycled glass cullet shall be produced from glass waste generated from local sources accepted by the Engineer.

(3) Each paving unit shall bear an inscribed mark for the identification purpose that the unit contains recycled glass cullet of 20% to 25% by weight of the total aggregates.

Additional requirements for Grade A units

11.66 (1) Grade A units shall have an abrasion resistance of not more than 23 mm to BS EN 1338.

(2) Colour Pigments for Grade A units shall comply with BS EN 12878. They shall be UV-stable and shall be iron oxides, chrome oxide, titanium oxide or cobalt aluminium oxide unless otherwise approved by the Engineer.

Sand

11.67 (1) Sand for bedding units shall have the particle size distribution stated in Table 11.1. The sand shall have a moisture content exceeding 4% and not exceeding 8% at the time of laying.

(2) Sand for filling joints between precast units shall have the particle size distribution stated in Table 11.2. The sand shall have a moisture content of less than 0.5% at the time of filling joints.

Table 11.1: Particle size distribution of sand for bedding units

BS test sieve size	**Percentage by mass passing**
10 mm	100
5 mm	85 - 100
2.36 mm	65 - 100
1.18 mm	40 - 98
600 μ m	25 - 72
300 μ m	10 - 35
150 μ m	0 - 15
75 μ m	0 - 10

Table 11.2: Particle size distribution of sand for filling joints between units

BS test sieve size	**Percentage by mass passing**
2.36 mm	100
1.18 mm	90 - 100
600 μ m	60 - 90
300 μ m	30 - 60
150 μ m	15 - 30
75 μ m	5 - 10

PRECAST CONCRETE PAVING BLOCKS

Materials and units 11.89*

(1) Units shall come in a mixture of natural stone chips of different colours to facilitate pavement design. The colour of units may vary due to the natural colours of aggregates. However, the colour tone of units shall be consistent over the area to be paved.

(2) The paving blocks should be “China origin” concrete or equivalent.

(3) Paving blocks shall be 60 mm thick for footpaths and 80 mm thick for carriageways and vehicular accesses.

(4) Paving blocks shall have natural aggregate surface texture, the colour of which is natural and not pigmented. It shall be stable and fade resistant under any outdoor climate conditions.

Technical Requirements 11.90*

(1) Paving blocks shall have an abrasion resistance of not more than 23 mm to BS EN 1338 or equivalent.

(2) Dimensional deviations of paving blocks to BS EN 1338 or equivalent.

(a) The tolerances for the dimensions of each individual units shall be within ±2 mm for length and width, and ±3 mm for thickness.

(3) Slip/skid resistance value of paving blocks to AS4586, or unpolished slip/skid resistance value of paving blocks to BS EN 1338 or equivalent.

(a) The mean slip/skid resistance of a sample shall not be less than 45 Skid Resistance Value for units in footways and cycle tracks.

(4) Paving blocks shall be tested to determine the 24-hour cold water absorption value to AS/NZS 4456.14 or equivalent.

(a) The sample shall have a characteristic water absorption value not more than 6% by 24-hour cold immersion method to AS/NZS 4456.14 or equivalent.

(b) The characteristic water absorption value (Wc) shall be calculated from the following equation:

$W_c = W_m + 1.65X_s\%$

where:

- W_m is the average water absorption rate of the sample
- X_s is the unbiased standard deviation as stated in AS/NZS 4456.2.

(5) The characteristic compressive strength of a sample to Clause 1.19 to 1.23 inclusive of paving blocks shall be:

(a) 30MPa for paving blocks in footways and cycle tracks, and

(b) 45 MPa for paving blocks in carriageways and paved areas to which vehicles will have access.

CRASH CUSHION SYSTEM

Crash Cushion system 11.91* The colour of the nosing of the crash cushion system shall be plain yellow. Yellow retroreflective sheeting complying with ASTM D4956 99 Type IV material shall be stuck on the nosing.

PERMEABLE PAVER FOR POROUS PAVEMENT

Additional requirements for Permeable Pavers 11.92* (1) Permeable pavers shall have an abrasion resistance of not more than 23 mm to BS EN 1338.

(2) Colour Pigments for permeable pavers units shall comply with BS EN 12878:2005, They shall be UV-stable and shall be iron oxides chrome oxide, titanium oxide or cobalt aluminium oxide.

PART 8: NOISE BARRIER WORKS

Materials of noise barrier panels 11.93* (1) All noise barrier panels shall incorporate resistance to the effects of ultra-violet light .

(2) Self-cleansing coatings shall be applied to the noise barrier panels.

(3) 5% of each size of each type of the noise barrier panels shall be provided as spare parts.

Alternative materials 11.94* The materials used for noise barrier panels shall be Polymethyl Methacrylate (PMMA) or absorptive type where appropriate as shown on the Drawings. Alternatives which are in full compliance with the requirements of the specified material may also be considered.

Transparent noise barrier panels 11.95* (1) The panels shall have a weighted sound reduction index of at least 25dB which shall be tested in accordance with EN 1793 or JIS 1416.

(2) The panels shall be ultra-violet light resistant.

PMMA panels for Noise Barrier 11.96* (1) (a) Polymethyl methacrylate (PMMA) noise barrier panels shall be either extruded or cast fully satisfying the EN1793 noise barrier standard and the requirements of this Specification.

(b) The PMMA noise barrier panels shall possess the following properties:

(i) light transmittance of at least

90 % for clear panel,

60 % for coloured panel,

50 % for translucent panel;

(ii) tensile strength of at least 65 N/mm^2;

(iii) modulus of elasticity of at least 2900 N/mm^2;

(iv) fire retardant property complying with the requirements in EN 1794-3 Class 2;

(v) stone impact resistance complying with the requirements in EN 1794-1 Annex C;

(vi) impact strength as Class A complying with BS 6206; and

(vii) no emission of noxious fumes or leachates as a result of fire.

(c) Notwithstanding the requirements above, the PMMA noise barrier panels at the cantilever portion of the noise barriers shall have non-glaring matt surface at top surface which shall meet the following requirements:-

(i) The matt surface shall not be produced by destructive method such as mechanical blast, chemical etching etc in order not to change the properties of material;

(ii) The appearance of non-glaring surface shall not be blemished either with fingerprints or after processing the matt surface;

(iii) Light transmission of non-glaring panels shall be 68 +/- 5%,

(iv) The specular gloss value of the non-glaring panels shall be tested according to BS 2782: Part 5 Method 520A;

Angle of Incidence	Specular gloss value
20°	10 (max.)
60°	30 (max.)
85°	20 (max.)

(2) The panel properties at the end of the 10-year period, which shall include but not limited to the following:-

(a) light transmittance loss not exceed 5% from the original value;

(b) tensile strength of at least 50 N/mm²;

(c) modulus of elasticity of at least 2600 N/mm²;

(d) colour difference shall be less than 20 units of ΔE_{ab} to BS EN ISO 11664-4;

(e) no mottling; and

(f) no loss in acoustic property, fire retardant property and stone impact resistance.

(3) All plastic materials are to be suitable for outdoor exposure and are to be UV resistant.

(4) All materials used at ground level or other areas of high traffic or exposure to damage are to be 'mar resistant'.

Polycarbonate panels 11.97* (1) (a) Polycarbonate transparent noise barrier panels shall be coextruded (i.e. fusion), with weather protection on both sides against UV radiation from sunlight and for avoidance of coating failure. Unless specified otherwise in the Specification, requirements in EN 1793 shall be fulfilled.

(b) The polycarbonate transparent noise barrier panels shall possess the following properties :

i. light transmittance of at least 80% for clear panel.
65% for coloured panel.
60% for translucent panel.

ii. tensile strength of at least 55N/mm^2.

iii. modulus of elasticity of at least 2100 N/mm^2.

iv. fire retardant property complying with the requirements in EN 1794-3 Class 2.

v. stone impact resistance complying with the requirements in EN 1794-1 Annex C or JIS K 6735.

vi. fire spread property complying the requirements of Class 1 or 2 Surface Spread of Flame under BS 476 Part 7.

vii. impact strength as Class A complying with BS 6206.

(2) The panel properties at the end of the 10-year period, which shall include

but not limited to the following :

(a) light transmittance loss not exceeding 7% from the original value.

(b) tensile strength of at least 45 N/mm^2.

(c) modulus of elasticity of at least 1800 N/mm^2.

(d) yellowing index shall be less than 10 to ASTM D 1925 or JIS K 7373.

(e) no mottling.

(f) no loss in acoustic property, fire retardant property and stone impact resistance.

Main structural steel frames and mountings 11.98* (1) All steelworks of noise barrier shall comply with Section 18 of the Specification.

(2) Bolts connecting components of the structural frame and holding down bolts shall be stainless steel with strength grade A4-80 to the requirements of BS EN ISO 3506-1&2 with either a locking nut or spring washer. Respectively with compatible stainless steel washers, a nylon or other approved plastics washer is to be provided between the surfaces of any different metal such as aluminium alloy, stainless steel and galvanized steel.

(3) The external and internal acoustical sealing material located inside and outside of the noise barrier panels shall be extruded siliconized Ethylene Propylene Diena Monomer (EPDM) type gasket profile with hardness of 60 degree shore and with quality compatible with the noise barrier panels. Such gaskets shall be supplied by the noise barrier panels manufacturer and supported by an original test report.

Absorptive noise barrier panels 11.99* (1) The absorptive noise barrier panels shall be made of seawater resistant aluminium to DIN 1725/1 with synthetic powder coating. The absorptive noise barrier panels shall comply with Noise Dampening Standard to DIN 52210: Δ LA,R,Str.:min.25dB and Noise Barrier Standard to ZTV-Lsw88. The panel manufacturer shall be awarded certification to ISO 9001 and provide a guarantee on retaining of quality satisfying all the requirements in accordance with ZTV-Lsw88 standard throughout a period of 10 years.

(3) The absorptive noise barrier panels and the in-fill materials shall be weather resistant. Repeated cycles of soaking by water and subsequent drying shall not affect the acoustic performance and durability of the panels.

(4) The external and internal acoustical sealing located inside and outside of the absorptive noise barrier panels shall be extruded siliconized Ethylene Propylene Diena Monomer (EPDM) type gasket profile with hardness of 60 degree shore and with quality compatible with the noise barrier panels. Such gaskets shall be supplied by the noise barrier panel manufacturer and supported by an original test report.

Glass panels 11.100* (1) (a) Glass transparent noise barrier panels shall be tempered (thermally toughened) and laminated glass complying with BS 952 as specified on the Drawings. Unless specified otherwise in the Specification, requirements in EN 1793 shall also be fulfilled. The panels shall have thickness and colour as

specified on the Drawings.

(b) Heat soaking shall be carried out to tempered glass to reduce the risk of damaging due to nickel sulphide. The process shall comply with BS EN 14179.

(c) Different sheets of the laminated glass noise barrier panels shall be bonded together by Polyvinyl butrate (PVB) interlayers or similar material with minimum thickness not less than 1.52mm.

(d) The tempered glass transparent noise barrier panels shall possess the following properties :

i. light transmittance of at least 85% for clear panel.
65% for coloured panel.
60% for translucent panel.

ii. breaking strength of at least 110 N/mm^2.

iii. fire retardant property complying with the requirements in EN 1794-3 Class 2.

iv. stone impact resistance complying with the requirements in EN 1794-1 Annex C.

v. fire spread property complying the requirements of Class 1 or 2 Surface Spread of Flame under BS 476 Part 7.

vi. impact strength as Class 1 complying with BS EN 12600.

vii. static or cyclic load resistance complying with requirements as stated in Clauses 33.14(7) and 33.14(8).

(2) The panel properties at the end of the 10-year period, which shall include but not limited to the following :

(a) light transmittance loss not exceeding 5% from the original value.

(b) breaking strength of at least 95 N/mm^2 for tempered glass, 65 N/mm^2 for laminated heat strengthened glass or 40 N/mm^2 for laminated float glass.

(c) colour difference shall be less than 20 units of $\triangle E_{ab}$ to BS EN ISO 11664-4.

(d) no mottling

(e) no loss in acoustic property, fire retardant property and stone impact resistance.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 12

WORKS TRAFFIC SIGNS, ROAD MARKINGS AND ROAD STUDS

SECTION 12

WORKS TRAFFIC SIGNS, ROAD MARKINGS AND ROAD STUDS

PART 1: TRAFFIC SIGNS

Steel 12.05 Steel for traffic signs shall comply with the following:

Hot finished seamless tubes	:	BS EN 10297:Part 1
Hot rolled sections	:	BS EN 10365
Hot rolled structural steel sections - equal and unequal angles	:	BS EN 10056
Weldable structural steels	:	BS EN 10025

Stainless steel 12.06 Stainless steel for traffic signs shall be Grade 1.4401 and shall comply with the following:

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes	:	BS EN 10088:Part 2
Stainless steel tubes suitable for threading in accordance with BS EN 10226	:	BS 6362

Aluminium alloy 12.07 (1) Aluminium alloy for traffic signs shall be EN AW-6082 in the T6, T651 or T62 tempers and shall comply with the following table:

Wrought aluminium and aluminium alloys for general engineering purpose	Standards
- Plate, sheet and strip	BS EN 485:Part 1, BS EN 485:Part 2, BS EN 485 Part 3 and BS EN 485:Part 4
- Drawn tube	BS EN 754:Part 1, BS EN 754:Part 2, BS EN 754:Part 3, BS EN 754:Part 4, BS EN 754:Part 5, BS EN 754:Part 6, BS EN 754:Part 7 and BS EN 754:Part 8
- Bars, extruded round tubes and sections	BS EN 755:Part 1, BS EN 755:Part 2, BS EN 755:Part 3, BS EN 755:Part 4, BS EN 755:Part 5, BS EN 755:Part 6, BS EN 755:Part 7, BS EN 755:Part 8 and BS EN 755:Part 9

(2) Aluminium alloy shall be anodized to Grade AA 25 in accordance with BS EN ISO 7599.

~~(3) Aluminium alloy sheet shall be free of twisting, warping and buckling~~

~~and the surfaces shall be free of blemishes and other defects.~~

Bolts, nuts, screws, washers and rivets 12.08 (1) Bolts, nuts, screws, washers and rivets for traffic signs shall comply with the following:

ISO metric black hexagon bolts, screws and nuts :	BS 4190
ISO metric black cup and countersunk head bolts and screws with hexagon nuts :	BS 4933
Metal washers for general engineering purposes :	BS 4320
Rivets for general engineering purposes :	BS ISO 1051
Wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock :	BS 1473
Mechanical properties of corrosion-resistant stainless-steel fasteners. Bolts, screws and studs :	BS EN ISO 3506:Part 1
Mechanical properties of corrosion-resistant stainless steel fasteners. Nuts :	BS EN ISO 3506:Part 2

(2) The length of bolts shall be such that after assembly 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 and expansion bolts and resin bonded bolts shall be of a proprietary type approved by the Engineer~~.~~

(4) Galvanised bolts, nuts, screws, washers and rivets shall be used with traffic signs secured to galvanised pedestrian guard-railing. Aluminium materials shall be insulated from ferrous materials by a non-conductive insulator at least 2 mm thick .

Materials for faces of traffic signs 12.09 (1) Prismatic retroreflective sheeting shall be Type IX material complying with ASTM D4956-16b. The use of Class RA2 glass bead retroreflective sheeting complying with BS EN 12899:Part 1, Table 4 shall be subject to the approval of the Engineer.

(2) Non-retroreflective sheeting shall comply with BS EN 12899:Part 1.

(3) Plastic sheeting shall be of a proprietary type approved by the Engineer.

~~(~~4) All materials and finishes shall be mutually compatible.

PART 2: ROAD MARKINGS

Hot-applied thermoplastic material 12.23 (1) Hot-applied thermoplastic material shall comply with BS EN 1871. In particular,

(a) The luminance factor when tested in accordance with Annex E of BS EN 1871 shall be Class LF4 for white material and Class LF2 for yellow material.

(b) The softening point when tested in accordance with Annex F of BS EN 1871 shall be Class SP2.

(2) Solid glass beads shall be included in the supplied mixture of hot applied thermoplastic material.

(3) Thermoplastic material shall be of a solvent-free marking substance supplied in block, granular or powder forms, which can be heated to a molten state and then applied with an appropriate hand or mechanical applicator, and form a cohesive film by cooling.

(4) Thermoplastic material shall belong to either of the following types:

- Type 'A'-Standard hot applied thermoplastic material.
- Type 'B'-Alkyd resin hot applied thermoplastic material.

Cold-applied preformed material 12.24 (1) Cold-applied preformed material for road markings shall be of a proprietary type approved by the Engineer

(2) Solid glass beads shall be applied to cold-applied preformed material at the place of manufacture.

Cold plastic road marking 12.25 Cold plastics road marking material shall comply with BS EN 1871. In particular, when applied at the manufacturer's stated thickness and tested in accordance with Annex A of BS EN 1871, the luminance factor shall be Class LF4 for white material and Class LF2 for yellow material.

Paint for road markings 12.26 Road-marking paint material, including water-based road-marking paint, shall comply with BS EN 1871. In particular,

(a) The luminance factor when tested in accordance with annex A of BS EN 1871 shall be Class LF6 for white material and Class LF2 for yellow material.

(b) The difference in luminance factor after UV ageing shall be Class UV1.

(c) The difference in luminance factor after bleed resistance test shall be Class BR1.

Solid glass beads 12.27 (1) Drop-on glass beads shall comply with BS EN 1423. In particular, the refractive index of the glass beads shall conform to Class A when determined in accordance with Annex A of BS EN 1423.

(2) Premix glass beads shall comply with BS EN 1424. In particular, the refractive index of the glass beads shall conform to Class A when determined in accordance with Annex A of BS EN 1423.

Functional life of the material 12.28 The functional life of the road-marking material as defined in BS EN 1436 shall be not less than 1 year after laying is carried out.

PART 3: ROAD STUDS

Road studs

12.42 (1) Road studs shall comply with the Road Traffic Ordinance, Cap 374 and its subsidiary legislation.

(2) Reflecting road studs shall comply with BS EN 1463:Part 1 and BS EN 1463:Part 2.

12.42A* (1) Studs bonded to the carriageway surface, including those with anchor devices inserted into the pavement construction, shall be installed as recommended in BS EN 1463:Part 1 using only adhesives which comply with BS EN 1463:Part 1, have been tested to the requirements of BS EN 1463:Part 2 and recommended by the manufacturer for the particular carriageway construction. The adhesive shall extend for the full area of the stud in contact with the pavement surface.

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 13
WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

SECTION 13

WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

GENERAL

Galvanization 13.04 Galvanization in this Section shall be hot dip galvanization to BS EN ISO 1461.

MATERIALS

Electrical conduits and fittings 13.06 (1) Electrical conduits and fittings shall comply with IEC 61386-1 and IEC 61386-21 and shall be hot-dip zinc coated or sherardized both inside and outside against corrosion. Conduits shall be heavy gauge with screw-end construction in steel and shall have an external diameter of at least 20 mm. Conduits shall be longitudinally welded.

(2) Metal boxes complete with covers for enclosing electrical accessories shall have heavy protection both inside and outside in accordance with IEC 60670-1 (e.g. hot-dip galvanised coating or sherardizing). The boxes shall be of preferred sizes and shall be 35 mm or 47 mm deep as appropriate.

(3) Circular boxes, dome covers and hook covers shall be galvanised malleable cast iron complying with IEC 60670-1. Ceiling mounted boxes shall be of deep pattern type having an internal depth of not less than 60mm. Bushes and tube end shall be of brass.

Cable ducts and fittings 13.07 (1) uPVC cable ducts for installation above ground or for casting into concrete shall be Class 0 uPVC pipes complying with BS 3506. Cable ducts for installation below ground shall be Class B uPVC pipes complying with BS 3506.

(2) Joints and fittings for use with uPVC cable ducts shall comply with BS EN ISO 1452 Part 1, 2, 3 and 5. Solvent cement for uPVC pipes and fittings shall comply with BS EN 14814.

(3) Steel cable ducts shall be steel tubes complying with BS EN 10255, medium series, screwed and socketted tubes and shall have screwed sockets suitable for screwing to BS EN 10226, Table 1 pipe threads. The tubes, sockets, clamps and saddles for ducts shall be hot dip galvanized in accordance with BS EN ISO 1461.

Paint for conduit and duct systems 13.08 (1) Bituminous paint for steel conduits and steel cable ducts shall comply with BS 3416, type 1.

(2) Zinc chromate primer for cable duct systems shall comply with BS 4652.

ELECTRICAL AND MECHANICAL (E&M) WORKS

General requirements 13.33* The E&M works shall include the design, manufacture, factory testing, supply and delivery to the Site, erection, connecting up, site testing and commissioning, maintenance, provision of drawings/manuals and spares,

liaison with relevant authorities for obtaining stamps, permits or the like, etc. of all the systems in accordance with the requirements in the Specification, Drawings and all relevant specifications, standards, and regulations including the followings:

(i) Statutory requirements of the Fire Services Department, HKSAR.
(ii) Statutory requirements of the Drainage Services Department, HKSAR.
(iii) Statutory requirements of the Water Supplies Department, HKSAR.
(iv) Statutory requirements of the Labour Department, HKSAR.
(v) Statutory requirements of the Environmental Protection Department, HKSAR.
(vi) Statutory requirements of the Electrical and Mechanical Services Department, HKSAR.
(vii) Chapter 406 Electricity Ordinance, and other subsidiary legislation.
(viii) The Safety Rules and other requirements of the gas production, supply and utilisation by the Electrical and Mechanical Services Department. (hereinafter referred to as EMSD's gas safety requirements).
(ix) All other statutory ordinances, regulations, orders, undertakings having the force of law in Hong Kong and required for the works.
(x) Codes of Practice for the Electricity (Wiring) Regulations published by Electrical and Mechanical Services Department, 2020 Edition.
(xi) Code of Practice for Energy Efficiency of Building Services Installation, by Electrical and Mechanical Services Department, 2018 Edition.
(xii) Codes of Practice on the Design and Construction of Lifts and Escalators issued by the Electrical and Mechanical Services Department, latest edition with amendments
(xiii) General Specification for Building Services Installations in Government Buildings of Hong Kong Special Administrative Region, by Building Services Branch, Architectural Services Department, 2022 Edition, (hereinafter referred to as the BSGS).
(xiv) General Specification for E & M Sewerage Facility Installations, by E&M Project Division, Drainage Services Department, (Latest edition) (hereinafter referred to as GSEMSFI).
(xv) Testing and Commissioning Procedures for Air Conditioning, Refrigeration and Mechanical Ventilation Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition
(xvi) Testing and Commissioning Procedures for Electrical Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition
(xvii) Testing and Commissioning Procedures for Fire Service Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition
(xviii) Testing and Commissioning Procedures for Lift, Escalator and Passenger Conveyor Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition
(xix) Testing and Commissioning Procedures for Plumbing Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition
(xx) Testing and Commissioning Procedures for Drainage Installation in Government Buildings of the Hong Kong Special Administrative Region, issued by Architectural Services Department, 2022 Edition

(xxi) General Requirements for Electronic Contracts, No. ESG01 by Electronics & Data Communication Division, Electrical & Mechanical Services Department. (Issue no. 11, 2016)
(xxii) General Technical Specification for Closed Circuit Television Systems, No. ESG14, by Electrical & Mechanical Services Department. (Issue No. 7, April 2021)
(xxiii) Code of Practice for Access Facilities of Buildings for the Provision of Telecommunications and Broadcasting Services COP-1/2012 dated April 2012 by OFCA.
(xxiv) Guideline for the Planning of Building Services (BS) Provision for Telephone / Telecommunications Systems dated 8/96 by OFCA.
(xxv) Guideline for property owners, developers and mangers for the provision of facilities within property developments for access to public telecommunications and broadcasting services dated 5/95 and revision 8/2001 by OFCA.
(xxvi) Standard Accommodation Provisions for Private Branch Exchange (PBX) in Government Buildings and Offices dated 9/96 by OFCA.
(xxvii) Requirements of PCCW-HKT Telephone Limited (hereinafter referred to as HKTL's requirements);
(xxviii) The Supply Rules, Code of Practice and other requirements of the CLP Power Company Limited (hereinafter referred to as CLP's Requirements).
(xxix) BS 7671:2008 (formerly the 17th Edition IET Wiring Regulations – 'Requirements for Electrical Installations') (hereinafter referred to as the IET Wiring Regulations).
(xxx) British Standards published by the British Standards Institution.
(xxxi) Standards of National Fire Protection Association.
(xxxii) Guide Books of Chartered Institute of Building Services Engineer.
(xxxiii) ASHRAE Handbook, Fundamental Volume.
(xxxiv) The Standards of American Society for Testing and Materials (hereinafter referred to as ASTM).
(xxxv) BS7430:2011 Code of Practice for Protective Earthing of Electrical Installations
(xxxvi) BS EN 62305 Protection Against Lightning
(xxxvii) Unless otherwise specified, all outdoor building services installations shall be weatherproof of index of protection not lower than IP65.
(xxxviii) General Technical Specification for Uninterruptible Power Supply (UPS) No. ESG15 published by Electrical and Mechanical Services Department.
(xxxix) Structures Design Manual for Highways and Railways, published by Highways Department, 2013 Edition (hereinafter referred to as SDM)
(xl) Public Lighting Design Manual Issued by the Highways Department, Third Edition.
(xli) Code of Practice on Working near Electricity Supply Lines published by Electrical and Mechanical Services Department, 2005 Edition
(xlii) Practice Notes, Flooding Warning System in Subways / Underpass, by Bridges & Structures Division, Highways Department, 2014.

Material and workmanship

13.34* (1) Material

(i) Unless otherwise specified, stainless steel materials shall conform to BS EN 10088, Grade 1.4401 or equivalent. Where high tensile stainless steel is required, it shall also comply with BS EN 10088.

For any welded stainless steel components, appropriate welding

methods such as metal inert gas (MIG), tungsten inert gas (TIG), or other approved processes shall be used, together with suitable welding consumables to prevent carbide precipitation and maintain corrosion resistance.

(ii) Unless otherwise specified, all metal components of equipment that are in direct contact with sewage, stormwater, floodwater, and/or screenings shall be fabricated from stainless steel Grade 316 S16. In addition, all metal parts not directly exposed to these media but forming an integral part of such equipment shall also be constructed from stainless steel Grade 316 S16, unless otherwise approved.

(2) Protective Coating System

(i) Unless otherwise specified, steel surfaces (except stainless steel) shall be blast cleaned to a minimum quality of Sa2.5 in accordance with BS 7079: Part A1, followed by hot-dip galvanizing or zinc metal spraying to a minimum coating thickness of 0.1 mm, in accordance with BS EN ISO 1461 or ISO 14713 as appropriate. The galvanized or zinc-coated surface shall then receive a suitable etching primer (minimum 30 microns), a heavy duty epoxy undercoat, and two appropriate topcoats. The total dry film thickness of the undercoat and topcoats shall not be less than 0.3 mm.

(ii) All paints and coatings shall comply with BS 3900, ISO 12944, and ISO 14713, or equivalent standards.

(iii) The selected protective coating system shall be suitable for the anticipated service environment and shall conform to the recommendations of ISO 12944 and ISO 14713.

(iv) Documentary evidence, including product data and test certificates demonstrating compliance with the above requirements, shall be submitted as part of the material approval process.

MATERIALS AND WORKMANSHIP REQUIREMENTS – P&D

Pump motor

13.35* (1) All motors shall be of the totally enclosed fan cooled type with Class 'F' insulation to BS EN 60034-1:2010 and BS EN 60085:2008 impregnated with non-hygroscopic oil resistant insulating varnish and standard of protection to BS EN 397:2012 IP 55.

(2) The type, design and manufacture of all motors shall comply with BS EN 60034-1:2010 and BS EN 50347:2001 and shall be of squirrel-cage, induction type. Motors shall be suitable for 380V, 3 phase, 50Hz supply.

(3) Motor design shall be such that vibration and noise are minimal and shall comply with BS EN 60034-14:2004, grade N for general purpose application.

(4) Each motor terminal box shall be fitted with sealing chamber, conduit gland or adapter plate, as required, together with the necessary fittings to suit the cable entry. Terminal markings and rating plates shall be in accordance with BS EN 60034-1:2010.

Pipework 13.36* (1) Ductile Iron Pipes and Fittings

(i) All flanges for pipes shall be cast-on or weld on standard flanges type PN 16 complying with the relevant requirements in BS EN 598. For weld on flange, the welding process shall be completed prior to ex-factory. The pipe with weld on flange shall be manufactured from centrifugal casting process.

(ii) Ductile iron change collars and ductile iron flange adaptors shall be used for jointing ductile iron pipes and fittings at locations as shown on the Drawings. All change collars shall be of a design similar to those in BS EN 598 (for sewerage applications) and have slip-on type mechanical joints at both ends.

(2) Galvanized Iron Pipes and Fittings

(i) Galvanized iron pipes and fittings shall comply with BS EN 10255, medium grade, BS 21 and BS EN 10241.

(ii) Galvanized iron pipes and fittings shall be medium class thickness and shall be galvanised in accordance with BS EN ISO 1461.

MATERIALS AND WORKMANSHIP REQUIREMENTS – MVAC

Ductwork 13.37* (1) Ductwork shall comply with the requirements indicated on the Drawings and with Part 6 of the Building Services General Specification (BSGS).

(2) All mechanical ventilation ductwork including ducts, dampers, fire dampers, diffusers, grilles, registers, louvers, etc. shall be provided.

(3) All ductwork shall be constructed to the recommendations of the United Kingdom Heating and Ventilating Contractors' Association (HVCA) Standard DW144.

(4) Fire dampers shall be provided wherever necessary and or where fire compartmentation is defined by the air-conditioning and mechanical ventilation systems in accordance with the FSD Codes of Practice / Circular Letter and in accordance with Part 6 of the BSGS.

ELECTRICAL WORKS REQUIREMENT

Distribution boards 13.38* (1) Moulded case circuit breaker (MCCB) boards and miniature circuit breaker (MCB) boards, herein referred to as distribution boards, shall comply with IEC 60439-1 / IEC 60439-3. The Contractor shall design, supply, deliver to the Site, install, test, commission and hold liability for Defects, up until the defects date, of the distribution board for the power distribution to the system provided by Contractor.

(2) Distribution boards shall have a minimum degree of protection IP31 to BS EN 60529 when located in clean and dry rooms. The protection classification for distribution boards located in other indoor locations shall be IP54. For outdoor location the degree of protection shall be not less than IP56.

(3) Unless otherwise specified, distribution boards shall be fitted with a

switch disconnector complying with BS EN 60947: Part 3 for isolation of the incoming supply. For three phase distribution boards, the switch disconnector shall be triple pole with neutral link. For single phase a.c. and d.c. distribution boards the switch disconnector shall be two poles.

(4) Danger and warning labels shall comply with BS 5378: Part 1.

Protection relays 13.39* Protection relays shall comply with BSEN 60255.

Current transformer 13.40* (1) Current transformers shall be of the dry indoor type complying with BS EN 60044. Characteristics shall be not less than the corresponding ratings assigned to their associated switchgear or control gear:

- Rated highest equipment voltage,
- Rated insulation level,
- Rated short-time current, and
- Rated time.

(2) Type test certificates demonstrating compliance with BS EN 60044 shall be submitted for current transformers of the same type and rating. All current transformers shall undergo routine tests in accordance with BS 7626, and magnetization curve tests shall be performed for each unit. Comprehensive test reports, including the actual measured test figures, shall be provided as part of the material approval documentation.

Electrical control and indication devices 13.41* (1) Controls Relays and Timers

Control relays shall be the plug-in type, rack mounted complying with BS 142 and BS EN 60255. Relays shall be provided with cable connection terminals and shall be anchored by quick fastening vibration-proof devices.

(2) Indicating lights

(i) Indicator lights shall comply with BS 4794: Part 2. Indicating lamps shall be rated to withstand not less than 20% continuous over-voltage and shall be operated 20% below its rated voltage. Indication lights shall be the panel mounted type with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the equipment without disturbance to the lamp holder or panel wiring.

(ii) Indicating lights shall be colour coded complying with BS 4099 unless otherwise stated. Colours of indicating lights for motor starters shall comply with BS 687. Indicating light lamps shall, whenever possible, be interchangeable throughout the works.

(3) Push-buttons

(i) Push-buttons shall be the heavy duty, double break, panel mounted pattern with fully shrouded moulded buttons complying with BS4794: Part 2. Push-buttons shall be rated Class 1 and utilization category AC-11. Push buttons shall have a spring return action through a flexible seal.

(ii) Push-button shall be colour coded complying with BS 4099 unless otherwise stated. Colours of push-buttons for motor starters shall comply with BS 587.

(4) Selector Switches

Selector switches shall be manually operated rotary switches complying with BS 4794. Selector switches shall be rated Class 1 and utilization category AC-11.

(5) Terminals

Terminal blocks shall be of the feed through type and moulded from high grade melamine to provide shrouding of the terminals. Comparative tracking indexes as measured by BS 3781 shall be not less than the rated voltage of the terminal blocks and this rated voltage shall be not less than the rated insulation voltage of the equipment. Rated current shall not be less than the rated thermal current of the short-circuit protective device.

(6) Fuses

(i) LV fuses for use on a.c. power circuits and directly connected control circuit shall be of the general purpose type rated not less than 415V and shall comply with BS 88: Part 2. General purpose fuse links, except for the motor circuit, shall be class Q1. Motor circuit fuse links shall have a continuous current rating and a rating on which their time/current and cut-off characteristics are based. Fuse holders and bases shall not be fitted with fuse links of a higher rating than the rating with which they are marked.

(ii) Other fuses shall comply with the British Standards as follows:

- Domestic consumer unit fuses shall be to BS1361.
- Plug top fuses shall be to BS 1362.
- Cartridge fuse links for telecommunication and light electrical equipment shall be to BS 2950.
- Cartridge fuse links for semi-conductors shall be to BS 88: Part 4.
- Sizes of fuses shall be standard and interchangeable throughout the bolted type.
- Unless otherwise specified, fuses shall be the bolted type.

(7) Control Circuit Breaker

(i) Miniature circuit breakers (MCB) shall comply with BS3871: Part 1, Type 3. Breakers shall be fitted with thermal magnetic tripping mechanisms giving an inverse time-current characteristic. Rated breaking capacities shall be a minimum of 6kA.

- MCBs shall comply with and be type tested to BSEN60898. MCBs with current carrying contacts of plug-in type shall not be accepted.
- The rated short circuit breaking capacity shall be certified in accordance with BSEN60898, to have at least M6 category of duty.

(ii) residual current circuit breaker with integral overcurrent protection (RCBO) shall be current operated and comply with BSEN 61008. Tripping currents shall be selected dependent on location within the supply network and the calculated loop impedances. RCD shall operate to trip all phases including the neutral.

- RCBOs shall be of double-pole or four pole as specified, type testes

to IEC61009 or BSEN61009. Unless otherwise specified, the rated residual operating current shall be 30mA, and the rated short circuit breaking capacity shall be 6kA or higher.

(iii) Moulded case circuit breaker (MCCB)

- MCCBs shall comply with and be type tested to BSEN 60947-2.

(8) Control Transformer

Isolating transformers shall comply with BSEN 61558: Part 1 and Part 2 and shall have an earthed screen between the windings.

Cabling and wirings 13.42* (1) Electrical cables shall comply with the following British Standards:

(i) PVC insulated non-sheathed cables for voltage up to and include 450/750V grade to be BS6004 and BS6007.
(ii) PVC insulated, PVC sheathed cable up to 35mm2 for voltage up to and include 300/500V grade to be BS6004. For cable equal or greater than 50mm2 with voltage up to 600/1000V grade to be BS6346.
(iii) PVC insulated, PVC sheathed armoured cables of any size for voltage up to 600/1000V grade to be BS6346.
(iv) XLPE insulated, non-sheathes or PVC sheathed cables with voltage up to 450/750V grade to be BS7211; voltage up to 600/1000V to be BS 5467
(v) XLPE insulated, PVC sheathed armoured cables with voltage up to 600/1000V grade to be BS5467 and BS6724.
(vi) 450/750 V thermosetting insulated, single-core non-sheathed, copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90oC – code designation H07Z-U and H07Z-R of BS 7211:1998
(vii) 450/750 V, fire resistant, thermosetting insulated, single core, non-sheathed copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90oC. Fire resistant cable shall also comply with the fire performance requirement specified in the Part 7 of the BSGS.
(viii) 450/750 V, fire resistant, thermosetting insulated, single-core or multi-core, sheathed with or without armour copper cables, with solid or stranded conductor and with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90oC. Fire resistant cable shall also comply with the fire performance requirement specified in the Part 7 of the BSGS.
(ix) 600/1000V Cross-linked polyethylene (XLPE) insulated, single-core, two-core, three-core or four-core, sheathed with armour copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90oC –IEC60502-1:2004.
(x) 600/1000 V fire resistant, cross-linked polyethylene (XLPE) insulated, two-core, three-core or four-core, sheathed with armour copper cable, with solid or stranded conductor, with low emission of smoke and corrosive gases when affected by fire, suitable for conductor operating temperature not exceeding 90oC -Category F2 of BS 7846:2000. Fire resistant cable shall also comply with the fire performance requirement specified in Part 7 of the BSGS.

(xi) Mineral insulated cables and their terminations with a rated voltage not exceeding 750V to be IEC 60702

(xii) The outer sheath of cable shall be of low smoke halogen free, or low smoke zero halogen, i.e. evolving very low content of smoke or corrosive gases during combustion when tested to IEC 60754-1:1994 and other associated Parts of the Standard.

(xiii) Performance requirements for cables required to maintain circuit integrity under fire conditions to BS 6387

(xiv) Cable markers for identification purposes shall comply with BS 3858.

(2) Electrical conduits and fittings

Conduits and accessories shall be of heavy gauge hot dip galvanized mild steel type complying with BS 4568 class 4.

(3) Protection of conduit systems

(i) Conduit to light fittings and other electrical equipment subject to vibration shall terminate in a conduit fitting with the adaptable box or junction box being made with liquid-tight flexible conduit and connectors in accordance with BS EN 61386.

(ii) Flexible steel conduit and solid type adaptors shall comply with BS EN 61386. The conduit shall be of metallic water tight pattern, PVC over sheathed and with a separate earth wire enclosed for earth continuity.

(4) Cable termination

(i) Cables shall be terminated with glands which shall be of a mechanical compression hexagon type to seal the cable against the ingress of dirt and moisture and provide adequate mechanical support. Cable glands shall be brass to BS 6121.

(ii) Copper earth tags shall be the flat circular ring type suitable for silpping-on to cables and shall be of minimum cross section as detailed in BS 6121.

(iii) Compression type cable sockets for LV cables shall be manufactured from tin plated, seamless, copper tubing with single bolt palm terminals to BS 4579.

(iv) Crimping type cable sockets for cables not exceeding 4mm2 shall be of the pin or ring type terminals, manufactured from copper strip to BS 1432, electroplated to BS 1872 and PVC pre-insulated.

Switches 13.43* (1) Switches shall comply with BS 3676 and shall be supplied complete with box, cover plate and fixing screws. Switches shall be white plastic or metal clad type according to the installation area and as specified.

(2) Switches for indoor location in process or damp areas shall have a minimum degree of protection IP55 to BS EN 60528. For outdoor location, the degree of protection shall be not less than IP56.

PV system 13.44* (4) The International System of Units (SI) shall be used. The PV System shall be designed and installed in compliance with the Specification and the

latest editions of the following standards and codes, including all latest amendments:

(i) General Requirement for Electronic Contracts Specification No. ESG01 issued by the Electronics Division, Electrical and Mechanical Services Department;
(ii) Technical Guidelines on Grid Connection of Small-scale Renewable Energy Power Systems issued by the Electrical and Mechanical Services Department;
(iii) IEC 60364-7-712: Electrical Installations of Buildings Part 7-712: Requirements for Special Installations or Locations – Solar Photovoltaic (PV) Power Supply Systems;
(iv) IEC 60891: Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices;
(v) IEC 60904-1: Photovoltaic devices Part 1: Measurement of photovoltaic current voltage characteristics;
(vii) IEC 60904-3: Photovoltaic devices Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data;
(viii) IEC 60904-4: Photovoltaic devices Part 4: Reference solar devices – Procedures for establishing calibration traceability;
(ix) IEC 60904-5: Photovoltaic devices – Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method;
(x) IEC 60904-6: Photovoltaic devices – Part 6: Requirements for reference solar modules;
(xi) IEC 60904-7: Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device;
(xii) IEC 60904-8: Photovoltaic devices – Part 8: Measurement of spectral response of a photovoltaic (PV) device;
(xiii) IEC 60904-9: Photovoltaic devices – Part 9: Solar simulator performance requirements;
(xiv) IEC 60904-10: Photovoltaic devices – Part 10: Methods of linearity measurement;
(xv) IEC 61173: Over-voltage protection for photovoltaic (PV) power generation systems – Guide;
(xvi) IEC 61215: Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval;
(xvii) IEC 61277: Terrestrial photovoltaic (PV) power generating systems – General and guide;
(xviii) IEC 61345: UV test for photovoltaic (PV) modules;
(xix) IEC 61683: Photovoltaic systems – Power conditioners Procedure for measuring efficiency;
(xx) IEC 61701: Salt mist corrosion testing of photovoltaic (PV) modules;
(xxi) IEC 61721: Susceptibility of a photovoltaic (PV) module to accidental impact damage (resistance to impact test);
(xxii) IEC 61724: Photovoltaic system performance monitoring – Guidelines for measurement, data exchange and analysis;
(xxiii) IEC 61725: Analytical expression for daily solar profiles;
(xxiv) IEC 61727: Photovoltaic (PV) systems – Characteristics of the utility interface;
(xxv) IEC 61730-1: Photovoltaic (PV) module safety qualification Part 1: Requirements for construction

(xxvi) IEC 61730-2: Photovoltaic (PV) module safety qualification Part 2: Requirements for testing
(xxvii) IEC 61829: Crystalline silicon photovoltaic (PV) array – On-site measurement of I-V characteristics;
(xxviii) IEC/TR2 61836: Solar photovoltaic energy systems –Terms and symbols;
(xxix) IEC 62116: Testing procedure – Islanding prevention measures for power conditioners used in grid connected photovoltaic (PV) power generation systems;
(xxx) IEEE 519: Recommended practices and requirements for harmonic control in electrical power systems;
(xxxi) IEEE 928: Recommended criteria for terrestrial PV power systems;
(xxxii) IEEE 929: Recommended practice for utility interface of residential and intermediate PV systems;
(xxxiii) IEEE 1374: Guide for terrestrial photovoltaic power system safety;
(xxxiv) IEEE P1547: Distributed resources interconnected with electric power systems;
(xxxv) UL1703: Flat-plate photovoltaic modules and panels;
(xxxvi) UL 1741: Static inverters and charge controllers for use in PV power systems;
(xxxvii) VDEW Guideline for operating in-plant generating units in parallel with the power company's low voltage main.

