GENERAL SPECIFICATION FOR CIVIL ENGINEERING WORKS

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FOREWORD

The General Specification for Civil Engineering Works lays down the quality of materials, the standards of workmanship, the testing methods and the acceptance criteria for civil engineering works undertaken for the Government of the Hong Kong Special Administrative Region. Where necessary, this General Specification should be supplemented by a particular specification.

The 2020 Edition of the General Specification comprises mainly the latest update on the review of obsolete standards with the updated text printed in green colour for easy reference. It was produced under the guidance of a Steering Committee comprising members from the main Government departments involved in civil engineering works. The Quality Management & Standards Unit of the Civil Engineering and Development Department (CEDD) was responsible for the overall co-ordination of comments received from departmental circulation, editing and production of the document. The 2020 Edition comprises 26 sections and is posted on CEDD Homepage on the Internet.

The General Specification will be updated continuously. The electronic files of the sections affected by any amendment issued will be kept up-to-date on CEDD Homepage.

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GENERAL SPECIFICATION FOR CIVIL ENGINEERING WORKS

CONTENTS

VOLUME 1

SECTION	1	GENERAL
	2	SITE CLEARANCE
	3	LANDSCAPE SOFTWORKS AND ESTABLISHMENT WORKS
	4	FENCING
	5	DRAINAGE WORKS
	6	EARTHWORKS
	7	GEOTECHNICAL WORKS
	8	PILING WORKS
	9	CARRIAGEWAYS: SUB-BASE MATERIAL AND BITUMINOUS MATERIALS
	10	CONCRETE CARRIAGEWAYS
	11	MISCELLANEOUS ROADWORKS
	12	TRAFFIC SIGNS, ROAD MARKINGS AND ROAD STUDS

VOLUME 2

SECTION	13	WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS
	14	FORMWORK AND FINISHES TO CONCRETE
	15	STEEL REINFORCEMENT
	16	CONCRETE AND JOINTS IN CONCRETE
	17	PRESTRESSING
	18	STEELWORK
	19	HANDRAILING, LADDERS, STAIRS AND FLOORING
	20	BRIDGEWORKS
	21	MARINE WORKS
	22	WATER SUPPLY PIPEWORKS
	23	WATER RETAINING STRUCTURES
	24	BUILDING WORKS
	25	ENVIRONMENTAL PROTECTION
	26	PRESERVATION AND PROTECTION OF TREES

CONTENT OF VOLUME 2

SECTION 13
WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

GENERAL

13.01 General requirements 13.3
13.02 Earthworks 13.3
13.03 Materials for grout 13.3
13.04 Galvanization 13.3

GLOSSARY OF TERMS

13.05 Concealed electrical conduit system 13.3

MATERIALS

13.06 Electrical conduits and fittings 13.3
13.07 Cable ducts and fittings 13.3
13.08 Paint for conduit and duct systems 13.4
13.09 Fire barriers 13.4
13.10 Cement grout for electrical and mechanical installations 13.4

STORAGE OF MATERIALS

13.11 Storage of materials for conduit and cable duct systems 13.4

HOLES AND RECESSES FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

13.12 Holes and recesses for electrical and mechanical installations 13.5

FIRE BARRIERS

13.13 Fire barriers 13.5

CONCEALED ELECTRICAL CONDUIT SYSTEMS

13.14 Construction of conduit systems 13.5
13.15 Installation of conduit systems 13.6
13.16 Terminations of conduit systems 13.6
13.17 Protection of conduit systems 13.7
13.18 Cleaning of conduit systems 13.7

CABLE DUCT SYSTEMS

13.19 Installation of cable duct system 13.7
13.20 Protection of cable duct systems 13.7
13.21 Cleaning of cable duct systems 13.8

ELECTRICAL EARTHING SYSTEMS

13.22 Electrical earthing systems 13.8

GROUTING FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

13.23 Grouting for electrical and mechanical installations 13.8

COMPLETION AND PROTECTION OF WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

13.24 Completion of work for electrical and mechanical installations 13.9
13.25 Protection of work for electrical and mechanical installations 13.9

TOLERANCES

13.26 Tolerances: floors of switchgear rooms 13.10
13.27 Tolerances: lamp standards 13.10

INSPECTION OF WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

13.28 Inspection of work for electrical and mechanical installations 13.10

TESTING: EARTHING CONTINUITY

13.29 Testing: earthing continuity 13.10
13.30 Compliance criteria: earthing continuity 13.10

TESTING: LOAD TESTS ON BEAMS AND JOISTS

13.31 Testing: load tests on beams and joists 13.11
13.32 Compliance criteria: load tests on beams and joists 13.11

SECTION 14
FORMWORK AND FINISHES TO CONCRETE

GENERAL

14.01 General requirements 14.3
14.02 Concrete carriageways 14.3
14.03 Cover spacers 14.3

GLOSSARY OF TERMS

14.04 Class 14.3
14.05 Falsework 14.3
14.06 Formed finish 14.3
14.07 Formwork 14.3
14.08 Permanent formwork 14.3

14.09 Profiled formwork 14.3
14.10 Sealed plywood 14.3
14.11 Spatterdash 14.3
14.12 Treated finish 14.3
14.13 Unformed finish 14.3
14.13A Wood preservative 14.3

MATERIALS

14.14 Formwork 14.4
14.15 Formwork Class of finish 14.4
14.16 Release agents 14.4
14.17 Formwork ties 14.8
14.18 Cement mortar for concrete surfaces 14.9
14.19 Surface retarders 14.9
14.20 Abrasives 14.9

SUBMISSIONS

14.21 Particulars of formwork and finishes to concrete and samples of materials 14.9

TRIAL PANELS

14.22 Trial panels 14.10
14.23 Non-compliance: trial panels 14.11
14.24 Commencement of formwork and concreting 14.11
14.25 Changes in materials and methods of construction 14.11

STORAGE OF MATERIALS

14.26 Storage of formwork 14.11
14.27 Storage of release agents and surface retarders 14.11

DESIGN AND CONSTRUCTION OF FALSEWORK AND FORMWORK

14.28 Design and construction of falsework and formwork 14.12
14.29 Construction of formwork 14.12
14.30 Construction of formwork for Class F2, F3, F4 and F5 finishes 14.13
14.31 Construction of formwork for Class F4 and F5 finishes 14.13
14.32 Built-in components 14.13