Motors 13.45* (1) General

(i) Motors shall be designed for duty type S1, according to IEC 34-1, and shall be suitable for the load characteristics and operational duty of the driven equipment.

(ii) Ratings of motors shall comply with IEC 72, 72A and BS 4999 and be based on Class F insulation used to Class B temperature rise.

(iii) Construction and mounting shall be in accordance with IEC 72, IEC 72A and BS 4999.

(iv) Motors shall be capable of providing the rated output at a voltage that may vary between 94% and 106% of the rated voltage. Permissible temperature rises under these conditions shall be as stated in IEC 34-1.

(v) Motors to be provided shall be of premium efficiency of class IE3 to IEC 60034-30-1:2014.

(2) Performance Requirement

(i) Locked rotor apparent power of LV motors shall comply with IEC 34-

(ii) Starting performances of LV motors shall comply with IEC 34-12. Design N shall apply for driven equipment which exhibits a quadratic torque-speed characteristic. Design H shall apply for driven equipment with different torque-speed characteristics.

(iii) Test conditions for free suspension and rigid mounted motors associated with vibration shall comply with IEC 34-14.

Lighting protection systems 13.46* (1) The Contractor shall be responsible for the design, supply, delivery to Site, installation, testing and commissioning and liability for Defects, up until

the defects date, of a complete lightning protection system for the proposed footbridges, subways, passenger lifts, gantries and luminance meters. The system shall comply with Part 7 of the BSGS and BS EN 62305.

(2) ~~Each lightning protection system shall consist of a network of copper tapes, including air terminals, down conductors, lightning earth pits and earth electrodes, etc. interconnected together. Horizontal and down conductors shall be of 25mm x 3mm tinned annealed copper strips.~~

(3) The down conductors shall be connected to lightning earth rods as specified in BS EN 62305. Warning labels shall be provided for the down conductors connection point. Lightning earth pits shall also be provided.

(4) ~~The Contractor shall test and demonstrate that all fixings, tapes, air termination and down conductors are properly installed, and of adequate mechanical strength. The Contractor shall also carry out soil resistivity test and demonstrate to the Project Manager that the resistance to earth (i.e. the resistance from the earth rods to the down conductors) is not greater than 10 ohms. The Contractor shall, by every means and at their own cost, ensure the resistance value to be met.~~

(5) The lightning protection system shall be designed in accordance with BSEN 62305 to protect the lift tower against lightning strikes. The lightning protection earthing system shall consist of the following principal component parts: air terminals, down conductors, bonding conductors, test links, earth electrodes and lightning earth pits. The overall earthing resistance of all electrodes shall be less than 10 ohm.

LIGHTING CONTROL SYSTEM

Lighting System for Open Road and Gantry 13.47* (1) Astronomical time switch shall be adopted so that the operation of road lighting can be based on sunset and sunrise time. The Astronomical time switch provided for the operation of road lighting and gantry lighting shall be comply with IEC 60730-1 and with battery reserve for at least 5 years.

(2) An adjustable digital photoelectric controller shall be operated in parallel under abnormal ambient condition such as heavy rainstorm so that the road lights can be turned on when ambient light level drops below a pre-set value. The pre-set value shall be confirmed with HyD/Lighting on site according to different ambient condition. The digital photoelectric controller shall be of electronic fail-safe type.

Lighting System for Subway 13.48* (1) The following design criteria according to the PLDM shall be adopted:

(i) Subway (SW1, 2 and 3)

(ii) The maintenance factor, overall uniformity, longitudinal uniformity shall comply with PLDM 2016.

(2) Astronomical time switch shall be adopted so that the operation of footbridge lighting can be based on sunset and sunrise time. The Astronomical time switch provided for the operation of the footbridge lighting shall be comply with IEC 60730-1 and with battery reserve for at least 5 years.

Lighting Installation System for Footbridges 13.49* Astronomical time switch shall be adopted so that the operation of footbridge lighting can be based on sunset and sunrise time. The Astronomical time switch provided for the operation of the footbridge lighting shall be comply with IEC 60730-1 and with battery reserve for at least 5 years.

ELECTRICAL AND MECHANICAL (E&M) WORKS FOR SEWAGE PUMPING STATION

General requirements of works 13.50* (1) General

(a) All moving parts shall be guarded by the stainless steel wire mesh guard to BS PD 5304.

(b) Unless otherwise specified, "watertight" shall mean an degree of protection provided by enclosure of IP68 to BS EN 60529 which protects against prolonged effects of immersion under 3m water pressure and "weatherproof" shall mean an degree of protection provided by enclosure of IP55 to BS EN 60529.

(2) Material

Unless otherwise specified, all stainless steel shall conform to BS EN 10088 Grade 316. High tensile stainless steel shall conform to BS EN 10088. Should welding be required during fabrication of the stainless steel works, titanium (or other approved suitable metallic additives) added flux shall be used with stainless steel welding electrodes to prevent carbide precipitation.

(2) Protective Coating System

(a) Steel surfaces except stainless steel shall be blast cleaned to the quality conforming to BS 7079:Part A1, Sa2.5 and hot-dip galvanized or zinc metal sprayed to a coating thickness of 0.1 mm. This shall be followed by a coat of suitable etching primer of thickness 30 microns, one heavy duty epoxy undercoat and two appropriate topcoats to be accepted by the Project Manager. The total dry film thickness of the undercoat and topcoats shall not be less than 0.3 mm. The Contractor shall carry out dry film thickness measurement as may be required by the Project Manager. The surface treatment shall conform, but not be limited, to the following:

- BS EN ISO 1461 "Specification for hot-dip galvanised coatings on iron and steel articles";
- BS 3900 "Methods of test for paints";
- ISO 12944 "Paints and varnishes. Corrosion protection of steel structure by protective paint systems";
- ISO 14713 "Protection against corrosion of iron and steel in structure – Zinc and aluminium coatings –Guidelines"
- BS 7079 "Preparation of steel substrates before application of paints and related products".

(b) The coating system to be selected shall be appropriate to the prevailing critical conditions and circumstances and shall be in accordance with the recommendations in ISO 12944 and ISO 14713. The Contractor shall provide at least one thickness gauge, with calibration equipment, for the use of the Project Manager or his Representatives.

Pipework & valves 13.51* (1) Drain valves shall be provided for complete drainage of the station pipework. One drain valve shall be provided downstream of each non-return valve at the supplementary pump discharge pipes. The drain valve shall be cast iron gate valve to BS EN 1171. The drainpipe shall be provided which shall lead the drain points to wet well. Drainpipes shall be 50mm diameter uPVC pipe to BS 3505 Class D.

(2) Gate valves shall comply with GSEM Part 2 Clause 2.6. The valve stem shall be manufactured from stainless steel to BS 970 Part 1 Grade 431 S29. Sealing shall be achieved by means of packed gland stuffing box seals.

(3) The check valves shall be recoil type. The valve body and door shall be made of ductile iron. Valve flanges shall comply with BS 4504:Part 1 PN 16. The minimum nominal pressure rating shall be PN 16. Each check valve shall be fitted with a limit switch. The open and close status of the check valve shall actuate the open and close of the limit switch, which shall be used as no-flow protection of the individual pumps.

(4) The material for the flap valve / gate components (if applicable) shall be as follows:

Component	Material
Framework	Stainless steel 316 to BS EN 10088 or accepted better material
Gate / Door	Stainless steel 316 to BS EN 10088 in natural finish or accepted better material
Tightness / Frame Seal	Natural rubber or EPDM with corrosion resistant retaining strip and stainless steel grade 316 fasteners or accepted better material
Seal Ring	Stainless steel 316 to BS EN 10088 or accepted better material
Bolt	Stainless steel 316 to BS EN 10088 or accepted better material
Screw	Stainless steel 316 to BS EN 10088 or accepted better material
Hinge Pin / Bracket / Cotton Pin	Stainless steel 316 to BS EN 10088 or accepted better material
Hinge Links	Stainless steel 316 to BS EN 10088 with bronze bushes or accepted better material
Rotation Kit	Stainless steel 316 to BS EN 10088 or accepted better material
Structure for counterweight (if applicable)	Stainless steel 316 to BS EN 10088 or accepted better material
Counterweight (if applicable)	Stainless steel 316 to BS EN 10088 or accepted better material
Tightness Seal Washer	Stainless steel 316 to BS EN 10088 or accepted better material

(5) Works Tests and Inspections

Valves bodies and seats shall be hydraulically tested at manufacturer's works in according to BS EN 12266 Part 1. Gate valves metal seat shall conform to leakage rate B. A pressure test certificate for each valve shall be provided by the manufacturer.

Building service equipment

13.52* (1) General

(a) Building Services installations shall comply with the Part 5 in the GSEM, the GSBSI and the General Air Conditioning Specification. All electrical accessories shall comply with relevant EN, IEC, BS, ISO or internationally recognized standards accepting by the Project Manager. All cables shall be thermosetting insulated with low smoke, zero halogen characteristics complying with BS 7211 and BS 6724 and routing inside the surface mounted conduit.

(b) The minimum illumination levels and the glare indexes for the lighting equipment in the sewage pumping stations shall be demonstrated to comply with BS5266 Part 1 and relevant CIBSE guidelines respectively.

(2) LED Lights

(a) The LED luminaires shall be fully assembled and tested before shipment from factory. The LED luminaire shall comply with the following international standards and their manufacturing process shall conform to the relevant quality standard of ISO 9000.

(i) IEC 60598-1: Luminaires – Part 1: General requirements and tests;
(ii) IEC 60598-2-1: Luminaires – Part 2 Particular requirements. Section 1 : Fixed general purpose luminaires or
(iii) IEC 60598-2-2: Luminaires – Part 2 Particular requirements. Section 2: Recessed luminaries

(b) The LED luminaires shall be marked in accordance with the requirements of IEC 60598-2-1 for general-purpose luminaires or IEC 60598-2-2 for recessed luminaires.
(c) The irradiance and radiance emission limits of the LED luminaires, that are exposed to view directly, shall be tested to comply with the hazard 'Risk Group 1' (low risk) as stated in the requirements of the IEC 62471 –Photobiological safety of lamps and lamp systems.
(d) The electronic driver (driver) for the LED luminaire shall include the components of power factor correction, radio interference suppression and also dimming facility if it is specified. The driver shall conform to the following international standards if applicable:

(i) IEC 61347-1: Lamp control gear – Part 1: General and safety requirements
(ii) IEC 61347-2-13: Lamp control gear – Part 2-13: Particular requirements for d.c. or a.c. supplied electronic control gear for LED modules
(iii) IEC62384: DC or AC supplied electronic control gear for LED modules – Performance requirements
(iv) IEC 61000-3-2 Class C: Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current < 16A per phase)
(v) IEC 61547: Equipment for general lighting purposes – EMC

immunity requirements;

(vi) BS EN 55015: Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment; and

(vii) Certificates of compliance issued by accredited test laboratories shall be provided for different ratings of drivers to be used in the Contract.

(3) Lighting Control System

Photo-electric controllers shall be of electronic fail-safe type with a switch on value of 15 lux, an on:off ratio of 1:1.5, and shall have an inherent time delay of 30 seconds to prevent operation by extraneous light. They shall be suitable for use in exposed weather conditions and shall function correctly within the temperature range of –5oC to + 50oC at local supply voltage and frequency. They shall also comply with BS 5972.

Fire services equipment

13.53* (1) Manual and Automatic Fire Detection and Alarm System

The AFA Systems shall be a hardwired addressable system consisting of heat or smoke detection, manual call points, alarm bells, remote indicative lamps, Fire Control Panel, etc. complete with the associated trunking, conduit and wiring to comply with the ArchSD GS, Fire Detection and Alarm Systems in Buildings BS5839 Part 1: 2017 ,FSD Circular Letter No. 1/2009 and 3/2010 and FSD requirements.

(2) Fire Alarm Indication and Control Panels

The batteries and charger with ammeter, voltmeter, alarm and fault indications shall comply with the ArchSD GS and BS 5839 Part 1: 2017. They shall be supplied and installed by the Contractor in the battery cabinet. The output from the batteries and charger system shall be capable of operating all the alarm units as well as the control and indicating equipment described in this Particular Specification, and as shown on the Drawings. The wiring for the system shall be generously sized and the system components shall be so chosen that any possible voltage drop can be kept to the minimum and all system equipment can be satisfactorily functioned with the voltage drops allowed for.

(3) Batteries and Chargers

The capacity of batteries shall be calculated in accordance with the relevant requirements of BS 5839 Part 1: 2017 and this Specification. The calculations shall be submitted for approval prior to installation.

(4) Alarm Bell

(a) Alarm bells shall be 150mm diameter steel gong type unless otherwise specified.
(b) Output shall be not less than 94 dBA at a minimum distance of 3000mm from the bell.
(c) All externally mounted alarm bells shall be weatherproof construction and shall be 250mm diameter.
(d) All alarm bells shall be suitable for 24V dc (nominal) supply.
(e) All internally mounted alarm bells shall have the clapper mechanism concealed under the gong.
(f) All alarm bells shall be of the low current consumption type, less than

0.3A, surface or flush mounted with corrosion - proof baked red enamel finish.

(g) All buzzers shall be of totally enclosed vibration type. The sound output shall be capable of adjusting and shall not be less than 80 dBA at a minimum distance of 3000mm from the buzzer.

(5) Linear Heat Detectors

All linear heat detectors shall comply with BS EN 54-5,. They shall be of the manufacture and type approved by FSD. The linear heat detection system shall be installed in accordance with BS 5839-1:2017 (incorporating Corrigendum No.1) and FSD circular letter No. 6/2021.

(6) Manual Call Point

All manual call point unit shall be of "break glass type" in compliance to BS EN 54-11, and shall be of the manufacture and type approved by FSD.

(7) Directional and Exit Signs

LED directional and exit signs shall comply with BS EN 60598-2-22, BS 5266 and Clause 5.10 of the "Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment" and the ArchSD GS.

(8) Fire Extinguisher

(a) Fire extinguishers shall be rechargeable hand-operated extinguishers of appropriate type to BS EN 3 Part 1 to 6 and BS 7863 for water, foam, dry powder, carbon dioxide type with a capacity as specified. Unless otherwise specified water, foam and powder type extinguishers shall be cartridge operated with a replaceable gas cartridge fitted into the extinguisher.

(b) The material of the body cylinder for fire extinguisher shall be of aluminium to a standard not less than BS 5045 Part 3 or approved equivalent. The external finish shall be of epoxy polyester powder stoved paint in red colour.

(9) Painting, Finishing, Protection and Identification

Primer shall be applied to metal surface before the application of under and finished coats of paint. Primer for non-galvanized metal surface shall be metallic zinc-rich primer to BS 4652, Type 2; and for galvanized surface shall be calcium plumbate primer to BS 3698, Type B. Bare copper tubing shall be polished bright and coated with approved heat resisting clear synthetic varnish. All surfaces shall receive one under coat and 2 finished coats.

(10) Optical Fiber Sensor Cables and Controllers

(a) Optical fiber sensor cables shall consist two independent fibers with polyamide core tube and sheathed by flame retardant and halogen free outer jacket.

(b) All cable fasterners and splicing devices including clips, straps, clamps, connectors shall be purchased from the same manufacturer as the optical fibers sensor cables.

(c) Each controller shall have at least 2 channels with a maximum measuring length up to suit the design.

(11) Optical Beam Smoke Detectors

(a) Optical beam smoke detectors shall be of line type smoke detectors using an optical light beam. The optical beam smoke detectors shall conform to BS EN 54-12 or other international standards acceptable to the FSD.
(b) Each optical beam smoke detector shall comprise an infrared transmitter, a receiver / reflector. The transmitter and receiver shall be either separated or housed within a single unit, in latter case, a reflector shall be used and mounted directly opposite to reflect light from the transmitter back to the associated receiver.
(c) The path length of the optical beam shall not exceed that recommended by the manufacturer.
(d) Optical beam smoke detectors shall be used for detection of smoke by the attenuation and / or changes in attenuation of an optical beam. They shall be suitable for 24-volt D.C. operation.
(e) Optical beam smoke detectors shall be fitted with swivel mounting brackets to allow accurate adjustment of the angle / aligning of transmitters and receivers / reflectors.

Electrical switchboards and associated equipment 13.54* (1) General

(a) Cubicle switchboards shall be of flush fronted, totally enclosed, floor standing type. The complete switchboards shall be protected to IP44 incorporating circuit breakers, contactors, fuses switches, starters, etc. General requirements are as follows:

Standard : BS EN 61439-1
Insulation Class : Class B
Enclosure Type : Form 4
Short Time Withstand current of switchboard busbar assembly

(b) All switchgear shall be suitably rated according to its duty. Contactors, overload relays, MCB and fuses of all motor starters shall be coordinated to the Type 'C' requirements to BS EN 600497-4-1. Design calculations shall be submitted to the Project Manager for acceptance before manufacturing.

(c) Requirements for the Air Circuit Breaker (ACB) shall be as follows:

The ACB shall be suitably rated four poles, withdrawable type air circuit breakers to IEC 60947-2. The circuit breakers shall comply with the GSBSI, GSEM and the General Specification;;

(d) Automatic Capacitor Bank Sections

The section shall consist of an automatic power factor correction capacitor bank complete with automatic power factor control relay and connection contactors to correct the overall power factor of the corresponding incoming supply to 0.95 lagging. Suitably rated TP&N fuseswitches complete with HRC fuses shall be provided. The capacitors shall be manufactured and installed to IEC 60871-1. A discharge device shall be provided for the capacitors. A suitable derating factor shall be applied in determining capacitor ratings.

(e) Sewage Pump Motor Starters (1 no. per pump)

It shall consist of star/delta starters designed and constructed to BS 4941, IEC 60947-4 and BS 5424 complete with suitably rated TP&N fuseswitch [MCCB]. It shall include all indication, measurement and control devices required for the operation requirement of the sewage pumps as specified in the Particular Specification. The requirement of the variable speed drive shall be in accordance with Clause 32.36 of this Particular Specification.

Cabling 13.55* (1) Subsequent to the revision of international standards (e.g. IEC 60446, EN 60446, BS EN 60446, BS 7671 and IEC 60364, the existing cable colour code in Hong Kong will no longer match with the international standards. In this project, LV cables (220Vac 1-phase and 380Vac 3-phase) to the new cable colour code to the revised international standards shall be provided.

(2) All cables used for the fire services equipment shall satisfy the requirements of FSD and GSBSI. Cables used for the fire services equipment and flameproof equipment shall be of the appropriate fire resistive type of mineral insulated wiring cable to BS EN 60702 or approved equivalent cables.

Lighting protection system 13.56* The system shall generally comply with GSBSI and the requirements and recommendations of BS EN 62305.

Portable equipment 13.57* Portable Gases Detector

The equipment shall comply with BS EN 50014, BS EN 50018 and BS EN 50020 and be approved to BASEEFA Exia d IIC T4.

Miscellaneous equipment 13.58* (1) Ear Muff

Ear muffler shall be of BS EN 352-1 and approved type under Factories and Industrial Undertaking (Noise at Work) Regulations. The minimum Noise Reduction Rate (NRR) shall be of 30 dBA.

(2) Platform Ladder

Construction of ladder shall comply with BS EN 131.

PUBLIC LIGHTING INSTALLATION

Luminaires for road 13.59* (1) Lanterns General

Lanterns shall be of sound and robust construction to BS EN 60598-2-3.

(2) Optical Performance

(i) Photometric data files shall be submitted for each luminaire under consideration. The data must be provided in a format that strictly conforms to the following standards, or another format approved by the Engineer, to facilitate optical performance evaluation:

(a) CIBSE TM-14, (British) Standard File Format for the Electronic Transfer of Luminaire Photometric Data.

(b) IESNA LM-63-02, the North American Standard File Format for the Electronic Transfer of Luminaire Photometric Data.

(ii) Luminaire shall be manufactured and tested in compliance with the following standards:-

Luminaire for public lighting	BS EN 60598-2-3
LED Driver Safety	BS EN 61347-2-1 and BS EN 61347-2-13
Radio frequency inference	BS EN 55015
Harmonics	BS EN 61000-3-2 and BS EN 61000-3-3
Electromagnetic immunity	BS EN 61547

(iii) Luminaire shall be tested in accordance with IEC 62471 for photo-biological safety and shall comply with the classification of Exempt Group or Group I.

Lamps for road 13.60* General Requirement

All LED lamps shall be manufactured to IEC 62471 hazard class Group 1 or Exempt Group and be suitable for operation on a supply of 220V ±6% 50 hertz using appropriate control gear.

All LED luminaires shall have a rated lifetime of not less than 50,000 hours at 70% lumen maintenance (L70/B50 ≥ 50,000 hours). The minimum luminous efficacy shall be 100 lm/W or higher. All LED lamps and luminaires shall comply with the requirements of the Public Lighting Design Manual issued by the Highways Department, the General Specification for Building (or Electrical) Works issued by the Architectural Services Department, and any project-specific specifications or appendices.

Control gear for public lighting 13.61* (1) General Requirement

LED drivers shall comply with IEC 61347-1 and IEC 61347-2-13. The major components of the LED drivers shall be of high quality and complying with international standards. The LED drivers shall have a useful life of not less than 50,000 hours.

(2) LED Driver, Package and Light Module

(i) The luminaire shall support a continuous dimming range of 10% to 100%, with dimming control achievable via one or more of the following methods: external/internal potentiometer, internal pre-programmed time-based dimming function, external 0-10V or PWM control, or DALI interface. The specific dimming method shall be determined in consultation with the relevant authority.
(ii) The LED driver shall have a minimum efficiency of 90%.
(iii) The LED driver shall be capable of withstanding open circuit and short circuit output conditions without damage.
(iv) The luminaire shall be designed such that failure of any individual LED package will not result in the failure of other LED packages within the

same module.

(v) An external surge protection device rated for at least 10kV shall be provided for the driver. Both the driver and the surge protector shall be housed in a separated front-access enclosure located at the column door level of the lighting column.

Power cables 13.62* (1) Lanterns General Requirement

Unless otherwise specified, cables shall conform to BS 5467 and other relevant IEC specifications or approved equivalents. Full technical specifications and evidence of compliance with the relevant standards shall be submitted as part of the material approval process.

(2) Conductor

The conductor shall comply with all the requirements of BS EN 60228. The conductors for 600/1000V, 2-core and 4-core cables shall be with stranded copper conductor.

(3) Steer Wire Armour

The steel wire armour (SWA) shall be in accordance with BS EN 10244-2 and BS EN 10257-1. The mass of zinc coating on the wire surface shall be not less than 206 g/m2.

(4) Identification of Cores For 600/1000V Cables

The cores for 600/1000V, 2-core or 4-core cables shall be identified as for Clause 7 of BS 5467. The colouring shall be impregnated in the insulation.

(5) PVC Outersheath

The nominal thickness of PVC outersheath shall be not less than the calculated values using the formula as specified in Clause 11 of BS 5467.

(6) Colour of Outer-sheath

The outer-sheath shall be of blue colour to BS 6746C.

(7) Type Tests

Special tests, type tests (electrical) and type tests (non-electrical) shall be carried out according Clause 18 of the BS 5467 for 600/1000V cables.

(8) Routine Test On 600/1000V Cables

Each drum of 600/1000V cables shall be subjected to the following tests in accordance with BS 5467.

(i) Measurement of DC resistance for each core and SWA.

(ii) AC pressure test at 3.5kV rms for 15 minutes.

Miniature circuit breakers (MCB) 13.63* General

Single Pole MCBs shall comply with BS EN 60898 and be suitable for 220V

50 Hertz supply operation with rated current of 6A, 10A or 16A.

Other approach public lighting equipment 13.64*

(1) Astronomical Time Switch and Digital Photoelectric Controller

Astronomical time switches used for the back-up of the photoelectric controller shall comply with IEC 60730-1. It shall have 2-channel, accuracy of ± 0.5 sec/day and battery reserve for at least 5 years.

The digital photoelectric controller shall be of electronic fail-safe type, and have a LCD display showing the local time, on/off settings and measured illuminance level. It shall also have a plug-in and replaceable photo sensor, and an on/off adjustable setting from 1 to 2,000lux with adjustable time delay of 0-60 seconds.

Both the switch and the controller shall be suitable for use in exposed weather conditions and shall function correctly at a temperature range of -5°C to +50°C at the local supply voltage and frequency.

(2) Contactor

Contactors shall be an air-break type, with contactor coil rated at local supply voltage and frequency, complying with BS EN 60947. The utilization category of the contactors shall be AC3. The contactors shall be suitable for continuous operation inside a public lighting control cubicle at an ambient temperature from -5°C to +40°C.

(3) Cable for Conduit Wiring Installation

All cables shall have copper conductors and shall be single core, 450/750V grade, PVC insulated, complying to BS 6004.

(4) Conduit and Accessories

Conduits and accessories shall be of heavy gauge hot dip galvanized steel with epoxy coating complying with BS 4568 class 4. Adaptor boxes complete with covers shall be of cast iron, or of galvanized mild steel not less than 3mm thick.

(5) Cold Pour Resin Joints for Public Lighting Cables

Straight and branch jointing kits shall be suitable for 2-core or 4-core low voltage 25mm² XLPE or PVC/SWA/PVC stranded copper conductor or 25mm² XLPE or PVC/ASA/PVC sector-shaped solid aluminium cables, in accordance with BS 6346 or BS 5467.

All joints shall be designed and tested in compliance with BS 6910-1.

All joint parts, compound, and constituents shall be suitable for cable conductor operating temperatures up to 90°C.

All constituent parts shall be capable of safe assembly with live LV cables.
Jointing kits shall be supplied complete with all necessary materials and compound for completion and shall include a list of any specific tools required for jointing.

The compound shall be a two-part, cold-pour polyurethane resin, tested in accordance with BS 7933: Part 1. The mixed compound shall be non-toxic and

shall set hard.

(6) Public Lighting Cut-Out

Public lighting cut-out shall have robust sealscrew facilities, possessing high mechanical and dielectric strength. The cable termination block shall be suitable for looping three nos. of 25mm2 solid core aluminium/copper conductor at the inlet, and for connection two nos. of 2.5mm2 XLPE insulated copper cable at the outlet.

Adequate phase barrier and PVC shrouding shall be provided to prevent cross phasing or accidental contact with live metal. The cut-out shall be provided with a fixed MCB standard mounting profile rail EN50-022 or equivalent and shall be supplied with one MCB and be capable of fitting up to 3 MCBs. Each unoccupied MCB space shall be covered by removable separate cover.

Brass cable glands 13.65* (1) General Requirement

Brass cable glands shall be suitable for 25mm² 2-cores or 4 cores and 2.5mm² 2-cores or 4-cores 600/1000V XLPE insulated, steel wire armoured, PVC over-sheathed copper conductor cable for public lighting cable termination. All cable glands shall comply with BS 6121 Part 1 and BS EN 62444.

(2) Certification

Test certificates giving the results of type-tests shall be produced to verify compliance with the test requirements stipulated in BS 6121: Part 1.

Directional sign lighting installation 13.66* (1) General Requirement

(i) Gantry Sign lighting shall comply with the requirements of Volume 3 of Transport Planning and Design Manual for Traffic Signs and Road marking, Public Lighting Design Manual and BS 8442.

(ii) Lighting for directional signs shall adopt the illuminance concept as described in BS EN 12899-1, and shall meet the lighting level and uniformity (minimum to maximum illuminance) requirements for sign faces as specified in Table 3-1 and Table 3-2 of the latest edition of the Public Lighting Design Manual.

(2) Lantern

(i) Lanterns shall be of sound and robust construction to the current edition of BS EN 60598.

(ii) Lanterns and the integral control gear shall have a minimum environment protection class not less than IP65 in accordance with BS EN 60529.

(3) Switch-Fuse

(i) The enclosure of switch-fuse shall be constructed of 2mm mild steel and shall be protected to IP 55 to BS EN 60947-1 “Low-Voltage Switchgear And Control gear - Part 1: General Rules”.

(iii) Switch-fuse shall be to BS EN 60947-3 “Low-voltage switchgear

and control gear. Switches, disconnectors, switch-disconnectors and fuse-combination units".

(iii) H.R.C. fuse shall be to BS 88 "Cartridge fuses for voltages up to and including 1000V a.c. and 1500V
d. c.".

(4) PVC Insulated Flexible Cable

PVC insulated flexible cable shall be PVC insulated, PVC sheathed, ordinary duty single flat twin 300/500V flexible cord in accordance with BS 6500 or IEC 60227.

(5) Surface Protection

(i) All ferrous pipework, supports, and brackets, except plated surfaces, shall be painted using a protective coating system designed for a minimum service life of 5 years.

(ii) The system shall provide the same protection to welded joints as to parent metal surfaces. Pipework shall be colour coded in accordance with BS 1710 and the paint colour schedule shall comply with BS 4800.

(iii) Corrosion protection for all steelwork shall conform to BS 5493 unless otherwise specified.

(iv) All surfaces shall be suitably prepared and free of dust, oil, grease, scale, rust, or other contaminants prior to application of the protective coating.

LED ROAD LIGHT LUMINAIRES

General 13.67* (1) Luminaire shall have the correlated colour temperature of 3,000K ± 300K. The colour rendering index shall be of at least 70 and luminaire efficacy shall be of not less than 100 lm/W.

(2) The lumen maintenance at 50,000 hours for the luminaire shall not be less than 70%. Lumen maintenance life time shall be in accordance with IES LM-80 and extrapolated methodologies of IES TM-21.

(3) The maximum power rating of luminaire shall generally not be higher than 150W. System power factor shall be of at least 0.9 during full power or dimmed operation. Total harmonic distortion shall be less than 20%.

(4) Luminaire shall be suitable for use on 220V, 50 hertz single phase power supply and operated normally under the ambient temperature from -10°C to 35°C and relative humidity up to 100%.

(5) The housing of luminaire shall be constructed from die cast aluminum with polyester powder coating or corrosion resistance painting. The optical lens, diffuser and luminaire transparent cover shall be stabilized to ultraviolet light. In case of any reflector is used, the reflector shall be made of high purity aluminum material.

(6) The Ingress Protection (IP) index of LED luminaire shall be of at least IP65 and optical assembly of luminaire shall be of minimum IP66.

(7) Luminaire shall include surge protection device not less than 10kV surge protection and the testing shall be according to BS EN 61000-4-5 or equivalent.

(8) Luminaire shall prevent flicker to the eye during full power or dimmed

operation.

(9) The upward light ratio of luminaire shall be below 15% and complied with the requirements as stipulated in the latest edition of Public Lighting Design Manual.

(10) Labels shall be securely affixed inside the lantern body. These shall include the mark of origin, model number, rated voltage, rated wattage of lamp, I.P. rating and terminal markings etc.

(11) The LED luminaries shall have a universal fixation with adjustable inclination/tilting from -5° to +10° in steps of 2.5°.

(12) The following maximum lantern weight and lantern windage area shall be met in order to match the wind loading of the corresponding lighting columns.

(13) The maximum weight and windage area of each lantern shall not exceed the following limits, including all internal components such as the LED driver and necessary wiring:

- For lanterns rated up to 100W: maximum weight 12 kg; maximum windage area 0.10 m^2.
- For lanterns rated above 100W up to 150W: maximum weight 15 kg; maximum windage area 0.29 m m^2.

Lantern windage area shall be calculated with the appropriate shape coefficient applied.

Each lantern shall be designed to accommodate the attachment of a safety sling, without affecting the ingress protection (IP) performance of the luminaire.

(14) The LED luminaires shall be provided with dimming function to enhance energy savings.

(15) The LED luminaires shall be equipped with configurable energy saving algorithms feature to perform Constant Light Output (CLO) by the LED driver to allow constant lumen throughout the lifetime of the light engine to compensate for the depreciation of luminous flux over time according to the maintenance factor of the luminaire and to avoid excess lighting at the beginning of the installation's service life for energy saving.

(16) The LED luminaires shall be equipped with a standard NEMA twist-lock receptacle (NEMA Socket) in compliance with ANSI C136.10/136.41 fit on top of the luminaire with all the essential wiring connections to the LED driver for future installation of the control node connecting to the Remote Monitoring and Control Road Lighting System. The NEMA Socket shall be provided with a water-proofed cover for necessary protection before in-use.

(17) The luminaires shall be of certified products under the "Product Certification Scheme for LED Lighting Products" published by the Hong Kong Electronic Industries Association. The product conformity certificate shall be issued by a certification body accredited by the Hong Kong Accreditation Service (HKAS) or an accreditation body which has entered into a mutual recognition agreement with the HKAS.

(18) Each LED luminaire supplied shall be provided with a unique serial number which shall be indicated clearly in a label traceable by the supplier/manufacturer for ease of reference for future maintenance and warranty. The labels shall be securely affixed inside the lantern body. All necessary product information shall also be indicated in the labels including the mark of origin, model number, rated voltage, rated wattage of lamp, I.P. rating and terminal markings etc.

Standards compliance and laboratory testing

13.68* (1) Luminaire shall be manufactured and tested in compliance with the following standards:

Luminaire for Road Lighting	BS EN 60598-2-3
LED Driver Safety	BS EN 61347-2-1 and BS EN 61347-2-13
Radio frequency interference	BS EN 55015
Harmonics	BS EN 61000-3-2 and BS EN 61000-3-3
Electromagnetic immunity	BS EN 61547

(2) Luminaire shall comply with international safety standards for European Conformity (CE) or Underwriters Laboratories Inc. (UL).

(3) Luminaire shall be tested in accordance with IEC 62471 for photo-biological safety and shall comply with the classification of Exempt Group or Group 1.

LED LINEAR WASHER LUMINAIRES FOR DIRECTIONAL SIGN AND GANTRY SIGN LIGHTING

General

13.69* (1) Luminaire shall be suitable for use on 220V, 50 hertz single phase power supply and operated normally under the ambient temperature from -10°C to 35°C and relative humidity up to 100%.

(2) System power factor shall be of at least 0.9 during full power or dimmed operation.

(3) The housing of luminaire shall be constructed from die cast aluminum with corrosion resistance coating or painting. The optical lens, diffuser and luminaire transparent cover shall be stabilized to ultraviolet light.

(4) The Ingress Protection (IP) index of LED luminaire shall be of at least IP65.

(5) The mounting angle of luminaire shall be adjustable for optimum illumination of the signs.

(6) Bolts, nuts and other metallic fasteners shall be of stainless steel to BS EN ISO 3506-1 and BS EN ISO 3506-2 grade A5-80.

Performance requirements of luminaire

13.70* The lumen maintenance at 50,000 hours for the luminaire shall not be less than 70%. Lumen maintenance life time shall be in accordance with IES LM-80 and extrapolated methodologies of IES TM-21.

Standards compliance and laboratory testing

13.71* (1) Luminaire shall be manufactured and tested in compliance with the following standards:

Luminaire for Road Lighting	BS EN 60598-2-3
LED Driver Safety	BS EN 61347-2-1 and BS EN 61347-2-13
Radio frequency interference	BS EN 55015

Harmonics	BS EN 61000-3-2 and BS EN 61000-3-3
Electromagnetic immunity	BS EN 61547

(2) Luminaire shall comply with international safety standards for European Conformity (CE) or Underwriters Laboratories Inc. (UL).

(3) Luminaire shall be tested in accordance with IEC 62471 for photo-biological safety and shall comply with the classification of Exempt Group or Group 1.

PUBLIC LIGHTING EQUIPMENT 600/1000V POWER CABLES

General requirements 13.72* Standard
Unless otherwise specified, materials and cable construction shall conform to BS 5467 and other relevant IEC specifications or approved equivalents.

Conductor 13.73* The Contractor shall provide the relevant current carrying capacities of all cables. The conductor shall comply with the requirements of BS EN 60228. The conductors for 600/1000V, 3-core cables shall be of stranded copper arrangement.

Steel wire armour 13.74* The steel wire armour (SWA) shall be in accordance with BS EN 10244-2 and BS EN 10257-1. The mass of zinc coating on the wire surface shall be not less than 206 g/m^2. A single wire galvanized steel armouring shall be provided over an extruded PVC bedding.

Identification of cores for 600/1000V cables 13.75* The cores for 600/1000V, 2-core, 3-core, 4-core or 5-core cables shall be identified as for Clause 7 of BS5467. The colouring shall be impregnated in the insulation.

PVC outersheath 13.76* The nominal thickness of PVC outsheath shall be not less than the calculated values using the formula as specified in Clause 11 of BS 5467.

Type test 13.77* Special tests, type tests (electrical), and type tests (non-electrical) for 600/1000V cables shall be carried out in accordance with Clause 18 of BS 5467.

The cables shall have been subjected to type tests for service frequency, impulse insulation level, and electrical and mechanical performance, as specified in BS 5467.

Routine test on 600/1000V cables 13.78* Each drum of 600/1000V cables shall be subjected to the following tests in accordance with BS 5467.

(a) Measurement of DC resistance for each core and SWA.

(b) AC pressure test at 3.5 kVrms for 15 minutes.

STREET LIGHTING LAMP

General requirement 13.79* All discharge lamps shall be manufactured to the appropriate International Standard Specification and be suitable for operation on a supply of 220V+6%, 50 hertz using appropriate control gear. High pressure lamps shall comply with the safety requirements laid down in BS EN 62035.

The International Standards for different types of lamps are :-

High pressure sodium vapour lamps : BS EN 62035
Low pressure sodium vapour lamps : BS EN 60192 High pressure mercury vapour lamps : BS EN 60188
Metal halide lamps : BS EN 62035
Fluorescent lamps : BS EN 60081 & BS EN 61195
Compact fluorescent lamps : BS EN 60901 & BS EN 61199
Self-ballasted compact fluorescent lamps : BS EN 60968 & BS EN 60969

STREET LIGHTING CONTROL GEAR

Electromagnetic ballasts 13.80* (1) The electromagnetic ballasts shall be of a straight tapped type with three tappings at voltages ranging from 200V to 220V at 10V interval (i.e. No autotransformers are to be used in conjunction with chokes or leak transformers). The package shall incorporate a substantial earthing terminal and shall be so constructed that the radio interference field strengths lie within the limits specified by BS EN 55015.

(2) The electromagnetic ballast shall be manufactured and tested in compliance with BS EN 60923 and BS EN 61347-1 and BS EN 61347-2-9.

Capacitors 13.81* The capacitor shall be manufactured and tested in compliance with BS EN 61048 and BS EN 61049.

Ignitors 13.82* The ignitor shall be manufactured and tested in compliance with BS EN 60927 and BS EN 60926 / BS EN 61347-2-1.

Electronic ballast for fluorescent and compact fluorescent lamps 13.83* The electronic ballasts shall be manufactured and tested in compliance with the following standards:-

General and Safety	BS EN 61347-2-1/2-3/-2-9 or BS EN 61347-2-12
Performance	BS EN 60929
Harmonics	BS EN 61000-3-2; BS EN 61000-3-3
Radio frequency interference	BS EN 55015 / BS EN 50561-1
Electromagnetic immunity	BS EN 61547

Electronic ballast for high intensity discharge (HID) lamps 13.84* The electronic ballasts shall be manufactured and tested in compliance with the following standards:-

General and Safety	BS EN 61347-2-1/2-3/2-9 or BS EN 61347-2-12
Harmonics	BS EN 61000-3-2; BS EN 61000-3-3
Radio frequency interference	BS EN 55015 / BS EN 50561-1
Electromagnetic immunity	BS EN 61547

Components and materials employed for the electronic ballast shall comply with the requirements of “The Restriction of Hazardous Substances Directive

(RoHS) 2002/95/EC". Certification and/or declaration of compliance to RoHS shall be submitted for verification of compliance.

Driver for LED luminaires 13.85* The LED drivers shall comply with IEC 61347-1 and IEC 61347-2-13.

ROAD LIGHTING LUMINAIRES EXCEPT LED LUMINAIRES

General 13.86* Lanterns shall be of sound and robust construction to BS EN 60598-2-3.

MINIATURE CIRCUIT BREAKERS, MOUNDED CASE CIRCUIT BREAKER, RESIDUAL CURRENT CIRCUIT BREAKER AND OUTDOOR SOCKET OUTLET

Miniature circuit breakers (MCBs) 13.87* General
MCBs shall comply with BS EN 60898 and be suitable for 220V 50 Hertz supply operation with a rated current of 6A, 10A or 16A.

Moulded case circuit breakers (MCCB) 13.88* (1) General

Four pole MCCB shall be complete with overcurrent and/or earth leakage tripping device and be suitable for operation at a nominal supply line voltage of 380V at 50 Hz. The MCCB shall comply with BS EN 60947.

(2) Add-on Earth Leakage Protection Module

An add-on earth leakage protection module, when equipped with an MCCB, shall not alter the MCCB circuit breaker characteristics. It shall be type tested to BS EN 60947-2.

Residual current circuit breaker without integral overcurrent protection (RCCB) 13.89* General

The RCCB shall comply with BS EN 61008-1. It shall be double-pole or 4-pole and suitable for 220V (1-phase) or 380V (3-phase) 50 Hertz supply operation.

Residual current circuit breaker with integral overcurrent protection (RCBO) 13.90* General

The RCBO shall comply with BS EN 61009-2-1. It shall be double-pole and suitable for 220V (1-phase) 50 Hertz supply operation.

Outdoor socket outlet 13.91* General

The socket outlet shall be 13A to BS 1363-2

FLUORESCENT LUMINAIRE INSTALLATION

General 13.92* (1) The luminaire shall be manufactured in accordance with the latest specific BS EN 60598-2-1;

(2) The conduits, conduit fittings and metal boxes for enclosure of electrical accessories in conduit installation shall be hot-dip galvanised and have

heavy protection both inside and outside to BS 4662 / IEC 60670-1 as appropriate;

(3) Cables in conduit shall be of single-cored copper conductors, 450/750V, PVC insulated, complying to BS 6004

OTHER PUBLIC LIGHTING EQUIPMENT

Pass light and bulk head light 13.93* Luminaires shall be of low glare design and shall comply with BS EN 60598. The power rating shall be between 20W and 40W. Each luminaire shall have a body constructed from die-cast aluminium and fitted with a vandal-resistant polycarbonate cover with an impact protection rating of at least IK09. The ingress protection rating shall be not less than IP65. Luminous efficacy shall be at least 100 lm/W, with a correlated colour temperature of 4,000K and a colour rendering index (CRI) of not less than 80.

Astronomical time switch 13.94* The on/off control of lighting circuits shall be by means of an astronomical time switch and a digital photoelectric controller as a backup. The astronomical time switch shall comply with IEC 60730-1. It shall have 2-channel, an accuracy of ± 0.5 sec/day and a battery reserve for at least 5 years. The switch shall be suitable for use in exposed weather conditions and shall function correctly at a temperature range of -5°C to +50°C at the local supply voltage and frequency.

Cable for conduit wiring installation 13.95* All cables shall have copper conductors and shall be single core, 450/750V, PVC insulated, complying to BS 6004.

The cables within a public lighting control cubicle, if not concealed in conduit or trunking, shall be PVC insulated and PVC sheathed, 300/500V to BS 6004 or armoured of 600/1000V of XLPE/SWA/PVC complying to BS 5467.

Conduit and accessories 13.96* The conduits, conduit fittings and metal boxes for enclosure of electrical accessories in conduit installation shall be hot-dip galvanised and have heavy protection both inside and outside to BS 4568 Class 4 / IEC 60614-2-1 & IEC 61035-2-1 and BS 4662 / IEC 60670 as appropriate.

Cold pour resin joints for public lighting cables 13.97* (1) For Hong Kong Island and Lamma Island areas, the jointing kits shall be suitable for jointing of 2-core or 3-core 35 mm2 XLPE insulated, steel wire armoured, PVC oversheathed and stranded copper conductor cables. For Kowloon & NT East and NT West areas, the straight jointing kits shall be suitable for 2-core or 4-core low voltage 25 mm2 XLPE insulated, steel wire armoured, PVC oversheathed and stranded copper conductor cables to BS5467.

(2) All joints shall be designed and tested in compliance with BS 7933.

(3) The compound shall be the 2 part mix cold poured polyurethane resin compound that has been tested in accordance with BS 7933 and BS EN 50393. When mixed, the compound must be non-toxic and set hard.

Street lighting cut-out 13.98* The cut-out shall be provided with a fixed MCB standard mounting profile rail EN50-022 or equivalent and shall be supplied with one MCB up to 16A and be capable of fitting up to 3 MCBs. Each unoccupied MCB space shall be covered by removable separate cover. Each lantern or outgoing circuit shall be protected by a separate MCB.

Brass cable glands 13.99* The cable type shall be complied with the cable requirement as specified in Part I of Section D of this Schedule. All cable glands shall comply with BS 6121-1.

SOLAR LED ROAD LIGHT

Photovoltaic (PV) panel 13.100* The PV panel shall be composed of monocrystalline or polycrystalline silicon solar cells and manufactured to BS EN 61215, safety protection class II.

Cables 13.101* (1) All power cables shall have copper conductors and shall be PVC insulated and PVC sheathed, single or multicore, 300/500V grade, to BS6004.

(2) The circuit protective conductors shall be green/yellow PVC insulated 2.5mm2 1-core copper cables, 400/750V grade, to BS6004.

Lighting column 13.102* The lighting column shall be designed in accordance with BS EN 40

NEON SIGN

General 13.103* The neon sign installation shall comply with the requirements of Code 26H of the "Code of Practice for the Electricity (Wiring) Regulations" published by the Electrical and Mechanical Services Department and BS EN 50107.

Neon transformer 13.104* (1) The neon transformer shall be double-wound, epoxy-resin encapsulated, with two high voltage windings magnetically separated from each other, with high tension mid point earthed, and short circuit proof to BS EN 61050.

(2) It shall comply with the standards for electromagnetic compatibility of BS EN 55015, BS EN 61000-3-2, BS EN 61000-3-3 and BS EN 61547.

High voltage cable 13.105* The high voltage cables between the neon transformers and the neon tubes shall be silicone rubber insulated with high dielectric strength, weather resistant insulated and braided cable to BS EN 50143 type B with tinned copper stranded wire. Other weatherproof silicone based high voltage discharge lighting cables of appropriate grade to JIS, UL or other international standard may also be accepted subject to approval.

LANDSCAPE LIGHT

General 13.106* (1) The landscape light shall be manufactured to BS EN 60598-2-5 and be suitable for operation on a 220V +/-6% 50Hz single phase electricity supply. A landscape light complying with other appropriate standards of JIS, UL or other international standard may also be acceptable for the landscape light subject to approval by the Engineer.

(2) The landscape light shall be fitted with a 150W/100W/70W metal halide/CDM-TT lamp complying with BS EN 62035. A metal halide/CDM-TT lamp complying with other appropriate standards of JIS, UL or other international standard may also be acceptable for the landscape light subject to approval.

LED LUMINAIRE

General 13.107* (1) Luminaire shall be manufactured and tested in compliance with the standard below:

General and safety	BS EN 60598, BS EN 61347-2-1/2-13
Harmonics	BS EN 61000-3-2/3-3
Radio frequency interference	BS EN55015
Electromagnetic immunity	BS EN 61547

(2) Luminaire shall be tested with minimum degree of protection to IP66 in accordance with BS EN 60529.

(3) Luminaire shall be tested in compliance with IEC 62471 and classified as exempt group in accordance with IEC/TR 62471-2. Test distance shall be included in the laboratory test report.

(4) Photometric data files of luminaire shall be submitted in the format strictly according to the CIBSE and IESNA standards below:-

(i.) CIBSE TM-14, (British) Standard File Format for the Electronic Transfer of Luminaire Photometric Data
(ii.) IESNA LM-63-02 Standard File Format for the Electronic Transfer of Luminaire Photometric Data

(5) Luminaire shall be tested and categorized as Class 4 in compliance with BS EN 61000-4-5. Testing of equivalent or better performance for lightning and surge protection in accordance with other standards may be accepted, subject to the satisfaction of the Engineer.

TRAFFIC CONTORL AND SURVEILLANCE SYSTEM (TCSS)

Installation of TCSS field equipment 13.109* (1) All ferrous pipework, supports, and brackets, except plated surfaces, shall be provided with a protective coating system designed for a minimum service life of 5 years.

(2) Pipework shall be colour coded in accordance with BS 1710, and the paint colour schedule shall comply with BS 4800. Welded joints and surfaces shall receive the same protective coating as the parent metal.

(3) All steelwork shall be protected against corrosion in accordance with BS 5493 unless otherwise specified.

TCSS CABLE

Flammability 13.110* (1) The oversheath, and bedding if exists, of the cable shall have a minimum oxygen index of 35 when tested in accordance with ASTM D2863/BS EN ISO 4589 Part 2.

(2) The temperature index of the oversheath, and bedding if exist, of the cable shall not be less than 280ºC when tested in accordance with BS EN ISO 4589 Part 3.

Flame propagation 13.111* (1) The cable shall be flame retardant and shall comply with the requirements of IEC60332: Part 1 / BS EN 50265 for tests on single cable under fire conditions when tested in accordance with that standard.

(2) The cable shall be flame retardant and shall comply with the requirements of Category C of IEC60332: Part 3 / BS EN 50266 Part 2-4 for tests on bunched cables under fire conditions when tested in accordance with that standard.

Fire resistance 13.112* Where fire resistance is specified in the relevant cable specification, cables shall be fire resistant and shall comply with the requirements of IEC 60331 when tested in accordance with that standard.

Corrosive and acid gas emission 13.113* (1) The emission level of hydrochloric acid (HCI) gases which are defined as the corrosive and acid gases, from all low smoke zero halogen compounds in the cable shall not be greater than 0.5% when tested in accordance with BS6425/IEC60754: Part 1.

(2) All non-metallic constituent materials (filler bedding, oversheath and insulation etc.) of all cables shall be halogen free and shall comply with the performance requirements in IEC60754: Part 2 when tested in accordance with that standard.

Smoke emission 13.114* (1) The values for the light transmittance of the low voltage power cables and earthing cables shall meet the requirements of BS 6724: Clause 17.3 when samples of complete cable are tested in accordance with IEC61034-2.

(2) The values for the light transmittance of all cables, except the low voltage power cables and the earthing cables, shall meet the requirements of IEC61034-2 when tested in accordance with that standard.

Summary of standards 13.115* The following standards, in particular, shall apply where appropriate:

High-voltage test techniques		IEC60060
Radio-frequency cables		IEC 60096
Radio-frequency connectors		IEC 60169
Low-frequency cables and wires with PVC insulation and PVC sheath	BS4808	IEC 60189
PVC insulated cable or rated voltage up to and including 450/750V		IEC 60227
Conductor of insulated cables	BS6360	IEC 60228
Fire-resisting characteristics of electric cables		IEC 60331
Tests on electric cables under fire conditions		IEC 60332
Degrees of protection provided by enclosures (IP code)		IEC 60529
Test on gases evolved during combustion of electric cables	BS 6425	IEC 60754
Optical fibres		IEC 60793
Connectors for optical fibres and cables		IEC 60874
Safety of information technology equipment		IEC 60950
Measurement of smoke density of electric cable burning under defined conditions	BS EN 50268	IEC 61034
Determination of burning behaviour by	BS EN ISO	ASTM D2863

oxygen index Part 2	4589-2	
Determination of burning behaviour by oxygen index Part	BS EN ISO 4589-3	
Specification for rolled copper and copper alloys: sheet, strip and foil	BS 2870	
Polyolefin copper-copper telecommunication cables	BS 3573	
Electric cables – Voltage levels for parking testing	BS 509	
Instrumentation cables	BS 5308	
Coaxial cable for wideband distribution systems	BS 5424	
Specification for 600/1000V and 1900/3300V armoured electric cables having thermosetting insulation	BS 5467	
Mechanical Cable Glands	BS 6121	
Electric Cables – Spark-test method	BS EN 62230	
Methods of test for insulation and sheaths of electric cables	BS 6469	
Specification for armoured Cables for Electricity supply having thermosetting insulation with low emission of smoke and corrosive gases when affected by fire	BS 6724	
Specification for rubber insulation and sheath of electric cables	BS 6899	
Thermosetting Insulated cable (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fires	BS 7211	
Code of practice for Earthing	BS 7430	
Characteristics of a 50/125um multimode graded index optical fibre cable		ITU-T G.651
Characteristics of a single-mode optical fibre cable		ITU-T G.652D
Characteristics of gas discharge tubes for the protection of telecommunication installations		ITU-T K.12
Methods of terminating metallic cables		ITU-T L.9
Information technology – telecommunications and information exchange between systems – local and metropolitan area networks – specific requirements		ISO/IEC 8802-3

OPTICAL FIBRE TRUNK CABLE / OUTDOOR OPTICAL FIBRE CABLE

Standard conformance 13.116* (1) Single-mode optical fibre cables shall comply with the ITU-T Recommendation G.652D and IEC 60793 standards specifications unless otherwise specified hereinafter.

(2) Multi-mode optical fibre cables shall comply with the ITU-T Recommendation G651 and IEC 60793 standards specifications unless

otherwise specified hereinafter.

(3) All outdoor multi-mode optical fibre cables for the data network shall conform to the ISO/IEC 11801 optical fibre cable Type OM2 standard specification as minimum.

INDOOR OPTICAL FIBRE CABLE

Standard conformance 13.117* (1) Single-mode optical fibre cables shall comply with the ITU-T Recommendation G.652D and IEC 60793 standards specifications.

(2) For 62.5/125µm multimode fibre type, the fibre characteristics of the optical fibre cable shall comply with IEC60793-2 type A1b unless otherwise specification hereinafter.

(3) For 50/125µm multimode fibre type, the fibre characteristics of the optical fibre cable shall comply with ITU-T G.651 unless otherwise specified hereinafter.

(4) All indoor multi-mode optical fibre cables shall conform to the ISO/IEC 11801 optical fibre cable Type OM2 standard specification as a minimum.

OPTICAL PATCH CORD AND PIGTAIL

Standard conformance 13.118* (1) All single-mode optical Standards Conformance 2.3.1.1 All single-mode optical patch cords and pigtails shall comply with ITU-T Recommendation G.652D and IEC 60793.

(2) For 62.5/125µm multimode fibre type, the fibre characteristics of the optical fibre cable shall comply with IEC60793-2 type A1b unless otherwise specified hereinafter.

(3) For 50/125µm multimode fibre type, the fibre characteristics of the optical fibre cable shall comply with ITU-T G.651 unless otherwise specified hereinafter.

Optical requirements multi-mode optical fibre 13.119* All multi-mode optical patch cords and pigtails for the MAN and Telephone Subsystems shall conform to the ISO/IEC 11801 optical fibre cable Type OM2 specification as a minimum.

CONNECTOR FOR MULTI-MODE OPTICAL FIBRE

Standard conformance 13.120* All optical connectors used including those for optical patch cords and pigtails, shall be of ST type complying with IEC60874-10.

ACCESSORIES AND OTHERS

Optical distribution frame and optical distribution box 13.121* All optical connectors shall comply with the ITU-T Recommendation G.652.

Cable joint 13.122* All fibre joints shall be protected by a suitable mechanical closure and conforming to IP65 in IEC60529.

CCTV COAXIAL CABLE

Outdoor coaxial cable 13.123* (1) Conductors
The inner conductors shall be of stranded, high conductivity annealed copper or tinned copper, or of copper clad steel wire complying with all the requirements of IEC60228 and BS6360.

(2) Insulation
The insulation resistance shall comply with BS5425: Part 1 when tested in accordance with that standard.

(3) Spark Test for Sheath
The insulation shall not break down when spark tested in accordance with BS EN 62230 and BS 5099.

(4) Armour
Armour for the cable shall consist of single layer of steel tape or galvanized steel wire to BS5467.

(5) Screening
The screening effectiveness shall comply with BS5425: Part 1

(6) Testing Requirements
Test methods of the cable shall conform to the IEC 60096: Part 4.

Indoor coaxial cable 13.124* (1) Conductors
The inner conductors shall be of stranded, high conductivity annealed copper or tinned copper, or of copper clad steel wire complying with all the requirements of IEC60228 and BS6360.

(2) Insulation
The insulation resistance shall comply with BS5425: Part 1 when tested in accordance with that standard

(3) Spark Test for Sheath
The insulation shall not break down when spark tested in accordance with BS EN 62230 and BS 5099.

(4) Screening
The screening effectiveness shall comply with BS5425: Part 1

(5) Testing Requirements
Test methods of the cable shall conform to the IEC 60096: Part 4.

MULTIPAIR DATA CABLE

Multipair data cable 13.125* (1) Conductors
The conductor sizes, cores and colours shall comply with IEC 60189.

(2) Spark Test for Sheath
The insulation shall not break down when spark tested in accordance with BS EN 62230 / BS5099 using alternating current from a supply at a minimum of

r.m.s. voltage of 6kV or by an alternative method of equivalent sensitivity.

(3 Core Identification
The insulated cores shall be clearly identified by colour, and the identification scheme shall be in accordance with IEC 60189/ BS 4808. Other identification scheme shall be submitted for approval.

The required number of pairs shall be laid up in concentric layer to form a compact symmetrical cable.

(4) Screening

(i) Screening shall be achieved by the use of laminated tape, consisting of an aluminium foil bonded to a polyester film for the strength, applied to the cable with an overlap so that full 100% coverage of the conductors is afforded (Note: spray on types of construction are not acceptable).

(ii) The data cable shall be individually screened pair cables to provide improved cross talk performance characteristics.

(iii) A drain wire or continuity conductor laid under and in contact with the aluminium foil shall be provided and shall be in accordance with BS5308 Part 1: Clause 12 as appropriate. The tinned annealed copper conductor, which may be solid or a standard construction, in keeping with current manufacturing techniques, shall have a minimum cross-sectional area of 0.5 mm2.

(iv) The maximum resistance of the drain wire or continuity conductor provided shall meet with the requirements of IEC 60228/BS 6360.

(5) Testing

(i) Electrical Test:
Test methods shall conform to IEC60189-1. The tests shall be carried out on every length of cable and shall include the following as a minimum:
a. Conductor resistance;
b. Insulation resistance; and
c. Mutual capacitance.

(ii) Mechanical Test:
a. Mechanical test as specified in BS 3573 shall be carried out and shall include the following as a minimum:
b. conductors - elongation test;
c. insulation - elongation;
d. insulation - breaking force;
e. insulation - resistance to compression;
f. insulation - retraction;
g. dimensions of magnetic screen tapes; and
h. extruded anti-corrosion flame retardant sheath thickness

COMPUTER SYSTEM CABLE

LAN cable UTP or ScTP 13.126* (1) Performance Requirements

(i) The performance of Category 5 LAN cable shall conform to the ISO/IEC

11801 / EN 50173-1:2007 Class D Category 5 standards specification at a reference temperature of 20°Cas a minimum.

(ii) The performance of Category 6 LAN cable shall conform to the ISO/IEC 11801 / EN 50173-1:2007 Class E Category 6 standards specification at a reference temperature of 20°Cas a minimum.

(2) Testing

(i) Electrical Test:
Test methods shall conform to IEC60189-1. The tests shall be carried out on every length of cable and shall include the following as a minimum:
a. Conductor resistance;
b. Insulation resistance; and
c. Mutual capacitance.

(ii) Mechanical Test:
a. Mechanical test as specified in BS 3573 shall be carried out and shall include the following as a minimum:
b. conductors - elongation test;
c. insulation - elongation;
d. insulation - breaking force;
e. insulation - resistance to compression;
f. insulation - retraction;
g. dimensions of magnetic screen tapes; and
h. extruded anti-corrosion flame retardant sheath thickness.

POWER CABLE (LV & EARTHING)

Low voltage power cable & earthing cable 13.127* (1) Standard

(i) The characteristics of low voltage power cables shall comply with BS6724, BS6899 and BS6469 where appropriate.

(ii) Unless otherwise specified hereinafter, the characteristics of earthing cable shall comply with BS7430, BS7211, and S6899 where appropriate.

(2) Conductors

(i) The conductors shall be of stranded, high conductivity annealed copper wire complying with all the requirements of IEC 60228 and BS 6360.

(ii) Cables for fixed installations shall have conductors with stranding to Table II Class 2 of IEC 60288, and flexible cables shall have stranded conductors to Table II Class 5 of IEC 60228.

(iii) The size of conductor for earthing cable shall comply with BS7430.

(3) Insulation

(i) The cable insulation shall be extruded cross-link polyethylene (XLPE) complying with BS6899 (type GP8).

(ii) The cable insulation shall consist of extruded low smoke halogen free material.

(iii) The nominal thickness of the insulation shall be as specified in BS 6724

(4) Spark Test for Sheath

The characteristics of low voltage power cables shall comply with BS6724, BS6899 and BS6469 where appropriate.

(5) Armour (for trackside Low Voltage power cables)

Armouring shall be of galvanized steel wire comply with BS6724. The direction of armour laying shall be left-handed, and the wire shall be sized in accordance with the manufacturer's recommendations.

(6) Cable Sheathing (low voltage power cable)

Physical properties of the cable sheathing materials shall comply with BS6724 and have the following requirements when tested in accordance with BS6469.

Property	Requirement
Minimum tensile strength at break	$10Nmm^{-2}$
Minimum elongation at break	100%
After aging for 7 days at 100ºC	
Minimum tensile strength at break	$10Nmm^{-2}$
Minimum elongation at break	100%
Maximum variation of tensile strength	±40%
Maximum variation of elongation at break	±40%
Minimum tear resistance	$8Nmm^{-1}$
Hot pressure test at 80ºC: Maximum indentation	50%
Cold elongation at -15 ºC: Minimum elongation	20%

Low voltage power 13.128* Testing

(1) The testing methods for armoured and non-armoured cables shall conform to BS6724 and BS7211 respectively.
(2) The testing methods for earthing cable shall conform to BS7211.

CABLE GLANDS AND ACCESSORIES

Non-armoured cables 13.129* All cable glands and accessories shall comply with BS6121 and be supplied by a single manufacturer.

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 14

FORMWORK AND FINISHES TO CONCRETE

SECTION 14

FORMWORK AND FINISHES TO CONCRETE

Formwork

14.14 (1) Formwork shall be timber, metal, plastic or other material, which will produce the specified finish. Tropical hardwood is strictly prohibited for use in the formwork. Materials used as formers for profiled formwork, chamfers, splays, rebates and other features shall be such that they produce the same finish as the main formwork.

(2) Plywood for formwork shall have a close, uniform grain and the edges shall be sealed with barrier paint, polyurethane varnish or other impermeable material. Plywood sheathing to formwork shall not be subjected to more than nine uses, irrespective of the use of one or both faces of such sheathing.

(3) The faces of formwork for Class F4 and F5 finishes shall have a uniform texture and a matt, not a shiny or polished, surface. The edges of the formwork shall be straight and square.

Formwork Class of finish

14.15 (1) The characteristics of each class of finish shall be as stated in Tables 14.1, 14.2 and 14.3.

(2) Formwork of the type stated in Table 14.1 will normally produce a concrete surface that complies with the characteristics of finish stated in Table 14.1 but other types of formwork may be used to produce the specified finish.

(3) The Class of formed and unformed finish required for different concrete surfaces shall be as stated in Table 14.4 unless otherwise stated in the Contract. The higher Class of finish shall start at least 150 mm below the finished ground level for concrete surfaces that are partly buried.

Release agents

14.16 (1) Release agents shall be of a proprietary type approved by the Engineer. Release agents containing mineral oils shall not be used. Barrier paint, polyurethane varnish, wax or other materials shall not be used instead of a release agent.

(2) Release agents shall be of a type that will not stain or colour the concrete and which will not affect the bond between the concrete and subsequent coverings. Release agents other than those that incorporate a surface retarder to produce a Class T1 finish shall be of a type that will not affect the hardening of the concrete.

(3) Release agents used on formwork for water retaining structures for potable and fresh water shall be non-toxic and shall not impart a taste to the water.

(4) Release agents used on steel formwork shall contain a rust-inhibiting agent.

(5) Release agents used on formwork for Class F4 and F5 finishes shall be a chemical release agent.

(6) On areas of formwork which in the opinion of the Engineer are likely to be affected by pedestrian traffic, rain or dust, release agents for Class F4 and F5 finishes shall be of a type which evaporates to leave a dry film on the formwork, unless protection from such effects is provided.

Formwork ties 14.17 (1) Formwork ties and components shall be of a type such that any removable part can be removed without damaging the concrete. Any part left in the concrete shall be at least 40 mm or the specified cover to the reinforcement, whichever is greater, from the concrete surface.

(2) Unless otherwise permitted by the Engineer, formwork ties and components used with profiled formwork shall be of a type such that holes left by the ties and components are small enough to be located completely within the recesses in the concrete surface.

(3) Formwork ties for use in water-retaining structures and waterproof structures shall incorporate a diaphragm welded to the mid point of the tie, designed to prevent water from passing along the tie. Ties shall be degreased before being placed and shall not touch or foul the reinforcement.

Cement mortar for concrete surfaces 14.18 (1) Cement mortar for filling blowholes shall consist of cement and fine aggregate together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the blowholes.

(2) Cement mortar for filling holes left by formwork ties and components shall consist of 1 part of cement to 3 parts of fine aggregate together with the minimum amount of water necessary to achieve a consistency suitable for compacting the mortar into the holes. The mix shall contain a non-shrink admixture.

(3) Cement mortar for filling blowholes and holes left by formwork ties and components in concrete surfaces with Class F4 and F5 finishes shall be the same colour as the hardened concrete. Light-coloured sand or white cement may be used for this purpose.

(4) Materials for cement mortar shall comply with Section 16.

Surface retarders 14.19 Surface retarders shall be of a proprietary type approved by the Engineer and shall be of a type that will not stain or colour the concrete.

Abrasives 14.20 Abrasives for blasting shall be grit or other materials approved by the Engineer and shall not contain any iron, clay or other materials which will stain or colour the concrete.

Table 14.1: Formed finishes

Class of finish	Type of formwork normally used	Characteristics of finish			
		Formwork pattern	Abrupt irregularities permitted	Gradual irregularities permitted	Specific requirements
F1	Sawn timber	Not required	< 10 mm	< 15 mm in 2 m	No specific requirements
F2	Plywood	Pattern of formwork joints and tie holes as stated in Clause 14.30(1) and (2)	< 5 mm	< 10 mm in 2 m	Even surface No grout runs
F3			< 3 mm	< 5 mm in 2 m	Even surface No grout runs
F4	Sealed plywood				Uniform, dense and smooth surface No grout runs No grain pattern No crazing No major blemishes
F5			< 2 mm	< 3 mm in 2 m	Uniform, dense and smooth surface No grout runs No grain pattern No crazing No blemishes No staining or discolouration

Table 14.2: Unformed finishes

Class of finish	Method of producing finish	Characteristics of finish		
		Abrupt irregularities permitted	Gradual irregularities permitted	Specific requirements
U1	Levelling the surface of the compacted concrete with a screed board	Screed marks < 5 mm	< 10 mm in 2 m	No specific requirements
U2	Forming a Class U1 finish and tamping the surface	Tamp marks < 10 mm	Not applicable	Ridged surface
U3	Forming a Class U1 finish and wood floating or power floating the surface	Float marks < 3 mm	< 10 mm in 2 m	Uniform, dense and smooth surface
U4	Forming a Class U3 finish and brushing the surface with a stiff brush	Brush marks < 3 mm	< 10 mm in 2 m	Rough texture
U5	Forming a Class U3 finish and steel trowelling the surface under firm pressure or power floating the surface	Nil	< 5 mm in 2 m	Uniform, dense and smooth surface, free of trowel marks No staining or discolouration

Table 14.3: Treated finishes

Class of finish	Type of finish	Method of producing finish	Characteristics of finish
T1	Exposed aggregate	Washing and brushing the concrete surface	Cement matrix removed and coarse aggregate exposed to a depth not exceeding one-third of the nominal maximum coarse aggregate size
T2	Point tooled	Point tooling the concrete surface	Cement matrix and aggregate surface removed sufficiently to expose the aggregate with a minimum penetration into the matrix between aggregates
T3	Bush hammered	Bush hammering the concrete surface	
T4	Broken rib	Hammering or chiselling the edges and faces of the concrete surface	Fragments of concrete ribs removed
T5	Light blasting	Blasting the concrete surface by abrasives and compressed air or by water jetting	Cement matrix removed and coarse aggregate exposed to a minimum depth
T6	Heavy blasting		Cement matrix removed and coarse aggregate exposed to a depth not exceeding one-third of the nominal maximum coarse aggregate size

APPLICATION OF RELEASE AGENTS

Application of release agents 14.33A* (1) Release agent containing mineral oil shall not be used. Barrier paint, polyurethane varnish, water or the other materials shall not be used to replace release agent.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 15

STEEL REINFORCEMENT

SECTION 15

STEEL REINFORCEMENT

Reinforcing steels 15.03 Except as stated in Clause 15.04 below, reinforcing steels for the reinforcement shall comply with the following:

Category	Reinforcement	Compliance
A	Steel reinforcing bars covered by CS2	CS2
B	Other reinforcing steel bars Grade 500 not covered by CS2	BS 4449
C	Plain round steel bars (diameter > 12 mm) of Grade 250 not covered by CS2	BS 4449:1997
D	Plain round steel bars (diameter ≤ 12 mm) of Grade 250 not covered by CS2	BS 4482
E	Steel fabric sheets	BS 4483

15.03A* For projects subject to requirements of DEVB TC(W) No. 1/2024, 15.03A*, 15.03B* and 15.12A* are referred instead.

Category	Reinforcement	Compliance
A	Steel reinforcing bar covered by CS2:2012 (including steels for fabric/wire)	PS Clauses 15.03B* and 15.12A1, in addition to CS2:2012, with the exception of the following, which should follow CS2:2012. 1. Steel reinforcing bar with exemption as per PS Clause 15.03A1(2), and; 2. Coil and decoiled products which are not product-certified reinforcement as per PS Clause 15.03A1(1)

Product certification 15.03B* (1) Steel reinforcing bars under Category A manufactured by Quality Assured (QA) Manufacturers under a third party product certification, traceable to their manufacturers and production data (optional to include heat/cast numbers) and handled by QA Stockists throughout the supply chain, shall be classified as product-certified reinforcement. The product-certified reinforcement is equivalent to Class 1 steel reinforcing bars of CS2:2012 when subject to the purchasers testing and rate of testing in accordance with Table 10 of CS2:2012.

(2) All steel reinforcing bars under Category A (except coil and decoiled products) shall be manufactured by Quality Assured (QA) Manufacturers under a third party product certification unless approval for exemption from using product-certified reinforcement is obtained. Such exemption shall follow Development Bureau Technical Circular (Works) No. 1/2024.

(3) The third party product certification shall comply to CS2 for technical requirements, and shall be issued by a certification body accredited by Hong Kong Accreditation Service or its Multilateral Recognition Arrangement partners based on ISO/IEC 17065:2012. The product certification scheme shall be Type 5 as per ISO/IEC 17067:2013.

(4) The certification body shall be independent from the manufacturer and

shall not be an associated company with the manufacturer.

(5) For the avoidance of doubt, only those steel reinforcing bars produced within the scope of a valid product certification (e.g. specified bar sizes and specified factory location) and within the certification validity period shall be regarded as "produced under a third party product certification".

Stainless steel reinforcement 15.04 Stainless steel bars for the reinforcement shall be ribbed bar to BS 6744. The steel designation numbers are in accordance with BS EN 10088-1. The requirements on sampling, testing and acceptance criteria shall be in accordance with BS 6744 except otherwise stated.

Epoxy coatings to reinforcement 15.05 (1) Epoxy coatings to reinforcement and patching materials for epoxy coatings shall comply with BS ISO 14654 except as stated in Clauses 15.05(2), 15.22, 15.32, 15.34 and 15.38. The coatings shall be applied by the electrostatic spray method complying with BS ISO 14654 at a factory approved by the Engineer.

(2) The film thickness of the coating after curing shall be at least 0.17 mm and shall not exceed 0.30 mm over the complete periphery including deformations and ribs. The bond classification of coated bars determined in bond performance tests shall not be less than that of uncoated bars.

Hot dip galvanizing to reinforcement 15.06 (1) Hot dip galvanizing to reinforcement shall comply with BS EN ISO 1461. The galvanization shall be applied after cutting and bending of the reinforcement.

(2) Materials for repair to hot dip galvanized reinforcement shall comply with BS EN ISO 1461.

Reinforcement connectors 15.07 (1) ~~Reinforcement connectors shall be of a proprietary type approved by the Engineer.~~

(2) Reinforcement connectors for tension joints shall be a cold swaged or threaded type. The connectors shall be capable of developing the full tensile strength of the parent bar and shall comprise high tensile steel studs and seamless steel tubes fitted with protective plastic caps.

(3) Reinforcement connectors for compression joints shall be of a wedge locking or bolted sleeve type.

15.07A* (1) When a test is made on a representative gauge length assembly comprising reinforcement of the size, grade and profile to be used and a coupler of the precise type to be used, the permanent elongation after loading to 0.6fy should not exceed 0.1mm.

(2) The design ultimate strength of the coupled bar should exceed the specified characteristic strength by the percentage specified in Clause 7 of BS 4449:2005+A2:2009. The tensile strength of reinforcement connector shall not be less than the specified requirements for the parent bars.

Cover spacers 15.08 (1) Cover spacers for reinforcement shall be concrete blocks or of a proprietary plastic or concrete type. Proprietary plastic and concrete cover spacers shall be of a type approved by the Engineer.

(2) Cover spacers for Class F3, F4 and F5 finishes shall be of a proprietary plastic or concrete type. Cover spacers for epoxy-coated reinforcement and

galvanized reinforcement shall be of a proprietary plastic type.

(3) Cover spacers shall be as small as practicable consistent with their purpose and shall be designed to maintain the specified cover to reinforcement. Cover spacers shall be capable of supporting the weight of reinforcement and construction loads without breaking, deforming or overturning.

(4) The strength and durability of concrete blocks and proprietary concrete cover spacers shall not be less than that of the surrounding concrete.

~~(5) Cover spacers for Class F3, F4 and F5 finishes shall be of a colour similar to that of the surrounding concrete and shall not cause indentations in the formwork.~~

15.08A* (1) Cover spacers for Class F3, F4 and F5 and other finishes shall be of a surface texture and colour similar to that of the surrounding concrete and shall not cause indentations in the formwork.

(2) All cover spacers at the exposed concrete surface shall have the same surface texture and colours as the finished concrete surface such that no isolated patches of different colour or texture is visible at the finished concrete surface.

Chairs, supports and spacers 15.09 Chairs, supports and spacers other than cover spacers for reinforcement shall be steel. The steel shall be coated with nylon, epoxy, plastic or other dielectric material for epoxy-coated reinforcement and shall be hot dip galvanized for galvanized reinforcement.

Tying wire 15.10A* (1) Tying wire for reinforcement adjacent to and above Class F4, F5 and better finishes shall be 1.2 mm diameter fully softened stainless steel wire to grade 316S (or equivalent and compatible with the reinforcement). For other cases,

(a) Tying wire for epoxy coated reinforcement shall be 1.6 mm diameter soft annealed steel wire coated with nylon, epoxy, plastic or other dielectric material.

(b) Tying wire for galvanized reinforcement shall be 1.6 mm diameter galvanized soft annealed steel wire.

(c) Tying wire for other reinforcement shall be 1.6 mm diameter soft annealed steel wire.

(2) The ends of wire ties shall not protrude into the concrete cover. Off-cuts from typing wires shall be removed from formwork and in no event shall the off-cuts be allowed to accumulate at the bottom of the formwork shutters.

Tying devices and clips 15.11 Tying devices and clips for reinforcement shall be of a proprietary steel type approved by the Engineer. Tying devices and clips for reinforcement adjacent to and above Class F4 and F5 finishes shall be stainless steel. Tying devices and clips for epoxy-coated reinforcement shall be coated with nylon, epoxy, plastic or other dielectric material. Tying devices and clips for galvanized reinforcement shall be galvanized.

Particulars of reinforcement 15.12 (1) The following particulars of the proposed steel reinforcement shall be submitted to the Engineer for approval:

(a) For Category A (i.e. CS2) reinforcement, a certificate from the quality assured stockist and a copy of the manufacturer's certificate/document in accordance with CS2 Cl. 4.1.

(b) For other reinforcement, a certificate/document from the manufacturer showing the manufacturer's name, the place of manufacture and showing that the reinforcement complies with the requirements stated in Clause 15.03, including:
- Chemical composition (cast analysis) and calculation of carbon equivalent value
- Dimensions and mass per metre of bar/wire
- Tensile properties and bend performance
- Bond property or evidence that the bond property has complied with the requirements
- Sheet dimensions and shear force of welded joints for steel fabric sheet

(2) The particulars together with other requirements stated in the Contract shall be submitted to the Engineer for approval for each batch of reinforcement delivered to the Site and at least 14 days before fixing of the reinforcement starts.

Particulars of reinforcement 15.12A*

(1) For each delivery of product-certified reinforcement, apart from the requirements in CS2:2012 Cl. 3.1.5 & 4.1.3.2, the manufacturer shall also supply a copy of product conformity certificate corresponding to that delivery. The product certification number shall be indicated on the manufacturer's certificate/document. In addition to the product conformity certificate, the delivery documentation should include a declaration, from the certification body, confirming that the requirements stated in Clauses 15.03A1(3) and (4) are met.

(2) For each delivery of product-certified reinforcement, apart from the requirements in CS2:2012 Cl. 4.1.3.1(a) to (f), the stockist's certificate shall indicate the product certification number corresponding to that delivery, and state the following statement (authorised by a designated means to indicate that the requirements of this PS are satisfied):

"Certified that the steel reinforcing bars supplied hereon are covered by the manufacturer's Product Conformity Certificate and manufacturer's Test Certificate referenced hereon and have been subjected to the traceable part of our certification to ISO 9001."

Particulars of epoxy coatings to reinforcement 15.13

(1) The following particulars of the proposed epoxy coatings to reinforcement shall be submitted ~~to the Engineer for approval~~:

(a) Name and location of the coating factory,

(b) Date and place of the coating application, and

(c) Original Certificate(s) of the coating materials in compliance with BS ISO 14656, including:
- Corrosion resistance
- Chemical resistance
- Cathodic disbondment
- Salt spray resistance

- Abrasion resistance
- Impact strength
- Coating flexibility

The above tests shall be carried out once every 5 years or when there are changes in the composition of the coating materials whichever is the earlier.

(2) ~~The particulars shall be submitted to the Engineer for approval at least 14 days before the first delivery of epoxy-coated reinforcement to the Site. Certificates together with the particulars of the reinforcement shall be submitted to the Engineer for approval for each batch of epoxy-coated reinforcement delivered to the Site and at least 14 days before fixing of the reinforcement starts.~~

Particulars of galvanized coatings to reinforcement

15.14 (1) The following particulars of the proposed galvanized coatings to reinforcement shall be submitted to the Engineer for approval:

(a) Name and location of the coating factory, and

(b) Original certificate from the manufacturer showing the date and place of application of the coating and showing that the galvanized coatings comply with the requirements stated in the Contract and including results of tests carried out by methods as recommended in BS EN ISO 1461 for thickness of coating.

(2) ~~The particulars shall be submitted to the Engineer for approval at least 14 days before the first delivery of galvanized reinforcement to the Site. Certificates together with the particulars of the reinforcement shall be submitted to the Engineer for approval for each batch of galvanized reinforcement delivered to the Site and at least 14 days before fixing of the reinforcement starts.~~

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 16

CONCRETE AND JOINTS IN CONCRETE

SECTION 16

CONCRETE AND JOINTS IN CONCRETE

PART 1: CONCRETE WORKS

Cement 16.06 (1) Cement shall comply with the following, unless otherwise approved by the Engineer:

Portland cement (PC)	: BS EN 197-1 (Type CEM I) Strength Class of cement used in structural concrete to be 52.5N
Sulphate resisting Portland Cement (SRPC)	: BS EN 197-1 (Types CEM I-SR 0, CEM I-SR 3, or CEM I-SR 5) Strength Class of cement used in structural concrete to be 52.5N
Portland fly ash (PFAC) cement	: BS EN 197-1 (Types CEM II/A-V and CEM II/B-V) Strength Class of cement used in structural concrete to be 42.5N or higher

(2) The limiting values applicable to acceptance inspection of cement at delivery shall be those given in Table NB.1 of National Annex NB of BS EN 197-1.

Pulverized Fly Ash (PFA) and Ground Granulated Blastfurnace Slag (GGBS) 16.07 (1) PFA shall comply with either BS 3892:Part 1 with the following modifications:

(a) Use Portland cement BS EN 197-1: CEM I (52.5N) to determine water requirement, strength factor at 28 days, soundness and initial setting time.

(b) The criteria for water requirement and strength factor at 28 days shall not apply, but the values of water requirement and strength factor at 28 days shall be reported on certificates as required in Clause 16.17(1)(b).

(c) PFA of total lime content over 10% but not over 20% and with soundness value not more than 10 mm is acceptable as “high-lime PFA’. When “high-lime PFA” is used, it shall be reported in certificates as required in Clause 16.17(1)(c).

or BS EN 450-1 with the following modifications

(a) The loss on ignition shall be either Category A or B.

(b) The fineness of Category N PFA, if used, shall be declared.

(2) GGBS shall comply with BS EN 15167-1 except that the scheme for the evaluation of conformity of GGBS specified in BS EN 15167-2 is not required. The glass content as determined by X-ray diffraction or optical-microscopy method shall be not less than 67%. The X-ray diffraction method detailed in Appendix D of BS 6699 is acceptable.

Aggregates 16.08 (1) Aggregates shall be obtained from a source approved by the Engineer. Aggregates from marine source shall not be used. All-in aggregates shall not be used.

(2) Fine aggregate shall be clean and hard complying with CS3. Natural sand shall not be used unless with the prior agreement of the Engineer.

(3) Coarse aggregate shall be clean and hard complying with CS3. Coarse recycled aggregates may be used subject to the prior agreement of the Engineer.

(4) The potential alkali-reactivity category of coarse aggregate and fine aggregate shall be determined from the results of tests on potential alkali-reactivity of aggregates using the test method given in Table 16.7.

(5) Aggregates in the alkali "Reactive" category shall not be used unless with the prior approval of the Engineer.

16.08A* (1) Marine dredged sand or aggregates shall not be used for concrete.

(2) Unless otherwise specified, the maximum aggregate size shall be 20mm.

(3) The chloride content of the coarse and fine aggregate (determined in accordance with CS3:2013), combined in the proportions intended for the particular concrete, shall not exceed 0.02% chloride ion by mass of combined aggregate.

(4) Measures to control the occurrence of alkali-aggregate reaction (AAR) in concrete for all concrete elements shall be submitted. In the absence of alternative proposals such control shall be achieved by limiting the reactive alkali content of the concrete. The properties of aggregates shall be such that the reactive alkali of any concrete used in the contract expressed as the equivalent sodium oxide per cubic metre of concrete shall not exceed 3.0 kg.

(5) The maximum Los Angeles value (CS3:2013) shall be 30% loss and maximum sodium sulphate soundness (CS3:2013) weighted average loss shall be 6%.

(6) The continuous gradation for all concrete aggregate shall be based on a maximum nominal aggregate size of 20 mm for general use, unless otherwise specified.

Admixtures 16.10 (1) Admixtures shall comply with the following:

Pigments for Portland cement and Portland cement products	: BS EN 12878
Accelerating admixtures, retarding admixtures and water-reducing admixtures	: BS EN 934-2
Superplasticising admixtures	: BS EN 934-2

(2) The chloride ion content of admixtures for concrete containing embedded metal or for concrete made with SRPC shall not exceed 2% by mass of the admixture or 0.03% by mass of the cementitious content, whichever is less.

Curing compound 16.11 ~~(1) Curing compound shall be a proprietary type approved by the Engineer~~

~~and shall have an efficiency index of at least 85%. Resin based curing compound shall not be used unless approved by the Engineer.~~

(2) Curing compound shall contain a fugitive dye. Curing compounds containing organic solvents shall not be used. The curing compound shall become stable and achieve the specified resistance to evaporation of water from the concrete surface within 60 minutes after application. Curing compound shall not react chemically with the concrete to be cured and shall not crack, peel or disintegrate within one week after application. Curing compound shall degrade completely within three weeks after application and the concrete surface s treated shall not impair the bonding of applied finishes.

(3) Curing compound for use on concrete surfaces against which potable or fresh water will be stored or conveyed shall be non-toxic and shall not impart a taste to the water.

16.11A* (1) Curing compounds for structures shall be a proprietary type and have a minimum efficiency index of 96%. Curing compound for concrete carriageways shall be a non-pigmented liquid resin or wax resin base membrane curing compound of a proprietary brand, with a minimum efficiency index of 90%.

(2) Curing compound shall contain a fugitive dye. Curing compounds containing organic solvents shall not be used. The curing compound shall become stable and achieve the specified resistance to evaporation of water from the concrete surface within 60 minutes after application. Curing compound shall not react chemically with the concrete to be cured and shall not crack, peel or disintegrate within three months after application. Curing compound shall degrade completely within three weeks after application and the concrete surfaces treated shall not impair the bonding of applied finishes.

PART 2: JOINTS IN CONCRETE

Materials for joints in water retaining structures and water tight structures

16.74 (1) Materials for joints in water retaining structures and water tight structures for sewage and effluent treatment shall be resistant to aerobic and anaerobic microbiological attack and resistant to attack by petrol, diesel oil, dilute acids and alkalis.

(2) Materials for joints in water retaining structures for potable and fresh water shall comply with the requirements of BS 6920.

Joint filler

16.75A* Joint filler shall be firm, compressible, single-thickness, non-rotting and resistant to pests such as termites. Joint filler for joints in water retaining structures and water tight structures shall be non-absorbent.

The joint filler shall show no sign of disintegration or shrinkage even the joint encounter the below scenario of changes of temperature:

"the joint filler exposed to a temperature of 50°C for seven days and then be immersed in water at room temperature for 24 hours. The temperature shall be gradually lowered to 0°C ± 1°C and maintained at that level for four hours. The temperature shall then be raised to not less than 30°C. The joint filler then be subjected to four further cycles of freezing and thawing. Afterwards the joint filler be removed from water and allowed to stand in air at room temperature for 48 hours."