APPLICATION OF RELEASE AGENTS

14.33 Application of release agents 14.13

INSPECTION OF FORMWORK AND REINFORCEMENT

14.34 Inspection of formwork and reinforcement 14.14

REMOVAL OF FALSEWORK AND FORMWORK

14.35 Times for removal of falsework and formwork 14.14
14.36 Removal of falsework and formwork 14.15

UNFORMED FINISHES

14.37 Unformed finishes 14.15

TREATED FINISHES

14.38 Treated finishes 14.16
14.39 Class T1 finish 14.16
14.40 Class T2 and T3 finishes 14.16
14.41 Class T4 finish 14.16
14.42 Class T5 and T6 finishes 14.16

COMPLIANCE OF FINISHES

14.43 Inspection of finishes 14.17
14.44 Compliance of finishes 14.17

WORK ON CONCRETE SURFACES

14.45 Remedial and repair work on concrete surfaces 14.17
14.46 Filling blowholes and formwork tie holes 14.17
14.47 Spatterdash 14.17

PROTECTION OF FINISHES

14.48 Protection of finishes 14.18

CURVED FORMWORK

14.49 Curved formwork 14.18

SECTION 15
STEEL REINFORCEMENT

GLOSSARY OF TERMS

15.01 Reinforcement connector 15.3
15.02 Reinforcement 15.3

MATERIALS

15.03 Reinforcing steels 15.3
15.04 Stainless steel reinforcement 15.3
15.05 Epoxy coatings to reinforcement 15.3
15.06 Hot dip galvanizing to reinforcement 15.3
15.07 Reinforcement connectors 15.4
15.08 Cover spacers 15.4
15.09 Chairs, supports and spacers 15.4
15.10 Tying wire 15.4
15.11 Tying devices and clips 15.4

SUBMISSIONS

15.12 Particulars of reinforcement 15.5
15.13 Particulars of epoxy coatings to reinforcement 15.5
15.14 Particulars of galvanized coatings to reinforcement 15.6
15.15 Particulars of reinforcement connectors 15.6
15.16 Bending schedules 15.6
15.17 Samples of materials 15.6

HANDLING AND STORAGE OF MATERIALS

15.18 Handling of reinforcement 15.6
15.19 Storage of reinforcement 15.6

CUTTING AND BENDING REINFORCEMENT

15.20 Cutting and bending reinforcement 15.7

SURFACE CONDITION OF REINFORCEMENT

15.21 Surface condition of reinforcement 15.7
15.22 Repairs to epoxy coatings and galvanized coatings 15.7

FIXING REINFORCEMENT

15.23 Fixing reinforcement 15.8
15.24 Fixing reinforcement connectors 15.9
15.25 Welding of reinforcement 15.9
15.26 Exposed reinforcement 15.9
15.27 Access over reinforcement 15.9

TOLERANCES

15.28 Tolerances: reinforcement 15.9

INSPECTION OF REINFORCEMENT

15.29 Inspection of reinforcement 15.9

TESTING: REINFORCEMENT

15.30 Batch: reinforcement 15.9
15.31 Samples: reinforcement 15.10
15.32 Testing: reinforcement 15.11
15.33 Testing: epoxy coating 15.12
15.33A Compliance criteria: reinforcement 15.13
15.34 Compliance criteria: epoxy coating to reinforcement 15.13
15.35 Compliance criteria: reinforcement connectors for tension joints 15.14
15.36 Non-compliance: reinforcement 15.14
15.37 Non-compliance: epoxy coatings 15.14
15.38 Non-compliance: galvanized coatings 15.15
15.39 Non-compliance: reinforcement connectors 15.15

SECTION 16
CONCRETE AND JOINTS IN CONCRETE

PART 1: CONCRETE WORKS

GENERAL

16.01 Sprayed concrete 16.3
16.02 Designation of concrete mixes 16.3

GLOSSARY OF TERMS

16.03 Mix constituents 16.3
16.04 Grade 16.3
16.05 Grade strength 16.3

MATERIALS

16.06 Cement 16.3
16.07 Pulverized Fly Ash (PFA) and Ground Granulated Blastfurnace Slag (GGBS) 16.4
16.08 Aggregates 16.4
16.09 Water 16.5
16.10 Admixtures 16.5
16.11 Curing compound 16.5

CONCRETE

16.12 Concrete mix 16.6
16.13 Chloride content of concrete 16.7
16.14 Cementitious content of designed mix concrete 16.7
16.15 Standard mix concrete 16.9
16.16 No-fines concrete 16.11

SUBMISSIONS

16.17 Particulars of materials for concrete 16.11
16.18 Particulars of concrete mix 16.13
16.19 Particulars of ready-mixed concrete supplier 16.14
16.20 Particulars of batching and mixing plant 16.14
16.21 Particulars of precast concrete units 16.14
16.22 Particulars of construction joints 16.15

TRIALS

16.23 Trial mix concrete 16.15
16.24 Plant Trials 16.16
16.25 Laboratory Mix Trials 16.16
16.26 Compliance criteria: Plant Trials 16.16
16.27 Compliance criteria: Laboratory Mix Trials 16.17
16.28 Trial lengths and trial panels 16.17
16.29 Non-compliance: trial mix concrete 16.17
16.30 Approved concrete mix 16.18
16.31 Commencement of concreting 16.18
16.32 Changes in materials and methods of construction 16.18

HANDLING AND STORAGE OF MATERIALS

16.33 Storage of cement, PFA and GGBS 16.18
16.34 Handling and storage of aggregates 16.18
16.35 Storage of admixtures and curing compounds 16.19
16.36 Handling and storage of precast concrete units 16.19

BATCHING AND MIXING CONCRETE

16.37 Batching concrete 16.19
16.38 Mixing concrete 16.19

TRANSPORTATION OF CONCRETE

16.39 Transportation of concrete 16.20

RECORDS OF CONCRETE

16.40 Records of concrete 16.20

PLACING AND COMPACTING CONCRETE

16.41 Placing concrete 16.21
16.42 Placing concrete by pumping 16.22
16.43 Placing concrete by tremie 16.22
16.44 Compacting concrete 16.22

CONSTRUCTION JOINTS

16.45 Construction joints 16.23

CURING CONCRETE

16.46 Curing concrete 16.23

INSTALLATION OF PRECAST CONCRETE UNITS

16.47 Installation of precast concrete units 16.25

LOADING OF CONCRETE

16.48 Loading of concrete 16.25

TESTING: CEMENT, PFA, GGBS, AGGREGATE, ADMIXTURE, CURING COMPOUND, RECYCLED WATER

16.49 Batch: cement, PFA, GGBS, aggregate, admixture, curing compound 16.25
16.50 Samples: cement, PFA, GGBS, aggregate, admixture, curing compound 16.26
16.51 Testing: cement, PFA, GGBS, aggregate, admixture, curing compound, recycled water 16.26