Bitumen emulsion 16.76 Bitumen emulsion for joints in water retaining structures and watertight structures shall comply with BS 3416. Bitumen emulsion for surfaces against which potable or fresh water will be stored or conveyed shall comply with BS 3416, type II.

Joint sealant 16.77 ~~(1) Joint sealant shall be a grade suited to the climatic conditions of Hong Kong and shall perform effectively over a temperature range of 0°C to 60°C. Joint sealant for exposed joints shall be grey.~~

(2) Joint sealant other than cold-applied bitumen rubber sealant shall be:

(a) A gun grade for horizontal joints 15 mm wide or less and for vertical and inclined joints,

(b) A pouring grade for horizontal joints wider than 15 mm.

(3) Polysulphide-based sealant shall be a cold-applied two-part sealant complying with BS 4254. Polysulphide-based sealant for expansion joints in water retaining structures and watertight structures shall have a transverse butt-joint movement range of at least 20%.

(4) Polyurethane-based sealant shall be a cold-applied two-part sealant complying with the performance requirements of BS 4254.

(5) Hot-applied bitumen rubber sealant shall comply with BS 2499, type N1.

~~(6) Cold-applied bitumen rubber sealant shall be of a proprietary type approved by the Engineer.~~

(7) Joint sealant for joints in water retaining structures and water tight structures shall be as stated in Table 16.11.

~~(8) Primers and caulking material for use with joint sealant shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer.~~

(9) Different types of joint sealant and primers that will be in contact shall be compatible.

16.77A* (1) Joint sealant shall be a grade suited to the climatic conditions of Hong Kong and shall perform effectively over a temperature range of 0°C to 60°C. Joint sealants shall be a proprietary type consisting of hot or cold-poured or gun grade compounds or of a preformed neoprene compression strip, and be used strictly in accordance with the manufacturer's recommendations. They shall be compatible with any material in contact with the sealant, and shall be resistant to attack or deterioration by liquids or other substances which can be expected to affect such joints. In areas which are exposed above finished ground level, the colour of the joint sealant shall be concrete grey unless shown otherwise on the Drawings.

Table 16.11 : Joint sealant for water retaining structures and water tight structures

Structure for retaining/ excluding	Type of joint	Type of joint sealant
Sewage	All joints	Polyurethane-based
Other than sewage	Expansion joints	Polysulphide-based or polyurethane-based
	Horizontal joints other than expansion joints	Hot-applied bitumen rubber, polysulphide-based or polyurethane-based
	Vertical and inclined joints other than expansion joints	Polysulphide-based, polyurethane-based or cold-applied bitumen rubber

Bond breaker tape 16.78 Bond breaker tape shall be of a proprietary type recommended by the joint sealant manufacturer and approved by the Engineer. The tape shall be a polyethylene film with adhesive applied on one side and shall be the full width of the groove.

Bearing strip for sliding joints 16.79 Bearing strip for sliding joints shall consist of two plastic strips of a proprietary type approved by the Engineer. The strips shall be resistant to all weather conditions and to chemicals to which the structure will be subjected without impairing the reaction, durability or function of the strips. The strips shall be of a type that will not require maintenance after installation. The strips shall be capable of withstanding a vertical load of at least 300 kN/m^2 and shall have a maximum coefficient of friction of 0.3 under a constant shearing force.

Waterstops 16.80 Waterstops, including intersections, reducers and junctions, shall be of a proprietary type approved by the Engineer. Waterstops shall be natural or synthetic rubber or extruded polyvinyl chloride and shall have the properties stated in Table 16.12.

Hydrophilic type waterstops 16.80A* Water swellable hydrophilic waterstop shall be made from a performed elastomeric strip which can integrate into existing waterstop networks. It shall be free from rubber, bentonite or other inclusion. The waterstop shall have an unrestrained volumetric expansion of not less than 170%. It must not deteriorate under prolonged wet/dry cycling. It must be able to withstand a hydrostatic head of 50 meters. It shall be used in accordance with the methods given in the manufacture's current data sheet.

Table 16.12: Properties of waterstops

Property	Rubber waterstops	PVC waterstops
Density	1100 kg/m^3 (± 5%)	1300 kg/m^3 (± 5%)
Hardness	60 - 70 IRHD	70 – 90 Shore A Hardness
Tensile strength	≥ 20 N/mm^2	≥ 13 N/mm^2
Elongation at break point	≥ 450%	≥ 285%
Water absorption	≤ 5% by mass after 48 hours immersion	≤ 0.15% by mass after 24 hours immersion
Softness number	-	42 - 52

PART 3: PRESCRIBED MIX CONCRETE WITH

100% RECYCLED COARSE AGGREGATE

Recycled Coarse Aggregate	16.100A*	Recycled Coarse Aggregate shall be produced by crushing old concrete and shall meet the requirements in Table A.
Fine aggregate	16.101A*	Fine aggregate shall be within the limits of grading M in CS3. Fine aggregate derived from recycled concrete shall not be used.
Grading of the coarse aggregates	16.102A*	The grading of the coarse aggregates shall comply with the limits of Table 3.1 of CS3 for single-sized 20 mm and 10 mm aggregates.

Table A

Mandatory Requirements	Limits	Testing Method
Minimum dry particle density (kg/m³)	2000	CS3, Section 17 BS EN 1097-6 (Supersede BS 812: Part 2)
Max. water absorption	10 %	CS3, Section 17 BS EN 1097-6 (Supersede BS 812: Part 2)
Max. content of wood and other material less dense than water	0.5 %	Manual sorting in accordance with BRE Digest 433
Max. content of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, glass etc)	1 %	
Max. fines	4 % - Note 1	CS3, Section 10 BS EN 933-1 (Supersede BS 812: Section 103.1)
Max. content of sand (<4mm) (% m/m)	5 %	CS3, Section 10 BS EN 933-1 (Supersede BS 812: Section 103.1)
Max. content of sulphate (% m/m)	1 %	CS3, Section 21 BS EN 1744-1 (Supersede BS 812: Part 118)
Flakiness index	40 % - Note 2	CS3, Section 11 BS EN 933-3 (Supersede BS 812: Section 105.1)
10% fines test	100kN – Note 3	CS3, Section 16 BS EN 1097-2 (Supersede BS 812: Part 111)
Grading	Table 3.1 of CS3 BS EN 12620, Section 4.3 (Supersede Table 3 of BS 882)	
Maximum Chloride content	CS3, Section 5.2 BS EN 12620, Section 6.2 – 0.05% by mass of chloride ion of combined aggregate – Note 4 (Supersede Table 7 of BS 882)	

Note 1: Filler (<0.063 mm) should be less than 2% in the RILEM Specification. BS 882 says that fines passing 75μm sieve shall not exceed 4%. The latter requirement is easier to satisfy.

Note 2: Clause 16.08(3) states that flakiness shall not exceed 35% whereas BS 882 states that it shall not exceed 40% for crushed rock or crushed gravel.

Note 3: Clause 16.08(3) states that the 10% fines value shall be at least 100 kN. BS 882 states that the 10% fines value to be 50 kN for concrete not subjected to wearing. BRE Digest 433 states that 70 kN is achievable in recycled aggregate derived from brickwork, and 100 kN for those derived from crushed concrete. In recent tests carried out on recycled aggregates derived from old concrete, 100 kN can be accepted.

Note 4: BRE Digest 433 recommends determining acid soluble chloride rather than water soluble chloride.

PART 4: DESIGNED MIX CONCRETE WITH 20% RECYCLED COARSE AGGREGATE

Coarse aggregates 16.103A* (1) Coarse aggregates shall consist of 80% natural rock aggregates as defined in Clause 16.08(3) and 20% recycled coarse aggregates.

(2) Recycled coarse aggregates shall be produced by crushing old concrete and shall meet the requirements in Table B.

(3) Tests on recycled aggregates from a particular source shall be carried out at weekly intervals to check compliance with Table A.

Fine aggregates 16.104A* Fine aggregates shall be as defined in Clause 16.08(2). Fine aggregates recycled from old concrete shall not be used.

Grading of Coarse aggregates 16.105A* The grading of the coarse aggregates shall comply with the limits of Table 3.1 of CS3:2013 for single-sized 20 mm and 10 mm aggregates.

PART 5: MISCELLANEOUS REQUIREMENTS

Protective coatings for concrete 16.106A* Protective coatings for concrete shall comply with the "Model Specification for Protective Coatings for Concrete" (July 1994) and the associated addendum on "Penetrants" (June 1998) published by the Civil Engineering Department. These documents are available from the Government Publications Centre.

PVC Protective Lining for water retaining structures 16.107A* (1) PVC lining shall be manufactured from high molar mass polyvinyl chloride combined with plasticizers, stabilizers and pigments compounded to produce permanently flexible sheets. PVC lining shall be light to dark grey in colour. Copolymer resins shall not be used and polyvinyl chloride shall constitute not less than 99% by mass of the resin used

(2) PVC lining shall have a thickness of not less than 1.5 mm

(3) PVC lining shall be formed by extrusion with locking keys or ribs on one side. The keys or ribs shall be diamond section and shall be at centres not exceeding 75 mm.

(4) PVC lining shall be capable of forming a continuous 100% effective seal to the concrete after jointing by welded strips.

(5) Welded strips, patches and other materials used for PVC lining shall have the same material composition as the PVC lining.

(6) The physical properties of PVC lining shall comply with the requirement as stated below

Physical Property	Test method	Acceptable limits
Tensile strength (both longitudinal and transverse to key)	ASTM D412	17.25 MPa min.
Elongation at break (both longitudinal and transverse key)	ASTM D412	225% min.
Hardness	Shore diameter D at 20°C	53 min. – 62 max.
Plasticizer permanence (24 hours at 90°C on 50 mm dia. disc)	ASTM D 1203-93 Method B	1.0% max.
Water absorption at 24 hours (sample size 76 mm x 25 mm by thickness of sheet)	ASTM D570	0.1% max.
Water soluble matter at 24 hours	ASTM D570	0.05% max.
Tear strength (both longitudinal and transverse key)	ASTM D1004 (Grip speed 8.5 mm/s)	80N/mm minute

(7) The following particulars of the proposed materials and methods of construction for PVC lining shall be submitted.

(8) Manufacturer's literature for PVC lining, including details of the composition and properties, sections, intersections and junctions and a

certificate showing the manufacturer's name, the date and place of manufacture and showing that the PVC lining complies with the requirements stated in the contract and including results of tests for:

- tensile strength
- elongation at break
- hardness
- plasticizer performance
- water absorption at 24 hours
- water soluble matter at 24 hours
- tear strength
- change in mass when exposed to chemicals
- immersion in sewage
- continuity

(9) Manufacturer's details of the method of fixing, testing and repairing PVC lining, including details of forming joints, corners, penetrations and seals at the edge of the PVC linings.

(10) Manufacturer's details of the method of fixing, testing and repairing PVC lining, including details of forming joints, corners, penetrations and seals at the edge of the PVC linings

Epoxy Lining for water retaining structure 16.108A*

(1) The composition of the lining shall be solvent free epoxy resin containing coal tar, acid resistant fillers and wetting agents.

(2) It shall be suitable for application to concrete structure under immersed conditions, primerless, waterproof and VOC free.

(3) The *Contractor* shall supply information which will satisfy Clauses 3 to 12, and independent test certificates from a HOKLAS or similar accredited laboratory, traceable to the paint proposed, demonstrating that the paint complies with the requirements of this Section. The *Contractor* shall also supply information on the surface finish, colours, chemical properties, weathering resistance under exposure to sunlight, and previous and existing applications of the paint in Hong Kong. All such information shall be independently verified; any tests or case histories on structures shall have been witnessed by an independent, accountable third-party such as a HOKLAS accredited laboratory.

(4) All paints to be used in the *works* shall be identified by a unique coding system, relating to the batch of raw materials from which the product was manufactured and the date of manufacture

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 17

PRESTRESSING

SECTION 17

PRESTRESSING

Prestressing tendons 17.06 (1) Prestressing tendons shall comply with the following:

High tensile steel wire and strand for the prestressing of concrete	: BS 5896
Hot rolled and processed high tensile alloy steel bars for the prestressing of concrete	: BS 4486.

(2) Steel wire and wire strand shall be in coils of sufficiently large diameter to ensure that the steel wire and wire strand will pay off straight.

(3) Alloy steel bars shall be straight.

(4) Grease for unbonded strand shall contain a corrosion inhibitor.

Prestressing components 17.07 (1) Prestressing components shall be of a proprietary type approved by the Engineer.

(2) Prestressing anchorages shall be tested in accordance with BS EN 13391 and shall allow a minimum of 25 mm cover to cropped ends of prestressing tendons.

(3) Anchorages shall be fabricated with inspection holes allowing a probe or inspection by borescope of the upper part of the duct behind the anchor heads. The holes shall also facilitate the post-grouting inspection. Alternatively, the anchorages shall be equipped with a device which permits the inspection personnel to monitor and verify the complete filling of grout in the anchorage.

17.07A* (1) The Contractor shall submit a certificate from the quality assured stocklist and a copy of the certificate from the manufacturers.

Sheath and Deviator Pipes 17.08 ~~(1) Sheaths shall be of a proprietary type approved by the Engineer and shall be steel or other material approved by the Engineer. Sheaths shall be rigid and strong enough to retain their shape during fixing and concreting and to withstand forces from the prestressing tendons without damage.~~

(2) The design of ducts shall allow for grout to be injected from either end. There shall be no sudden changes in the diameter of the duct.

(3) For the sheath made of steel, the sheath shall be hot-dip galvanized to BS EN ISO 1461 for corrosion protection purpose.

(4) For the sheath made of material other than steel, the sheath shall be non-metallic type.

(5) Sheaths for external prestressing shall be continuous between anchorages and shall be airtight and watertight under the working conditions.

(6) Results of tests on duct friction during tendon stressing shall be supplied to the Engineer. It shall be demonstrated that at least 2 mm thickness of sheath will remain on completion of the stressing operation.

(7) If the deviator pipes for external prestressing sheaths is made of steel, the deviator pipes shall be hot-dip galvanized to BS EN ISO 1461. Additional protection in the form of Paint System "II" to Clause 16.4 of the Structures Design Manual for Highways and Railways shall be applied to all surfaces of the deviator pipes.

Sheaths 17.08A* (1) Sheaths shall be rigid and strong enough to retain their shape during fixing and concreting and to withstand forces from the prestressing tendons and grouting without damage.

(2) Sheaths that are cast into a concrete section to form a duct shall be galvanized steel.

(3) Sheaths that are not cast into a concrete section to form a duct shall be Ultra-Violet resistant HDPE tube complying with German Standard DIN 8075. The minimum wall thickness of HDPE sheath shall be $1/16^{th}$ of the internal diameter of the sheath.

(4) The design of ducts shall allow for grout to be injected from either end. There shall be no sudden changes in the diameter of the duct.

(5) The system of sheaths, sheath connectors, grouting connections, vents, vent connections, drains, transitions to anchorages and deviators and caps for anchorages shall form a complete encapsulation for the tendon that is resistant to the passage of air and water. An acrylic based proprietary waterproofing membrane shall be applied to cover all anchorages of internal and external tendons, including the adjacent concrete surface.

(6) The system shall be fully compatible with the prestressing anchorages, couplers and other details.

(7) Where sheaths are non-conductive, metal parts of anchorages shall be electrically bonded to the adjacent reinforcement at each end of the tendon and electrical continuity of the structure over the length of the tendon shall be tested.

Grout vents and taps 17.09 Taps for grout vents in ducts shall be of a proprietary type approved by the Engineer and shall allow closure of the vents without loss of pressure in the duct. Vents to be used as grout entry points shall be threaded or fitted with screw connectors or other similar devices for connection to grout pumps. All vents and vent connections shall have an internal diameter no less than 20 mm and shall be clearly identified by labeling.

Grout for prestressing systems 17.10 (1) Grout for prestressing systems shall consist of ordinary Portland cement and water. Sand, PFA and admixtures shall not be used unless permitted by the Engineer.

(2) Grout shall have a minimum crushing strength of 27 MPa at 7 days.

(3) The amount of bleeding of grout shall not exceed 0.3% of the initial volume of the grout after 3 hours kept at rest when tested in accordance with Clause 17.60 for the average of three results. The water shall be reabsorbed by

the grout within 24 hours after mixing.

~~(4) The volume change of the grout at rest for 24 hours shall be within the range of -1% and +5% when tested in accordance with Clause 17.60.~~

(5) The maximum total chloride content of grout, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the grout, shall not exceed 0.1%.

(6) The maximum water/cement ratio of the grout shall be 0.40.

(7) Where admixture is permitted by the Engineer, grout shall be non-shrink mix and comply with the following requirements:

(a) the volume change of the grout shall be within the range as stated in Clause 17.10(4).

(b) Admixtures shall not contain chlorides, thiocyanides, nitrates, formats, sulphates or other ingredients which may cause the grout to promote corrosion of the prestressing steel by rusting, pitting or stress corrosion.

(c) The admixtures shall not segregate and shall be uniform in colour.

(d) Admixtures shall comply with BS EN 934 Part 2 or Part 4 but full account shall be taken of their effects on the finished product.

(e) The dosage shall be within the range recommended by the supplier and shall not exceed 5% of the weight of the cement.

(8) The fluidity of the grout immediately after mixing and 30 minutes after mixing shall not be more than 25 seconds when tested in accordance with Clause 17.66. The fluidity of the grout shall not change by more than 20% for immediately after mixing to 30 minutes after mixing.

17.10A* (1) Grout shall consist of pre-bagged products complying with Clause 17.10A*(3) and only requiring a measured amount of water together with controlled admixture to be added on Site.

(2) Where Common Grout to BS EN 447 is used, the grout shall consist only of Portland cement complying with BS 12 Class 42.5N or cement type CEM1 to BS EN 197-1, admixtures complying with Clause 17.10A, and water complying with BS 3148.

(3) The grout, when tested in accordance with Clauses 17.58 to 17.79, shall comply with the following requirements:

(a) The fluidity (flow cone passage time) of the grout shall meet the criteria given in Table 17.2. Additionally, the fluidity at outlets shall not vary from that of the injected grout by more than 20%.

Table 17.2 Testing requirements for fluidity of grout

Test method	Cone
Fluidity immediately after mixing	< 25 sec †
Fluidity at end of injection period, subject to a minimum of 30 minutes after mixing*	< 25 sec †
Fluidity at duct outlet	> 10 sec
Notes: * Mixing time shall be measured from the time when all materials are in the mixer. † For grouts prepared in some mixers that have a high shear mixing action, the upper limits given in Table 17.2 may be increased to 50 seconds.	

(b) The bleeding shall be less than 1.0% of the initial volume of the grout and the average of 4 successive results shall be less than 0.3%.

(c) The compressive strength of 100 mm cubes made of the grout shall exceed 27 N/mm² at 7 days.

(d) The grout shall contain no lumps. This shall be verified by checking the sieving medium on the fluidity test cone.

(e) The grout shall not exhibit variation in density from top to bottom of a single test sample in excess of 5%.

(f) The volume change of the grout at rest for 24 hours shall be within the range of -1% and +5% when tested in accordance with Clause 17.60

(4) Grout shall have a water/cement ratio as low as possible consistent with the necessary workability and under no circumstances shall the water: cement ratio exceed 0.4.

(5) Admixtures shall comply with Clause 17.10A but full account shall be taken of their effect on the finished product.

Admixtures 17.10B* (1) Admixtures shall be used where required to achieve a low water/cement ratio and impart good fluidity, minimum bleed and volume stability or expansion to the grout to comply with Clause 17.10A*(f). For site-mixed grout, admixtures shall be added on site during the mixing process and used in accordance with the manufacturer's recommendations. For pre-bagged grout they shall form a pre-blended component.

(2) Admixtures are divided into two types:

(a) Expanding grout admixtures are supplied as powders that expand to ensure that there is no overall decrease in the volume of grout at the end of the hardening period.

(b) Non-expanding grout admixtures are supplied in liquid or powder form.

(3) Both types of grout admixture may also permit a reduction in water/cement ratio, improve fluidity, reduce bleeding and retard the set of the grout.

(4) Admixtures may be used to obtain the required grout performance. Admixtures used in combination shall be checked for compatibility.

(5) Admixtures shall not contain substances in quantities that will adversely affect the grout or cause the grout to promote corrosion of the prestressing steel by rusting, pitting, stress corrosion or hydrogen embrittlement.

(6) The admixture shall not segregate and shall be uniform in colour. The composition shall not change and the supplier shall have obtained BS EN ISO 9001 or BS EN ISO 9002 certification.

(7) Where appropriate, admixtures shall comply with BS EN 934 Part 2 or Part 4. Other admixtures shall be permitted provided they satisfy Sections 6, 7.1 and 7.3 of BS 5075:Part 1 and full account is taken of their effects on the finished product and their fitness for purpose.

(8) The optimum dosage of any admixture shall be determined by trial mixes with the cement to be used in the grout. This dosage shall be expressed as percent by mass of the cement. It shall be within the range recommended by the supplier and shall not exceed 5% by mass of the cement. The method of measuring dosage and checking weights of pre-packed dry materials shall comply with Clause 17.44A.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 18

STEELWORK

SECTION 18

STEELWORK

Requirements 18.01 (1) Steelwork shall comply with BS EN 1090:Part 2 and this Section.

(2) Certain requirements in BS EN 1090:Part 2 have been revised and are stated in this Section which shall be complied with. Those requirements of BS EN 1090:Part 2 which are not stated in this Section shall also apply to this Section.

(3) Where requirements or revised requirements of BS EN 1090:Part 2 are stated in this Section, the other requirements in the related clause or sub-clause in BS EN 1090:Part 2 shall also apply to this Section unless otherwise stated in this Section.

(4) Where there is a choice between two or more different requirements in a clause or sub-clause in BS EN 1090:Part 2, the selected requirement(s) shall be as stated in this Section. All other requirements in that clause or sub-clause in BS EN 1090:Part 2 shall apply to this Section unless otherwise stated in this Section.

(5) Where a requirement in BS EN 1090:Part 2 is qualified in that standard by the words 'unless otherwise specified, the requirement shall not be amended unless it is specified otherwise in this Section ~~or in the Contract~~.

~~(6) 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.~~

~~(7) The compatibility of the dimensions and setting out data of steelwork shall be verified by the Contractor before the materials for steelwork are ordered.~~

18.01A* (1) This Specification shall apply equally to structural steel and stainless steel components of the structure as appropriate.

(2) All measurements shall be made by means of an accepted steel tape or other accepted instrument. Dimensions of all steelworks shown on the Drawings are assumed to be taken at a temperature of 20°C.

(3) Protection of steelwork against corrosion shall comply with BS EN ISO 12944 and BS EN ISO 14713.

CONSTITUENT PRODUCTS

Requirements 18.11 Constituent products shall comply with Clause 5 of BS EN 1090:Part 2 and Clauses 18.12 to 18.25.

General 18.12 Constituent products complying with other standards not specified in BS EN 1090:Part 2 or this Section shall not be used unless approved by the Engineer. If approved, the constituent products shall have equivalent properties and performance to, and their dimensional tolerances shall comply with, the relevant standards in BS EN 1090:Part 2 and this Section.

Structural steel

18.12A* (1) Hot rolled sections complying with BS 4: Part 1: 2005, BS EN 10025, BS EN 10210-1&2 : 2006, BS EN 10034 : 1993, BS EN 10056-1: 1999, BS EN 10056-2 : 1993, BS EN 10067 : 1997 shall not be replaced with sections complying with other standards.

(2) High strength S690QL steel shall comply with BS EN 10025: Part 6.

(3) All materials and components shall be ~~ordered from and~~ produced by ~~manufacturers and~~ suppliers with proven and documented experience of producing material to the codes and standards required in the following specification:

- Structural steel shall in general comply with BS 5400 : Part 6, Section 3.1
- Structural steel rolled shapes and plates shall be thermo-mechanical rolled steel according to BS EN 10025 Part 3 / Part 4 and :
- BS EN 10025 Part 4 for plate thickness less than or equal to 40mm.
- BS EN 10025 Part 4 for plate thickness greater than 40mm.
- Structural steel for parapets, lamp posts, sign gantries, gantry rails and other components specified on the Drawings as S355 steel shall be normalized rolled steel according to BS EN 10025 Part 3 / Part 4 and:
- BS EN 10025 Part 3 for plate thickness less than or equal to 40mm.
- BS EN 10025 Part 3 for plate thickness greater than 40mm

Structural steel products – General

18.13A* (1) Flat rolled stainless steel shall comply with BS EN 10029, BS EN 10048, BS EN 10051 + A1, BS EN 10095 and BS EN ISO 9445, Grade 1.4436 in the softened condition.

(2) Wrought stainless steel shall comply with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10088, BS EN10095, BS EN 10250-4 and PD 970, Grade 1.4436.

Structural steel flats and long products

18.13B* (1) Structural steel flat (e.g. plate) and long products (e.g. UC Sections) shall be of grade S355J0 complying with the requirements in BS EN 10025-2: 2004.

(2) The following options as provided in Section 13 of BS EN 10025-2: 2004 shall apply:-

Option 2) Product analysis shall be carried out for each cast of materials produced. The verified chemical composition shall be stated in the manufacturer's certificate.

Option 5) The product shall be suitable for hot-dip zinc-coating. The suitability class for hot-dip zinc-coating based on ladle analysis shall be Class 3.

Options 6 & 7) The internal soundness shall be verified by ultrasonic testing.

Option 10) No hard steel stamping for steel delivered shall be incorporated in the works. Steel shall be identified by other suitable

marking. The marking shall enable the material to be clearly identified and checked against the documentation which must include details of origin, methods of production, composition of material, inspection reports and test certificates. The marking shall be according to the rules in BS EN 10025 and BS EN 10204: 2004, so that a statement of this marking on the manufacturer's certificate is sufficient for an unambiguous identification of the steel.

Option 11) It applies to the materials for all components for which a special suitability for cold forming is required. The steel manufacturer shall guarantee and state on the manufacturer's certificate that the steel shall be suitable for flanging without cracking.

(3) The tolerance in steel plate thickness shall be Class C in accordance with BS EN 10029. The tolerance class shall be stated in the manufacturer's certificate.

(4) The manufacturing process shall follow the quality assurance requirements in accordance with BS EN 10021: 2006 and BS EN ISO 9001.

Structural hollow sections 18.13C* Structural hollow section shall be of grade S355J0H complying with the requirements in BS EN 10210. These structural steel sections shall not be replaced with sections complying with other standards. The use of cold formed sections as an alternative shall not be permitted.

Welding consumables 18.16A* (1) Welding of steel shall be in accordance with BS EN 1011-1 and BS EN 1011-2 and electrodes shall be in accordance with BS EN ISO 2560:2009, BS EN ISO 14341:2008, BS EN ISO 14171:2010, BS EN ISO 14174:2012, BS EN ISO 14343: 2009. Welding consumables used in the fusion weld of steel casting shall comply with BS 4570.

(2) Welding consumables used in metal-arc welding of grades of steel complying with the requirements of the standards designated in BS EN 1090-2, Clause 5.3.1 shall comply with the requirements of ECCS Information Circular IC2 and BS EN 1011. Covered electrodes for manual arc welding shall be acceptable according to BS EN ISO 2560 and marked according to BS EN ISO 6848.

(3) Welding consumables used in the fusion welding of steel castings shall comply with the requirements of BS EN 1011:Part 8 (to partially supersede BS 4570).

(4) Welding consumables used for arc welding of stainless steel shall comply with BS EN ISO 14343 and BS EN ISO 3581 and shall be chosen to ensure that the mechanical properties and corrosion resistance of the weld metal are not less than those required for the parent metal.

(5) The welding consumables shall fulfil the requirements to chemical composition and mechanical properties in order to be fully compatible with the Material being welded. The consumables and procedures used shall be such that the yield and tensile strengths of deposited weld metal shall not be less than the respective minimum values of the parent metal being welded.

Mechanical fasteners – Structural bolting assemblies for non-preloaded applications

18.18A* Stainless steel bolts and nuts shall comply with BS EN ISO 3506-1 & 2, steel Grade A4 and property class 80. Stainless steel washers shall comply with BS EN 10029, BS EN 10048, BS EN 10051:2010 + A1, BS EN 10095 and BS EN ISO 9445, Grade 1.4436 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.

Mechanical fasteners – Structural bolting assemblies for preloading

18.19A* All bolts shall be securely locked by double nuts and spring washers. Nylon washer to Form A to BS 4320 shall be used at all interface between stainless steel bolts and nuts and structural steel members.

Mechanical fasteners – Washers: Plain washers

18.21 Stainless steel washers shall be grade A4 and conform to BS EN ISO 7089, BS EN ISO 7090, BS EN ISO 7092 or BS EN ISO 7093:Part 1.

Studs and shear connectors

18.22 Headed stud connectors shall be type SD1 in accordance with BS EN ISO 13918.

Grouting materials

18.23 (1) Clause 5.9 of BS EN 1090:Part 2 shall not apply.

(2) Grout for bedding steel bases and for filling bolt pockets and pocket bases shall be based on Ordinary Portland Cement 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.

(3) Grout for bedding steel bases and for filling bolt pockets shall be of 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.

(4) A dry packed mortar may be used for bedding steel bases that 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.

(5) Grout for filling pocket bases shall be a mix approved by the Engineer with a nominal maximum aggregate size of 10 mm.

Pins & Pin Holes

18.25A* Pins, where described as such on the structural steel of bridge drawings, shall be made from the following materials:

Carbon Steel Pins
1.6582 or 1.7225 in accordance with BS EN 10083 or equivalent. The minimum 0.2% Proof Strength shall be 650N/mm^2.

Stainless Steel Pins
1.4418 + QT900 to BS EN 10088 or equivalent. The minimum 0.1% Proof Strength shall be 650N/mm^2.

The steel provided shall have a minimum Charpy impact energy of 35J when tested at room temperature.

Pins and pin holes shall be manufactured to the tolerances specified in B5400-6.

APPENDIX 18.2
PAINTING OF STEELWORK

Paint for steelwork

18.2.1 (1) ~~Zinc-rich primers shall comply with BS EN ISO 12944:Part 5.~~

(2) Lead-based paint shall not be used for finishing coats.

(3) 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:

(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.

~~(4) Paint and associated materials shall be stored in sealed containers marked as stated in Clause 18.2.1(3) and protected from exposure to conditions that 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.~~

(5) The Volatile Organic Compound (VOC) content of all paint applied on surfaces of steelwork shall comply with the VOC limits stipulated in the Air Pollution Control (Volatile Organic Compounds) Regulation.

18.2.1A* (1) Zinc-rich primers shall comply with BS EN ISO 12944: Part 5. Organic zinc-rich paint shall comply with BS 4652, both codes are applicable for S690 steel.

Paint systems for steelwork

18.2.2 (1) The paint system for steelwork shall comply with Clause 10.1a) of BS EN 1090:Part 2 or Clause 16.4 of the Structures Design Manual for Highways and Railways as appropriate ~~and shall be as specified in the Contract~~.

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

18.2.2A* (1) The volatile organic compounds (VOC) content for the paints shall be in compliance with the Air Pollution Control (Volatile Organic Compounds) Regulation (the Regulation), and shall not exceed the maximum limits of VOC content for the Regulated Architectural Paints as listed in the Regulation. As a general reference for highway works, paints classified as "Industrial Maintenance Coatings" with a VOC content limit of 250 g/L under the Regulation are appropriate paint materials to be used for compliance.

(2) The paint system for steelwork adopted shall be Paint System II of Clause 16.4 of the Structures Design Manual for Highways and Railways.

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 19

HANDRAILING, LADDERS, STAIRS AND FLOORING

SECTION 19

HANDRAILING, LADDERS, STAIRS AND FLOORING

General requirements 19.01 (1) ~~The works and materials specified in Clauses 19.02 to 19.06 shall comply with the sections stated, unless otherwise stated in this Section.~~ Hot dip galvanization shall comply with BS EN ISO 1461.

Steel 19.07 Steel for handrailing, ladders, stairs and flooring shall comply with the following:

Steel tubes and tubulars suitable for screwing to BS EN 10226 pipe threads	: BS EN 10255
Hot rolled sections	: BS EN 10365
Hot rolled structural steel sections	
Equal and unequal angles	: BS EN 10056
Hollow sections	: BS EN 10210
Weldable structural steels	: BS EN 10025

Stainless Steel 19.08A* Stainless steel for handrailing, ladders, stairs and flooring shall be grade 316 S33 complying with BS 970: Part 1 and BS EN 10250-4.Handrails shall be fabricated from austenitic stainless steel with a minimum of 2.5% molybdenum composition, or non-ferrous material such as aluminium alloy. Stainless steel tubes shall be longitudinally welded tubes complying with BS 6323: Part 8, designation LW 23 GZF(S). Tubes for handrails shall be polished.

Aluminum 19.09 (1) Aluminium for handrailing, ladders, stairs and flooring shall be of type EN-AW-6082 and shall comply with the following:

Wrought aluminium and aluminium alloys for general engineering purposes	
- Plate, sheet and strip	: BS EN 485
- Drawn tube	: BS EN 754
- Bars, extruded round tubes and sections	: BS EN 755

(2) Aluminium shall be anodised to Grade AA 25 in accordance with BS EN ISO 7599.

Bolts, Nuts, Screws, 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 ISO 1051
Wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock	: BS 1473
Stainless steel fasteners	: BS EN ISO 3506:Part 1 & 2

~~(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 of a proprietary type approved by the Engineer and shall be capable of withstanding the design working load.

(4) Hot dip galvanized bolts, nuts, screws, washers and rivets shall be used with hot dip galvanized handrailing, ladders, stairs and flooring. 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.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 20

BRIDGEWORKS

SECTION 20

BRIDGEWORKS

PART 1: WATERPROOFING

Prefabricated sheeting 20.01 (1) Prefabricated sheeting for waterproofing shall be of a proprietary type approved by the Engineer.

(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 that will be exposed to sunlight after installation shall be of a type that is unaffected by ultraviolet light.

(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.

(4) Prefabricated bituminous sheeting shall be of a self-adhesive, self-sealing type and shall have a thickness of at least 1.2 mm.

(5) Prefabricated rubberised base sheeting shall be of a type which is unaffected by fuels, oils or grease.

(6) Primers and mastic for prefabricated sheeting shall be of a proprietary type recommended by the sheeting manufacturer and approved by the Engineer.

Bentonite panels 20.02 (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.

(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.

(3) Bentonite joint seal and bentonite granules shall be of a proprietary type recommended by the bentonite panel manufacturer and approved by the Engineer.

(4) Polyethylene sheeting for use with bentonite panels shall be of a heavy-duty type.

Bituminous paint 20.03 Bituminous paint for waterproofing shall be cut-back bitumen complying with BS EN 15322. 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 of a proprietary type recommended by the bituminous paint manufacturer and approved by the Engineer.

Properties of Waterproof Membranes 20.03A* (1) The membrane shall have the following properties:

Table 20.1: Performance requirements of sheet waterproof membrane

Property	Test Method	Requirements
Thickness	BS EN 1849-2	2.0mm±10%
Tensile Strength	BS EN ISO 527-3	16MPa
Elongation at break	BS EN ISO 527-3	Not less than 300% (-10%/+20%)
Resistance under water pressure	BS EN 1928 method B	2 bars at 1 hour
Root resistance	DD CEN/TS 14416	No penetration
Tear resistance	BS EN 12310-2	80 N/mm
Tensile strength of welded seam	BS EN 12317-2	Cracks occur next to the seam
Water absorption	BS EN ISO 62	< 4.0%
Fire Rating	BS EN ISO 11925-2	Self-extinguishing
Smoke class	BS EN ISO 11925	E

SPRAYED-APPLIED WATERPROOFING MEMBRANE

Materials 20.03B* (1) The product shall conform to the performance requirements shown in the Table 20.2.

Table 20.2: Material performance criteria

Property	Requirements
Bend to substrate	Failure shown to be in substrate or bond > 0.5 MPa
Permeability	Zero penetration of water through membrane
Crack bridging	Capable of bridging a 2mm gap without diminishment or resistance to permeation.

PART 2: BRIDGE BEARING

Holding-down bolts for bridge bearings 20.14 Holding-down bolts for bridge bearings shall be of a proprietary type of stainless steel approved by the Engineer.

Cement mortar, grout and adhesive for bridge bearings 20.15 (1) Cement mortar for bedding and construction of unreinforced plinths for bridge bearings shall be a of proprietary non-shrink type approved by the Engineer having a grade strength of at least 50 MPa.

(2) Chemical-resin mortar for the construction of plinths for bridge bearings shall be of a proprietary non-shrink type approved by the Engineer having grade strength of at least 50 MPa.

(3) Grout for grouting base plates and holding-down bolts shall be of a proprietary non-shrink cementitious type approved by the Engineer having grade strength of at least 50 MPa. The grout shall be flowable and shall not bleed or segregate. The suitability of grout shall be demonstrated by site trials to the satisfaction of the Engineer. Chemical-resin based grout shall not be used.

(4) Adhesives and chemical resin mortars for locating and bedding elastomeric bridge bearings shall be of a proprietary type approved by the Engineer. They shall be compatible with the elastomer.

Dowel bars for bridge bearings 20.16 Dowel bars for bridge bearings shall be stainless steel of Grade 1.4401, BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10095, BS EN 10250-4 and PD 970.

DESIGN OF BRIDGE BEARINGS

Design of bridge bearings 20.17 ~~(1) Bridge bearings shall be designed by the Contractor unless otherwise stated in the Contract.~~

(2) The design and manufacture of bridge bearings and the materials used shall comply with BS EN 1337, except as stated in Clauses 20.18, 20.19 and 20.26(4). Inspection and maintenance of bridge bearings shall be easy to carry out and the bearings shall be easily replaceable.

~~(3) The maximum bearing stress in concrete underlying or overlying a bridge bearing under the design load at the ultimate limit state shall comply with Clause 10.9.5.2(2) of BS EN 1992:Part 1-1. 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 complying with BS EN 1992:Part 2.~~

~~(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.~~

Design of fixing for bridge bearings 20.21A* (1) Mechanical fixings fabricated from austenitic stainless steel. Materials used shall comply with the following:

• Wrought stainless steel:

BS970:Part 1 and BS EN 10250-4, grade 316 S 33

• Flat rolled stainless steel:

BS EN ISO 9445, grade 316 S 33

• Stainless steel washers:

BS EN ISO 9445, grade 316 S 33

• Stainless steel fasteners:

BS EN ISO 3506-1 and BS EN ISO 3506-2, grade A4-80

Protective coatings to bridge bearings 20.22A* Metal components of bridge bearings shall be protected against corrosion by a protective coating complying with, and selected in accordance with, BS EN ISO 12944. 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).

PART 3: VEHICULAR PARAPETS

Vehicular parapets 20.39 ~~(1) Vehicular parapets shall be of the types stated in the Contract.~~

(2) Steelwork for vehicular parapets shall comply with Section 18. The requirements for inspection and testing of materials and welded components shall follow Clauses 18.70 to 18.82 and 20.46 to 20.52 except:

(a) Clause 18.72(1)(a), 18.72(1)(b), 18.72(1)(c), 18.72(1)(h) and 18.75; and

(b) Clause 7.6 and 12.4.2.3 of BS EN 1090:Part 2.

(3) Protective treatment to steel for vehicular parapets shall comply with Section 18 and shall be- applied after welding, drilling and cutting are complete.

(4) Aluminium for vehicular parapets shall comply with the following or equivalent approved by the Engineer:

Wrought aluminium and aluminium alloys for general engineering purposes

- plate, sheet and strip : BS EN 485
- rivet, bolt and screw stock : BS 1473
- bars, extruded round tubes and sections : BS EN 755

(5) Aluminium shall be anodised to Grade AA 25 in accordance with BS EN ISO 7599 or equivalent approved by the Engineer.

(6) Welding of aluminium for vehicular parapets shall comply with BS EN 1011 Part 4 or equivalent approved by the Engineer.

(7) All bolts, nuts and washers for vehicular parapets shall be made of

stainless steel. Stainless steel bolts and nuts shall be Grade A4-80 and comply with BS EN ISO 3506 Part 1 and Part 2 or equivalent approved by the Engineer. Stainless steel washer shall be grade A4 and comply with Clause 18.21.

Holding-down bolts for Vehicular parapets 20.40 (1) Holding-down bolts, nuts and washer for vehicular parapets shall be made of stainless steel and comply with Clause 20.39(7).

(2) For post -drilled applications, the holding-down bolts shall be of a proprietary type approved by the Engineer and comply with Clause 20.40(1).

Grout for Holding-down bolts 20.41 Grout for holding down bolts for vehicular parapets shall be polyester resin based grout and shall be of a proprietary type approved by the Engineer. Epoxy resin based grout shall not be used.

20.41A* Water / cement ratio

The water/cement ratio for concrete parapets and median barriers shall not exceed 0.4.

PART 4: MOVEMENT JOINTS

Joint filler 20.57 Joint filler for movement joints formed in place shall be non-absorbent.

Joint sealant 20.58 (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.

(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.

Compression seals 20.59 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.

PVC capping strip 20.60 PVC capping strip shall be a proprietary type approved by the Engineer.

Holding-down bolts for movement joints 20.61 Holding-down bolts for movement joints shall be a proprietary type approved by the Engineer.

Grout for movement joints 20.62 Grout for holding-down bolts for movement joints shall be based on polyester resins and shall be of 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 20.63A* (1) All metal components not embedded in concrete shall be adequately protected against corrosion by hot-dip galvanising or hot zinc spraying. The protective coatings shall comply with BS EN ISO 14713 – Zinc coatings. Guidelines and recommendations for the protection against corrosion of iron and steel in structures. The environment for the purpose of selecting the coating system shall be "Exterior Exposed - Polluted Coastal" and the typical time for

first maintenance shall be "Very Long" (20 years or more).

Fire resisting board 20.74* (1) The fire resisting board material shall be non-combustible to BS476: Part 4 and Class 1 surface spread of flame to BS476: Part7.

(2) The fire resisting board shall be of monolithic asbestos-free calcium silicate material. The performance shall not be affected by moisture absorption. Mechanical strength shall be maintained and the board shall not delaminate or the fire resisting properties shall not deteriorate even under 100% water saturation.

(3) The fire resisting board shall not attract pests and shall not rot or support the growth of mould.

FALL ARREST SYSTEM

General 20.75* (1) The fall arrest system shall comprise stainless steel cables, end plates, pre-tensioner, shuttles, intermediate pick-up points, energy absorbers, crimp-on end clevis, and any other accessories necessary for the proper functioning and completion of the entire fall arrest system.

PART 5: PRECAST SEGMENTAL CONSTRUCTION

Epoxy bonding agent for joints between precast concrete segmental units 20.76* (1) General

(a) The manufacture, testing, storage and application of the epoxy bonding agent shall generally be in accordance with the recommendations set out in the FIP publication FIP/9/2 March 1978 “Proposal for a standard for acceptance tests and verification of epoxy bonding agents for segmental construction” except that the requirements of this Specification shall take precedence.