TESTING: CONCRETE - GENERAL REQUIREMENTS

16.52 Batch: concrete 16.28
16.53 Reduction of testing frequency 16.28

TESTING: CONCRETE - WORKABILITY

16.54 Samples: workability of concrete 16.29
16.55 Testing: workability of concrete 16.29
16.56 Compliance criteria: workability of concrete 16.29
16.57 Non-compliance: workability of concrete 16.29

TESTING: CONCRETE - COMPRESSIVE STRENGTH

16.58 Samples: compressive strength of concrete 16.30
16.59 Testing: compressive strength of concrete 16.30
16.60 Non-compliance: compressive strength of standard mix concrete 16.31
16.61 Compliance criteria: compressive strength of designed mix concrete 16.31
16.62 Non-compliance: compressive strength of designed mix concrete 16.32

TESTING: HARDENED CONCRETE

16.63 Samples: hardened concrete and concrete cores 16.33
16.64 Testing: concrete cores 16.33
16.65 Compliance criteria: concrete cores 16.33
16.66 Analysis of hardened concrete 16.33

TESTING: PRECAST UNITS

16.67 Batch: precast units 16.34
16.68 Samples: precast units 16.34
16.69 Testing: precast units 16.34
16.70 Compliance criteria: precast units 16.34

PART 2: JOINTS IN CONCRETE

GENERAL

16.71 General requirements 16.35
16.72 Joints in concrete carriageways 16.35
16.73 Construction joints 16.35

MATERIALS

16.74 Materials for joints in water retaining structures and water tight structures 16.35
16.75 Joint filler 16.35
16.76 Bitumen emulsion 16.35
16.77 Joint sealant 16.35
16.78 Bond breaker tape 16.36
16.79 Bearing strip for sliding joints 16.36
16.80 Waterstops 16.36

SUBMISSIONS

16.81 Particulars of materials for joints 16.37
16.82 Samples of materials 16.38

STORAGE OF MATERIALS

16.83 Storage of materials for joints 16.38

FORMING JOINTS

16.84 Forming joints 16.39
16.85 Forming grooves 16.39
16.86 Protection of grooves 16.39
16.87 Sealing joints 16.39

TOLERANCES

16.88 Tolerances: joints 16.40

TESTING: MATERIALS FOR JOINTS

16.89 Batch: joint filler, joint sealant, waterstops 16.40
16.90 Samples: joint filler, joint sealant, waterstops 16.40
16.91 Testing: joint filler, joint sealant, waterstops 16.41
16.92 Compliance criteria: joint filler 16.42

APPENDIX 16.1
DETERMINATION OF THE EFFICIENCY INDEX OF CURING COMPOUNDS

16.1.1 Scope 16.43
16.1.2 Materials 16.43
16.1.3 Apparatus 16.43
16.1.4 Procedure: preparation of specimens 16.44
16.1.5 Procedure: determination of efficiency index 16.45
16.1.6 Calculation 16.46
16.1.7 Reporting of results 16.47

APPENDIX 16.2
DETERMINATION OF THE DEFLECTION, RECOVERY AND RESISTANCE TO CRACKING OF PRECAST UNITS

16.2.1 Scope 16.48
16.2.2 Equipment 16.48
16.2.3 Procedure 16.48
16.2.4 Reporting of results 16.48

APPENDIX 16.3
DETERMINATION OF THE RECOVERY VALUE AND REDUCTION IN MASS, AND THE EXTRUSION OF JOINT FILLER

16.3.1 Scope 16.50
16.3.2 Apparatus 16.50
16.3.3 Procedure: compression and recovery test 16.50
16.3.4 Procedure: extrusion test 16.51
16.3.5 Calculation 16.51
16.3.6 Reporting of results 16.51

SECTION 17
PRESTRESSING

GENERAL

17.01 Materials for grout 17.3

GLOSSARY OF TERMS

17.02 Duct 17.3
17.03 Prestressing components 17.3
17.04 Prestressing tendon 17.3
17.05 Sheath 17.3

MATERIALS

17.06 Prestressing tendons 17.3
17.07 Prestressing components 17.3
17.08 Sheath and Deviator Pipes 17.4
17.09 Grout vents and taps 17.4
17.10 Grout for prestressing systems 17.4

SUBMISSIONS

17.11 Particulars of prestressing systems 17.5
17.12 Particulars of prestressing tendons 17.6
17.13 Particulars of grout mix and grouting procedure 17.6
17.14 Samples of materials 17.6

TRIALS

17.15 Trial mixes for grout 17.7
17.16 Samples: trial mixes for grout 17.7
17.17 Testing: trial mixes for grout 17.7
17.18 Non-compliance: trial mixes for grout 17.7
17.19 Grouting trials 17.8
17.20 Testing: grouting trials 17.8
17.21 Compliance criteria: grouting trials 17.8
17.22 Non-compliance: grouting trials 17.8
17.23 Approved grout mix 17.8
17.24 Commencement of grouting 17.8
17.25 Changes in materials and methods of construction 17.9

HANDLING AND STORAGE OF MATERIALS

17.26 Handling of prestressing tendons 17.9
17.27 Handling of prestressing components 17.9
17.28 Storage of materials for prestressing systems 17.9

SURFACE CONDITION OF MATERIALS FOR PRESTRESSING SYSTEMS

17.29 Surface condition of materials for prestressing systems 17.9

INSTALLATION OF PRESTRESSING SYSTEMS

17.30 Installation of prestressing systems 17.10
17.31 Installation of prestressing tendons 17.10
17.32 Cutting prestressing tendons 17.10
17.33 Joints in prestressing tendons 17.10
17.34 Use of prestressing components 17.10
17.35 Installation of sheaths 17.10
17.36 Joints in sheaths 17.10
17.37 Installation of grout vents and taps 17.10

TENSIONING OF PRESTRESSING TENDONS

17.38 Tensioning of prestressing tendons 17.12
17.39 Pretensioning 17.12
17.40 Post-tensioning 17.13
17.41 Protection of external prestressing tendons and anchorages 17.14
17.42 Records of tensioning operations 17.14

INSPECTION OF PRESTRESSING SYSTEMS

17.43 Inspection of prestressing systems 17.14

GROUTING OF PRESTRESSING SYSTEMS

17.44 Grouting equipment 17.15
17.45 Grouting effectiveness 17.15
17.46 Grout injection 17.16
17.47 Records of grouting operations 17.17

TOLERANCES

17.48 Tolerances: sheaths 17.18

TESTING: PRESTRESSED UNITS

17.49 Testing: prestressed units 17.18

TESTING: PRESTRESSING TENDONS

17.50 Batch: prestressing tendons 17.18
17.51 Samples: prestressing tendons 17.18
17.52 Testing: prestressing tendons 17.19
17.53 Compliance criteria: characteristic breaking load, characteristic 0.1% proof load 17.19
17.54 Non-compliance: elongation, diameter, cross-sectional area, unit mass, modulus of elasticity, ductility 17.19

TESTING: DUCT FRICTION

17.55 Testing: duct friction 17.20
17.56 Compliance criteria: duct friction 17.20
17.57 Records of duct friction tests 17.20

TESTING: GROUT - GENERAL REQUIREMENTS

17.58 Batch: grout for prestressing systems 17.20

TESTING: GROUT - BLEEDING AND VOLUME CHANGE

17.59 Samples: bleeding and volume change of grout 17.21
17.60 Testing: bleeding and volume change of grout 17.21

TESTING: GROUT - CRUSHING STRENGTH

17.61 Samples: crushing strength of grout 17.21
17.62 Testing: crushing strength of grout 17.21
17.63 Non-compliance: crushing strength of grout 17.21

TESTING: GROUT – FLUIDITY

17.64 Samples: fluidity of grout 17.22
17.65 Testing: fluidity of grout 17.22
17.66 Non-compliance: fluidity of grout 17.22

SECTION 18
STEELWORK

GENERAL

18.01 Requirements 18.3
18.02 Specialist contractors 18.3

SCOPE

18.03 Requirements 18.3

NORMATIVE REFERENCES

18.04 Requirements 18.4

TERMS AND DEFINITIONS

18.05 Requirements 18.4
18.06 Inspection lot for mechanical fasteners 18.4
18.07 Constructor 18.4

SPECIFICATIONS AND DOCUMENTATION

18.08 Requirements 18.4
18.09 Execution specification – Execution classes 18.4
18.10 Contractor's documentation – Quality plan 18.4

CONSTITUENT PRODUCTS

18.11 Requirements 18.4
18.12 General 18.5
18.13 Structural steel products – General 18.5
18.14 Structural steel products – Surface conditions 18.5
18.15 Structural steel products – Additional properties 18.5
18.16 Welding consumables 18.5
18.17 Mechanical fasteners – Terminology 18.5
18.18 Mechanical fasteners – Structural bolting assemblies for non-preloaded applications 18.5
18.19 Mechanical fasteners – Structural bolting assemblies for preloading 18.5
18.20 Mechanical fasteners – Foundation bolts 18.6
18.21 Mechanical fasteners – Washers: Plain washers 18.6
18.22 Studs and shear connectors 18.6
18.23 Grouting materials 18.6
18.24 Expansion joints for bridges 18.6
18.25 Structural bearings 18.6

PREPARATION AND ASSEMBLY

18.26 Requirements 18.7
18.27 General 18.7
18.28 Identification 18.7
18.29 Handling and storage 18.7
18.30 Assembly 18.8
18.31 Assembly check 18.8

WELDING

18.32 Requirements 18.9
18.33 General 18.9
18.34 Qualification of welding procedures and welding personnel – Qualification of welding procedures: General 18.9
18.35 Qualification of welding procedures and welding personnel – Qualification of welding procedures: Validity of a welding procedure qualification 18.10
18.36 Qualification of welding procedures and welding personnel – Welders and welding operators: General 18.10
18.37 Qualification of welding procedures and welding personnel – Welding coordination 18.10
18.38 Preparation and execution of welding – Joint preparation: General 18.10
18.39 Preparation and execution of welding – Assembly for welding 18.10
18.40 Preparation and execution of welding – Temporary attachments 18.11
18.41 Preparation and execution of welding – Butt welds: General 18.11
18.42 Preparation and execution of welding – Butt welds: Single sided welds 18.11
18.43 Preparation and execution of welding – Stud welding 18.11
18.44 Preparation and execution of welding – Slot and plug welds 18.11
18.45 Preparation and execution of welding – Execution of welding 18.11

MECHANICAL FASTENING

18.46 Requirements 18.12
18.47 Use of bolting assemblies – General 18.12
18.48 Use of bolting assemblies – Bolts 18.12
18.49 Use of bolting assemblies – Washers 18.12
18.50 Preparation of contact surfaces in slip resistant connections 18.12
18.51 Tightening of preloaded bolting assemblies – General 18.12
18.52 Tightening of preloaded bolting assemblies – Torque reference values 18.13
18.53 Tightening of preloaded bolting assemblies – Combined method 18.13
18.54 Tightening of preloaded bolting assemblies – HRC method 18.14

ERECTION

18.55 Requirements 18.14
18.56 Survey – Reference system 18.14
18.57 Supports, anchors and bearings – Setting out and suitability of supports 18.14
18.58 Supports, anchors and bearings – Temporary supports 18.14
18.59 Supports, anchors and bearings – Grouting and sealing 18.15
18.60 Erection and work at site – Erection methods: Fit-up and alignment 18.15

SURFACE TREATMENT

18.61 Requirements 18.15
18.62 General 18.15
18.63 Preparation of steel substrates for paints and related products 18.16
18.64 Sealing of spaces 18.16
18.65 Repairs after cutting or welding 18.16

GEOMETRICAL TOLERANCES

18.66 Requirements 18.17
18.67 Tolerance types 18.17
18.68 Essential tolerances – Erection tolerances: Full contact bearing 18.17
18.69 Functional tolerances – Tabulated values 18.17

INSPECTION,TESTING AND CORRECTION

18.70 Requirements 18.18
18.71 General 18.18
18.72 Constituent products and components – Constituent products 18.18
18.73 Manufacturing: geometrical dimensions of manufactured components 18.20
18.74 Welding – General 18.20
18.75 Welding – Inspection after welding: Routine inspection and testing 18.21
18.76 Welding – Production tests on welding 18.21
18.77 Mechanical fastening – Inspection and testing of preloaded bolted connections: Inspection during and after tightening 18.21
18.78 Erection – Inspection of trial erection 18.22
18.79 Erection – Survey of geometrical position of connection nodes: Survey methods and accuracy 18.22
18.80 Erection – Survey of geometrical position of connection nodes: Location and frequency 18.22
18.81 Inspection authority and testing consultant 18.22
18.82 Inspection and test reports 18.23