(2) Packaging

(a) The epoxy component of the adhesive must be packed by the supplier in containers which are different and distinct from those in which the hardener is packed. The label on each container must clearly indicate the component it contains, the net weight, the words "Epoxy Resin" or "Epoxy Hardener" according to the container, the application temperature range of the formulation, the storage temperature range and the date of packaging.

(b) The contents of one container of resin and one container of hardener must be so proportioned as to form a mix of fixed net weight of epoxy bonding agent.

(c) The container for the resin must be large enough for it to accommodate the hardener during mixing.

(1) Colour

The epoxy resin and hardener must possess clearly contrasting colours. When properly mixed the bonding agent should be of homogeneous

greyish colour, matching the colour of the precast concrete units to be bonded.

(2) Properties

(a) The paragraphs under this heading are to be read in conjunction with the publication "Proposal for a Standard for Acceptance Tests and Verification of Epoxy Bonding Agents for Segmental Construction." The paragraph numbers given in brackets (FIP 5.1) thus, refer to this publication.

(b) Minimum Pot Life (FIP 5.1)

At upper limit of specified application temperature range: 20 minutes.

(c) Minimum Open Time (FIP 5.2)

At upper limit of specified application temperature range, measured from the start of the Pot Life: 60 minutes.

(d) Thixotropy (FIP 5.3)
No sag flow at minimum thickness of 3mm when tested according to ASTM D2730 at the upper limit of the specified application temperature range.

(e) Angle of Internal Friction (Squeezability) (FIP 5.4)

At the lower limit of the specified application temperature range the area of the epoxy adhesive to be tested should have the following minimum values, at the given squeezing loads :

Squeezing Load	Surface Area
0.15 kN	3,000mm^2
2.0 kN	7,500mm^2
4.0 kN	10,000mm^2

(f) Bonding of Cured Epoxy Adhesive to the Concrete Surfaces to be Jointed (FIP 5.5 and 5.14)

The characteristic of the bond between the adhesive and the concrete surfaces to be jointed must be such that in the bond tension tests specified, total fracture of the concrete paste and aggregate occurs with no evidence of the bonding agent failure.

(g) Curing Rate (FIP 5.6) and Compressive Stress (FIP 5.12)

Trials in accordance with FIP 6.5 shall be carried out to predict the rate of curing.

The compressive strength of the epoxy adhesive should attain the following values at the specified times after jointing has occurred at the lower limit of the specified application temperature range:

12 hours	20 MPa
24 hours	60 MPa
7 days	75 MPa

(h) Shrinkage (FIP 5.7)

The shrinkage of the epoxy adhesive should not exceed 0.4% after 7 days at the upper limit of the specified application temperature range.

(i) Creep (FIP 5.8)

At the upper limit of the specified application temperature ranges the following values should be attained :

Pure compression. For an instantaneous modulus of elasticity, E, of 8000 MPa, the deferred modulus at 1 hr should not be less than 6000 MPa.

Pure shear for an instantaneous modulus of shear G, of 1500 MPa, the deferred modulus of 28 days should not be less than 1000 MPa.

(j) Water Absorption and Solubility in Water (FIP 5.9)

When subject to the specified tests the quantity of bonding agent dissolved in water should be less than 0.1% and the water absorption should be less than 0.5%.

(k) Heat Resistance (FIP 5.10)

The heat resistance of the cured adhesive determined according to DIN 53458 (Martens) on the rods of the mixed epoxy bonding agent with dimensions of 10mm x 15mm x 120mm when cured for 7 days at the upper limit of the specified application temperature range shall be 50°C.

(l) Instantaneous and Deferred Modulus in Compression (FIP 5.13)

The instantaneous modulus in compression (Ei) should not be less than 8000MPa and the deferred modulus in compression at 1 hour (Ed.1) not less than 6000MPa.

(m) Tensile Bending Strength (FIP 5.14)

After 24 hours at 100% humidity and at the lower limit of the specified application temperature range subject to a tensile bending strength test, total fracture of concrete paste and aggregate should occur, with no evidence of epoxy bonding agent failure.

(n) Shear Strength (FIP 5.15)

The shear (bond) strength of the epoxy bonding agent at failure, at the lower limit of the specified application temperature range when

subject to the slant test with a rectangular prism or cylinder is to be at least 12MPa.

(o) Shear Modulus

At the lower limit of the specified application temperature range if the epoxy bonding agent the instantaneous shear modulus (G); should be a minimum of 1500MPa, the shear modulus at 1 hour (Gd.1h) 1200MPa.

Metal tendon sheaths 20.77* Metal tendon sheaths shall be corrugated galvanized semi-rigid conduit as detailed on the Drawings.

Non-Metallic Cast-in Sockets for Concrete 20.78* (1) Non-metallic cast-in sockets for concrete shall have material properties as follows or similar approved:

Tensile strength	>	60N/mm²
Compressive strength	>	140N/mm²
Shrinkage / expansion	<	0.003mm/mm
Water absorption	<	0.25%
Track resistance	>	600 mins
Arc resistance	>	3 mins
High flame resistance	=	V-0
Low toxicity when heated		
High corrosion and chemical resistance		
UV Stabilised		
Tensile Creep (23ºC, 1000 hours, 30mPa)	<	0.5% strain
Tensile Fatigue (23ºC, 5Hz, 1000000 Cycles)	>	40mPa

(2) The material properties shall be tested in accordance with the following Standards or similar approved:

Water absorption	FED-STD-406/7031
Track resistance	ASTM D2303-68
Arc resistance	FED-STD-406/4011
Flame resistance	UL-94
Tensile Creep	ASTM D 2990 (modified)
Tensile Fatigue	ASTM D 671

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 21

MARINE WORKS

SECTION 21

MARINE WORKS

GENERAL

Concrete 21.07 Concrete shall comply with Appendix 21.2 entitled "Specification for Reinforced Concrete in Marine Environment" to address the corrosion of reinforced concrete for marine structures and also shall comply with Section 16 in general. In addition, the abrasion resistance in Los Angeles value for coarse aggregates in concrete shall not exceed 30% loss in accordance with CS3.

MATERIALS

Fill material for marine works 21.12 (1) The different types of fill material for reclamation shall either be Type 1, Type 2, rock or inert construction and demolition material or recycled rock fill material ~~as specified in the Contract~~. The fill material, other than public fill as stated in Clause 6.59, shall have the particle size distributions of an appropriate type of fill material within the ranges stated in Table 6.1 and Table 21.1 ~~unless otherwise stated in the Contract~~.

(2) The different types of fill material for marine structures shall either be Type 1, Type 2 or rock ~~as specified in the Contract~~ and shall have the particle size distributions of appropriate type of fill material within the ranges stated in Table 6.1 and Table 21.1 ~~unless otherwise stated in the Contract~~.

(3) Unless otherwise agreed by the Engineer, inert construction and demolition materials shall not be used as rockfill materials in marine structures.

(4) Underwater fill material (Type 1) shall consist of natural material extracted from the seabed or a riverbed.

(5) Underwater fill material (Type 2) shall consist of material that has a coefficient of uniformity exceeding 5 and a plasticity index not exceeding 12.

(6) 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.

(7) 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.

(8) Recycled rock fill material (Grade 200) shall be recycled rock or inert construction and demolition material which is hard and durable, and free from cracks, veins, and other evidence of decomposition.

Table 21.1: Particle size distributions of fill material for marine works

Type of fill material	Percentage by mass passing				
	Size		BS test sieve size		
	700 mm	200 mm	75 mm	20 mm	63 μm
Underwater fill material (Type 1)	-	-	100	-	0 – 30
Underwater fill material (Type 2)	-	-	100	-	0 – 25
Rock fill material (Grade 75)	-	-	100	0 - 5	-
Rock fill material (Grade 700)	100	0 - 10	0 - 5	-	-
Recycled rock fill material (Grade 700)	100	0 - 10	0 - 5	-	-

Rock armour 21.13 (1) The different types of rock armour shall have the maximum and minimum masses as stated in Table 21.2 ~~or as specified in the Contract~~. 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)	6500	4000

Table 21.3: Properties of rock for rock armour

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

Rock for underlayer 21.14 Rock for underlayer of rock armour shall have the same properties as the rock armour as stated in Clause 21.13 except that the weight and size of the rock shall be in accordance with the requirements ~~as specified in the Contract~~.

Facing stones 21.15 (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.

Bermstones 21.16 (1) Bermstones for seawalls and revetments shall consist of pieces of sound fresh rock or concrete free from cracks and similar defects. Rock shall also be free of veins.

(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.

Levelling stones 21.17 Stones for levelling founding layers for marine structures shall be rock fill material (Grade 75) as stated in Clause 21.12.

Joint filler for slip joints 21.18 (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 EN 13707.

(2) Adhesive for use with joint filler shall be a proprietary type recommended by the joint filler manufacturer and approved by the Engineer.

Iron and steel fittings for marine structures 21.19 Iron and steel fittings for marine structures shall comply with the following requirements:

(a) Cast iron for bollards, pumphouse screens and screen guides shall be Grade EN-GJL-150 complying with BS EN 1561.

(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 6405.

(e) Stainless steel bolts and nuts shall comply with Grade A4 and property class 80 of BS EN ISO 3506-1 and BS EN ISO 3506-2.

(f) Stainless steel washers shall be Grade 1.4401 austenitic steel complying with BS EN 10029, BS EN 10048, BS EN 10051, BS EN 10088-2, BS EN 10095 and BS EN ISO 9445. 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 1.4401 austenitic steel complying with the following:

Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes	: BS EN 10088-2
Specification for stainless and heat-resisting steel plate, sheet and strip	: BS EN 10029, BS EN 10048, BS EN 10051, BS EN 10095, BS EN ISO 9445

Timber for fendering systems

21.20 (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 5756 + A2 and BS EN 16737. The species shall comply with the strength requirements for strength class D70 or above as stated in BS EN 338, 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 that 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/m^3 and the minimum net dry salt retention for treatment with CCA shall be 30 kg/m^3.

Table 21.4: Properties of timber for fendering systems

Property	Minimum value
Oven dry density	655 kg/m^3
Static bending at rupture	56 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	6.5 MPa

Rubber for fenders

21.21 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
Density	1100 kg/m^3 to 1300 kg/m^3	BS ISO 2781
Hardness (International rubber hardness degrees)	≤ 72	BS ISO 48 Method N
Tensile strength	≥ 16 N/mm^2	BS ISO 37
Elongation change	≥ 350%	BS ISO 37
After accelerated air ageing test: Hardness (increase in IRHD) Reduction in tensile strength Reduction in elongation	 ≤ 8° ≤ 20% ≤ 20%	BS ISO 188 Method A at 70°C x 96 hours
Oil resistance (measured by volume change percentage) Industrial gasoline Heavy oil	 ± 60% ± 20%	BS ISO 1817 at 23°C x 22 hours
Compression set	≤ 30%	BS ISO 815-1 Method 1 at 70°C x 22 hours using Type A test pieces
Ozone resistance	no crack visible	BS ISO 1431-1 at 40°C x 100 hours
Tear resistance	≥ 60 kN/m	BS ISO 34-1 Method C at 23°C
Abrasion resistance (volume loss at 3000 revolutions)	≤ 1500 mm^3	BS ISO 4649: Method A

Plastic fenders 21.22 (1) Plastic fender shall be a composite material that is formed by recycled plastic and reinforced by fibreglass bar. The recycled plastic consists of a mixture of high-density polyethylene, low density polyethylene, and polypropylene obtained from recycled plastic materials.

(2) Plastic fender shall be black in colour or as instructed by the Engineer.

(3) Each plastic fender shall be reinforced with fibreglass bar. The proposed arrangement of fibreglass bar shall be submitted to the Engineer for approval.

(4) For rectangular section of plastic fender, the corner shall be right angle or rounded as instructed by the Engineer.

(5) Recycled plastic shall comply with the requirements of Table 21.6.

Table 21.6 – Physical properties of plastic fenders

Physical Property	Value	Standard
Hardness	Min. 40 (skin material)	ASTM D2240 (Shore D)
Ultraviolet Resistance	1. No obvious change in colour or uniformity. 2. Less than 10% change in Shore D durometer hardness as before ultraviolet test.	ASTM D4329 (min. 500 hrs exposure)
Loading Test	The applied test load and allowable deflection at mid span shall not exceed the values specified by the Engineer.	Appendix 21.1

Paint for marine works 21.23 (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 EN ISO 10601.

(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 of Type 2 coal tar creosote as stated in BS 144:Part 1.

Precast concrete pipes and fittings for submarine outfalls 21.24 (1) Precast concrete pipes for submarine outfalls shall comply with BS 5911-1 and shall have gasket type flexible rebated joints with clamps and bolts.

(2) The clamps and bolts shall be cast steel complying with BS EN 10293 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.

(3) Gaskets for joints in precast concrete pipes shall be Type WC (drainage) rubber gaskets complying with BS EN 681-1. The rubber gaskets shall be moulded jointless in ring moulds and shall not contain any reclaimed rubber.

(4) Epoxy resin for joints between precast concrete pipes shall be of a type approved by the Engineer.

(5) Marker buoys shall be of a hard plastic type approved by the Engineer.

APPENDIX 21.2

SPECIFICATION FOR REINFORCED CONCRETE IN MARINE ENVIRONMENT

(To be read in conjunction with section 16 and the amendments)

PART 1: CONCRETE WORKS

Cement 21.2.2 Clause 16.06 – Sub-clause (1) is replaced by the following: -

(1) All cement and supplementary cementitious materials shall comply with the following standards:-

Portland-blast furnace cement	: BS EN 197-1
Low heat Portland-blast furnace cement	: BS EN 197-1
Condensed Silica Fume (CSF)	: CSA-A3000 (Canadian Standard) / BS EN 13263

Clause 16.06 – Sub-clause (3) is added below:-

~~(3) The Contractor shall nominate the source of any of the materials mentioned in sub-clause (1) above proposed to be used in each concrete mix.~~

Aggregates 21.2.2A Clause 16.08 – New sub-clause (6) is added below: -

(6) The abrasion resistance in Los Angeles value for coarse aggregates in concrete shall not exceed 30% loss in accordance with CS3.

Admixtures 21.2.3 Clause 16.10 – Sub-clauses (1) and (2) are replaced by new sub-clauses (1) to (4) below: -

(1) An admixture is defined as a constituent material of concrete other than cementitious materials, aggregates and water. The admixtures shall comply and be used in accordance with the supplier's recommendation. The admixtures shall comply with the following:-

Pigments for Portland cement and Portland cement products	: BS EN 12878
Accelerating admixtures, retarding admixtures and water-reducing admixtures	: BS EN 934-2
Superplasticising admixtures	: BS EN 934-2

Where two or more admixtures are used in a concrete mix, the compatibility shall be verified in writing by the supplier with the following: -

BS EN 934-2 Concrete Admixtures

(2) The use of admixtures shall only be permitted subject to the ~~Contractor~~

~~carrying out~~ prior testing on trial mixes in accordance with this specification.

(3) The chloride content of admixtures shall not exceed 0.1% by mass of the admixture in accordance with BS EN 934-1.

(4) ~~The Contractor~~ shall submit relevant test data which demonstrates that the properties of concrete composed of the admixture meets the requirements of this specification.

Curing compound 21.2.4 Clause 16.11 - Sub-clause (1) is replaced by the following:

(1) Curing compound and the material and methods of applications shall be submitted for the approval of the Engineer prior to concrete placement. The use of curing compound shall be limited to the following type: -

Wax Emulsion

The curing compound shall have an efficiency index of not less than 85%. The minimum application rate shall be 0.2 litre/m^2 or the minimum stated on the certificate of compliance, whichever is greater.

CONCRETE

Concrete mix 21.2.5 Clause 16.12 – New sub-clauses (10) and (11) are added below: -

(10) All-in aggregates shall not be used.

(11) For reinforced concrete in marine environment: -

(a) The water/cementitious ratio of the concrete mix shall not exceed 0.38.

(b) Unless otherwise permitted by the Engineer, the minimum designed slump value for designed mix concrete for reinforced elements, after the addition of superplasticiser if used, shall be 75 mm.

(c) The acid soluble sulphate content of all concrete expressed as SO_3 shall be determined in accordance with Clause 21.10.3 of CS1 and shall not exceed 4% of total weight of concrete.

Chloride content of concrete 21.2.6 Clause 16.13(2) is added below: -

(2) For reinforced concrete in marine environment, the acid soluble chloride ion content of all concrete shall be determined in accordance with Clause 21.10.2 of CS1, and shall not exceed 0.02% of total weight of concrete.

Cementitious content of designed mix concrete 21.2.7 Clause 16.14 - Sub-clauses (2) and (6) are replaced by the following: -

(2) The maximum cementitous content of designed mix concrete for reinforced concrete in marine environment shall be 450 kg/m^3 unless otherwise approved by the Engineer. The maximum cementitious content of designed mix concrete (other than for reinforced concrete in marine environment) in, water retaining structures and water tight structures, shall be 450 kg/m^3 for concrete containing either PFA, GGBS or PFAC and 400 kg/m^3 for concrete containing PC only.

(6) For reinforced concrete in marine environment, CSF and either PFA or GGBS shall be incorporated into the concrete as separate materials complying with the following requirements:

(a) The proportion of CSF replacement shall be within the 5-10% range by mass of the cementitious content.

(b) The proportion of PFA replacement shall be within the 25-40% range by mass of the cementitious content for normal applications, or if GGBS is used instead of PFA, the proportion of GGBS replacement shall be within 60-75% range by mass of the cementitious content.

~~New sub-clause (7) is added below: -~~

~~(7) The Contractor shall nominate the source of any of the materials of CSF and PFA or GGBS proposed for being used in each concrete mix.~~

PART 2: JOINT IN CONCRETE

Waterstops 21.2.20 Clause 16.80 is replaced by the following: -

Swellable waterstop shall be a proprietary type approved by the Engineer and shall:

(a) be a water swellable hydrophilic waterstop and made from a preformed elastomeric strip,

(b) be free from rubber, bentonite or other inclusions,

(c) have an unrestrained volumetric expansion of not less than 170%,

(d) not deteriorate under prolonged wet/dry cycling,

(e) be able to withstand a hydrostatic head of 50 m.

(f) be in form of 10 mm x 20 mm rectangular section elastomeric strips, and

(g) be in good serviceable conditions under a temperature range of -30^{o}C to +70^{o}C.

The swellable waterstop shall be installed in strict accordance with the manufacturer's instructions and shall be kept in dry conditions for at least 48 hours prior to casting.

GROUT

Grout 21.2.27 New Sub-clause 16.96 is added below: -

"Where directed by the Engineer, cement mortar or concrete used for grouting in bolts, pipes, etc. shall be supplied with an expandable compound additive to provide a non-shrink grout. The additive shall in no case affect the durability performance, and aesthetics of the structure. Such additive shall be submitted to the Engineer for approval and be applied in accordance with the manufacturer's recommendations."

Marine Grout 21.2.28 New Sub-clause 16.97 is added below: -

(1) Marine grout shall be a proprietary non-shrink cementitious grout for underwater application approved by the Engineer and shall be a cement based product which is iron and chloride free.

(2) It shall be mixed with clean water at a water/powder ratio of 0.22 and not exhibit bleed or segregation. A volumetric expansion of up to 4% (by means of a gaseous system) shall occur while the grout is in a plastic state.

(3) The grout shall contain admixtures to minimise wash-out in underwater applications.

(4) The compressive strength of the grout must exceed 30 N/mm² at 7 days and 50 N/mm² at 28 days.

~~(5) The storage, handling, mixing and placement of the grout must be in strict accordance with the manufacturer's instructions.~~

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 22

WATER SUPPLY PIPEWORKS

SECTION 22

WATER SUPPLY PIPEWORKS

Materials for water supply pipeworks 22.13 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. Non-metallic materials used in pipeworks, which will be in contact with potable water, shall be suitable for use at a minimum water temperature of 35°C and tested to this concerned temperature under BS 6920-3.

Steel Pipes and Fittings 22.14 (1) Steel pipes, fittings and specials shall conform to the requirements of BS EN 10224 and BS EN 10220 where appropriate unless otherwise specified.

(2) Steel pipes and fittings shall be seamless or manufactured by the electric- resistance welded and induction-welded process or by the submerged- arc welded process or otherwise as approved by the Engineer. The steel grade shall be at least L275.

(3) Steel pipes, fittings and specials (including all flanges and blank flanges) shall be coated or lined internally and externally as stated in Table 22.1. Other requirements of using epoxy system shall be in accordance with Appendix 22.2.

(4) Tees and gusseted bends shall conform to the requirements of BS EN 10224.

Table 22.1: Protection to steel pipes and fittings

Protection	Description
Pipe External	A Fusion Bonded Epoxy system, complying with latest revision of ANSI/AWWA C213, manufactured under a quality system certified to ISO 9001, and factory applied by an applicator approved by the manufacturer, to a minimum dry film thickness of 400 microns. **OR** A chemically-cured Liquid Epoxy system, complying with the latest revision of ANSI/AWWA C210 manufactured under a quality system certified to ISO 9001, and factory applied by an applicator approved by the manufacturer, to a minimum dry film thickness of 400 microns. **AND** For pipes to be installed outdoor under direct sunlight, a topcoat of aliphatic polyurethane at 50 microns shall be applied for extra protection.

Pipe Internal	A Fusion Bonded Epoxy system, complying with latest revision of ANSI/AWWA C213, manufactured under a quality system certified to ISO 9001, and factory applied by an applicator approved by the manufacturer, to a minimum dry film thickness of 400 microns. **OR** A chemically-cured Liquid Epoxy system, complying with the latest revision of ANSI/AWWA C210 manufactured under a quality system certified to ISO 9001, and factory applied by an applicator approved by the manufacturer, to a minimum dry film thickness of 750 microns.

22.14A* (1) The sizes of pipes, fittings and specials shall be designated by the outside diameters (o.d.) as listed in Table 1 of BS EN 10220.

Method of Manufacture

(2) The pipes shall be manufactured by the electric welding process or the submerged arc welding process. Fittings and specials shall be manufactured in accordance with Clause 6.3.3 of BS EN 10224:2002. Branches or tees of size equal to or less than 457 mm o.d. may be manufactured by other processes as listed in Clause 6.3.2.1 of BS EN 10224:2002.

Grade of Steel

(3) The minimum tensile strength of the steel shall be 430 N/mm².
Designation

(4) The designation of the pipes shall comply with Clause 4.2 of BS EN 10224:2002.

Length

(5) Full-length pipes shall be supplied in uniform effective length of 8 m each. Half-length and quarter-length pipes shall be supplied in random effective lengths, the average effective length of half-length pipes being not less than 4 m and the average effective length of quarter-length pipes being less than 2 m.

(6) Effective length shall be as defined in Clause 3.2 of BS EN 10224:2002.
Thickness

(7) The thickness of the pipes corresponding to the various outside diameters shall be as specified below: -

Outside Diameter (o.d.) (mm)	Thickness (t) (mm)
114.3	5.0
168.3	5.0
219.1	5.4
273	5.4
323.9	5.4
406.4	6.3
457	6.3

508	6.3
610	6.3
711	7.1
813	8.0
914	8.8
1016	10.0
1219	10.0
1422	11.0
1626	12.5
1829	12.5
2032	14.2
2235	16.0

Truly Circular Pipes

(8) Pipes shall be made truly circular and uniform in size throughout their length, with the tolerances on outside diameter as given in Clause 7.7 of BS EN 10224:2002 for the full length.

(9) They shall be marked "Truly circular" and identified by painting red bands on the external surface of the pipes one at each of the two diametrically opposite locations over the full length.

Flange Joints

(10) Flanges shall be made from steel plate for welding and shall conform to the requirements of BS EN 1092-1:2002 where appropriate.

Fitting and Specials

(11) Collars shall be of the ordinary type complying with the requirements of BS EN 10311:2005 or the split type as detailed in Drawing No. WSD 1.21. They shall be suitable for use with cut pipes or plain end pipes.

(12) Tees and gussetted bends shall conform to the requirements of BS EN 10224:2002 and the details shown in Drawing No. WSD 1.21.

Flanges

(13) Flanges shall be made from steel plate for welding. Ring flanges shall be machined to the bore diameters as specified in Table 9 of BS EN 1092-1:2002.

Bolts and Nuts

(14) Bolts and nuts supplied with flanges or flange ended pipes, fittings or specials shall conform to BS EN ISO 4016:2001 and BS EN ISO 4034:2001, grade 4.6.

Gaskets and Joint Rings

(15) Unless otherwise specified, each fitting and special including expansion joint, flange, slip-on type coupling and adaptor shall be supplied with one complete set of gaskets. Gaskets shall be Type WA elastomeric joint seals to BS EN 681-1:1996 and be suitable to withstand the field test pressure of the associated pipes, fittings, flanges or specials. The dimension of gaskets for use with flanged joints shall comply with BS EN 1514-1:1997.

Ductile Iron pipes and fittings

22.15 (1) DI pipes and fittings shall conform to the requirements of BS EN 545. Pipes shall be cement mortar lined internally and the cement mortar lining shall comply with the requirements in BS EN 545. Linings shall be made with sulphate-resisting Portland cement complying with BS EN 197-1. An epoxy seal coat shall be applied on top of the internal cement mortar lining. The epoxy seal coat shall be suitable for use in potable water, and shall comply with BS 6920 and BS ISO 16132. DI fittings shall be internally protected by a fusion-bonded epoxy coating. The epoxy coating material and patching material for repair shall comply with BS 6920 and BS EN 14901.

(2) DI pipes shall be externally coated with metallic zinc or alloy of zinc and aluminium (with or without other metals) covered by a finishing layer of a bituminous product or synthetic resin compatible with zinc in accordance with BS EN 545. DI fittings shall be externally protected by a fusion-bonded epoxy coating. The epoxy coating material and patching material for repair shall comply with BS 6920 and BS EN 14901.

22.15A* (1) Gaskets shall conform to BS EN 681-1, type WA and Clause 4.1.3 of BS EN 545.

Design of Joints

(2) Unless otherwise specified, joints for pipes and fittings shall be designed to be fully flexible and shall conform to Clause 4.1.3.3 of BS EN 545.

(3) For fittings with flange ends, the joint design shall conform to Clause 4.1.3.2 of BS EN 545. Unless otherwise specified, all flanges shall be standard flange type PN16 conforming to BS EN 1092-2.

(4) All joint design shall be performance tested in accordance with Clause 5 of BS EN 545.

Flanges and Flanged Joints

(5) Each flange ended pipes, fittings or specials shall be supplied complete with bolts and nuts, and joint rings or gaskets. Bolts and nuts shall conform to BS EN ISO 4016 and BS EN ISO 4034, grade 4.6 and shall be compatible with the type of joint.

Flange Adaptors

(6) Flange adaptor shall be designed to be used with ductile iron pipes and fittings conforming to BS EN 545 and shall consist of the following:

(a) end flange with sleeve, with flange of standard flange type PN 16 conforming to BS EN 1092-2,
(b) gasket for end flange,
(c) bolts and nuts conforming to BS EN ISO 4016 and BS EN ISO 4034, grade 4.6 for end flanges,
(d) gland or flange follower,
(e) joint ring or gasket for flange follower, and
(f) studs and nuts conforming to BS EN ISO 4016 and BS EN ISO 4034, grade 4.6 for connecting flange follower and end flange.

Polyethylene Pipes

22.16 (1) Polyethylene (PE) pipes and fittings shall comply with BS EN 12201-

and Fittings

1, BS EN 12201-2 and BS EN 12201-3.

22.16A* (1) All non-metallic components in contact with potable water, including but not limited to PE compounds, sealing rings, gasket materials, O-rings, etc., shall comply with the requirements of BS 6920.

(2) PE100 compounds shall be used for the manufacture of pipes and fittings supplied under this specification. The compounds shall have a minimum required strength of 10MPa when classified in accordance with BS EN ISO 9080 and shall conform to BS EN 12201-1.

Flanges

22.18 (1) Steel flanges shall comply with BS EN 1092-1, 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 EN 1092-1 Table 13 unless otherwise specified.

(2) Steel ring flanges shall be machined to the bore diameters as specified in Table 13 of BS EN 1092-1.

(3) All DI flanges shall be cast-on, except for flanges on pipes or flange spigot pieces which shall either be cast-on or welded-on. Where the manufacturing process is not specified for pipes with flanges or for flange spigot pieces, the Contractor is required to submit whether welded-on or cast- on flanges are to be supplied. Unless otherwise specified, all DI flanges shall be standard flange type PN16 conforming to BS EN 1092-2.

22.18A* (1) Material to be used for manufacture of iron castings shall be grey cast iron of a quality not less than that specified as Grade EN-GJL-150 in Table 1 of BS EN 1561 : 1997.

(2) For all coating materials in contact with or likely to come into contact with potable water, certificates to show their compliance with BS 6920 - 1 : 2000 shall be issued by an independent testing laboratory/inspection authority to show the necessary evidence of suitability and compliance with this Specification.

(3) The threads shall be parallel female threads to BS EN 10226 - 1 : 2004. They shall be effectively covered with a good quality, non-toxic grease or other suitable compound as protection during transit and storage.

(4) Flange jointing materials for each pipe flange shall be supplied as follows:

(a) Gaskets shall comply with the appropriate requirements of BS EN 1514.
(b) All fittings and specials specified in sub-clauses (1) to (2) of GS Clause shall be manufactured from steel of the same composition as that of the connecting pipes and if appropriate shall be hydrostatically tested in accordance with Clause 7 of BS EN 10311:2005.

Bolts and Nuts

22.19 (1) Bolts and nuts for flanged joints shall comply with BS EN ISO 4016 and BS EN ISO 4034, grade 4.6.

22.19A* (1) All nuts, bolts, washers and other mild steel joint components, shall be galvanised in accordance with BS EN ISO 1461: 2022.

Elastomeric joint rings 22.20 Elastomeric joint rings shall comply with BS EN 681-1, Type WA. In addition elastomeric joint rings for DI pipes and fittings shall comply with BS EN 545, Clause 4.1.3. The dimensions of rings for use with flanged joints shall comply with BS EN 1514-1. 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 22.21 (1) Anticorrosion tape shall be of a proprietary type approved by the Engineer. The tape shall either be a petrolatum tape with fabric reinforcement or a bituminous tape with PVC backing. Petrolatum tape shall be used for valves, flanged joints, slip-on type couplings and flange adaptors of all sizes. Bituminous tape shall be used in buried or non-exposed condition for welded joints of steel pipe, repair of steel pipe sheathing and other applications as specified on the Drawings.

(2) Anticorrosion tapes shall have a high resistance to cathodic disbondment, acids and alkalis. Colour of bituminous tape shall be black. Anticorrosion tapes shall have the minimum properties stated in Table 22.2.

~~(3) Primer and mastic filler for use with anticorrosion tape shall be compatible with the tape and shall be of a type recommended by the manufacturer of the tape and approved by the Engineer. Notwithstanding Clause 22.28(1)(f), primer and mastic filler for use with anticorrosion tape shall be supplied by the Contractor.~~

Table 22.2: Properties of anticorrosion tape

Properties		**Petrolatum tape**	**Bituminous tape**
Thickness of PVC backing (mm)		-	0.75
Total thickness (mm)		1.1	1.65
Mass (kg/m^2)		1.4	2.0
Tensile strength (N/mm)		4	10
Adhesion strength (180^o peel) (N/mm)	Self	N/A	2.5
	Steel	N/A	2.5
Tacky adhesion strength to JIS Z 1902 (N/mm)	Self	0.5	N/A
	Steel	0.5	N/A
Dielectric strength (2 layers) (kV)		15	30
Elongation (at break) (%)		-	260
Temperature range(^{0}C)	Wrapping	-5 to +55	+5 to +50
	In service	-20 to +70	-20 to +75

22.21A* (1) Primer and mastic filler for use with anticorrosion tape shall be compatible with the tape and shall be of a type recommended by the manufacturer of the tape.

Bituminous Coatings 22.22 Bituminous coatings used for repairing joints and coatings shall be compatible with the adjacent coating.

Whitewash 22.23 Whitewash shall comply with AWWA C 203.

Zinc-based Paint 22.24 (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 that is capable of converting rust into iron phosphate.

Joint Filler and Compressible Padding 22.25 (1) Joint filler for joints in concrete bed, haunch and surround shall be of 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 22.3.

(2) Compressible padding between pipes and supports shall be bitumen damp-proof sheeting complying with BS 743.

Table 22.3: 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

Extension Keys 22.27 Extension keys, clamps and its associated bolts, nuts and washers for valves shall be Grade 1.4401 stainless steel complying with BS EN 10084, BS EN 10085, BS EN 10087, BS EN 10095, BS EN 10250-4 and PD 970.

150MM Pedestal Fire Hydrants 22.85* <u>General</u>

(1) The manufacture, machining, assembling of 150 mm pedestal fire hydrants shall be in accordance with Drawing No. WSD 1.54.
Ferrous Castings

(2) Ferrous castings of the hydrant body shall conform to BS EN 1561 : 1997 – grey cast iron, with material designation EN-GJL-250, and shall have a density of not less than 7200 kg/m. The caps of the hydrant shall be of ductile iron casting, conforming to BS EN 1563 : 1997 with material designation EN-GJS-450-10.

<u>Non-Ferrous Castings</u>

(3) The chemical composition and mechanical properties of bronze castings shall be as specified in BS EN 1982 : 2008 with material designation CC480K.

<u>Stainless Steel Screws</u>

(4) Screws shall be M20 countersunk square head type and shall be made of stainless steel to BS EN 10088-1 : 2005 with steel designations 1.4305, 1.4311 or 1.4315.

<u>Rubber Gasket and Rubber Insertion Piece</u>

(5) Gaskets and insertion pieces made from 6mm thick rubber insertion

jointing material shall conform to BS EN 681-1 : 1996 (Type WA). Test certificates from an independent institution are required to verify compliance with Clause 4 of BS EN 681-1 : 1996 (Type WA).
Chains

(6) The chain attaching the ductile iron cap to the hydrant body shall be made of stainless steel links to BS EN 10088-1 : 2005 with steel designation 1.4315.

Swan Neck Fire Hydrants 22.86* General

(1) The manufacture, machining, assembling, testing, painting and delivery of swan neck fire hydrants Type II comprising stainless steel hydrant pipes, bronze connections, D.I. caps and S.S. chains shall be in accordance with Drawing No. WSD 1.55.

(2) The dimensions of all threaded parts shall be in full compliance with Drawing No. WSD 1.55 for the compatibility of the supplied goods to other fittings.

Materials

(3) Ductile iron cap shall be of grade EN-GJS-450-10 ductile iron conforming to BS EN 1563 : 1997.

(4) The chemical composition and mechanical properties of bronze castings shall be as specified in the BS EN 1982 : 1999 with material designation CC480K.

Rubber Gasket and Rubber Insertion Piece

(5) Gaskets and insertion pieces made from 6 mm thick rubber insertion jointing material to Drawing No. WSD 1.55 shall conform to BS EN 681-1 : 1996 (Type WA). Test certificates from an independent institution are required to verify compliance with Clause 4 of BS EN 681-1 : 1996 (Type WA).

Chains

(6) The chain attaching the ductile iron cap to the hydrant body shall be made of stainless steel links to BS EN 10088-1 : 2005 with steel designation 1.4315.

Air Relief Valves 22.87* General

(1) All valves and valve components supplied shall conform to the requirements of the following Standards in every respect where appropriate :-

- BS EN 10226-1 : 2004
- BS EN 1074-1 : 2000
- BS EN 1092-2 : 1997
- BS EN 1074-4 : 2000
- BS EN 1561 : 1997

Small orifice air valve

(2) The valve shall be mounted on a 25 mm dia. bronze isolating stopcock with bronze nipple end or other approved equivalent isolating valve for connecting to the pipeline. The pipe threads of the nipple end shall be R1 as specified in BS EN 10226-1 : 2004.

Double orifice air valve

(3) The valve shall be flanged and mounted on a double flanged horizontal isolating valve having mitre gearing for vertical operation by tee key. The isolating valve shall conform to Clause 22.92* and shall have a nominal pressure rating equal to the maximum working pressure of the air valve. Flanges shall comply with the relevant requirements of BS EN 1092-2 : 1997 and shall be machined in accordance with Table 1 contained therein. Drilling and diameter of flanges shall be to Table 9 of BS EN 1092-2 : 1997 even where nominal pressure rating lower than PN 16 is specified.

Materials

(4) All air valve bodies, pressure covers and splash covers shall be of grey cast iron with material designation EN-GIL-250 confirming to BS EN 1561 : 1997 Grade 250, carefully machined and jointed. Small orifice valves shall have float guides and ABS (Acrylonitrile Butadiene Styrene) plastic non-corroding floats closing on moulded rubber sealing faces. Large orifice valves shall have ABS plastic float guides, seat rings and floats closing on moulded rubber sealing rings. Similar equivalent materials will also be considered.

Ball Float Valves 22.88*

(1) The nominal pressure of the quick acting float valve with or without auxiliary tank shall be 1.6 MPa unless specified otherwise.

(2) Quick acting ball valves shall be in accordance with the requirements as follows:

i. Valve body : Cast iron to BS 1452: 1990 Grade 220
ii. Valve seat ring : Gunmetal to BS 1400: 1985 Grade LG2
iii. Float : Brazed Copper
iv. Lever : Stainless Steel
v. Fulcrum : Stainless Steel
vi. Stud : Stainless Steel
vii. Float Tank : Stainless Steel
viii. Coating : Suitable for potable water application and compliant with BS 6920: 1996
ix. Flange Details : To BS 4504, Section 3.2, PN 16
x. Pressure Test : Body test at a pressure of 1.5 times the PN rating and seat test at 1.1 times the PN rating

Brass Stop Valves for Both Fresh and Salt Water Underground Services 22.89*

(1) The stop valves to be supplied under the contract shall conform to the requirements of BS 1010: Part II: 1973 and in strict compliance to the following:

(a) Rising Spindle
(b) Loose Jumper
(c) Crutch Handle
(d) Screwed double female Taper Thread to BS 21: 1985 body ends.

(2) In the subsequent references to British Standards, alternative national

or international standards that can be shown to be equivalent maybe accepted for the supply of brass stop valves, except that, for compatibility to other fittings, threads shall be in full compliance with Clause 1.1(d) above.

Butterfly Valves 22.90* General

(1) All valves and components supplied shall conform to the requirements of BS EN 593 in every aspect unless otherwise specified. Valves shall be suitable for use in fresh water, salt water or treated effluent pipeline systems in the tropics.

Dimensions

(2) Dimensions and tolerance shall be in accordance with BS EN 593. The face to face dimensions of the butterfly valves shall comply with BS EN 558-1 Table 4, Basic Series 13.

Flanges

(3) Valves shall be double-flanged type. Flanges shall comply with the requirements of BS EN 1092-2 and shall be machined. However, drilling and diameter of flanges shall be to Table 9 of BS EN 1092-2 even where nominal pressure rating lower than PN16 is specified. Valves with threaded holes on the flanges for fastening the bolts will not be considered.

(4) One complete set of bolts and nuts and rubber gaskets suitable for jointing flanges of the valves shall be supplied with each valve. Bolts and nuts shall conform to Property Class 4.8 of BS EN ISO 898-1 and Property Class 5 BS EN 20898-2 respectively.

(5) Rubber gaskets shall be Type WA elastomeric joint rings to BS EN 681-1.

Body and seat

(6) Body shall be spheroidal graphite iron of grade EN-GJS-400-18 or above to BS EN 1563. All wetted areas shall be lined with rubber seat made from Buna-N, EPDM or elastomer with equivalent abrasion resistance and resistance to chlorinated salt water. Valve seat shall be suitable for use in operation temperature of 5oC to 50oC and operation pressure of 16 bar. Rubber seat shall be repairable or replaceable. The seats shall be adequately reinforced to prevent the seat from becoming inflated and designed to provide tight shutoff with flow in both directions.

Disk

(7) Disk shall be aluminum bronze to CCC333G in BS EN 1982.

Shaft

(8) Valve shaft shall be stainless steel to BS 970: Part 1 Grade 316. The disk shaft sealing shall be of replaceable ‘O’ rings and cup-seal design. The shaft seals and bearings shall be independent of external lubrication.
Surfaces

(9) All internal and external surfaces except for seating and disk shall be

coated with fusion bond epoxy applied over a sand blasted surface to a minimum thickness of 150µm over the edges and of 250µm over flat and load bearing parts in compliance with AWWA C550.

Internal fastenings

(10) All internal fastenings shall be stainless steel Grade 316 to BS 970: Part 1.

Copper Alloy Gate Valves 22.91*

General

(1) All copper alloy gate valves and valve components supplied shall conform to the requirements of the following standards in every respect where appropriate :-

- BS 5154 : 1991
- BS 6920 - 1 : 2000
- BS EN 10226 - 1 : 2004

Materials

(2) Materials to be used for the manufacture of the copper alloy gate valves shall comply with Table 22.91.

(3) For all non-metallic materials in contact with or likely to come into contact with potable water, certificates to show their compliance with BS 6920 - 1 : 2000 shall be issued by an independent testing laboratory/inspection authority to show the necessary evidence of suitability and compliance with this Specification.

Requirements

(4) The threads shall be screwed double female taper thread to BS EN 10226 - 1 : 2004 body ends. Position indicator conforms to Clause 9.8 of BS 5154 : 1991 should be provided at the handwheel of the copper alloy gate valve.

Table 22.91

Component	Material	Reference	Grade/Designation
Body, bonnet, cover, disk, wedge, body seat and disk facing ring where renewable, stem bush, union nut	Gunmetal	BS EN 1982 : 2008	CC491K
Stem	1. Aluminium bronze	BS EN 1982 : 2008 BS EN 12163 : 2011 BS EN 12165 : 1998 BS EN 12167 : 2011	CC333G CW307G
	2. Gunmetal (continuous casting)	BS EN 1982 : 2008	CC491K
Disk stem nut Disk nut	Gunmetal	BS EN 1982 : 2008	CC491K
Stuffing box, gland	Gunmetal	BS EN 1982 : 2008	CC491K
Internal fasteners (where applicable)	1. Brass	BS EN 12163 : 2011 BS EN 12165 : 1998 BS EN 12167 : 2011	CW505L CW506L CW508L
	2. Phosphor bronze	BS EN 12163 : 1998 BS EN 1982 : 208	CW451K CC481K
Handwheel	1. Grey cast iron	BS EN 1561 : 1997	EN-GJL-200
	2. Steel		any grade
	3. Aluminium alloy	BS EN 1676 : 1997	EN-AB-44100
	4. Zinc alloy	BS EN 12844 : 1998	ZP0400
	5. Malleable iron	BS EN 1562 : 1997	EN-GJMB-300-6
	6. Ductile iron	BS EN 1563 : 1997	EN-GJS-500-7 EN-GJS-450-10 EN-GJS-400-18
Bolting	Carbon steel except free cutting	BS EN 10269 : 1999	1.1133

Double Flanged Key-operated Ductile Iron Gate Valves

22.92* General

(1) All valves and valve components supplied shall conform to the requirements of the following Standards in every respect where appropriate:

- BS EN 1074-1
- BS EN 1074-2
- BS 4190
- BS 5163-1
- BS 5163-2
- BS 6920
- BS EN 558
- BS EN 681-1
- BS EN 1092-2
- BS EN 1503-3
- BS EN 1563
- BS EN 1982
- BS EN 12163
- BS EN 12165
- BE EN 10088-1
- BS EN 12266-1

- BS EN ISO 5210
- BS EN ISO 5211
- WIS 4-52-01
- WIS 4-52-02

Flanges

(2) Valves shall be supplied with flanged ends. Flanges shall comply with the requirements of BS EN 1092-2 and the sealing (raised) face shall be machined. Valves with threaded holes on the flanges for fastening the bolts will not be considered.