SUBMISSIONS

18.83 Quality documentation 18.23
18.84 Quality plan 18.23
18.85 Particulars of fabrication yard 18.23
18.86 Particulars of constituent products supplied for use in the works 18.24
18.87 Particulars of welding procedures 18.24
18.88 Particulars of cutting, shaping and holing procedures 18.24
18.89 Particulars of vent holes for hot-dip galvanizing 18.24
18.90 Particulars of workshop drawings 18.24
18.91 Particulars of delivery of steelwork 18.25
18.92 Particulars of method of erecting steelwork 18.25
18.93 Inspection and test plan 18.25
18.94 Particulars of method of non-destructive testing 18.25
18.95 Particulars of welders 18.25
18.96 Particulars of welding coordination personnel 18.26
18.97 Particulars of inspection authority and testing consultant 18.26
18.98 Particulars of paint 18.26
18.99 Samples of materials 18.26

APPENDIX 18.1
PREPARATION OF STEELWORK SURFACES

18.1.1 Cleaning of steelwork and coated surfaces 18.27
18.1.2 Cleaning of bolts, nuts and washers 18.27
18.1.3 Removal of rust and mill scale from steelwork 18.27
18.1.4 Blast cleaning of steelwork 18.28
18.1.5 Acid-pickling of steelwork 18.28
18.1.6 Mechanical cleaning of steelwork 18.28
18.1.7 Flame cleaning of steelwork 18.29
18.1.8 Approval of surface preparation 18.29
18.1.9 Metal coatings to steelwork 18.29

APPENDIX 18.2
PAINTING OF STEELWORK

18.2.1 Paint for steelwork 18.30
18.2.2 Paint systems for steelwork 18.30
18.2.3 Application of paint to steelwork 18.30
18.2.4 Working conditions for painting 18.31
18.2.5 Priming and overcoating time limits 18.31
18.2.6 Stripe coats to steelwork 18.32
18.2.7 Paint coats to steelwork 18.32
18.2.8 Etch primers and blast primers 18.32
18.2.9 Repairs to damaged areas of paint 18.32
18.2.10 Painting trials 18.32

APPENDIX 18.3
TREATMENT OF JONTS IN STEELWORK

18.3.1 Preloaded bolting assemblies 18.34
18.3.2 Non-preloaded bolting assemblies 18.34
18.3.3 Welded joints 18.34
18.3.4 Joints made after coating of the parent material 18.35
18.3.5 Sealing of joints 18.35

APPENDIX 18.4
TREATMENT OF SPECIAL SURFACES IN STEELWORK

18.4.1 Hollow steel sections 18.36
18.4.2 Bearing surfaces for bridge bearings 18.36
18.4.3 Uncoated steelwork surfaces 18.36

SECTION 19
HANDRAILING, LADDERS, STAIRS AND FLOORING

GENERAL

19.01 General requirements 19.3
19.02 Fencing 19.3
19.03 Pedestrian guardrailing 19.3
19.04 Materials for grout 19.3
19.05 Steelwork 19.3
19.06 Vehicular parapets 19.3

MATERIALS

19.07 Steel 19.3
19.08 Stainless steel 19.3
19.09 Aluminium 19.3
19.10 Bolts, nuts, screws, washers and rivets 19.4
19.11 Cement mortar 19.4

DESIGNED BY CONTRACTOR

19.12 Designed by Contractor 19.5

FABRICATION OF HANDRAILING, LADDERS, STAIRS AND FLOORING

19.13 Fabrication of steelwork 19.5
19.14 Galvanizing to steel 19.5
19.15 Welding steel 19.5
19.16 Fabrication of handrailing 19.5
19.17 Fabrication of ladders 19.5
19.18 Fabrication of stairs 19.6
19.19 Fabrication of flooring 19.6
19.20 Fabrication of toe plates 19.6
19.21 Fabrication of safety chains 19.6

SUBMISSIONS

19.22 Particulars of handrailing, stairs, ladders and flooring 19.6
19.23 Samples of materials 19.7

STORAGE OF MATERIALS

19.24 Storage of handrailing, ladders, stairs and flooring 19.7

INSTALLATION OF HANDRAILING, LADDERS, STAIRS, AND FLOORING

19.25 Installion of handrailing, ladders and stairs 19.7
19.26 Installation of flooring 19.8

TOLERANCES

19.27 Tolerances: handrailing, ladders, stairs and flooring 19.8

SECTION 20
BRIDGEWORKS

PART 1: WATERPROOFING

MATERIALS

20.01 Prefabricated sheeting 20.3
20.02 Bentonite panels 20.3
20.03 Bituminous paint 20.3

SUBMISSIONS

20.04 Particulars of waterproofing systems 20.4
20.05 Samples of materials for waterproofing systems 20.4

DELIVERY AND STORAGE OF MATERIALS

20.06 Delivery of bentonite panels 20.4
20.07 Storage of materials for waterproofing systems 20.5

INSTALLATION OF WATERPROOFING SYSTEMS

20.08 Installation of waterproofing systems 20.5
20.09 Installation of prefabricated sheeting 20.5
20.10 Installation of bentonite panels 20.5
20.11 Bituminous paint waterproofing systems 20.6

PART 2: BRIDGE BEARING

GLOSSARY OF TERMS

20.12 Schedule of bearings 20.7
20.13 Type of bridge bearing 20.7

MATERIALS

20.14 Holding-down bolts for bridge bearings 20.7
20.15 Cement mortar, grout and adhesive for bridge bearings 20.7
20.16 Dowel bars for bridge bearings 20.7

DESIGN OF BRIDGE BEARINGS

20.17 Design of bridge bearings 20.7
20.18 Design of sliding bearings 20.8
20.19 Design of elastomeric bearings 20.8
20.20 Design of guides for bridge bearings 20.8
20.21 Design of fixings for bridge bearings 20.8
20.22 Protective coatings to bridge bearings 20.8
20.23 Marking of bridge bearings 20.8

SUBMISSIONS

20.24 Particulars of bridge bearings 20.8

STORAGE OF MATERIALS

20.25 Storage of bridge bearings 20.9

INSTALLATION OF BRIDGE BEARINGS

20.26 Installation of bridge bearings 20.9

TOLERANCES

20.27 Tolerances: bridge bearings 20.10

TESTING: BRIDGE BEARINGS - GENERAL REQUIREMENTS

20.28 Batch: bridge bearings 20.11
20.29 Testing: bridge bearings 20.11

TESTING: FRICTION TEST FOR BRIDGE BEARINGS

20.30 Samples: friction test for bridge bearings 20.11
20.31 Testing: friction test for bridge bearings 20.11
20.32 Compliance criteria: friction test for bridge bearings 20.11

TESTING: BRIDGE BEARINGS OTHER THAN ELASTOMERIC BEARINGS

20.33 Samples: bridge bearings other than elastomeric bearings 20.11
20.34 Testing: bridge bearings other than elastomeric bearings 20.12
20.35 Compliance criteria: bridge bearings other than elastomeric bearings 20.12

TESTING: ELASTOMERIC BEARINGS

20.36 Samples: elastomeric bearings 20.12
20.37 Testing: elastomeric bearings 20.12

20.38 Compliance criteria: elastomeric bearings 20.12

PART 3: VEHICULAR PARAPETS

MATERIALS

20.39 Vehicular parapets 20.14
20.40 Holding-down bolts for Vehicular parapets 20.14
20.41 Grout for Holding-down bolts 20.14

SUBMISSIONS

20.42 Samples of materials for vehicular parapets 20.15

STORAGE OF MATERIALS

20.43 Storage of vehicular parapets 20.15

INSTALLATION OF VEHICULAR PARAPETS

20.44 Installation of vehicular parapets 20.15

TOLERANCES

20.45 Tolerances: Vehicular parapets 20.15

TESTING OF VEHICULAR PARAPETS

20.46 Batch: Vehicular parapets 20.15
20.47 Samples: Vehicular parapets for testing 20.15
20.48 Testing: Vehicular parapets 20.15
20.49 Testing: Parapets Materials 20.16
20.50 Testing: Fasteners 20.16
20.51 Testing: Welded components of Vehicular parapets 20.16
20.52 Testing: Metal vehicular parapet posts 20.17

PART 4: MOVEMENT JOINTS

GENERAL

20.53 Movement joints formed in place 20.18

GLOSSARY OF TERMS

20.54 Fabricated movement join 20.18
20.55 Movement joint 20.18
20.56 Movement joint formed in place 20.18

MATERIALS

20.57 Joint filler 20.18
20.58 Joint sealant 20.18
20.59 Compression seals 20.18
20.60 PVC capping strip 20.18

20.61 Holding-down bolts for movement joints 20.18
20.62 Grout for movement joints 20.18

DESIGN OF FABRICATED MOVEMENT JOINTS

20.63 Design of fabricated movement joints 20.19
20.64 Design of fixings for fabricated movement joints 20.19

SUBMISSIONS

20.65 Particulars of movement joints 20.20

STORAGE OF MATERIALS

20.66 Storage of fabricated movement joints 20.20

INSTALLATION OF FABRICATED MOVEMENT JOINTS

20.67 Installation of fabricated movement joints 20.20
20.68 Road surface adjoining fabricated movement joints 20.21
20.69 Protection of fabricated movement joints 20.21

CONSTRUCTION OF MOVEMENT JOINTS FORMED IN PLACE

20.70 Forming movement joints 20.21
20.71 Forming grooves 20.21
20.72 Sealing grooves 20.21

TOLERANCES

20.73 Tolerances: fabricated movement joints 20.21

APPENDIX 20.1
FRICTION TEST FOR BRIDGE BEARINGS

20.1.1 Scope 20.22
20.1.2 Equipment 20.22
20.1.3 Procedure 20.22
20.1.4 Calculation 20.22
20.1.5 Reporting of results 20.22

APPENDIX 20.2
LOAD TEST FOR BRIDGE BEARINGS OTHER THAN ELASTOMERIC BEARINGS

20.2.1 Test loads 20.24
20.2.2 Loading and unloading procedure 20.24
20.2.3 Serviceability limit state load tests 20.24
20.2.4 Ultimate limit state load tests 20.24

SECTION 21
MARINE WORKS

GENERAL

21.01 General requirements 21.3
21.02 Pipes and fittings 21.3
21.03 Fill material 21.3
21.04 Public filling area 21.3
21.05 Formwork 21.3
21.06 Steel reinforcement 21.3
21.07 Concrete 21.3
21.08 Joints in concrete 21.3

GLOSSARY OF TERMS

21.09 Reclamation 21.3
21.10 Marine structures 21.3
21.11 Final surface of any work 21.3

MATERIALS

21.12 Fill material for marine works 21.3
21.13 Rock armour 21.4
21.14 Rock for underlayer 21.5
21.15 Facing stones 21.6
21.16 Bermstones 21.6
21.17 Levelling stones 21.6
21.18 Joint filler for slip joints 21.6
21.19 Iron and steel fittings for marine structures 21.6
21.20 Timber for fendering systems 21.7
21.21 Rubber for fenders 21.7
21.22 Plastic fenders 21.8
21.23 Paint for marine works 21.9
21.24 Precast concrete pipes and fittings for submarine outfalls 21.9

SUBMISSIONS

21.25 Particulars of marine works 21.9
21.26 Particulars of dredging 21.10
21.26A Particulars of transportation of imported fill material 21.10
21.27 Particulars of deposition of fill material 21.10
21.28 Particulars of lifting seawall blocks, copings and wave deflectors 21.11
21.29 Particulars of rock armour and rock for underlayer 21.11
21.30 Particulars of slip joints 21.11
21.31 Particulars of timber for fendering systems 21.11
21.32 Particulars of rubber fenders 21.12
21.33 Particulars of plastic fenders 21.12
21.34 Particulars of submarine outfalls 21.12
21.35 Particulars of demolition of marine structures 21.12

TRANSPORTATION, HANDLING AND STORAGE OF MATERIALS

21.36 Storage of fill material and dredged material 21.13

21.36A Transportation of imported fill material 21.13
21.37 Handling and storage of fill material 21.13
21.38 Handling and storage of precast concrete seawall blocks, copings and wave deflectors 21.13
21.39 Handling and storage of timber fenders 21.14
21.40 Handling and storage of rubber fenders and fittings 21.14
21.41 Handling and storage of plastic fenders 21.14

GENERAL MARINE WORKS REQUIREMENTS

21.42 Notification of marine works 21.14
21.43 Marking of marine works 21.14
21.44 Marine traffic and waterfront operations 21.14
21.45 Temporary tide gauges 21.15
21.46 Work boats 21.15
21.47 Silt curtains 21.15
21.48 Removal of floating debris 21.15
21.49 Refuse containment booms and floating refuse for use of inert construction and demolition material in reclamation 21.16
21.50 Surveys for marine works 21.16
21.51 Fill material allowed to become unsuitable or to deteriorate 21.17
21.52 Concreting in locations affected by tides 21.17