(3) Bolts and nuts shall conform to Grade 4.8 of BS 4190.

Seating

(4) Resilient seating materials shall be EPDM or NBR conforming to BS EN 681-1, Type WA, Hardness Category "70" with a nominal thickness of minimum 4 mm on the seating areas and minimum 1.5 mm on the other non-seating areas. Natural rubber will not be accepted.

(5) In accordance with Clause 4.4 of BS 5163-1, any area behind the seal or seat rings (the interface) shall be coated in accordance with WIS 4-52-01 and WIS 4-52-02. The use of a sealant for the purpose of protecting the interface between the seal, seat and body is also required.

Operational Features

(6) Valves shall be non-rising stem type and shall conform to the operational features as specified in Clauses 4.3.1 to 4.3.4 of BS 5163-1.
Materials

(7) Materials for manufacture of valves shall comply with Clause 4.1.1 and 4.1.2 of BS EN 1074-1 and Clause 4.5 of BS 5163-1.

(8) The valve manufacturer shall issue for the copper/copper alloy materials the appropriate declaration of conformity including any inspection document in accordance with Clauses 9.1 and 9.2 of BS EN 1982, BS EN 12163 and BS EN 12165. For other non-copper/non-copper alloy materials, the valve manufacturer shall provide test certificates on composition analysis, chemical, physical and mechanical properties of the materials issued by an approved independent laboratory to provide the necessary evidence of suitability and compliance with this Specification.

(9) All rubber gaskets, O-rings and seals shall be Type WA, Hardness Category "70" elastomeric joint rings to BS EN 681-1. Test certificates of the rubber gaskets issued by an approved independent laboratory/inspection authority shall be provided to show the necessary evidence of suitability and compliance with this Specification.

(10) For gate valves not exceeding DN 600, all fasteners used in the assembly of valves shall be threaded into blind holes. The fastener head shall not protrude above the casting and shall be completely encapsulated from the environment by a removable, water resistant sealing compound. Fasteners shall be stainless steel according to BS EN ISO 3506-1 grade A2 or better. All fasteners shall be surrounded by the seal between mating

surfaces such that they are completely isolated from both the pipeline media and the external environment.

(11) For valves larger than DN 600 and gearbox connections on all size valves which are installed in valve chambers, all fasteners, including nut bolts and washers shall be stainless steel according to BS EN ISO 3506-1 grade A4.

Double Offset Butterfly Valves 22.93* General

(1) All double offset butterfly valves and components supplied shall conform to the requirements of BS EN 593 unless otherwise specified.

Materials Selection

(2) For critical valves or the valves at critical locations, the body and all valve components shall be stainless steel 316. For other locations, the body shall be graphite iron of grade EN-GJS-400-18 or above to BS EN1563. All wetted area shall be lined with rubber seat made from Buna-N, EPDM or elastomer with equivalent abrasion resistance to chlorinated salt water. Valve seat shall be suitable for use in operation temperature of 5 - 50 degree Celsius and operation pressure of 16 bar. Rubber seat shall be repairable or replaceable. The seat shall be adequately reinforced to prevent the seat from becoming inflated and designed to provide tight shutoff with flow in both directions. All internal fastenings shall be stainless steel Grade 316 to BS 970:Part 1.

Dimensions

(3) Dimensions and tolerance shall be in accordance with BS EN 593. The face to face dimensions of the double offset butterfly valves shall comply with BS EN 558-1 Table 4, Basic Series 13.

Flanges

(4) Valves shall be double flanged type. Flanges shall comply with the requirements of BS EN 1092-2 and shall be machined. However, drilling and diameter of flanges shall be to Table 9 of BS EN 1092-2 even where nominal pressure rating lower than PN16 is specified. Valves with threaded holes on the flanges for fastening the bolts will not be considered.

(5) Bolts and nuts shall conform to Property Class 4.8 of BS EN ISO 898-1 and Property Class 5 BS EN 20898-2 respectively.

(6) Rubber gaskets shall be Type WA elastomeric joint rings to BS EN 681-1.

Surfaces

(7) For non-stainless steel double-offset butterfly valves, all internal and external surfaces except for seating and disk shall be coated with fusion bond epoxy applied over a sand lasted surface to a minimum thickness of 150 micrometers(μm) over the edges and of 250 micrometers (μm) over the flat and load bearing parts in compliance with AWWA C550.

Shaft

(8) Valve Shaft shall be stainless steel to BS 970: Part 1 Grade 316. The disk shaft sealing shall be of replacement 'O' rings and cup-seal design. The shaft seals and bearings shall be independent of external lubrication.

Disc Orientation

(9) For non-stainless steel double-offset butterfly valves, the disk shall be aluminum bronze to CCC333G in BS EN 1982.

Ductile Iron Manhole Covers 22.94*

General

(1) Ductile iron (D.I.) manhole covers shall be supplied with frames and shall conform to the relevant requirements of BS EN 124 : 1994.

Material

(2) The material to be used for the manufacture for iron castings shall be ductile iron (spheroidal graphite iron or nodular graphite iron) complying with Grades EN-GJS-500-7,EN-GJS-600-3 or EN-GJS-700-2 of BS EN 1563: 1997 and test pieces prepared from separately cast samples shall be used for testing.

(3) Bolts supplied for coupling separate sections of the covers shall be of stainless steel to BS EN 10088-1 : 2005 with steel designation 1.4057. Dimensions of the coupling bolts shall comply with the relevant requirements of BS 4190 : 2001.

Coating

(4) Manhole covers and frames shall be coated with coal tar or bitumen solution as specified in Clause 6.1(b)(1) or (2) of BS 5834:Part 2 : 1983.

Ductile Iron Surface Boxes 22.95*

General

(1) Ductile iron (D.I.) surface boxes shall conform to the relevant requirements of BS 5834:Part 2 : 1983.

Material

(2) Notwithstanding Clause 3.1.2(b) of BS 5834:Part 2 : 1983, the material to be used for the manufacture of iron castings shall be ductile iron (spheroidal graphite iron or nodular graphite iron) complying with Grades EN-GJS-500-7, EN-GJS-600-3 or EN-GJS-700-2 of BS EN 1563 : 1997 and test pieces prepared from separately cast samples shall be used for testing.

(3) Hinge pins shall be made of stainless steel to BS EN 10088-1 : 2005 with steel designation 1.4057.

(4) Bolts supplied for coupling separate sections of the covers shall be made of stainless steel to BS EN 10088-1 : 2005 with steel designation 1.4057. Dimensions of the coupling bolts shall comply with the relevant requirements of BS 4190 : 2001.

Coating

(5) Surface boxes shall be coated with coal tar or bitumen solution as specified in Clause 6.1(b) (1) or (2) of BS 5834:Part 2 : 1983.

In-line Strainers and Separators

22.96* In-Line Strainers

(1) The strainer shall comprise a stainless steel mesh to grade 316 of BS970. The mesh shall be designed to optimize the head loss across the strainer and to provide the largest possible area of filter element. The standard openings in the mesh shall be 2 mm. The total area of screen openings shall not be less than the pipeline area at each end of the strainer.

(2) The strainer body shall be provided with integral flange connections, raised faced and drilled to BS EN 1092-2:1997 PN 16 rating.

(3) The body and cover of the strainer shall have a protective WRAS-listed fusion-bonded epoxy coating applied to all internal and external surfaces. The protective fusion-bonded epoxy coating shall have a minimum thickness of 0.15 mm and shall conform to ANSI/AWWA C116/A21.16 specification (current version). The coating shall be suitable for use in potable water and shall comply with the full requirements of BS 6920.

Separators

(4) The separator shall be fabricated of stainless steel to grade 316 of BS970.

Polyethylene/PVC Lined Screwed Steel Tubes and Fittings

22.97* Reference

(1) For all non-metallic materials in contact with or likely to come into contact with potable water, certificates to show their compliance with BS 6920 – 1 : 2000 shall be issued by an independent testing laboratory/inspection authority to show the necessary evidence of suitability and compliance with this Specification.

Steel tubes

(2) The steel tubes shall be of medium series to BS EN 10255 : 2004.

Polyethylene lined pipes

(3) The quality of PE lining in the interior surface shall conform to the requirements in Table 2 of Clause 4.1, Clauses 5.1 and 6.2 of JWWA K132 :1986.

PVC lined pipes

(4) The quality of PVC lining in the interior surface shall conform to the requirements in Table 2 of Clause 4.1, Clauses 5.3 and 6.2 of JWWA K116 : 1987.

Fittings

(5) The outlets are specified by their nominal sizes (DN or dn) as defined in BS EN 10241 : 2000. Where fittings are specified to BS 143 & 1256 : 2000, the fittings so defined shall be deemed to be equivalent to those defined by the fitting sizes, which are defined in Clause 3.4 of BS 143 & 1256 : 2000 and related to the nominal sizes as in Annex A of BS 143 &

1256 : 2000.

(6) For fittings having more than one outlet, the method of specifying as in Clause 4 of BS EN 10241 : 2000 is adopted in this Specification.

(7) Threads at the outlets of all fittings shall be of sizes appropriate to the nominal sizes of the outlets as set out in Annex A of BS 143 & 1256 : 2000.

(8) Internal threads on the ends of all fittings shall be parallel or tapered unless otherwise specified, and shall comply with the appropriate requirements of BS EN 10226 – 1: 2004.

(9) Fittings shall be steel threaded pipe fittings complying with BS EN 10241 : 2000 or cast copper alloy pipe fittings complying with BS 143 & 1256 : 2000.

Longscrews

(10) Longscrews shall be single longscrews complying with Table 21 and other relevant requirements of BS EN 10241 : 2000. Each longscrew shall be fitted with a hexagon backnut and a parallel threaded faced socket as shown in Table 19 and 12 of BS EN 10241 : 2000 respectively.

Internal linings

(11) All steel threaded pipe fittings supplied shall be galvanized in accordance with Clause 8.2.1 of BS EN 10241 - 1 : 2000.

Pressure Reducing Valves (PRVs) and the Associated Accessories

22.98* General

(1) The pressure reducing valve shall maintain a constant downstream pressure regardless of fluctuation in flow rate and/or upstream pressure. The downstream pressure shall be adjustable.

(2) The valve shall be self-contained and pilot-operated. It shall use pipeline pressure for operation and shall not require any other external energy source.

(3) The pressure reducing valves shall consist of a main valve and a pilot control system, completely pre-piped into an assembly and tested as a unit.
Main Valve

(4) For diaphragm type pressure reducing valves, the main valve shall be a hydraulically operated, pilot-controlled, diaphragm type globe valve. For piston type pressure reducing valves, the main valve shall be a hydraulically operated, pilot-controlled, piston type globe valve.

(5) For diaphragm type pressure reducing valves, the main valve shall have either a full internal port size (with the seat size the same as the flange connection size) or a reduced internal port size (with the seat size one standard pipe size smaller than the flange connection size except that the seat size is 65 mm for flange connection size of 80 mm). For piston type pressure reducing valves, the main valve shall have a full internal port size.

(6) The main valve shall consist of three major components:

(a) a diaphragm and disc assembly for diaphragm type pressure reducing valves or a piston and disc assembly for piston type pressure reducing valves;
(b) a body, with a bearing for the diaphragm/piston assembly at the valve seat; and
(c) a cover, with a bearing for the diaphragm/piston assembly at the top.

The diaphragm and disc assembly or piston and disc assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating the operating pressure in the sealed chamber from the line pressure in the pipeline. There shall be no diaphragms in the main valve for piston type pressure reducing valves.

(7) The valve body and cover shall be constructed of ductile iron to BS EN 1563:1997 Grade 420/12 or ASTM A536-65/45/12. No fabrication or welding shall be used in the process of manufacturing the valve body and cover.

(8) The valve body shall be provided with integral flange ends, designed to BS EN 1092-2:1997 or ANSI B16.42 Class 150 or Class 300 standards and drilled to PN 16 rating.

(9) The valve body and cover shall have a protective WRAS-listed NSF/ANSI 61-approved fusion-bonded epoxy coating applied to all internal and external surfaces. The protective fusion-bonded epoxy coating shall have a minimum thickness of 0.15 mm and shall conform to ANSI/AWWA C116/A21.16 specification (current version). The coating shall be suitable for use in potable water and shall comply with the full requirements of BS 6920.

Stainless Steel Gate Valves 22.99* <u>General</u>

(1) All valves and valve components supplied shall conform to the requirements of the following Standards in every respect where appropriate:

- BS EN 1074-1
- BS EN 1074-2
- BS 4190
- BS 5163-1
- BS 5163-2
- BS 6920
- BS EN 558
- BS EN 681-1
- BS EN 1074-2
- BS EN 1092-2
- BS EN 1503-3
- BS EN 1563
- BS EN 1982
- BS EN 12163
- BS EN 12165
- BS EN 10088-1
- BS EN 10088-3
- BS EN 12266-1
- BS EN ISO 3506-1
- BS EN ISO 5210

- BS EN ISO 5211
- WIS 4-52-01
- WIS 4-52-02

Dimensions and Tolerances

(2) The face-to-face dimensions and tolerances, body flange dimensions and maximum height dimensions of the valves shall be in accordance with Clauses 4.2.1, 4.2.2 and 4.2.3 of BS 5163-1. Notwithstanding the above, the body flange dimensions of PN 16 flanges shall also apply to those of flanges below PN 16.

Flanges

(3) Flanges shall comply with the requirements of BS EN 1092-2 and the sealing (raised) face shall be machined. Valves with threaded holes on the flanges for fastening the bolts will not be considered.

(4) Bolts and nuts shall conform to BS EN ISO 3506-1 Grade A2.

Seating

(5) In accordance with Clause 4.4 of BS 5163-1, any area behind the seal or seat rings (the interface) shall be stainless steel or coated in accordance with WIS 4-52-01 and WIS 4-52-02. The use of a sealant for the purpose of protecting the interface between the seal, seat and body is also required.

Operational Features

(6) Valves shall be non-rising stem type and shall conform to the operational features as specified in Clauses 4.3.1 to 4.3.4 of BS 5163-1.

Materials

(7) Materials for manufacture of valves shall comply with BS EN 1074-1, BS EN 1074-2, BS 5163-1 and BS 5163-2. The valve components shall be manufactured from the materials given, as appropriate, in Table 22.99.

(8) All rubber gaskets, O-rings and seals shall be Type WA, Hardness Category “70” elastomeric joint rings to BS EN 681-1.

(9) Fasteners shall be stainless steel according to BS EN ISO 3506-1 grade A2 or better.

(10) For valves larger than DN600 and gearbox connections on all size valves which are installed in valve chambers, all fasteners, including nuts bolts and washers shall be stainless steel according to BS EN ISO 3506-1 grade A4.

Table 22.99 – Materials for Valves

Item	Metal Seated (all stainless steel)
Body, Bonnet and Stuffing Box	Stainless Steel 1.4401 to BS EN 10088-1
Stem	Duplex Stainless Steel 1.4462 to BS EN 10088-3
Wedge	Stainless Steel 1.4401 to BS EN 10088-1
Gate / Wedge Shoes	Stainless Steel 1.4401 to BS EN 10088-1
Channel Guides / Body Guides	Stainless Steel 1.4401 to BS EN 10088-1

Stem Nut	Aluminum Bronze to BS EN 1982 Grade CC333G
Bolt	Stainless Steel to BS EN ISO 3506-1 Grade A2

Note : The materials shall comply with BS EN 681-1 Type WA, and the requirements stated in BS 6920 series for use in potable water and shall be suitable for use at a minimum water temperature of 35°C and tested to this concerned temperature under BS 6920-3.

Stainless Steel Pipes, Fittings and Corrugated Stainless Steel Tubes

22.100* General Requirement

(1) The manufacturer for the supply of stainless steel pipes, fittings and corrugated stainless steel tube (CSST) shall operate a quality system relating to the relevant part(s) of the specification stated hereunder in accordance with BS EN ISO 9002 or similar equivalent standard.

Stainless Steel Pipes, Fittings and CSST

(2) Stainless steel pipes, fittings and CSST shall comply with BS 6362:1990 and ISO 4144. The hydraulic pressure rating of pipes, fittings and CSST shall be 1.6 MPa (gauge) unless otherwise specified.

(3) The classification of the stainless steels is given in EN 10088-1. Steel grade for pipes and CSST shall be 1.4404 (Grade 316L) while that for fittings shall be 1.4401 (Grade 316).

GI Pipes and Fittings

22.101* GI pipes used for water supply shall be wrapped with two layers of anticorrosion tape.

PIPE LAYING BY TRENCHLESS CONSTRUCTION METHOD

Precast Concrete Jacking Pipes

22.102* Precast concrete jacking pipes shall comply with BS EN 1916:2002 titled "Concrete pipes and fittings, unreinforced, steel fibre and reinforced", BS 5911-1:2002+A2:2010 titled “Concrete pipes and ancillary concrete products. Specification for unreinforced and reinforced concrete pipes (including jacking pipes) and fittings with flexible joints”.

CHILLED WATER PIPEWORKS FOR DCS PURPOSES

General Requirements for Chilled Water Pipeworks

22.103* Flexible (Metric) pre-insulated pipes and accessories for DCS shall be manufactured within an ISO 9001 accredited environment in accordance with EN 15632-4.

Black Steel Pipes and Fittings

22.104* (1) All chilled water pipes shall be black steel and in accordance with BS EN 10255, BS EN 10217-1 P265TR1 or API 5L Grade B PSL 1.

(2) The standardised pipe length shall be 6m or 12m in accordance with BS EN 10255, BS EN 10217-1 or API 5L.

Pre-Insulated Pipe (PIP) System

22.105* The PIP system shall comply with the BS EN 253, BS EN 448, BS EN 488, BS EN 489 and BS EN 14419 or any other specification cross referenced from the documents.

Flanges 22.106* (1) Steel flanges shall comply with BS EN 1092-1, 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 EN 1092-1 Table 13 unless otherwise specified.

(2) Steel ring flanges shall be machined to the bore diameters as specified in Table 13 of BS EN 1092-1.

(3) All DI flanges shall be cast-on, except for flanges on pipes or flange spigot pieces which shall either be cast-on or welded-on. Where the manufacturing process is not specified for pipes with flanges or for flange spigot pieces, the Contractor is required to submit whether welded-on or cast-on flanges are to be supplied. Unless otherwise specified, all DI flanges shall be standard flange type PN16 conforming to BS EN 1092-2.

(4) The dimensions and drilling of flanges shall comply with BSEN1092-1:2018, as appropriate regardless of the nominal pressure rating. Unless otherwise specified, flanges shall be designed and manufactured to suit a nominal pressure of 16 bars (1.6MPa). All blank flanges shall be designed and drilled to the same criteria specified for pipe flanges except that the design shall comply with BS 5500: Figure 3.5.5(2) for a flange with gasket entirely within the bolt circle.

(5) Gaskets shall comply with the appropriate requirements of BS 4865: Part 1.

Nuts and Bolts 22.107* (1) Bolts and nuts for flanged joints shall comply with BS EN ISO 4016 and BS EN ISO 4034, grade 4.6.

(2) All nuts and bolts shall be stainless steel complying with Grade A4 and property class 80 of BS EN ISO 3506- 1 and BS EN ISO 2506-2 or equivalent. Stainless steel washers shall be grade A4 and conform to BS EN ISO 7089, BS EN ISO 7090, BS EN ISO 7092 or BS EN ISO 7093:Part 1. The dimensions and tolerances of stainless steel washers shall comply with BS 4320. Stainless steel bolts and nuts and washers shall be insulated from the cast iron flange or valve body by non-metallic washers and sleeves.

Valves 22.108* (1) Valves DN65 and above shall have flanged ends in accordance with BS EN 1092-2 of appropriate pressure rating

(2) Connection of valves to pipes shall use stainless steel bolts and nuts complying with Grade A4 and property class 80 of BS EN ISO 3506- 1 and BS EN ISO 2506-2 or equivalent. Stainless steel washers shall be Grade 316 austenitic steel complying with BS 1449-2. The dimensions and tolerances of stainless steel washers shall comply with BS 4320. Stainless steel bolts and nuts and washers shall be insulated from the cast iron flange or valve body by non-metallic washers and sleeves.

Double Flanged Key-operated Cast iron valves 22.109* (1) All valves and valve components supplied shall conform to the requirements of the following Standards where appropriate: -

- BS EN 1074-1:2000
- BS 5163-1:2004
- BS EN-1074-2:2000
- BS 5163-2:2004

- BS EN 681-1:1996
- BS EN 1092-2:1997
- BS EN 1561:1997
- BS EN 1563:1997
- BS EN 1982:1999
- BS EN 12163:1998
- BS EN 12165:1998
- BS 970: Part 1:1996
- BS EN 558-1:1996
- BS EN 1503-3:2000
- BS EN 12266-1:2003

Flanges

(2) Valves shall be supplied with flanged ends. Flanges shall comply with the requirements of BS EN 1092-2:1997 and shall be machined. Valves with threaded holes on the flanges for fastening the bolts will not be considered.

(3) Bolts and nuts shall conform to Grade 4.8 of BS 4190:2001.

(4) Rubber gaskets shall be Type WA, Hardness Category "70" elastomeric joint rings to BS EN 681-1:1996.

Seating

(5) Seating shall be either Category 'CF' (copper alloy faced) or Category 'RES' (resilient seated). Resilient seating materials shall conform to BS EN 681-1:1996, Type WA, Hardness Category "70" with a nominal thickness of minimum 4 mm on the seating areas and minimum 1.5 mm on the other non-seating areas.

Operational Features

(6) Valves shall be non-rising stem type and shall conform to the operational features as specified in Clauses 4.3.1 to 4.3.4 of BS 5163-1:2004

Materials

(7) Materials for manufacture of valves shall comply with Clause 4.1.1 and 4.1.2 of BS EN 1074-1:2000 and Clause 4.5 of BS 5163-1:2004.

Air Relief Valves 22.110* General

(1) All valves and valve components supplied shall conform in every respect to the requirements of the following British Standard Specifications unless otherwise specified:

- BS EN 10226-1 : 2004
- BS EN 1074-1 : 2000
- BS EN 1092-2 : 1997
- BS EN 1074-4 : 2000
- BS EN 1561 : 1997
- BS EN 6920 : 2000

Single orifice air valve

(2) The valve shall be mounted on a 25 mm dia. stainless steel isolating stopcock with bronze nipple end or other equivalent isolating valve for connecting to the pipeline. The pipe threads of the nipple end shall be R1 as specified in ES 10226-1: 2004.

Double Orifice Air Valve

(3) The valve shall be flanged and mounted on a double flanged horizontal isolating valve having mitre gearing for vertical operation by tee key. The isolating valve shall conform to Clause 22.109* and shall have a nominal pressure rating equal to the maximum working pressure of the air valve. Flanges shall comply with the relevant requirements of BS EN 1092-2: 1997 and shall be machined in accordance with Table 1 contained therein. Drilling and diameter of flanges shall be to Table 9 even where nominal pressure rating lower than PN 16 is specified.

Materials

(4) All air valve bodies, pressure covers and splash covers shall be of grey cast iron to BS EN 1561 : 1997 Grade 250, carefully machined and jointed.

(5) Small orifice valves shall have float guides and ABS (Acrylonitrile Butadiene Styrene) plastic non-corroding floats closing on moulded rubber sealing faces. Large orifice valves shall have ABS plastic float guides, seat rings and floats closing on moulded rubber sealing rings. Similar equivalent materials will also be considered.

(6) All non-metallic components of the air relief valves which will come into contact with or likely to come into contact with water shall comply with the requirements of BS 6920 : Part 1:2000.

Brass Stop Valves 22.111* (1) The stop valves to be supplied under this specification shall conform to the requirements of BS 1010:Part II:1973 and in strict compliance to the following:

(a) Rising Spindle
(b) Loose Jumper
(c) Crutch Handle
(d) Screwed double female Thread to BS 21:1985 body ends.

(2) In subsequent references to British Standards, alternative national or international standards that can be shown to be equivalent may be accepted for the supply of brass stop valves, except that, for compatibility to other fittings, threads shall be in full compliance with Clause 22.111*(1)(d).

Ductile Iron Covers and Frames and Surface Boxes 22.112* General

(1) General notes for ductile iron (DI) covers / surface boxes are given in WSD Standard Drawing No. 7.43b.

(2) Ductile iron (D.I.) surface boxes shall conform to the relevant requirements of BS 5834: Part 2.

Materials

(3) Notwithstanding Clause 3.1.2(b) of BS 5834:Part 2, the material to be used for the manufacture of iron castings shall be ductile iron (spheroidal graphite iron or nodular graphite iron) complying with Grades EN-GJS-500-7, EN-GJS-600-3 or EN-GJS-700-2 of BS EN 1563 and test pieces prepared from separately cast samples shall be used for testing.

(4) Hinge pins shall be made of stainless steel to BS 970: Part 1 Grade 431S29.

(5) Bolts supplied for coupling separate sections of the covers shall be made of stainless steel to BS 970: Part 1 Grade 431S29. Dimensions of the coupling bolts shall comply with the relevant requirements of BS 4190.

Coating

(6) Surface boxes shall be coated with coal tar or bitumen solution as specified in Clause 6.1(b) (1) or (2) of BS 5834: Part 2.

Insulation 22.113* Pre-insulated polyurethane black steel pipes shall be mainly based on BS EN 253, and pre-insulated polyurethane steel fittings shall be fabricated mainly based on BS EN 448 and BS EN 489.

uPVC Pipes and Fittings 22.114* uPVC Pipes

(1) uPVC pipes shall be those designated as class D in BS 3505: 1986 and shall conform to the relevant requirements of BS 3505: 1986.

(2) uPVC pipes of nominal size 1" and below shall be provided with integrally formed socket for solvent welding at one end. Details of sockets shall conform to BS 4346: Part 1:1969.

(3) uPVC pipes of nominal size 2" and above shall be provided with integrally formed socket and works fitted gasket at one end for push-fit type jointing. Details of the push-fit type joint shall conform to the relevant requirements of BS 4346:Part 2:1970.

uPVC Fittings for Solvent Welding

(4) All fittings shall be designed for a working pressure of 12 bar at 200C and shall conform to the relevant requirements of BS 4346: Part 1:1969.

uPVC Repair Couplings (Simple Joint)

(5) uPVC repair couplings shall be designed for a working pressure of 12 bar and shall conform to the relevant requirements of BS 4346: Part 2:1970.

(6) Threads of uPVC repair couplings shall conform to BS 21.

(7) Rubber rings shall be made of rubber to BS 2494:1990 Type W (water).

C.I. Repair Couplings (Dresser Joint)

(8) Centre sleeve and end flanges shall be made of grey cast iron to BS 1452: 1990, Grade 220 or above and shall be coated with one of the following materials -

(a) BS 4147 type I, grade C
(b) BS 34l6 type I.

(9) Rubber rings shall be made of rubber to BS 2494: 1990 Type W (water).

Flange Assemblies

(10) Socket stub flanges shall be made of uPVC and shall conform to the relevant requirements of BS 4346: Part 1:1969.

(11) Metal backing rings shall be made of grey cast iron to BS 1452: 1990, Grade 220 or above and shall be coated with one of the following materials -

(a) BS 4147 type I, grade C
(b) BS 3416 type I.

(12) Rubber gasket shall be made of rubber to BS 2494: 1990 Type W (water).

Solvent Cement

(13) Solvent cement shall conform to the relevant requirements of BS 4346: Part 3:1982.

Bolts and Nuts

(14) The dimensions and finish of the bolts and nuts shall comply with the requirements of BS 4190: 1967 and the threads on bolts and nuts shall be of the ISO metric series specified in BS 3643: Part 2:1966 with coarse pitch series thread.

(15) Screw threads shall be to the tolerances for the free class of fit as specified in BS 3643: Part2: 1966.

(16) Bolts and nuts shall be rust protected by a compound coating - Parkerised or hot-dip galvanised coating to BS 729: 1971, or electroplated zinc coating to BS 3382: Part 2:1961.

Copper Alloy Longscrews for use with Lined Screwed Steel Tubes

22.115* Longscrews shall be single longscrews with external parallel threads and dimensions complying with Table 9 (Fig.4) of BS1387:1985. Each longscrew shall be fitted with a backnut and a parallel threaded faced socket as described in Clause 5.5 of BS1387:1985. The outside diameter of the longscrew shall comply with Table 5 of BS1387:1985.

APPENDIX 22.2

PROTECTION TO STEEL PIPES, FITTINGS AND SPECIALS USING EPOXY SYSTEM – OTHER REQUIREMENTS

General requirements 22.2.1 (1) Pipes, fittings and specials shall be protected both internally and externally and shall be suitable for use in and transport through the tropics.

(2) For pipes with outside diameter less than 1016 mm, internal protection with sulphate resistant cement mortar lining in accordance with the requirement of BS EN 10298:2005 will also be considered.

(3) Slip-on type couplings and flanges adaptors (including nuts and bolts) shall be protected with Rilsan Nylon 11 or a fusion bonded epoxy, coating (as in Table 22.2) and shall not require bituminous paint.

(4) All bolts and nuts shall be hot dip galvanized or be coated with an epoxy- or plastic-based corrosion-protection coating.

(5) For pipes, fittings and specials to be jointed together by welding, internal and external protections shall be stopped back at the ends as follows:-

(a) Butt welded joints – 75mm from the ends of pipes to be welded
(b) Sleeve welded joints – for sleeve and spigot sleeve, length plus 75mm

In all cases, priming shall extend to the ends of the pipes.

(6) For pipes, fittings and specials not to be jointed by welding, the external protection shall be stopped back a distance sufficient to permit assembly of the joint and internal protection shall extend to the pipe end.

General Protection Coating Requirements 22.2.2 Selection of coating systems and application procedures shall be made with due consideration to environmental conditions during fabrication, installation and service of the installation. All coating application procedures shall be carried out in accordance with ANSI/AWWA C210.

Coating Materials 22.2.5 The coating materials shall be suitable for the intended use and shall meet the following requirements:

In compliance with health, safety and environment protection requirements
Suitable for raw water, salt water, fresh water and treated effluent

For fresh water main coating, the material shall be suitable for drinking water uses

Steel Materials 22.2.6 Steel used for fabrication, before abrasive blast cleaning, shall as a minimum requirement be in accordance with Rust Grade B according to BS EN ISO 8501-1:2001. Any primer applied by the steel manufacturer shall be regarded as temporary corrosion protection and shall be removed in appropriate manner before application of the coating systems herein.

Coating System Requirements 22.2.20 The coating system for carbon steel pipe shall be in accordance with coating system as in Table 22.2.20(a), (b) and (c) as appropriate:

Table 22.2.20(a): System 1 for carbon steel pipe – internal lining

SYSTEM 1. For carbon steel pipe – internal lining	**Coating Material and Surface Protection Requirements**	**Minimum Dry Film Thickness (DFT) (Microns)**
Surface Preparation	Abrasive blast to Min. Sa2.5 (BS EN ISO 8501) Roughness to medium grade (BS EN ISO 8503) or 10Na according to Rugotest No. 3	
Primer Coat	Solvent free two-component, high build polyamine cured epoxy	250
Intermediate Coat	Solvent free two-component, high build polyamine cured epoxy	250
Final Coat	Solvent free two-component, high build polyamine cured epoxy	250
Total Dry Film Thickness		**750**

Table 22.2.20(b): System 2 for carbon steel pipe – external lining pipe shielded from direct sunlight (buried underground)

SYSTEM 2. For carbon steel pipe– external lining pipe shielded from direct sunlight (buried underground)	**Coating Material and Surface Protection Requirements**	**Minimum Dry Film Thickness (DFT) (Microns)**
Surface Preparation	Abrasive blast to Min. Sa2.5 (BS EN ISO 8501) Roughness to medium grade (BS EN ISO 8503) or 10Na according to Rugotest No. 3	
Primer Coat	Solvent free two-component, high build polyamine cured epoxy	200
Final Coat	Solvent free two-component, high build polyamine cured epoxy	200
Total Dry Film Thickness		**400**
NOTES: 1. For pipe to be installed outdoor under direct sunlight, a topcoat of aliphatic polyurethane at 50 microns is required for extra protection.		

Table 22.2.20(c): System 3 for carbon steel pipe – temporary protection after blasting (approx. 15 cm)

SYSTEM 3. For carbon steel pipe end – temporary protection after blasting (approx. 15cm)	**Coating Material and Surface Protection Requirements**	**Minimum Dry Film Thickness (DFT) (Microns)**
Surface Preparation	Abrasive blast to Min. Sa2.5 (BS EN ISO 8501) Roughness to medium grade (BS EN ISO 8503) or 10Na according to Rugotest No. 3	
Blast Primer	2-component amine adduct cured epoxy primer	50
Total Dry Film Thickness		**50**

BTRi PRODUCT SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 23

WATER RETAINING STRUCTURES

SECTION 23

WATER RETAINING STRUCTURES

Eurocode 23.01A* Reference to British Standards in this Section should be superseded by the respective Eurocode Standards and also the Eurocode requirements shall prevail if inconsistency exists between the two standards.

Sliding layers 23.09 Sliding layers below floor slabs of water retaining structures shall be of 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.

Waterproofing for wet wells, inlet chamber, distribution chamber and screen chamber 23.09A*

(1) All internal concrete walls, floors and soffits exposed to sewage shall be coated with a two component solvent free pitch extended epoxy resin coating.

(2) Pull out tests and thickness tests or any other equivalent tests recommended by the manufacturer shall be carried out by a HOKLAS accredited laboratory.

(3) Records of tins of resin shall be kept upon their arrival on Site. The quantity consumed per day and the number cleared away shall be evaluated to check the actual spreading rate of the material against the manufacturer's technical data. Tins and packages may be marked on arrival and again when consumed.

Hydrophilic gaskets 23.38* Hydrophillic rubber gaskets shall be water swellable. The gasket shall be used in accordance with the manufacturer's instructions and shall have an unrestrained volumetric expansion of not less than 170%.

STORMWATER DRAINAGE TANK

Penstock and Actuator 23.39*

Penstock

(1) Penstocks shall conform to GSEM Part 2. Penstock door and frame shall be stainless steel BS EN 10088 grade 1.4404 (316L) fabricated. Stem shall be stainless steel grade 316 or suitable grade accepted.

(2) Door seals shall be resilient EPDM (ethylene propylene to BS4255: Part 1). Seals shall be mechanically fixed to the frame with stainless steel fasteners.

(3) Penstock shall comply with BS 7775 and a minimum figure of 0.75 times & the 0.2% minimum proof stress given in Table 10 of BS EN 10088 Part 3 shall be used when sizing components of stainless steel grade 316.

(4) Penstock shall be fixed to the civil structure with accepted stainless steel grade 316 chemical anchor bolts.

Requirements of Hydraulic Actuators for Penstocks

(i) Hydraulic Power Unit

(a) The hydraulic pipeworks shall be made of stainless steel 316 or

flexible reinforced hose with stainless steel braided cover. SS316 covers for protection of exposed oil pipework shall be provided.

Stormwater Pump 23.40* Technical Requirements of the Stormwater Pump

(1) The pump shall consist of the following principal pump components constructed from the following materials:

(a) Pump casing: Austenitic Cast Iron BS EN 13835 Designation EN-GJSA-XNiCrNb 20-2
(b) Pump impeller: Stainless Steel BS EN 10213 Designation 1.4408
(c) Pump shaft: Duplex Stainless Steel ASTM A240 S31803
(d) Pump bellmouth, casing, column pipes, discharge bend, bearing spiders: Austenitic Cast Iron BS EN 13835 Designation EN- GJSA-XNiCrNb 20-2
(e) Auxiliary pipework and small bore pipework: Stainless Steel 316.

(2) Pump casing wear ring and impeller wear ring, shaft sleeves, etc. shall be made of stainless steel 316.

(3) Shaft seal shall be of split type mechanical seal suitable for saline water pumping application with self-supply flushing water (if applicable). Necessary pipework, valves and flow switch shall be provided. The small-bore pipework shall be of grade stainless steel 316.

Low Flow Pump, Cleansing Water Pump and Wastewater Pump 23.41* (1) Low Flow Pumps in the SWT

(i) The low flow pumps shall be of submersible type with a cast iron pump casing, stainless steel shaft and impeller.

(ii) The submersible low flow pumps shall be completed with stainless steel double-guide rails, stainless steel lifting chains with stainless steel hooking rings, pump guide shoe and duckfoot bend for automatic connection to discharge pipe, cables and all other necessary accessories. Each stainless steel lifting chain shall have at least seven stainless steel rings at suitable intervals along the chain for the removal of the submersible low flow pump. Each lifting chain shall be fixed to a stainless steel hook which was installed at the top of the low flow chamber. The handles of the submersible low flow pumps, stainless steel lifting chains, rings and hooks shall be robust enough to lift the entire submersible low flow pump together with its motor from the low flow chamber. The lifting chain and the associated gear shall fulfil the requirements of "Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulation". The validity period of the test reports/certificates for the lifting chain shall cover up to the defects date or the end of the last defects correction period whichever is the latest followed by a period of nine months thereafter.

(2) Cleansing Water Pumps for SWT and Pumping Station

(i) Pump casing in cast iron, impeller and shaft shall be made of stainless steel. Pump motor shall be squirrel-cage induction type and with totally enclosed fan ventilation. The motors shall be protected to IP55 and suitable for 380V, 3ph, 50 Hz supply and tested to BS4999.

(3) Sewage Pump

(i) The sewage pump casing in Cast iron, impeller and shaft shall be made of stainless steel. Pump motor shall be squirrel-cage induction type. The motors shall be protected to IP68 and suitable for 380V, 3ph, 50 Hz supply and tested to BS4999.

Pipework and Valves

23.42* Pipework

(1) All pipes and fittings for handling stormwater/low flow shall be made of ductile iron, lined internally with sulphate resistant cement and bitumen paint and externally coated with bituminous layer or coal tar epoxy in accordance with BS EN 598. The pipes shall be centrifugally cast with cast-on flanges to Class K9 or Kl2 and with external coating of metallic zinc in accordance with BS EN 598 prior to bitumen or coal tar epoxy coating.

(2) Flexible adaptors with stainless steel grade 316 tie bars shall be provided for ease of assembly and dismantling of the pipework.

(3) The bolts and nuts shall be made of stainless steel. The Contractor shall also provide flange adaptors or short double flanged pipes to cater for misalignment of the end flanges.

Gate Valves

(4) The gate valves shall comply with Part 2 Clause 2.6.2 of the GSEMSFI. Sealing of the valve shall be by means of packed gland stuffing box seals.

(5) All gate valves shall have rising stem. Electric actuators shall be provided for all main stormwater pump discharge valves and the valves in the rising mains and the circulating pipes. The actuators shall comply with the requirements of the actuators for penstocks.

Check Valves

(6) The check valves shall be of recoil type. The valve body and door shall be made of ductile iron. Valve flanges shall comply with BS 4504:Part 1 PN 16. The minimum nominal pressure rating shall be PN 10. Each check valve shall be fitted with a limit switch. The close status of the check valve shall actuate the close of the limit switch which shall be relayed to the MACS and trip the corresponding energised main stormwater pump and low flow pump at an adjustable time delay of 0 to 5 minutes under no flow conditions. Adjustable timers to inhibit the no-flow detection system during starting of pumps shall also be provided.

Air Relief Valves

(7) Ductile iron fittings shall have cast—on boss for connecting air relief valve if required.

(8) The body, cover, cowl and float chamber of each air relief valve shall be of cast iron to BS1452 Grade 220 or equivalent.

BTRi PRODUCT SPECIFICATION FOR CIVIL ENGINEERING WORKS

SECTION 24

BUILDING WORKS

SECTION 24

BUILDING WORKS

PART 1: ASPHALT ROOFING

Mastic asphalt 24.01 Mastic asphalt for asphalt roofing shall comply with BS 6925, Type R988.

Isolating membrane 24.02 Isolating membrane for asphalt roofing shall be black sheathing felt complying with BS EN 13707.

Bitumen dressing compound 24.03 Bitumen dressing compound shall be cut-back bitumen to BS EN 12591, BS EN 13924-1 and BS EN 15322 class 1.

Bituminous paint 24.04 Bituminous paint for asphalt roofing shall comply with BS 6949.

Sand 24.05 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.

Stone chippings 24.06 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.

Reflective paint 24.07 Reflective paint for asphalt roofing shall be of a proprietary type approved by the Engineer and shall be a bituminous-based aluminium paint or a paint compatible with bituminous surfaces.

Metal lathing 24.08 Metal lathing for asphalt roofing shall be zinc coated or stainless steel expanded metal lathing complying with BS EN 13658-1 & BS EN 13658-2.

PART 2: CARPENTRY AND JOINERY

Timber for carpentry and joinery 24.25 (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) Hardwood or teak shall only be used in special circumstances under the direction of the Engineer.

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

(5) Plywood shall be of the following grades, as specified:

(i) Grade 1 veneer plywood shall be used for natural finishes and shall be hardwood faced ~~as stated in the Contract~~.

(ii) Grade 2 veneer plywood shall be used for painted finishes and shall be luan faced.

(6) Timber either softwood or hardwood shall be obtained from a sustainable forest or plantation. Hardwood of unknown species or from unidentified sources are expressly prohibited.

(7) Timber either softwood or hardwood shall be originating from a sustainable resource or managed plantation as certified by the Forest Stewardship Council (FSC) or other Approved Authority.

(8) All wood-based panels shall comply with the following requirements with supporting certificates:

(a) The panels shall be of formaldehyde class E1 in accordance with BS EN 13986+A1.

(b) The level of hazardous materials or their compounds in the panels shall not exceed the following limits in mg/kg of dry panel:

- Arsenic - 25
- Cadmium - 50
- Chromium - 25
- Copper - 40
- Lead - 90
- Mercury - 25
- Fluorine - 100
- Chlorine - 1000
- Pentachlorophenol (PCP) - 5
- Benzo(a)pyrene – 0.5

(c) The panels shall not contain flame retardant of polybrominated biphenyl (PBB), polybrominated diphenyl ether (PBDE) or short-chain chlorinated paraffin added as formulated components.

Nails, screws and plugs 24.26 (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 of a proprietary type approved by the Engineer and shall be plastic, soft metal, fibre or similar material.

Wood preservative 24.27 (1) Wood preservative for carpentry and joinery shall be of a proprietary

type approved by the Engineer. Wood preservative that will be completely concealed or not decorated shall be an exterior grade and colourless. Wood preservative that is likely to be exposed to or in contact with painted finishes shall be coloured and suitable for over-painting.

(2) Wood preservative shall be applied in a manner that is not hazardous to health and adhered strictly to the manufacturer's instructions.

Adhesive 24.28 (1) Adhesive for timber shall comply with BS EN 301 and tested according to BS EN 302.

(2) Adhesive for plywood for external use or in areas of high humidity shall be phenol formaldehyde resin adhesive of durability class H4 in accordance with BS 1203. Adhesive for plywood for other uses shall be resin adhesive of durability class H2 in accordance with BS 1203.

PART 3: GLAZING

Glass 24.42 (1) Glass shall comply with BS 952-1, BS 952-2 or ASTM C1036 and be of a proprietary type approved by the Engineer. Glass used in windows shall not be formulated with Arsenic, Cadmium, Hexavalent chromium, Lead, Mercury, Organic tin, Phthalates or their compounds. Its thermal transmittance (U-value) shall not exceed 1.4 W/m^2K when determined in accordance with BS EN ISO 12567-1. ~~The Contractor~~ shall submit supporting certificates showing that the glass used complies with the specification. 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.

(2) Clear float glass shall be used for glazing~~ unless otherwise stated in the Contract.~~

(3) Sheet glass shall be clear sheet glass and shall be at least 3 mm thick.

(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.

(5) Hollow pressed glass blocks shall have a pattern approved by the Engineer and shall have radius corner blocks to match.

(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.

Putty 24.43 Putty for glazing to metal, hardwood and softwood shall be a proprietary type approved by the Engineer.

Bituminous paint 24.44 Bituminous paint for cut edges of wired glass shall comply with BS 6949.

PART 4: PLUMBING

Draw-off taps and stop 24.52 (1) Draw-off taps for those of a single tap type shall comply with BS EN

valve

200. Draw-off taps for those of a combination tap type shall comply with BS EN 200, BS EN 1286 or BS EN 1287. Draw-off taps for those of a self-closing tap type shall comply with BS EN 816. Draw-off taps for those of a sensor tap type shall comply with BS EN 15091.

(2) Copper alloy gate valves and check valves shall comply with BS 5154 or BS EN 12288 as appropriate.

(3) Cast iron gate valve for fresh potable water application, street fire hydrant system and underground pipework system for fresh/flush water application shall be to BS 5163-1 and BS 5163-2 in conjunction with BS EN 1074-1 and BS EN 1074-2.

Sanitary appliances 24.54

(1) Sanitary appliances shall be of 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 of other types approved by the Engineer. Basins shall be supported on brackets to suit the basin. The brackets shall be of 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 of a proprietary type approved by the Engineer. WC pan connectors shall be PVC.

(6) Urinals shall be of 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 of a proprietary type approved by the Engineer and shall be provided with a 75 mm deep seal.

PART 5: PLASTERWORK AND OTHER

FINISHES

Cement, water and sand

24.65 (1) Cement for plasterwork and other finishes shall be ordinary Portland cement complying with BS EN 197-1.

~~(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 24.2. Sand for mixes which incorporate lime shall be clean natural sand and shall have the particle size distribution stated in Table 24.3.

(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 EN 932-1, BS EN 932-6 and BS EN 933-7 and CS3. The chloride content of sand or crushed rock shall not exceed 0.03 % by mass when determined in accordance with CS3.

Table 24.2: Particle size distribution of sand for mixes that 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 mm	40 – 80
300 mm	5 – 40
150 mm	0 – 10

Table 24.3: 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 mm	55 - 100
300 mm	5 - 50
150 mm	0 - 10

Premixed plaster

24.66 (1) Premixed plaster shall be factory-produced by weighted combination of plaster raw materials and chemicals. It shall be supplied to sites in bags. Mixing with clean water shall be required before application.

(2) There are two types of premixed plaster, cement-based and gypsum-based. Gypsum based is for internal use only.

(3) Cement-based plaster contains mineral filler material as aggregate and Portland cement as main binder, with additives for improved compressive strength and reduced shrinkage.

(4) Gypsum-based plaster contains pre-mixed minerals, gypsum-based rendering materials and additives that may be applied in one single thick application without cracking and separation from the substrate.

(5) The premixed plaster shall comply with BS 8481, BS EN 13279-1, BS EN 13279-2, BS EN 13914-1, BS EN 13914-2 and PD/CEN/TR 15123. The

premixed plaster manufacturing company shall have acquired ISO certification in their manufacturing process of the premixed plaster product.

Gypsum plaster 24.67 Gypsum plaster for plastering shall comply with BS EN 13279 and shall be Retarded hemihydrate gypsum plaster to BS EN 13279-2 and BS EN 13279-1, Class B of the following types:

(a) Undercoat Plaster:

Type a – 1 Browning plaster
i. 2 Metal lathing plaster

(b) Final Coat Plaster:

Type b – 1 Finish plaster
ii. 2 Board finish plaster

Lime 24.68 Lime for plastering shall be hydrated lime or quicklime complying with BS EN 459-1.

Stone chippings 24.69 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.

Metal lathing 24.70 Metal lathing for plastering shall comply with BS EN 13658-1 & BS EN 13658-2 and shall be one of the following types:

(a) Zinc-coated or stainless steel expanded metal lathing 6 mm short way of mesh and weighing at least 1.6 kg/m^2, or
(b) Zinc-coated or stainless steel ribbed metal lathing weighing at least 2.25 kg/m^2.

Aggregates for lightweight screeds 24.71 Aggregates for lightweight screeds shall be 5 mm exfoliated vermiculite to BS EN 13055-1 or of a proprietary type of lightweight beads or granules approved by the Engineer.

Vapour barrier 24.72 Vapour barrier for lightweight roof screeds shall be polyethylene sheeting and shall have a nominal thickness of 80 μm.

Aggregates for terrazzo 24.73 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.

Aggregates for granolithic concrete 24.74 Aggregates for granolithic concrete shall be crushed grey granite or white stone complying with BS EN 12620+A1. 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.

Tiles 24.75 Each type of tile and fitting shall be obtained from the same manufacturer and shall match in colour and texture. For ceramic tiles with antimony, cadmium, lead or their compounds used in the glazes, the content of antimony, cadmium and lead shall not exceed 0.25%, 0.1% and 0.5% respectively by weight of the glazes with supporting certificates.

24.75A* External glazed ceramic wall tiles shall be to BS EN 14411 and in Group A IIa or B IIa with a water absorption not exceeding 6%.

Floor tiles

24.76 Clay floor tiles and fittings shall comply with BS EN 14411. 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.

24.76A* (1) Colour and pattern of floor tiles shall be as specified.

(2) Precast concrete paving blocks shall be to BS 7533-3+A1 & BS EN 1338 standards, and the size, colour and surface textured shall be specified.

(3) Adhesives for tiles shall be to BS EN 12004-1 standard. Method statement specifying the types of equipment to be used, method of mixing, setting time and application time schedule shall be submitted. The approved adhesive shall be used in strict accordance with the manufacturer's technical specifications and recommendations, including and not limited to the valid shelf life and the setting time of the product, and the method statement. The expiry date and the setting time shall be clearly indicated with label and stamp for necessary inspection. The following requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

(c) Shall contain no more than 0.01% by wet weight of formaldehyde.

(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

Ceramic floor tiles and floor quarries

24.76B* (1) Ceramic floor tiles including corresponding accessories, shall be to BS EN 14411.

(2) Ceramic floor tiles shall be Group A I or B I: water absorption not exceeding 3%.

(3) Floor quarries shall be to Group A IIb of BS EN 14411: water absorption of 6% < E =< 10%.

(4) Where ceramic floor tiles or clay floor quarries are described as "including specials" the full range of BS fittings shall be required. Elsewhere mitred angles of coved skirtings and the like shall be permitted.

(5) All tiles and fittings shall be from the same manufacturer and shall match in colour and texture.

(6) Where tiles are described as anti-slip, they shall be suitably embossed or treated with carborundum or similar grit to comply with relevant standards, e.g. Germany DIN standard or other recognized international

standards to provide an anti-slip surface.

(7) Concrete roofing tiles and fitting shall be to BS EN 490+A1 and BS EN 491. The tiles shall be flat tiles 30 mm thick and 300 mm^2 or 35 mm thick and 400 mm^2 .

(8) Roofing tiles shall be 40 mm thick and 300 mm^2 or 400 mm^2 with a density of 1,250 kg/m^3 ± 10%. The upper surface of roofing tiles shall be hard and suitable for pedestrian traffic. Five legged tiles shall not be permitted.

(9) Fix floor tiles as follows:

(a) Semi dry method direct to concrete base (for preparation of base, see Clause 18.16):

(i) Soak tiles in clean water and allow to drain.

(ii) Lay semi-dry mix cement and sand 1:4 bed thoroughly compacted to the required thickness (20 mm minimum) finished to the required levels, falls and currents.

(iii) Pour cement and sand slurry over bedding and spread and trowel to 3 mm (minimum) thick.

(iv) Lay tiles, mixed from six boxes, and tamp firmly into bed with straight and even joints and 3 mm (minimum) wide.

(v) Allow bedding to set.

(vi) Grout up joints and clean surplus grout face of tiles as work proceeds.

(b) Thick bed method to screed:

(i) Soak tiles in clean water and allow to drain.

(ii) Damp the screed with clean water to reduce suction if required.

(iii) Lay cement and sand 1:3 bed generally 15 mm thick but never thicker than the tiles.

(iv) Coat back of tiles with slurry immediately before fixing.

(v) Lay tiles mixed from six boxes and tamp firmly into bed with straight and even joints and 3 mm (minimum) wide.

(vi) Allow bedding to set.

(vii) Grout up joints and clean surplus grout from face of tiles as work proceeds.

Non-homogenous floor tiles 24.77 Non-homogenous floor tiles shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-6, BS EN ISO 10545-8, and BS EN ISO 10545-13. The tiles shall be 200 mm x 200 mm, 300 mm x 300mm or 400mm x 400 mm.

Ceramic wall tiles 24.78 Glazed ceramic wall tiles and fittings shall comply with BS EN 14411 and shall be eggshell glazed. The tiles shall be 108 mm x 108 mm or 152 mm x 152 mm or 200 mm x 200 mm and shall be at least 5.5 mm thick. The tiles shall have cushion edges.

Mosaic tiles 24.79 (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. The tiles shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-8, BS EN ISO 10545-13.

(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. The tiles shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-7, BS EN ISO 10545-8, BS EN ISO 10545-11, BS EN ISO 10545-13, BS EN ISO 10545-14.

(3) Unglazed vitreous mosaic tiles shall have a water absorption not exceeding 3% and shall be 20 mm x 20 mm or 50 mm x 50 mm and shall be respectively 4 mm or 5 mm thick with matching coved tiles. The tiles shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-6, BS EN ISO 10545-8, BS EN ISO 10545-13.

Homogenous coved tile skirting 24.80 Homogenous coved tile skirting shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-6, BS EN ISO 10545-8, and BS EN ISO 10545-13. The tiles shall be 200 mm x 75 mm x 7mm thick.

Homogenous wall tiles 24.81 Homogenous wall tiles shall comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-6, BS EN ISO 10545-8, and BS EN ISO 10545-13. The tiles shall be 100 mm x 100 mm.

External facing tiles 24.82 External facing tiles shall be of the specified type from an approved manufacturer and comply with BS EN ISO 10545-2, BS EN ISO 10545-3, BS EN ISO 10545-4, BS EN ISO 10545-7, BS EN ISO 10545-8, BS EN ISO 10545-11 and BS EN ISO 10545-13. The tiles shall be 45 mm x 45 mm x 7mm thick or 45mm x 95 mm x 7 mm thick.

Concrete roof tiles 24.83 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.

Tile adhesive and tile grout 24.84 (1) Tile adhesive shall be of a proprietary brand approved by the Engineer.

(2) Tile adhesive and tile grout shall be cement-based compatible with the substrate and tiles to be installed;

(3) Tile adhesive shall be in accordance with BS EN 12004-1 and BS EN 12004-2 cementitious adhesive, normal setting type with minimum tensile adhesive strength of 0.5N/mm², and comply with Table 24.4.

(4) Tile grout shall be in accordance with ANSI A108/A118/A136.1, and comply with Table 24.5.

(5) The colour of the tile adhesive shall be white or grey and the colour of

the grout shall be subject to the approval of the Engineer.

(6) Packed in three ply together with preparation procedures and application methods. Minimum one set of the preparation procedures and application methods shall be printed in Chinese and diagrammatic forms for each lot that is delivered to site.

~~(7) Brand name, batch number, shelf life, pot life and open time shall be clearly printed on outside of package;~~

(8) No prior soaking of tiles is required;

Table 24.4: Tensile adhesion strength

Characteristic	Requirement	Test Method
Initial tensile adhesion strength	≥ 0.5 N/mm²	8.2 of BS EN 1348
Tensile adhesion strength after water immersion	≥ 0.5 N/mm²	8.3 of BS EN 1348
Tensile adhesion strength after heat ageing	≥ 0.5 N/mm²	8.4 of BS EN 1348
Tensile adhesion strength after freeze-thaw cycles	≥ 0.5 N/mm²	8.5 of BS EN 1348
Open time: tensile adhesion strength	≥ 0.5 N/mm² after not less than 20 min	BS EN 1346

Table 24.5: Tile grout test acceptance standards

Items	Test Method	Acceptance Standards	Remarks
Linear Shrinkage	ANSI A–108/A1 18/A136.1	1 day shrinkage< 0.1% 7 days shrinkage< 0.2%	Cast and store grout specimens at 21° - 25°C, 45 - 55% R.H.
Water Absorption	ANSI A–108/A1 18/A136.1	From 50% R.H. to immersion < 5% From immersion to dry < 7%	Determine water absorption from 50% R.H. to immersion and from immersion to dry.
Characteristics of cementations adhesive	BS EN 1348	≥0.5N/mm^2	cl. 8.2 initial adhesive strength cl. 8.3 tensile adhesion after water immersion
	BS EN 1346	≥0.5N/mm^2	Open time: tensile adhesion strength
Resistance to Mould Growth	To be decided by the Engineer	No sign or evidence of mould growth on tile grout.	3 mm thick tile grout is applied over biscuit side of test piece tile and the assembly be placed in Petri dishes for incubation at 29° ± 1°C for 24 hrs after addition of potato dextrose agar. Aspergillus niger is inoculated into the grout. The whole assemble is incubated for 14 days at 29° ± 1°C.

Bitumen 24.85 Bitumen for tiles shall be as stated in Clause 24.03.

PLASTERING AND RENDERING

Premixed plaster 24.106 ~~(1) Premixed plaster and clean water shall be mixed on site with portable electrical mixer or other equipment according to manufacturer's recommendations.~~

~~(2) Tolerance of evenness of substrate shall be ± 5 mm for internal concrete wall, block wall and beams, and ± 3 mm for internal ceiling soffit.~~

~~(3) Substrate shall be clean; free from dust, contamination, paint, oil and loose scale. Dampen dry substrate before plastering.~~

~~(4) Premixed plaster may require the substrate to be treated with spatterdash or to be keyed before application depending on manufacturer's recommendations.~~

~~(5) Do not use mixes after initial set has taken place and do not re-temper or reconstitute mixes unless permitted by the manufacturer's instructions.~~

~~(6) Premixed plaster shall be carried out by experienced applicators. All the workers and supervisory staff employed for the work shall be fully instructed and trained on the method of preparation and application in accordance with the manufacturer's recommendations~~.

~~(7) Cement based premixed plaster shall be applied with trowel or spraying machine in several coats. Application method, thickness, number of coats and drying time between coats shall be strictly in accordance with manufacturer's recommendations.~~

~~(8) (a) Gypsum based premixed plaster shall be applied with trowel or spraying machine in single coat of thickness in accordance with manufacturer's recommendations.~~

~~(b) Half set plaster shall be leveled with featheredge, scraped off surplus material and worked from bottom to top of wall.~~

~~(c) Allow drying time of 30-60 minutes in accordance with manufacturer's recommendations. Sprinkle surface with clean water and smooth with a hard sponge float to remove trowel and featheredge marks in circular motion.~~

(9) The premixed plaster shall comply with BS 8481, BS EN 13279-1, BS EN 13279-2, BS EN 13914-1, BS EN 13914-2 and PD/CEN/TR 15123. The premixed plaster manufacturing company shall have acquired ISO certification in their manufacturing process of the premixed plaster product.

Cement render 24.107 (1) Cement render shall consist of cement and sand or granite fines in the proportions 1:3 by volume.

(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.

Gypsum plaster 24.108 (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. Where specified, bonding agents for use with gypsum plaster shall comply with BS 5270-1.

(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 24.108(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.

PART 6: PAINTING

Paint and associated materials 24.128 (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 of 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.

Aluminium primer 24.129 Aluminium primer shall comply with BS 4756, Type 1.

Zinc chromate primer 24.130 Zinc chromate primer and metallic zinc-rich primer Type 2 shall comply with BS 4652.

Lead primer 24.131 Lead primer shall comply with BS 2523.

Calcium plumbate primer 24.132 Calcium plumbate primer shall comply with BS 3698.

Bitumastic paint 24.133 Bitumastic paint shall be quick drying Type B complying with BS 1070.

Bituminous paint 24.134 Bituminous paint shall comply with BS 6949.

Knotting 24.135 Knotting shall comply with BS 1336.

Stopping 24.136 Stopping for internal woodwork, plywood, hardwood and fibreboard shall be poly putty or linseed oil putty**,** tinted if required. Stopping for external woodwork shall be poly putty or white lead paste and gold size, well mixed.

Rust inhibitor 24.137 Rust inhibitor shall be a chemical agent that is capable of converting rust into iron phosphate.

Sealers 24.138 Sealers for plaster, masonry and similar materials shall be a stabilising solution or oil based plaster sealer.

Wood preservative 24.139 Wood preservative shall be as stated in Clause 24.27**.**

Polyurethane paint 24.140 Polyurethane paint shall be a two-pack type.

Epoxy paint 24.141 Cold cure epoxy paint shall be a two-pack type.

Textured paint 24.142 Textured paint for external use shall be a heavy duty masonry paint incorporating a fine aggregate filler.

Plastic emulsion paint 24.143 Plastic emulsion paint shall be a vinyl or acrylic based emulsion incorporating a fungicide.

Cement paint 24.144 Cement paint shall be a waterproof cement based paint supplied in drums and shall not be mixed with lime or similar materials.

Gloss paint 24.145 Synthetic gloss paint for internal and external use shall have an alkyd resin base combined with drying oils and pigments.

Volatile organic compound content 24.146 The Volatile Organic Compound (VOC) content of all paint applied on surfaces of building fabrics, building elements and any installations/equipment inside semi-enclosed/enclosed areas of the building shall comply with the VOC limits stipulated in the Air Pollution Control (Volatile Organic Compounds) Regulation.

PART 7: BRICKWORK AND BLOCKWORK

Clay bricks 24.157 (1) Clay bricks shall be a brand approved by the Engineer and shall be well burnt, hard, sound, square and clean.

(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~~.

(3) Clay bricks for fair-faced work shall be selected for evenness, texture, sharpness of arrises and uniformity of colour.

(4) The compressive strength of the clay bricks shall be at least 7.0 MPa.

Concrete bricks and blocks 24.158 (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.

(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.

(3) Concrete bricks and blocks for fair-faced work shall be selected for evenness, texture and sharpness of arrises.

Concrete hollow blocks 24.159 The compressive strength of the concrete hollow blocks shall be at least 2.8 MPa over the gross area.

Brickwork reinforcement 24.160 Brickwork reinforcement shall be expanded metal or mild steel rods and shall be galvanized in accordance with BS EN ISO 1461 or otherwise approved by the Engineer, or painted with two coats of bituminous paint complying with Clause 24.134.

Damp proof course 24.161 Damp proof course shall be two layers of 2-ply bituminous paper or other types complying with BS 6398, BS 6515 and BS 8215. Hessian based types of bitumen damp proof course shall not be used.

Wall ties 24.162 (1) Wall ties between the ends of walls and concrete shall be:

(a) 6 mm diameter steel rods 350 mm long galvanized or painted with two coats of bituminous paint complying with Clause 24.134, or

(b) 20 mm x 3 mm galvanized mild steel flats 350 mm long and fanged at both ends.

(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.

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

(4) The galvanized mild steel flats shall comply with BS EN ISO 1461 or otherwise approved by the Engineer.

Mortar for brickwork and blockwork 24.163 (1) Cement, water and sand for mortar for brickwork and blockwork shall be as stated in Clause 24.65.

(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.

PART 8: METAL WINDOWS AND DOORS

Materials for metal windows and doors 24.181 (1) Materials for metal windows and doors shall be as stated in Clause 24.181(2) to (10).

(2) Except specified otherwise, all structural steel shall be hot-rolled or hot-finished structural steel complying with BS EN 10025 or BS EN 10210 respectively. Hot dipped galvanized plain steel sheet and coil shall comply with BS EN 10143. Steel tubing shall comply with BS EN 10255 medium grade and shall be galvanized. Slotted steel angles shall be self-finished angles and shall have stainless steel fittings.

(3) Aluminium alloy plate, sheet and strip shall comply with BS EN 485-1, BS EN 485-2, BS EN 485-3, BS EN 485-4, BS EN 515, BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5 and shall be of the specified alloy designation. Aluminium alloy bars, extruded tube sections and hollow sections shall comply with BS EN 515, BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5, BS EN 755, BS EN 12020, alloy designation 6063. Aluminium sections for structural purposes shall comply with BS 1161. Aluminium alloy drawn tubes shall comply with BS EN 515, BS EN 573-2, BS EN 573-3, BS EN 573-5 and BS EN 754, alloy designation 6063.

(4) Brass rods and sections shall comply with BS EN 12163, BS EN 12164, BS EN 12167, designation CW 106C, condition M.

(5) Stainless steel shall be of the 18/9 chromium nickel group. Stainless steel plate, sheet and strip shall comply with BS EN 10029, BS EN 10048, BS EN 10051, BS EN 10095, BS EN ISO 9445-1 and BS EN ISO 9445-2 and shall be Finish No. 2B for mill finish and Finish No. 2G for polished finish. Stainless steel tubes for structural and general engineering purposes shall comply with BS EN 10296-2, 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 of 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 EN ISO 11600+A1.

(9) Adhesive for bonding metal to wood or metal to metal shall be of a proprietary type approved by the Engineer.

(10) All components of windows (including frame, paint, surface treatment, etc.) shall not be formulated with Arsenic, Cadmium, Hexavalent chromium, Lead, Mercury, Organic tin, Phthalates or their compounds.

24.181A* (1) All sections shall have a thickness of not less than 2mm.

(2) All steel components including locks, latches, hinges, bolts, rivets, washers and other miscellaneous shall be of grade 316 S31 stainless steel.

Steel windows and doors

24.182 (1) Steel windows and doors shall be designed and fabricated by the Contractor in accordance with BS 6510 and as stated in Clauses 24.182(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 EN ISO 1461 or zinc sprayed to 0.2 mm nominal thickness in accordance with BS EN ISO 2063.

(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.~~

Aluminium windows and doors 24.184

(1) Aluminium windows and doors shall be designed and fabricated ~~by the Contractor~~ in accordance with BS 4873 and as stated in Clauses 24.184(2) to (14) and 24.185.

(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 1/180th of the length of the particular member. Galvanized steel cores, anchors, brackets and similar fittings shall be used as stiffeners where necessary.

(3) Sections shall be extruded aluminium alloy complying with BS EN 485-1, BS EN 485-2+A1, BS EN 485-3, BS EN 485-4, BS EN 515, BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5, BS EN 755 and BS EN 12020, 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 AAMA 611 and of the thickness grade and surface texture as follows:

(i) Interior work Class 15 (minimum average thickness of 15μm).
(ii) Exterior work Class 25 (minimum average thickness of 25μm).
(iii) Internal concealed surface Class 10 (minimum average thickness of 10μm).

(b) Colour anodised in accordance with AAMA 611, 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 24.184(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.

~~(14) The galvanization of the steel, fixing lugs, steel water bars and concealed fastening devices above shall comply with BS EN ISO 1461 or otherwise approved by the Engineer.~~

Fittings and furniture to aluminium windows and doors

24.185 (1) Fittings and furniture to aluminium windows and doors shall be of a proprietary type approved by the Engineer and shall comply with the requirements stated in Clause 24.185(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 EN 1774 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 24.185(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 24.130 and painted with two coats of bituminous paint complying with Clause 24.134.

(14) Concealed aluminium or stainless steel surfaces that may come into contact with wet mortar, cement, plaster or similar materials shall be painted with one coat of bituminous paint complying with Clause 24.134. Exposed aluminium or stainless steel surfaces shall be protected with a strippable coating or masking tape that shall not be removed until instructed by the Engineer.

PART 9: MASONRY

Stone 24.192 Stone for masonry shall be local granite and shall be free from defects that will adversely affect the strength or appearance of the masonry.

Mortar 24.193 Cement mortar for masonry shall be as stated in Clause 24.163.

Wall ties 24.194 Wall ties between masonry walls and concrete shall be galvanized mild steel flats complying with BS EN ISO 1461 or otherwise approved by the Engineer. The ties shall be at least 40 mm wide, 3 mm thick and 150 mm long and shall be fanged at both ends.

Damp proof course 24.195 Damp proof course for masonry shall be as stated in Clause 24.161.

MANSORY LINING

Masonry lining 24.208* (1) Masonry for lining shall be of selected granite. The exposed and joint faces of each stone shall be square and true plane surfaces. The exposed face shall be dressed and fine tooled to an accepted smooth surface.

(2) The stones shall be laid on a full even bed of cement mortar with all joints filled and 15mm wide. The joints shall be raked out to a depth of 15mm as the work proceeds and be pointed using bedding mortar, with flush joints on completion.

(3) Stone, generally, shall be granite of consistent colour, free from defects and ferrous materials that will adversely affect strength or appearance, to BS EN 771-6 and shall comply with BS EN 1996-1-1, NA to BS EN 1996-1-1, BS EN 1996-1-2, NA to BS EN 1996-1-2, BS EN 1996-2, NA to BS EN 1996-2, BS EN 996-3, NA+A1 to BS EN 1996-3 and PD 6697 when applied to masonry structures. Test methods according to clause 2 of BS EN 771-6.

PART 10: ARCHITECTURAL WORKS

PERMANENT SIGNBOARDS

Permanent signboards 24.209* (1) The permanent signboards shall be made of 3mm thick hard aluminium plates with plywood backing. The border, the symbols, the Roman and the Chinese lettering shall be embossed 0.8mm thick. The paint applied shall be of special stoving enamel quality. Each plate having predrilled countersunk holes is to be fastened to a 20mm thick piece of marine plywood by 10 gauge 20mm long brass.

(2) The plywood backing to receive two coats of specified undercoat before the plate is fixed. There should be one screw for every 0.2m^2 and no less than four screws.

(3) The aluminium sheeting for the permanent signboards shall be wrought aluminium of 3mm thick and shall conform in every way to BS1470 for aluminium sheeting and aluminium alloy. Aluminium coated sheet may be used, such as “Alclad” or other products having equivalent functions or performance.

FIXING BOLTS, CONCRETE ANCHORS, ETC.

Fixing bolts, concrete anchors, etc. 24.210* (1) Fixing bolts shall be to BS1494 : Part 2. Concrete anchors, suitable for fitting in drilled holes shall be of the expanding or resin bonded type.

(2) Fixing bolts, nuts and washer and concrete anchors shall be 18/8 stainless steel but when used for fixing aluminium items they shall have non-

metallic sleeve and under-washer or other insulating system havening equivalent functions or performance.

INTERNAL FINISHES

Spray plaster 24.211* Spray plaster shall be chemically inert and non-toxic. The 28-day adhesion strength shall not be less than 1.1N/mm² in accordance with BS3900: Part E10.

Hydrophobic Polymer Silica Paint 24.212* (1) The paint system shall consist of denatured silica binder which has a siloxane bond and a metal-based inorganic pigment.

- The paint system should display the following properties:-
- Highly resistant to sulfite pas.
- Protects from ultra-violet rays and salt air and displays none of the deterioration or chalking.
- Forms a highly dense ceramic coat, which is excellent water resistance and ultra hydrophobicity.

(2) The performance of the system should not be inferior to the following criteria:-

Test Item	Test Result	Test Method
Adhesiveness	100/100	A cellophane adhesive tape is stuck to the P-5000 surface which is cut to make a grid and then peeled off quickly
Water resistance	Normal	Immersion in water for 3 months at room temperature
Boiling water resistance	Normal	Immersion in boiling water for 24 hours
Alkali resistance	Normal	Immersion in saturated slaked lime for 1 month.
Freeze thaw	Normal after 15 cycles	According to 5.7 of JIS A 6910
Accelerated weathering	Normal after 2,000 hours	According to 6.5 of JIS A 6910
Coat hardness	HB-H	Pencil lead hardness
Acid resistance	Normal	5% hydrochloride acid spot test
Hydrophobicity	Very High	Repetition of a cycle of water flow and drying
Tensile strength	Base destroyed at 27 kg/cm³	Tensile tester
Air permeability	190 g/m², 24 hours	According to JIS z 0208

(3) The coating system should be the following:-

"Air Dry Inorganic Aqueous Surface Coating System" or product having equivalent function or performance.

(4) The System shall consist of the following:-

- One Prime Coat – Primer 1000 : 0.10 kg/sq.m.
- One Under Coat – P-5000 : 0.25kg/sq.m.
- Top Coat – P-5000 : 0.10kg/sq.m.

EXTERNAL FINISHES

External Paint 24.213* External paint shall be consisting of:

Undercoat: N-sealer (Water Base)

Texture Compound: Acrylic Texture Compound

Intermediate Coat: Bonntile Surfacer

Finishing Coat: Acrylic Polyurethane Solvent Base (QA2)

Ceramic Tile 24.214* Ceramic tile shall be equivalent to the following requirements:

(i) Product: extruded ceramic tile

(ii) Grade: European Quality Standard or equivalent - Precision, Terms and Classification - DIN EN 14411, Group AIa and unglazed.

Permeable Paver 24.215* (1) The units shall comply with GS Clause 11.61.

(2) Dimension stability shall comply with BS EN 1338.

(3) Coefficient of permeability shall be > 0.1mm/s to JIS A 5371.

(4) Compressive strength shall be greater of equal to 30MPa for footway and 45MPa for carriageway as to GS Appendix 11.1

(5) Compressive strength shall be tested with maximum vehicle weigth to be supported. No observable rupture should be allowed for 45 ton.

(6) Units shall have an abrasion resistance of not more than 23 mm to BS EN 1338.

(7) Units shall fulfill skid resistance of at least 45 for footway and at least 60 for carriageway to AS4586.

(8) Units shall be 200mm x 100mm unless otherwise specified.

(9) Units shall be at least 60mm thick for footway and at least 80 thick for carriageway.

(10) Recycled glass cullet shall be included as recycled fine aggregates and shall constitute (i) 30-35% by weight of total aggregate for paving units with

a thickness of 60mm or (ii) 20-25% by weight of total aggregate for paving units with a thickness of 80mm.

FRP (FIBER REINFORCED PLASTIC) MATERIAL

FRP (Fiber Reinforced Plastic) Material 24.216* All FRP material used including but not exclusively chequer plates, platforms, handrails and access covers shall comply with BS 476-21 for fire retardance of surface flame spread and ASTM D-365 for self-extinguishing equipment. FRP flooring/access covers complete with supports, if necessary, within the SPS shall be designed to withstand the most onerous requirements of imposed loading as defined by the SPS loading key plan drawing, the current Code of Practice for Dead and Imposed Loads or a minimum uniform loading of not less than 5 kN/m². The deflection at the imposed loading shall not exceed 1/200 of the span, or 15mm whichever is the smaller.

RECYCLED COMPOSITE TIMBER

Material Description 24.217* (1) Recycled composite wood shall be suitable for exteriors. The panels can be in solid/ hollow boards which are specially formulated for higher strength and superior moisture-resistant properties.

(2) Recycled composite wood should be with natural colour variation on the board surface and a motte embossed grain finish on the surface of both faces, so as to give the best timber-like appearance after installation.

Physical Properties 24.218* (1) Recycled composite wood shall be of an extruded blend of wood and recycled plastic so as to have excellent water resistance. Moisture absorption (full submersion) should be less than 1% in 7 days.

(2) Termite Resistance: recycled composite wood shall have high degree of termite resistance tested by CSIRO (The Commonwealth Scientific and Industrial Research Organisation) or equivalent, particularly towards the attack by important species of subterranean termites, Mastotermes darwinensis and Coptotermes acinaciformis. The composite wood shall be tested by CSIRO or equivalent.

(3) Fire Rating: recycled composite wood shall be tested by CSIRO or equivalent for ignitability, flame propagation and Smoke Developed.

(4) Weathering characteristic: composite wood shall be pre-coloured during the manufacturing process with extremely light-fast pigments. During first couple of months' exposure to weather, the colour of the product will lighten somewhat, before stabilizing to a more natural timer-like appearance that needs no painting or staining.

(5) Standard Size and colours: recycled composite wood shall be available at least in 4 standard colour:-

(i) Dark brown, Brown, Light Brown and Silver Grey.

VERTICAL ROLLER SHUTTER

Vertical folding Shutter doors 24.219* (1) Vertical roller shutter doors shall be made of stainless steel. No part of the fixings shall obstruct the clear opening and the door shall be capable of being

bolted from the inside only.

(2) The shutter door, guides and housing steelwork shall be sheradised or stainless. The sheradised or stainless surfaces shall be abraded before priming with an accepted epoxy resin based primer and then painted with one coat of undercoat before delivery.

GREEN TRELLIS SYSTEM

Materials 24.220* (1) All stainless steel materials Grade: 1.4401 / AISI 316 (Din EN 12385 /Din EN 10264) with manufacturer EN Test Report.

(2) A minimum breaking load (9.1kN) of S.S AISI 316 / 1.4401.

(3) Highly acid-resistant vertical 4mm Wire (6 x 7 +WC), Both end S.S AISI 316 Turnbuckle with external thread LT2 for on-site assembly / Patent / DBGM / Pending, the other end turnbuckle with greenguide eye LT2 or equivalent for on-site assembly / with no less than 90% of minimum rope breaking load and support by S.S AISI 316 cover disk with internal thread diameter 50mm M8.

(4) Fixing accessories shall be S.S 316 /1.4401, Dome nut M8, Hexagon nut M8 and screw thread R, M8.

EPOXY FLOORING

Material 24.221* Finishes material shall be as follows:

(1) Proprietary non-slip, non-abrasive, heavy duty burn-resistant epoxy resin.

(2) Flooring system shall be designed for compliance with OSHA requirements: 40-60 mesh fine quartz texture for light anti-slip finish in pedestrian traffic areas

(3) Epoxy composition flooring system shall be a resin rich composite consisting of

(a) Low viscosity clear epoxy primer, for maximum bond potential and

(b) 100% solids epoxy mortar underlayment for cracked, spalled or depressed area patching; for sloping & pitching to drains; for forming cove bases; for sealing around drains 100% solids resin rich epoxy mortar matrix layer with high polymer to aggregate ratio for thickness and texture.

(c) Two 100% solids topcoats for final seal and texture.

(4) Sealer (Primer) shall be minimum 10 mils thickness, used for penetration into concrete to bond subsequent layer, to prevent dusting, or to prevent vapour transmission.

(5) Epoxy mortar underlayment shall be at a minimum 120 mils thickness for use as a thin layer of self-leveling protective surfacing.

(6) Topping: minimum 120 mils thick (for two topcoat layers) epoxy coating with fine anti-slip aggregate broadcast as a top coat in a composition flooring

system.

GLASS BLOCKS

Glass blocks 24.222* (1) Glass blocks shall be installed directly into concrete structure and supported on four sides by anchorage into the recesses at the concrete structure with cement mortar. The recess should be 65 mm wide and 40 mm deep with all faces of joint pointed with nonhardening compound to exclude moisture.

(2) Towards the concrete structure at the top and the sides, slip joints and expansion joints are to be provided. The expansion joint shall be kept free of mortar spilling and filled with a non-hardening compound or fibreglass. On the outside, the expansion joints are to be sealed with joint sealant to prevent moisture from penetrating. Expansion joint is also provided in long panels at spacing of 4 m to 6 m.

(3) Cement mortar shall be one part of Portland Cement and 3 parts of sand by volume. Grain size of sand shall not exceed 3 mm. Hydrated lime may be added to improve plasticity, but the amount should not exceed 20% of cement by weight. White cement mortar shall be used for finishing joints between glass blocks.

ALUMINIUM FINS, FRAMING MEMBERS AND TRIMS

Aluminium, framing members and trims 24.223* (1) The aluminium fins and associated framing members and trims comply with the following minimum requirements:

- Standards: Generally BS 8118
- Aluminium framing members and trims shall be extruded aluminium grade 6063-T5, 6063-T6.
- Stricter tolerances shall be maintained where required for proper fit of components (both visually and functionally), including interlocking shapes, glazing gaskets and glass.
- Aluminium bracketaries shall be extruded aluminium grade 6063-T5, 6063-T6 or 6061-T6.
- All extruded aluminium shall be the manufactured and painted by one company.
- All sections shall be formed true to detail and free from defects, impairing appearance, strength or durability.
- Provide 3.0mm minimum nominal thickness for structural members and 2mm minimum for non-load-bearing and nonstructural trims. Aluminium thickness must be designed to meet the performance specified in lieu of the minimum thickness shown.
- Mill finish aluminium shall not be allowed in the contract.
- All surfaces of aluminium extrusions and cladding panels exposed to exterior shall be finished with PVF2-3 coat metallic system.

- Composite aluminium panels shall not be used.

MATERIALS / FINISHES / TESTING

Lift Shafts 24.224*

(1) The architectural finishes of the lift shafts shall consist of the following:

(i) Laminated tempered glass;

(ii) Fixing bolts and sockets, corrosions-resistant stainless steel fasteners complying with BS EN ISO 3506-1:2009 and BS EN ISO 3506-2:2009;

(iii) Back-up strips, gaskets and spacers, silicone rubber compatible with the silicone sealant employed;

(iv) Structural sealants and weather seals, silicone sealants complying Section 24.236* and 24.237*;

(v) Structural steel brackets; and

(vi) Weather proof louvres.

Aluminium cladding 24.225*

(1) Thickness shall not be less than 3mm with stiffeners wherever needed. Exact thickness shall be as required for both structural and visual considerations.

(2) Sheet alloy shall be 3003-H14 or 5005-H34 for painted finishes.

Aluminium extrusions 24.226*

(1) To comply with BS 8118.

(2) Aluminium framing members and trims shall be extruded aluminium grade 6063T5, 6063-T6, 6061-T6 or similar.

(3) All extruded aluminium shall be the manufactured and painted by one company.

(4) All sections shall be formed true to detail and free from defects, impairing appearance, strength or durability.

(5) Provide 3.0mm minimum nominal thickness for structural members and 1.5mm minimum for non-load-bearing and non structural trims. Aluminium thickness must be designed to meet the performance specified in lieu of the minimum thickness shown.

Coated aluminium surface 24.227*

All exposed surfaces of aluminium extrusions and cladding panels shall be finished with a coat metallic system. Custom colour finish selected for durability, colour fastness and resistance to damage. The formulation shall have at least 70% resin in the residual solids.

Stainless steel 24.228*

(1) Stainless steel in plate, sheet and strip shall comply with BS EN 10029, BS EN 10048, BS EN 10051+A1, BS EN 10095, BS EN ISO 9445 and BS EN 10088 as appropriate.

(2) Unless noted otherwise, grade 1.4436 to relevant BS EN standard shall be used for wet zone.

Fixings and fasteners 24.229*

(1) Fixings and fasteners shall comply with BS EN ISO 3506-1 and BS EN ISO 3506-2. Unless noted otherwise, grade A4 shall be used for exposed fasteners.

(2) The fastener property class shall be selected so as to meet the performance criteria specified herein.

Welding consumables 24.230*

Welding consumables shall comply with BS EN 12072 and/or BS EN 1600 as appropriate.

Articulated glass fixing 24.231*

(1) It shall be a proprietary product; model type, size and finish.

(2) The articulated glass fixings shall have sufficient rotation capacity to allow for the anticipated rotations under the ultimate load case. The glass fixing shall be manufactured with grade 1.4436 stainless steel with finishes.

Chemical Composition for steel casting 24.232*

The chemical composition is to be established as required by BS 3100.

Gutter 24.233*

All gutters shall be made of grade 1.4436 to relevant BS EN standard stainless steel with a minimum thickness of 2mm or 3003/5005 aluminium with a minimum thickness of 3mm. Construction joints shall be made up with sleeve of the same material and thickness, mechanically fixed to the underside of the gutter, with a lap joint filled with silicone sealant of 150mm in length on each end, or continuously butt welded.

Laminated tempered Glass 24.234*

(1) Laminated tempered glass shall conform to ANSI Z97.1-2009, BS 952, BS 6206, CP152 and ASTM C 1172-09e1.

(2) Laminated tempered glass shall be heat soaked and coated with a pyrolitic or vacuum deposition low emissivity (Low-E) coating and conform to the requirements of ASTM C1376 - 10 as a minimum.

Polycarbonate Panels 24.235*

(1) Polycarbonate panels shall be coextruded (i.e. fusion), with weather protection on both sides against UV radiation from sunlight and for avoidance of coating failure.

(2) The polycarbonate panels shall possess the following properties.

(i) Light transmittance of at least;

80% for clear panel

55% of coloured panel

40% for translucent panel.

(ii) Impact strength as Class A complying with BS 6206;

(iii) Tensile strength of at least 55 N/mm^2;

(iv) Modulus of elasticity of at least 2100 N/mm^2;

(v) Fire retardant property complying with the requirements in EN 1794-2 Annex A Class 2;

(vi) Fire spread property complying the requirements of Class 1 or 2 Surface Spread of Flame under BS 476 Part 7.

Weather and air seals 24.236* (1) Non-structural sealants shall be:

(i) silicone (at exposed or concealed locations);

(ii) polyurethane (at completely concealed locations only); and

(2) Colour shall be custom.

(3) Non-structural sealants shall be compatible with structural silicones.

(4) Acrylic sealants are not acceptable for frame seals or smoke flashings.

Structural Silicone Sealants 24.237* Only two-part silicone shall be used for factory installed structural sealant and the colour shall be in light grey. Structural sealants shall be compatible and fit for their purposes.

Primer 24.238* Primers shall be the same brand manufacture as the sealants used and shall be compatible with the substrate and all adjacent Materials.

Back-up material 24.239* (1) Use of double sided tape shall be silicone compatible, non-gassing or staining. Tapes shall facilitate silicone glazing but under no circumstances be used to permanently restrain glazing, transfer loads or to act as a weather seal.