DREDGING

21.53 Commencement of dredging 21.17
21.54 Dredging 21.17

DEPOSITION OF FILL MATERIAL BELOW +2.5 m PD

21.55 Commencement of deposition of fill material 21.17
21.56 Deposition of fill material 21.18
21.57 Deposition of fill material in dredged trenches 21.18
21.58 Deposition of rock fill material adjacent to structures and utilities 21.18

DEPOSITION OF ROCK ARMOUR AND ROCK FOR UNDERLAYER

21.59 Deposition of rock armour and rock for underlayer 21.18

LEVELLING AND COMPACTION OF FILL MATERIAL

21.60 Levelling of rock fill material in underwater foundations 21.19

CONSTRUCTION OF MARINE STRUCTURES

21.61 Construction of seawall blocks, copings and wave deflectors 21.19
21.62 Setting of seawall blocks 21.19
21.63 Facing stones to seawalls and revetments 21.19
21.64 Slip joints in seawalls 21.19
21.65 Filling of channels in seawall blocks 21.19
21.66 Concrete copings to seawalls 21.19
21.67 Bermstones for marine structures 21.19
21.68 Bagged concrete 21.20
21.69 Cutting and jointing timber for fendering systems 21.20
21.70 Painting to timber fendering systems 21.20

21.71 Installation of rubber fenders 21.20

TRIALS FOR SUBMARINE OUTFALLS

21.72 Trials for submarine outfalls 21.21
21.73 Results of trials for submarine outfalls 21.21
21.74 Commencement of pipe-laying for submarine outfalls 21.21

CONSTRUCTION OF SUBMARINE OUTFALLS

21.75 Laying of submarine outfall pipes 21.21
21.76 Marker blocks for submarine outfalls 21.21
21.77 Diffuser pipes for submarine outfalls 21.21
21.78 Diffuser caps for submarine outfalls 21.22

DEMOLITION OF MARINE STRUCTURES

21.79 Demolition of marine structures 21.22

TOLERANCES

21.80 Tolerances: dredging 21.22
21.81 Tolerances: deposition of fill material 21.22
21.82 Tolerances: precast concrete seawall blocks and copings 21.22
21.83 Tolerances: timber fendering systems 21.22
21.84 Tolerances: rubber fenders 21.23
21.85 Tolerances: plastic fenders 21.23
21.86 Tolerances: submarine outfalls 21.23

TESTING: DREDGED MATERIAL

21.87 Samples: dredged material 21.23
21.88 Testing: dredged material 21.24

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

21.89 Batch: fill material for marine works 21.24
21.90 Samples: fill material for marine works 21.24
21.91 Testing: fill material for marine works 21.24
21.92 Non-compliance: fill material for marine works 21.24

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

21.93 Batch: rock armour 21.25
21.94 Samples: rock for rock armour 21.25
21.95 Testing: rock for rock armour 21.25
21.96 Samples: rock armour 21.25
21.97 Testing: rock armour 21.26

21.98 Non-compliance: rock for rock armour 21.26
21.99 Non-compliance: dropping test 21.26
21.100 Non-compliance: weighing test 21.26
21.101 Testing: rock for underlayer 21.26

TESTING: TIMBER FOR FENDERING SYSTEMS

21.102 Batch: timber for fendering systems 21.27
21.103 Samples: timber for fendering systems 21.27
21.104 Testing: timber for fendering systems 21.27
21.105 Compliance criteria: Janka indentation test, test for shear stress parallel to grain at maximum load 21.27
21.106 Non-compliance: timber for fendering systems 21.27

TESTING: RUBBER FENDERS

21.107 Batch: rubber fenders 21.28
21.108 Samples: rubber fenders 21.28
21.109 Testing: rubber fenders 21.28
21.110 Compliance criteria: rubber fenders 21.28
21.111 Non-compliance: rubber fenders 21.28

TESTING: PLASTIC FENDERS

21.112 Batch: plastic fenders 21.28
21.113 Samples: plastic fenders 21.28
21.114 Testing: plastic fenders 21.28
21.115 Compliance criteria: plastic fenders 21.29

TESTING: SUBMARINE OUTFALLS

21.116 Testing: submarine outfalls 21.29
21.117 Compliance criteria: submarine outfalls 21.29
21.118 Non-compliance: submarine outfalls 21.29

APPENDIX 21.1
LOADING TEST FOR PLASTIC FENDERS

21.1.1 Scope 21.30
21.1.2 Equipment 21.30
21.1.3 Procedure 21.30
21.1.4 Reporting of results 21.30

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

MATERIALS

21.2.1 Mix constituents 21.32
21.2.2 Cement 21.32

21.2.2A Aggregates 21.32
21.2.3 Admixtures 21.32
21.2.4 Curing compound 21.33

CONCRETE

21.2.5 Concrete mix 21.33
21.2.6 Chloride content of concrete 21.33
21.2.7 Cementitious content of designed mix concrete 21.34

SUBMISSIONS

21.2.8 Particulars of materials for concrete 21.34
21.2.9 Particulars of ready-mixed concrete supplier 21.35
21.2.10 Particulars of precast concrete units 21.35

HANDLING AND STORAGE OF MATERIALS

21.2.11 Storage of cement, PFA, GGBS and CSF 21.35

BATCHING AND MIXING CONCRETE

21.2.12 Batching concrete 21.36
21.2.13 Mixing concrete 21.36

TRANSPORTATION OF CONCRETE

21.2.14 Transportation of Concrete 21.36

RECORDS OF CONCRETE

21.2.15 Records of concrete 21.36

PLACING AND COMPACTING CONCRETE

21.2.16 Placing concrete 21.36
21.2.17 Compacting Concrete 21.37

CURING CONCRETE

21.2.18 Curing concrete 21.37

TESTING: CONCRETE – COMPRESSIVE STRENGTH

21.2.19 Testing: compressive strength of concrete 21.38

PART 2: JOINT IN CONCRETE

MATERIALS

21.2.20 Waterstops 21.39

MISCELLANEOUS

21.2.24 Blinding concrete 21.39
21.2.25 Construction tolerances 21.39
21.2.26 Use of displacers 21.40

GROUT

21.2.27 Grout 21.41
21.2.28 Marine Grout 21.41

REINFORCED CONCRETE IN MARINE ENVIRONMENT

21.2.29 Reinforced Concrete in Marine Environment 21.41

SECTION 22
WATER SUPPLY PIPEWORKS3

GENERAL

22.01 General requirements 22.3
22.02 Drainage works 22.3
22.03 Earthworks 22.3
22.04 Formwork 22.3
22.05 Concrete 22.3

GLOSSARY OF TERMS

22.06 Fitting 22.3
22.07 Flexible joint 22.3
22.08 Mechanical joint 22.3
22.09 Nominal size 22.3
22.10 Push-in joint 22.3
22.11 Special fitting 22.3
22.12 Thin- walled pipe 22.3