(2) Sealant back-up materials shall be jacketed, non-gassing, close cell backer rods.

(3) Custom designed shapes of compatible foam tapes shall be used when required for glass pocket shape.

Gaskets and spacer 24.240* (1) All gaskets/dry weather seals shall be polychloroprene (neoprene) or similar, except where used in contact with a silicone sealant. Where in contact with silicone sealants, all gaskets and spacers shall be preformed heat cured silicone rubber, chemically compatible with the silicone sealant and suitable for the specific purpose intended. All gaskets/weather seals/spacers shall have continuous mechanical engagement to framing members; adhesive attachment is not acceptable.

(2) Sponge gaskets/weather seals/spacers shall be extruded black neoprene or silicone rubber with a hardness of 40 + 5 durometer Shore A and conform to ASTM C509 (for neoprene) and shall be compressed 20-35% when in the installed position. Interior and exterior gasket profiles shall be designed to produce a glass edge pressure of not less than 182N, nor more than 450N per 25.4mm.

(3) Wedge gaskets shall have a hardness of 75 ±5 durometer Shore A for hollow profiles and 60 ±5 for solid profiles. The design of these gaskets must prevent “roll out” or dislocation under all performance requirements.

Setting blocks for 24.241* (1) Setting blocks shall be dense heat cured Silicone rubber (when in contact

glazing

with Silicone sealant) or Neoprene (when not in contact with Silicone sealant) with a Shore A hardness of 80-90 durometer.

(2) Side blocks shall be dense heat cured Silicone rubber (when in contact with Silicone sealant) or Neoprene (when not in contact with Silicone sealant) with a Shore A hardness of 60-70 durometer.

(3) The Material shall not contain any compounds that can leach out over time and cause staining.

Weather proof louvres 24.242* Louvres shall consist of stainless steel frames and blades to Grade 1.4436. Frame corners and blade ends shall be welded or fastened with 300 series stainless steel screws. Provide concealed extruded stainless steel stiffeners for blades, such that vector sum of blade deflections parallel to blade principal axes does not exceed 1/175 times span at design pressure. Assume that pressure acts perpendicular to the plane formed by the corners of the perimeter frame, and that the tributary area for one blade equals its projected area on the same plane.

STANDARD AND CODES

Aluminum, Steelwork and Stainless Steel 24.243*

BS 729	Specification for Hot-Dip Galvanised Coatings on Iron and Steel Articles
BS 1449.2	Specification for Stainless and Heat-Resisting Steel Plate, Sheet, Strip
BS 1474	Specification for wrought aluminium and aluminium alloys for general engineering purposes; bars, extruded round tubes and sections
BS 1706	Method for specifying electroplated coatings of zinc and cadmium on iron and steel AMD 6731, May 1991 (Gr O).
BS 2569	Specifiations for sprayed metal coatings
BS 2994	Specification for Cold Rolled Steel Sections
BS 4190	Specification for ISO metric black hexagon bolts, screws and nuts.
BS 4848	Hot Rolled Structural Steel Sections
BS 5950	Structural Steel Sections
BS 5950.5	Code of Practice for Design of Cold-Formed Steel Sections
BS 6105	Specification for Corrosion Resistant Stainless Steel Fasteners
BS 6338	Specifications for chromate conversion coatings on electroplated zinc and cadmium coatings.
BS 7613	Specification for hot rolled quenched and tempered weldable structural steel plates
BS 7668	Specification for weldable structural steels. Hot finished structural hollow sections in weather resistant steel
BS 8118	The Structural Use of Aluminium
BS EN 485	Aluminium and Aluminium Alloys. Sheet strip and plate
BS EN 515	Aluminium and aluminium alloys. Wrought products. Temper designations
BS EN 573	Aluminium and Aluminium Alloys. Chemical composition and form of wrought products

		BS EN 22063	Metallic and other inorganic coatings. Thermal spraying. Zinc, aluminium and other alloys
Glazing and caulking	24.244*	CP 153	Code of Practice for Windows and Roof Lights
		BS 952	Glass for Glazing
		BS 4254	Specification for two-part polysulphide based sealants.
		BS 4255	Rubber used in preformed gaskets for weather exclusion from buildings.
		BS 4255.1	Specification for non-cellular gaskets.
		BS 5215	Specification for one-part gun grade polysulphide based sealants.
		BS 5713	Specification for Hermetically sealed flat double glazing units
		BS 5889	Silicone Seals
		BS 6262	Code of Practice for Glazing of Buildings
		BS 6375	Performance of Windows
		BS EN 572	Glass in Building- basic soda lime silicate glass products
		BS EN 1096	Glass in Building- coated glass
		BS EN 1863	Glass in Building- heat strengthened soda lime silicate glass
		BS EN 12150	Glass in Building- thermally toughened soda lime silicate safety glass
		BS EN 29046	Building Construction Sealants – Determination of adhesion/cohesion properties at constant temperature
		BS EN ISO 12543	Laminated glass and laminated safety glass
		ASTM C509	Specification for Cellular Elastomeric Preformed Gasket and Sealing Material
		ASTM C864	Specification for dense elastomeric compression seal gaskets, setting locks and spacers
		ASTM C864	Specification for dense elastomeric compression seal gaskets, setting locks and spacers
		ASTM C1036	Standard Specification for Flat Glass
		ASTM C1048	Standard Specification for Heat Treated Flat Glass
		ASTM	Standard Specification for Laminated Architectural

C1172	Flat Glass
19/GP-18M	Sealing compound elastomeric type, multicomponent. (Canadian Government Specification Board)
TT-S-0229E	Sealing compound elastomeric type, multicomponent. (US Federal Interim Specification Board)
AS 1288	Glass in Buildings – Selection and installation

PART 11: MANUFACTURERED SAND

GEOMETRICAL REQUIREMENTS

Aggregate Size 24.245* Manufactured sand for cement mortar is limited to fine aggregates with an upper sieve size of not larger than 5.0 mm. Coarse aggregates shall not be used. Depending on the thickness of mortar application and the surface finish wanted, the upper sieve size of the aggregates may be selected between 5.0 mm and 2.36 mm.

Grading 24.246* The grading of manufactured sand i.e. C (coarse graded), M (medium graded) or F (fine graded) as determined in accordance with Section 10 of CS3:2013, shall be declared and documented by the manufactured sad producer or supplier. This grading shall comply with both the overall limits and the limits for the declared grading given in Tables 1 and 2 below for fine aggregates of size 0/5.l0 mm and 0/2.36 mm, respectively. In addition, not more than one in ten consecutive samples shall have a grading outside the limits for the declared grading.

Table 1 – Grading test of manufactured sand of size 0/5.0 mm.

Sieve size	Percentage by mass passing test sieves (%)			
	Overall limits	Limits for declared grading		
		C	M	F
10 mm	100	-	-	-
5 mm	89-100	-	-	-
2.36 mm	60-100	60-100	65-100	80-100
1.18mm	30-100	30-90	45-100	70-100
600 µm	15-100	15-54	25-80	55-100
300 µm	5-70	5-40	5-48	5-70
150 v	0-20	-	-	-

Table 2 – Grading test of manufactured sad of size 0/2.36 mm

Sieve size	Percentage by mass passing test sieves (%)			
	Overall limits	Limits for declared grading		
		C	M	F
5 mm	100	-	-	-
2.36 mm	89-100	-	-	-
1.18mm	60-100	60-100	65-100	80-100
600 µm	30-100	30-90	45-100	70-100
300 µm	15-100	15-54	25-80	55-100
150 µm	5-70	5-40	5-48	5-70
75 µm	0-14	-	-	-

(ii) Manufactured sand for cement mortar not incorporating lime shall conform to the grading limits set out in Table 1, whilst manufactured sad for cement mortar incorporating lime shall conform to the grading limits set out in Table 2. Lime shall be hydrated lime to BS EN 459-1, delivered in sealed bags bearing the manufacturer's name or brand.

(iii) Manufactured sand of grading C (coarse graded) shall not be used unless prior approval from the Supervising Officer is obtained.

Fines Content 24.247* The amount of material passing the 7.5 μm test sieve as determined in accordance with Section 10 of CS3:2013, shall not exceed the quantities given in Table 3.

Table 3 – Limit for fines content

Fines content class	Maximum percentage by mass passing 75 μm test sieve (%)
F5	5

Foreign Materials Content 24.248* The maximum content of foreign materials in the manufactured sad as determined by manual sorting in accordance with BR Digest 433, shall not exceed the quantities given in Table 4.

Table 4 – Limits for foreign materials in the manufactured sad

Type of foreign materials	Maximum percentage by mass (%)
Wood and other material less dense than water	0.5
Other foreign materials (e.g. shell, metals, plastics, clay lumps, asphalt and tar etc.)	1.0

Angularity 24.249* The shape of manufactured sad shall be sub-angular, sub-rounded or rounded. Angular manufactured sad is unacceptable.

PHYSICAL REQUIREMENTS

Particle Density 24.250* The oven-dried particle density of manufactured sad as determined in accordance with Section 17 of CS3:2013, shall not be less than 2,000 kg/m^3.

Durability 24.251* (i) Drying Shrinkage

The drying shrinkage of the manufactured sand as determined in accordance with Section 20 of CS3:2013, shall not exceed 0.075%

(ii) Alkali-silica Reactivity

(a) The linear expansion of mortar-bars immersed in NaOH solution at elevated temperature as determined in accordance with Section 22 of CS1:2013, shall be evaluated using Equation 22-1 of CS1:2010. The potential alkali-reactivity of manufactured sad can then be obtained from Table 10 of CS1:2010.

(b) Alternatively, the concrete prism test in accordance with Section 23 of CS1 may also be used and the potential alkali-reactivity of manufactured sad can then be obtained from Table 13 of CS1:2010.

(c) Manufactured sands fall into the alkali "Reactive" category shall not be used unless prior approval of the Supervising Officer is obtained.

CHEMICAL REQUIREMENTS

Chlorides 24.252* (i) Water Soluble Chloride Ion Content

The water-soluble chloride ion content of natural aggregates of manufactured sand shall be determined in accordance with Clause 21.3 of Section 21 of CS3:2013.

(ii) Acid-Soluble Chloride Ion Content

The acid-soluble chloride ion content of recycled aggregates of manufactured sand shall be determined in accordance with Clause 21.4 of Section 21 of CS3:2013.

Sulphur Containing Compounds 24.253* (i) Acid-Soluble Sulphate Content

(a) The acid-soluble sulphate content of natural aggregates of manufactured sand as determined in accordance with Clause 21.5 of Section 21 of CS3:2013, shall not exceed 0.8% by mass.

(b) The acid-soluble sulphate content of recycled aggregates of manufactured sand as determined in accordance with Clause 21.5 of Section 21 of CS3: 2013, shall not exceed 1.0% by mass.

(ii) Total Sulphur Content

The total sulphur content of the natural aggregate of manufactured sand, when determined in accordance with Clause 21.6 of Section 21 of CS3:2013, shall not exceed 1.0% by mass.

Other Constituents 24.254* (i) Manufactured sand shall be clean and free of organic substances. The manufactured sad producers or supplier shall demonstrate that the supplied manufactured sad is clean and free of organic substances or alternatively the presence of organic substances does not affect the stiffening or hardening of mortar.

(ii) The presence of organic substances in the form of humus shall be determined in accordance with Clause 21.7 of Section 21 of CSS:2013. Where the test result under Clause 21.7 is negative, the manufactured sand shall be considered to be free of organic substances. Otherwise, the manufactured sand shall be further tested in accordance with Section 22 of CS3:2013 to assess the effect of organic substances on the stiffening time and compressive strength of mortar. The organic substances shall be of such proportion that:

(a) the stiffening time of mortar test specimens does not increase by more than 120 minutes; and

(b) The 28-day compressive strength of mortar test specimens does not

decrease by more than 20%.

PART 12: GLAZING SYSTEM

General 24.255* (1) The glazing system shall comprise:-

(i) Glass: minimum 25mm thick laminated tempered glass capable of withstanding the loads, and complying with Clause 24.250* to Clause 24.252*;

(ii) Structural sealants and weather seals: Silicone sealants complying with Clause 24.253*;

(iii) Back-up strips, gaskets, and spacers: Silicone rubber compatible with the silicone sealant employed;

(iv) Fixing bolts and sockets: Corrosions-resistant stainless steel fasteners complying with BS EN ISO 3506-1:2009 and BSEN ISO 3506-2:2009; and

(v) Steel brackets.

Laminated Tempered Glass 24.256* (1) All glass panels shall be laminated tempered glass complying with the requirements of both laminated glass and tempered glass as shown in Clause 24.251* and Clause 24.252* respectively.

(2) All edges of the glass shall be ground and have a frosted appearance unless otherwise stated.

(3) All edgework, holes and notches in the fully tempered laminated glass shall be completed before toughening and shall comply with the requirements of the manufacturer's toughened glass specification.

(4) Scratches, bubbles, inclusions, smoke wanes, air holes, white surface scars and other defects shall not be permitted in glass.

(5) Each glazing unit shall be clearly identified with a label stating the glass type. Labels shall not be removed until the completion of the lift enclosure Works.

(6) Glazing system shall impose even pressure on external gaskets to avoid localized edge deflection of glass.

(7) Translucent glass is considered as having a coloured sheet or gel as part of the interlayer makeup that provides a reduction in transparency for laminated tempered glass. It will be used in lift door and lift car.

Laminated Glass 24.257* (1) Laminated glass shall be an approved proprietary product comprising of two or more sheets of glass bonded together and incorporating a plastic interlayer, or other method of bonding, to ensure the performance specified.

(2) All laminated glass should comply with AS2208 and FGMA Glazing Manual.

(3) The interlayer of laminated glass shall be polyvinylbutyral (PVB) interlayer with minimum thickness not less than 1.5mm. The interlayer shall not be deteriorated or discoloured by any other glazing materials.

(4) Glass must conform to ASTM C 1172 as a minimum and is considered a safety glass if it has been tested to BS 6206 and is in conformance with the categories A, B or C of this standard.

(5) Other national standards that are equivalent to BS 6206 are also acceptable but must be submitted and accepted before the glass can be considered as a safety glass.

(6) Where non-pyrolitic Low-E coatings on laminated glass are used, edge deletion of the coating is necessary unless specifically stated as not being required by the glass manufacturer.

(7) The addition of an applied adhesive film, either to the external face or the internal face will not be considered as, and does not constitute, an upgrading of the glass from that originally supplied.

(8) All laminated glass shall have clean cut edges, or polished edges if required to eliminate thermal stress breakage risk.

(9) Silicone sealant shall not contact the interlayer of any laminated glass. Joints shall be drained to prevent water ponding against interlayer.

Tempered Glass 24.258* (1) Tempered glass shall comply with BS 952 or ASTM C 1048 and possess the following properties:

(a) Breaking strength of at least 110N/mm^2.

(b) Visible light transmittance of at least 70%.

(c) Solar transmittance of 30% to 45%.

(d) Stone impact resistance complying with the requirements in BS EN 1794-1 Annex C.

(e) Impact strength as Class A complying with BS 6206 “Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings”.

(f) Static load resistance complying with requirements as stated in Clause 39.08.

(2) The glass shall be of accurate size, with clean undamaged edges. Glass for flush glazing shall have the edges machined to produce a smooth edge. Unframed edges shall be ground to a straight uniform radiused profile. The surface shall be free of distortion and tong marks.

(3) Tinted glass shall be body tinted to the colour and intensity specified.

(4) Tempered glass shall be ultra-violet light resistant. The glass shall not reflect light in such a way as to prejudice road safety or produce undesirable glaring effects. It shall not form sharp and harmful pieces when shattered.

(5) Tempered glass shall be heat soaked to reduce the risk of damaging due to nickel sulphide. The process shall include, inter alia, an oven capable of taking the glass from room temperature up to and maintaining at a constant temperature between 260˚C and 290˚C for a minimum of two hours.

(6) Tempered glass shall be ultra-violet light resistant. The glass shall not reflect light in such a way as to prejudice road safety or produce undesirable glaring effects. It shall not form sharp and harmful pieces when shattered.

Silicone Sealants 24.259* Silicone sealants shall be one part, self priming, neutral cure sealants recommended by the manufacturer as appropriate for the prevailing service conditions. They shall be either low or medium modulus to suit the joint movement range. The tack-free time before initial surface set shall be sufficient to allow tooling and removal of masking tapes without detriment to either the adhesive bond or the finished surface.

PART 13: MISCELLANEOUS

CORRUGATED STEEL SHEETING

General Requirements 24.260* (1) The corrugated steel sheeting shall be proprietary product.

(2) The corrugated steel sheeting system shall comprise corrugated steel sheeting with zinc/aluminium alloy coating on exposed surfaces, sealing gaskets, clamping bars, fasteners, flashings, sealants, holding- down bolts, supporting frames, and any other accessories necessary for the proper functioning and completion of the entire corrugated steel sheeting system as shown on the Drawings and herein specified.

Materials 24.261* (1) The corrugated steel sheeting shall be of a proprietary product. The profile height shall not exceed 60 mm.

(2) All sealant shall be capable of withstanding all imposed stresses during assembly, transportation and installation, and provide an air and watertight seal in service.

(3) The steel sheeting and its coatings shall be suitable for using in Hong Kong climate without excessive deterioration or damage.

(4) The coating system for the corrugated steel sheeting shall be zinc/aluminium alloy coating, at least 200 g/m2 to AS1397-2011.

(5) The flashing shall be of the same steel and finish as the sheeting. The flashing shall be supplied by the same manufacturer. Suitable junction pieces shall be devised for all corners and changes of gradient. Specially fabricated pieces are required at all junctions of footbridge with the adjoining structures.

(6) All components of the system including purlins, fasteners, gaskets, washers, fixing clips and filler blocks shall be protected from corrosion by coating system compatible with that of the structure. The heads of the screw and rivet shall be protected by plastic caps of matching colour.

(7) The fasteners shall be supplied by the same manufacturer. The fasteners shall be of stainless steel with strength grade A4-70 to the requirements of BS EN ISO 3506. The fasteners shall be self-drilling and tapping screws, supplied with colour caps to match the colour of the sheeting. The caps shall be manufactured from ultra-violet resistant material to retain colour.

(8) The flashing shall be capable of being neatly lapped end to end. The fixing arrangement shall be neat and not obstructive. The fasteners shall be positioned inconspicuously in the valleys.

(9) The size of corrugated steel sheeting shall be ordered to suit the required dimensions.

(10) Filler blocks that are used to seal cavities formed between the profiled sheeting and supports or flashing shall be supplied by the same manufacturer. The filler block shall be manufactured from materials which are weather resistant.

Anchorage System and Supporting Frame

24.262* The corrugated steel sheeting shall be fixed with fasteners and supporting frames to the steel structures. The supporting frames shall be painted with colours shown on the Drawings.

All steel (except stainless steel) supporting frames, structure and fixings shall be galvanised to BS EN ISO 1461 or equivalent.

Lock washer or other locking device shall be provided at all bolted connections.

Where the possibility of galvanic corrosion exists, all dissimilar metals shall be isolated with zinc coating or other accepted material.

LOUVRES

General Requirements

24.263* (1) The louvres shall comprise stainless steel bank lourve clamping bars, fasteners, flashings, sealants, holding down bolts, supporting frames, and any other accessories necessary for the proper functioning and completion of the entire louvres as shown on the Drawings and herein specified.

(2) Louvres shall consist of stainless steel frames and blades to Grade 1.4436. Frame corners and blade ends shall be welded or fastened with 300 series stainless steel screws. Provide concealed extruded stainless steel stiffeners for blades, such that vector sum of blade deflections parallel to blade principal axes does not exceed 1/175 times span at design pressure. Assume that pressure acts perpendicular to the plane formed by the corners of the perimeter frame, and that the tributary area for one blade equals its projected area on the same plane.

(3) Louvres in external walls are to comply with the water resistance requirements of AMCA 500 or EN 13030:2001. Coordinate free area of louvres with mechanical requirements. Louvres and their components shall be moisture resistant at maximum relative atmospheric humidity of 100% and shall be 100% dimensionally stable with regard to moisture, heat and cold. Louvres shall be free of visual discontinuities and defects such as: ripples, oil-canning, creases, dents, bubbles and blisters, variation in colour and gloss, etc. regardless of the measured deviation from flatness of the panels.

(4) Triple bank louvre shall achieve the weathering classification to BS EN 13030:2001: Class A3 – up to 3.5 m/s suction velocity and the minimum aerodynamic coefficient to EN 13030:2001 air-inlet 0.25 and air-extract 0.20. Maximum thickness of the triple bank louvre is 220mm.

(5) Single bank louvre for aesthetic compatibility as specified on the Drawings shall achieve the weathering classification to BS EN 13030:2001: Class D1. The single bank louvre for aesthetic compatibility proposed shall bear the same or similar appearance as the triple bank louvre proposed. Thickness of the single bank louvre for aesthetic compatibility proposed shall be compatible with the triple bank louvre proposed.

(6) For Louvre for lift pit ventilation opening in subway case which is not exposed outdoor, the louvre shall achieve the weathering classification to BS EN 13030:2001: Class D1.

All components and fixings of the louvre system shall be designed to withstand wind loadings according to Code of Practice on Wind Effects Hong Kong 2004.

Adjustable and fixed steel louvres and frames 24.264*

(1) Adjustable metal louvre frames and weatherstrips shall be obtained from an accepted supplier and constructed in accordance with the following:

(a) Frames and clips shall be of 1.2 and 0.9 mm (minimum) stainless steel sheet respectively. Clips shall be suitable for receiving 100, 150 or 230 mm wide and 6 mm thick glass blades, as required. GMS frames and stainless or plastic clips may be supplied subject to acceptance.

(b) Frames shall be designed for hand or pole operation, as required, with single control and to automatically lock when closed.

(c) Weatherstrips shall be shaped metal strips of an accepted design and thickness.

(d) GMS frames, clips and weatherstrips shall be treated on all surfaces prior to assembly.

(e) Where specified, provide 45 x 10 mm GMS steel sub-frames for single side louvre frames, with necessary slotted adjustable lugs and screws for building in.

(f) Provide matching stainless screws, bolts and spacers etc. for coupling adjacent frames to form mullions, where required.

(2) Fix adjustable GMS louvre frames as follows:

(a) Avoid distortion during handling and storage;

(b) Position plumb, level and square;

(c) Where required, form pockets to receive fixing lugs, build in lugs and screw to sub-frames or plug and screw sub-frames using packing pieces where necessary.

(d) Bed sub-frames in mortar as used for adjacent work, leaving no gaps.

(e) Where required, screw single side louvre frames to sub-frames at 225

mm centres. Do not distort frames when tightening fixings.

(f) Where required, plug and screw louvre frames and weather strips.

SLIP-RESISTANT CONFORMABLE TAPES AND THREADS ON METAL SURFACE

Slip-resistant Conformable Tapes and Threads 24.265*

(1) Slip-resistant conformable tapes and threads shall be mineral coated, high friction slip-resistant surface. Aluminium backing shall be provided to conform to corners, curves and irregular surfaces. The tapes and threads shall be aggressive, high performance adhesive forms an excellent bond for a secure hold.

(2) The maximum service temperature shall be at least 79 Celsius Degree.

(3) The coefficient of friction shall meet USA Military Specification MIL-PRF-24667 C.

(4) The fire retardancy shall be stated as follows:-

i. NFPA101 Type I
ii. GSA classification Class A
iii. FAA 25.855-F-1 Passes
iv. FAA 25.853-F-1 Passes

GLASS REINFORCED PLASTIC (GRP) ROOFING

General Requirements 24.266*

The GRP roofing system shall comprise GRP roofing, sealing gaskets, clamping bars, fasteners, flashings, sealants, holding-down bolts, supporting frames, and any other accessories necessary for the proper functioning and completion of the entire GRP roofing system.

Materials 24.267*

The GRP roofing shall be fabricated by GRP units custom-made to the form and shapes as specified in the Drawings meeting the following requirements,

(1) The GRP units shall have a minimum fiber glass content of 65% by weight, suitable for using in Hong Kong climate between 0˚C and 40˚C and inert to hostile environments without excessive deterioration or damage.

(2) The GRP units shall be UV resistant with integral UV inhibitors in the resin and a synthetic surfacing veil to help producing a resin rich surface. The GRP unit shall have 2000 hours UV resistance when tested in accordance with ASTM G53 accelerated weathering tests with no loss of gloss and no change in colour.

(3) The GRP shall be integrally pigmented within the GRP component and coloured.

(4) All sealant shall be capable of withstanding all imposed stresses during assembly, transportation and installation, and provide an air and watertight seal in service.

(5) The flashing shall be supplied by the same manufacturer manufactured in individual pieces to suit shipping constraints. Suitable junction pieces shall

be devised for all corners and changes of gradient. Specially fabricated pieces are required at all connections with adjoining structures.

(6) All components of the system including purlins, fasteners, gaskets, washers, fixing clips and filler blocks shall be of matching colour.

(7) The fasteners shall be supplied by the same manufacturer.

(8) The flashing shall be capable of being neatly lapped end to end. The fixing arrangement shall be neat and not obstructive. The fasteners shall be positioned inconspicuously in the valleys.

(9) Filler blocks that are used to seal cavities formed between the components and supports or flashing shall be supplied by the same manufacturer. The filler block shall be manufactured from materials which are weather resistant.

(10) The flexural strength/ tensile strength/ compressive strength of the GRP components shall not be less than 200N/mm2 when tested in accordance with ASTM D760, D638 and D695 respectively.

(11) The GRP components shall be fire retardant with a tested flame spread rating of 25 or less as per ASTM E-84 Tunnel Test.

(12) Finished surfaces of the GRP components shall be smooth, non-skid, resin-rich, free of voids and without dry spots, cracks, or unreinforced areas. The GRP units shall be well covered with resin to protect against their exposure due to wear or weathering.

ALUMINIUM CLADDING SYSTEM

Aluminium Cladding Panels 24.268*

(1) The aluminium cladding panels shall be of aluminium sheets with a minimum thickness of 4 mm complying with BS 4868 with aluminium substrate complying with BS EN 485, BS EN 515 and BS EN 573, designation 3003-H14.

(2) Aluminium composite panels comprising a polyurethane core sandwiched between two skins of aluminium alloy is also acceptable. In such case, the minimum thickness of the composite panels shall be 4 mm, and the minimum thickness of each aluminium skin shall be 0.5 mm.

(3) The external cladding panel surface shall be factory pre-finished by the manufacturer with PVDF (Fluorocarbon) coating applied through a “Reverse Roller Coating” process or other approved process producing comparable finishing quality. Total dry-film thickness of the coating shall be 55 microns minimum consisting of a chromate conversation coating, an inhibitive primer and a clear UV-absorbing top coat. The coated surface shall comply strictly with the “Specification for coated coil for exterior building applications” issued by ECCA (European Coil Coating Association) to achieve The Quality Label Category 1. The finished surface shall be factory protected with a self-adhesive peel off foil, tested to withstand at least 6 months exposure to local weather condition without losing the original peel off characteristics or causing stains or other damages.

(4) Opening shall be allowed in the cladding panels at the required location for installation of lighting fixture.

(5) All exposed edges and corners of the aluminium cladding panels shall be formed by a smooth aluminium sheet of the thickness specified and shall be finished with the same type of coating as the aluminium cladding system. Exposed sandwich core or cut edges of aluminium sheets will not be accepted.

(6) Joints between aluminium cladding panels shall be applied with "G.E. Silpurf" or "Dow Corning 795" sealants or similar equivalent.

(7) All coatings, when cured, shall be visibly free of flow lines, streaks sags, blisters or other surface imperfections.

(8) All finishes shall match in gloss and fall within the colour range of the approved samples.

Anchorage System and Supporting Frame 24.269*

(1) The anchorage system comprises fasteners, holding down bolts and any other accessories necessary for fixing the supporting frames to the concrete/steel structures.

(2) The aluminium cladding panels shall be fixed with fasteners, supporting frames and anchorage system to the concrete/steel structures. Welding to the steel structures shall be prohibited unless otherwise accepted.

(3) Assembly fasteners shall be stainless steel of Grade A4-80 to BS EN ISO 3506.

(4) Supporting frame shall be hot-dip galvanized steel.

(5) Aluminium sub-frame, if adopted, shall be of aluminium alloy 6063-T6 to BS EN 573, BS EN 755 and BS EN 12020. The exposed surface shall be factory pre-finished with approved fluorocarbon coating system.

(6) Lock washer or other locking device shall be provided at all bolted connection.

(7) Where dissimilar metals are in contact with each other, all dissimilar metals shall be isolated with a membrane of PVC or other isolation materials.

FALL ARREST SYSTEM

System Components and Accessories 24.270*

(1) The system components shall include but not limited to the following items, reference shall be made to the manufacturer's recommendation for the schedule of components:

(a) end anchor plate: Grade 1.4401 stainless steel, designed for mounting on steel standing post to provide direct attachment for tensioners, absorbers and pretension indicators;
(b) forked end: a swaged connection ensuring secure assembly of the cable, made of Grade 1.4401 stainless steel with breaking strength not less than 52kN;
(c) tensioner and tension indicator: Grade 1.4401 stainless steel of breaking strength not less than 52kN, with pre-set tension of minimum 0.8kN for minimum 8mm diameter cable;
(d) intermediate bracket: Grade 1.4401 stainless steel, withs crews and nuts of Grade A4-80 stainless steel for fixing on vertical or horizontal support with ultimate strength not less than 12kN;

(e) stainless steel cable: Grade 1.4401 stainless steel, minimum 8mm diameter with breaking strength not less than 40kN; and
(f) shuttle: Grade 1.4401 stainless steel, with breaking strength not less than 25kN for use on minimum 8mm diameter stainless steel cable.

(2) Personal protective equipment shall consist of:

(a) shuttle for anchorage to the fall arrest system cable;
(b) guided type fall arrester with high strength stainless steel rope of minimum 12mm diameter, with energy absorbing lanyard, and complying with BS EN 353-2; and
(c) all body harness in accordance with the manufacturer's recommendation which shall consist of shaller, thigh and sit straps with chest, waist or abdominal straps, and complying with BS EN 361. The thigh and sit straps shall be ideally positioned to improve comfort at reception in case of a fall.

PART 14: LANDSCAPE OPEN SPACE

CHILDREN PLAY EQUIPMENT, FITNESS AND SAFETY MATTING

General requirement 24.271* The works should fulfil the requirement as follow:

(a) The use zone surrounding the playground equipment, which shall consist of obstacle-free surfacing that conform to ASTM F1292 appropriate for the fall height of the installed playground equipment, shall extend for no less than 1.83m in all directions.

(b) Some of the play components shall be accessible by children with disabilities and complied with the American With Disabilities Act (ADA), or equivalent.

(c) The playground equipment shall meet the requirements of the US Consumer Product Safety Commission (CPSC), ASTM F1487, BS EN 1176 and the Americans with Disabilities Act (ADA).

(d) Acceptable materials for equipment:

1. Deck-perforated galvanized steel with PVC coating

2. Post-aluminum or galvanized steel with appropriate finish coating.

3. Vertical and horizontal climbers- galvanized steel with appropriate finish coating

4. Rails- galvanized steel with appropriate finish coating

5. Play panel – high density polythene

6. Slide – Polythene

7. Each post of equipment shall be a minimum of 125mm in diameter.

8. The Playground equipment should be ground fixed, excluding the spring riders.

Impact Absorbing Surfacing Material (IASM) or Safety Matting

24.272* (a) The Head injury Criteria (HIC) as per ASTM F1292 for safety matting shall not be less than the fall height of the playground, fitness and elderly fitness equipment.

(b) The impact absorbing material shall comply with the requirements of BS EN 1177 and BS 7188 or equivalent and reported are:

1.Critical height (of fall)

2.Durability

3.Slip resistance

4.Flammability

5.Resistance to abrasive wear

6.Resistance to indentation

7.Ease of ignition

The safety tiles shall be hardwearing: colorfast: weather and UV resistant, not be liable to delamination and not easily be vandalized

(c) Submission of test reports or certificates of matting sample: the test reports or certificates shall be valid for at least one year from the date of submission and issued by a laboratory accredited by the HOKLAS or its equivalent.

(d) Drainage system should be integrated under the safety matting.

(e) The thickness of safety matting should be 50mm for fitness area, and 110mm for children play area.

(f) Recessed type matting (flushed with adjacent paving) shall be used, unless otherwise accepted by the LCSD.

(g) Each proprietary IASM product shall carry a 5-year guarantee/warranty for workmanship and material performance over a normal lifespan without material loss of mechanical properties, impact attenuation performance, and against de-colouring, shrinkage (in any dimension), failure of adhesion to the base, lose of resilience, corrosion, distortion, etc., under normal operational conditions. Such guarantee/warranty for the proprietary IASM product on workmanship and material performance (inclusive of its prescribed Critical Fall Height) shall be provided by a recognized applicator and by the manufacturer respectively. The guarantee/warranty shall cover the rectification and/or replacement of any IASM that shows any of the above-mentioned defects within the guarantee/warranty period.

(h) Written confirmation is required from the manufacturer for the place of manufacturing of the IASM.

(i) The installation/application of IASM shall be accepted as complete only when it is laid and evenly surfaced. If during the warranty period, any joint between adjoining IASM is subsequently wider than 12mm or any point of the installed surface is higher than the mean level of the installed surface by 12mm due to expansion/shrinkage of tiles or whatsoever, or the tiles are reduced in thickness by 12mm or fail to adhere to the base, the concerned tiles are deemed to be non-compliant with these Specifications. The recognised applicator shall at his own cost replace the defective tiles within 14 days upon written notice served to him. It is taken that no gap exists between tiles when installed, and the mean level of the surface means the level at the centre of the tiles. In addition, any area installed/laid/tiled with the IASM showing any signs of cracking or splitting shall be replaced and rectified by the recognised applicator at his own cost within 14 days upon written notice served to him.

(j) The installation/application of IASM shall meet the requirements of BS7188: 1998+A2:2009 in regard of Resistance to Abrasive Wear, Tensile Properties, Ease of Ignition, Slip Resistance, Resistance to Indentation.

(k) The installation/application of IASM shall comply with "Specification for Impact Absorbing Surfacing Materials for Children's Playgrounds" (most recent version) published by the Architectural Services Department of the Hong Kong SAR Government.

Specifications for Elderly/Adult Fitness equipment and Children play equipment

24.273* (a) There shall be a use zone for each play structure which shall consist of obstacle-free surfacing that conforms to Specification F 1292 appropriate for the fall height of the equipment. The dimensions and configuration of the use zone shall be dependent upon the type of play equipment, as specified in b-f.

(b) Pieces of equipment may be free-standing structures, may be in combination with other play equipment, or may be part of a composite play structure

(c) The use zone for pieces of equipment shall extend no less than 72 in. (1830 mm) from all sides of the play structure.

(d) The use zones for two or more pieces of equipment that are not physically attached but are play-functionally linked shall be determined as if the separate equipment were parts of a composite play structure

(e) The use zones of two stationary pieces of equipment that are positioned adjacent to one another may overlap if the adjacent designated play surfaces of each structure are no more than 30 in. (760 mm) above the protective surface (that is, they may be located a minimum distance of 72 in. (1830 mm) apart. If adjacent designated play surfaces on either structure exceed a height of 30 in. (760 mm), the minimum distance between the structures should be 108 in.

(f) The use zone for equipment that rotates around a horizontal axis shall be no less than 72 in. (1830 mm) from the perimeter of the play structure.

(g) No other play structure use zone shall overlap the use zone of rotating play equipment.

COLORED CONCRETE

Colouring Admixture 24.274*

(1) The coloured concrete shall not use conventional concrete dye or pigment, but colour conditioning granules. It is a precision manufactured concrete admixture with stringently controlled properties. All the pigments must conform to BS EN 128 78:1999. The mix for the concrete shall be applied in accordance with the manufacturer's current technical data sheet and with reference to the specific health & safety information sheet.

(2) The colouring admixture shall be a single component, coloured, water-reducing admixture. It must be formulated and packaged in cubic metre increments, not multiple pigments and additives incorporated separately into the mix. It should be supplied in sealed water soluble bags that can be discharged directly into the mixer. The concrete colour mix is pre-weighed and blended, based on the required cement content of the concrete to which it will be added. Each unit is formulated to be added directly to the mixer truck or concrete plant. The concrete mix should be cured and sealed with a compatible sealing product as verified by the colourmix manufacturer.

STAMPED AND PATTERNED CONCRETE

Stamped and patterned concrete 24.275*

(a) Provide pre-formed mats or stamps and other required tools designed to achieve specific patterns and textures as indicated on drawings and to match approved samples.

(b) Release agent for textured patterns: Colored bond-breaking powder applied in two colors Placement:

(c) Prepare concrete mix and place in accord with all specifications herein.

(d) After final floating, apply colored release agents at a min. rate of 3 ½ lbs. per 100 sq. ft. of surface area. Additional material may be required depending on concrete and depth of impressions to be made.

(e) Imprint pattern or texture in surface in accord with pattern manufacturer's recommendations and to match approved samples.

(f) Poorly registered patterns or finishes with "flat-spot" that are void of the required texture will be considered deficient.

STONE WORKS

Materials and Workmanship 24.276*

(1) General

(a) Obtain stone from quarry with consistent colour range and texture throughout the work. The stone should be pre-sort to ensure consistent colour range.

(b) Provide stone of the kind, colour and finish matching approved

sample(s) for each area of use.

(c) Soundness, texture, graining, colour, tone, size, and frequency of voids shall match the approved sample.

(d) Stone shall be sound and free from clips, cracks, voids, stains and defects which would impair its strength, durability, or appearance.

(e) Provide each stone type from a single quarry sources to satisfy the total requirements.

(f) Type - as specified on drawings.

(2) Finishes

Sandblasted factory finish on all exposed edges and faces unless otherwise specified. Same finish to the exposed edges and face of the same piece of stone panels and tiles. Paved surfaces will be a combination of line chiselled and sand blasted and the cladding for planter walls sand blasted or as indicated on the detail drawings.

(3) Floor and Wall Sealer

Colourless, slip (for wall only) and stain resistant sealant shall be factory applied to all six (6) surfaces of stone in accordance to sealer manufacturers and stone supplier's recommendation. The sealant shall be compatible to the stone selected and will not affect the colour or physical properties of the stone.

(4) Sources of Stone

(a) All materials supplied for each type of stone specified, shall be sourced from one quarry

(b) The supplier shall supply the name and address of the quarries concerned for each type of stone specified.

(c) The blocks from the quarry shall be cut from a selected portion of the bed.

(5) Physical Characteristics of Stone Materials

. The physical properties obtained from a recognized independent laboratory required are listed below: -

(a) Compressive strength;

(b) Skid resistance test;

(c) Flexural strength (Ultimate tensile strength by bending);

(d) Shear strength;

(e) Coefficient of thermal expansion;

(f) Weight;

(g) Frictional wear test;

(h) Knoop microhardness

(i) Compressive strength (after freezing);

(j) Impact resistance test;

(k) Absorption (Inhibition Coefficient);

(l) Elasticity modulus; and

(m) Chemical resistance.

The material shall be suitable for the intended use in the environmental conditions prevalent in Hong Kong and the physical properties can achieve durable and satisfactory performance for use in the proposed location. The skid / slip resistance of the paving, with its specified finish and applied sealers / sealants shall be minimum R12. Compliance with this requirement shall be demonstrated by testing as per item (b) above.

(6) Tolerances and Dimensions

(a) Stones shall be to sizes as shown in the approved shop drawings.

(b) Stones shall be square and variations of face dimensions shall not exceed ±1 mm in 900mm.

(c) Variation of thickness on any stone panel shall not exceed ±2 mm.

(d) Bow and twist shall not vary from the finish plane by 1 mm in 1200 mm.

(e) Notches and holes shall not vary from the designed locations by more than ±2 mm. The size of slots and holes shall not be greater than the designed value by ±1 mm.

(7) Forming of Stones

(a) All mitred joints as specified for all corners of the planter walls shall be formed in the factory, to show only a hairline joint. The mitred joint shall be securely bonded with epoxy resin and reinforced with SS cramps or additional stone pieces.

(b) All stone panels forming an arc or circle on plans, elevations or sections shall be true curved panels instead of facetted ones.

(8) Sealer

Impregnating sealer to comply with relevant BS standards. Impregnating sealers, which penetrate deeply into the material, impregnating it with molecules which bond to the capillary pores and repels water and / or oils from within the material. Some modified silane sealers impregnate deeply enough to protect against salt attack, such as efflorescence, spalling and picture framing. A good depth of penetration is also essential for protection from weathering and traffic.

CONCRETE PAVERS

Matching Covers for concrete pavers 24.277* Where Utility Manholes covers, drainage catch pits and draw pits are encountered in block paving areas these are to be provided with recessed covers to receive paving blocks laid to match the colour, pattern and orientation of the surrounding paving. The position and orientation of the covers are to be adjusted such that they align with the orientation of the paving and that small pieces and awkward angles of paving are avoided. Covers to be provided in accordance with HyD standard drawings H21484B, H21485B and H21486C.

COMPOSITE WOOD/ARTIFICIAL TIMBER

Materials 24.278* (1) Artificial Timber material shall be recycled / composite wood. Fixings to be invisible.

(2) The artificial timber shall be weather proof and resist the occurrence of cracks and rotting caused by daily temperature and humidity differentiation.

Fixing generally 24.279* (1) The artificial timber shall be fixed on aluminium sleepers with stainless steel screw by tongue & groove method as indicated on the drawings. The spacing between the centre of the sleepers shall not exceed 500mm. The gap between slats shall be 10mm maximum and in compliance with manufacturer's recommendation.

(2) Artificial timber shall be in solid form for seats and cladding; hollow section for horizontal surface decking.

Particular of recycled plastic 24.280* The Recycled plastic referred to in this specification shall be compliant with the technical requirements of Architectural Services Department and Hong Kong Buildings Department, with particular reference to the material's fire retardant properties.

Technical properties 24.281* The recycled plastic shall meet the following technical properties:

(a) FULL Thermoplastic Elastomers based (TPE) Solid Body PPT Pure Plastic Timber, anti- bacteria and free of heavy metal, Anti-acid or alkali characteristics.

(b) 100% heavy metal free (chromium VI, lead, mercury, copper, cobalt, nickel, antimony, cadmium, arsenic, chromium) and anti photo- oxidation. 100% co-polymer foaming without adding any wood grains/powder/crush, wood waste or sawdust. Eco-friendly, and 100% made by recycled Thermoplastic Elastomers (TPE),

(c) Materials must fulfill RoHs Standards and ASTM standards. All ASTM standard and certificates must be tested and issued by HOKLAS accredited laboratories. Base materials of the product should compose of recycled Thermoplastic Elastomers (TPE) and be fully recyclable after product life.

(d) Factory or supplier will provide recycling services, but not include demolition and delivery (in tones and current market prices of Thermoplastic

Elastomers (TPE) raw material)

(e) 100% waterproof, Non-toxic, odorless, and harmless to the environment and human body.

(f) The density of the product is around (D:0.6~0.7 g/cm3) comparable to that of most wood species.