MATERIALS

22.13 Materials for water supply pipeworks 22.3
22.14 Steel pipes and fittings 22.4
22.15 DI pipes and fittings 22.5
22.16 Polyethylene pipes and fittings 22.5
22.17 Not used 22.5
22.18 Flanges 22.5
22.19 Bolts and nuts 22.5
22.20 Elastomeric joint rings 22.5
22.21 Anticorrosion tape 22.6
22.22 Bituminous coatings 22.8
22.23 Whitewash 22.8
22.24 Zinc-based paint 22.8
22.25 Joint filler and compressible padding 22.8
22.26 Polyethylene sheeting 22.8
22.27 Extension keys 22.8

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

22.28 Materials provided by the Employer 22.8
22.29 Equipment loaned by the Employer 22.9

INSPECTION OF MANUFACTURE

22.30 Inspection of manufacture and testing 22.9

SUBMISSIONS

22.31 Particulars of independent inspection authority 22.9
22.32 Particulars of pipes, joints and fittings 22.9
22.33 Particulars of welding 22.10
22.34 Particulars of pressure tests 22.10

TRIALS

22.35 Welding trials 22.11
22.36 Pipe jointing trials 22.11
22.37 Trials for drilling and tapping 22.11

TRANSPORT, HANDLING AND STORAGE OF MATERIALS

22.38 Transport, handling and storage of pipes, joints and fittings 22.12
22.39 Handling of pipes and fittings 22.12
22.40 Storage of pipes 22.12
22.41 Transport of thin walled pipes 22.12
22.42 Handling and storage of thin walled pipes 22.13
22.43 Storage of valves 22.13

ACCESS TO PIPELINES

22.44 Access to pipelines 22.13

SETTING OUT OF PIPELINES

22.45 Setting out of pipelines 22.13

LAYING AND BEDDING PIPES

22.46 Laying pipes 22.14
22.47 Laying steel pipes 22.15
22.48 Laying pipes with flexible joints 22.15
22.49 Installation of valves 22.15
22.50 Bedding pipes 22.15

CUTTING AND DRILLING PIPES

22.51 Cutting pipes 22.15
22.52 Drilling pipes 22.16

JOINTING PIPES

22.53 Jointing pipes 22.16
22.54 DI pipes with push-in joints 22.17
22.55 DI pipes with mechanical joints 22.17
22.56 Welding joints in steel pipes 22.17
22.57 Steel pipes with spigot and socket joints 22.17
22.58 Steel pipes with welded steel collar joints 22.18
22.59 Steel pipes with couplings and flange adapters 22.18
22.60 Not used 22.18
22.61 Not used 22.18
22.62 Not used 22.18

MAKING FLANGED JOINTS

22.63 Making flanged joints 22.18

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

22.64 Protection to steel flanged joints, slip-on type couplings and flange adapters 22.19

REPAIRS TO JOINTS, COATINGS AND LININGS

22.65 Repairs to joints, coatings and linings 22.24
22.66 Repairs to DI pipes with bitumen coatings 22.24
22.67 Internal repairs to DI pipes with cement mortar lining 22.24
22.68 Not used 22.24

THRUST AND ANCHOR BLOCKS

22.69 Thrust and anchor blocks 22.24

BED, HAUNCH AND SURROUND

22.70 Concrete bed, haunch and surround 22.25

TOLERANCES

22.71 Tolerances: pipelines 22.25

SWABBING

22.72 Swabbing of pipelines 22.25

CLEANING AND STERILISATION OF PIPELINES

22.73 Cleaning and sterilisation of pipelines 22.27

CONNECTION TO EXISTING WATERMAINS

22.74 Connection to existing watermains 22.27

IDENTIFICATION TAPES FOR WATERMAINS

22.75 Identification tapes for watermains 22.28

DETECTABLE WARNING TAPE FOR NON-METALLIC WATERMAINS

22.76 Detectable warning tape for non-metallic watermains 22.28

WORK ON ASBESTOS CEMENT PIPES AND DISPOSAL OF ASBESTOS WASTES

22.77 Work on asbestos cement pipes and disposal of asbestos wastes 22.29

TESTING: JOINTS IN STEEL PIPES

22.78 Testing: joints in steel pipes 22.29
22.79 Compliance criteria: joints in steel pipes 22.30
22.80 Non-compliance: joints in steel pipes 22.30

TESTING: PRESSURE PIPELINES FOR WATER SUPPLY PIPEWORKS

22.81 Testing: pressure pipelines for water supply pipeworks 22.30
22.82 Compliance criteria: pressure pipelines for water supply pipeworks 22.30
22.83 Non-compliance: pressure pipelines for water supply pipeworks 22.31

TESTING: WATER STERILISATION

22.84 Testing: water sterilisation 22.31

APPENDIX 22.1
PRESSURE TESTS ON PIPELINES

22.1.1 Scope 22.32
22.1.2 Equipment 22.32
22.1.3 Procedure 22.32
22.1.4 Filling of polyethylene pipelines 22.33
22.1.5 Calculation 22.33
22.1.6 Modifications to Procedure for Polyethylene Pipelines 22.33
22.1.7 Reporting of results 22.35

APPENDIX 22.2
PROTECTION TO STEEL PIPES, FITTINGS AND SPECIALS USING EPOXY SYSTEM – OTHER REQUIREMENTS

GENERAL

22.2.1 General requirements 22.36

GENERAL PROTECTION COATING REQUIREMENTS

22.2.2 General 22.37
22.2.3 Planning and documentation 22.37

22.2.4 Ambient conditions 22.37
22.2.5 Coating materials 22.37
22.2.6 Steel materials 22.37
22.2.7 Pre-qualification of coating, personnel and procedures 22.37

HEALTH, SAFETY AND ENVIRONMENTAL CONCERNS

22.2.8 Requirements 22.38

SURFACE PREPARATION OF THE SUBSTRATE

22.2.9 Pre-blasting preparation 22.38
22.2.10 Blast cleaning 22.38
22.2.11 Final surface condition 22.39

PAINT APPLICATION

22.2.12 General 22.39
22.2.13 Application equipment 22.39
22.2.14 Application 22.39
22.2.15 Repair 22.40

QUALIFICATION OF PERSONNEL, SUPPLIER AND PRODUCT

22.2.16 Operators 22.40
22.2.17 Supplier 22.40
22.2.18 Coating material 22.40
22.2.19 Paint working specification (PWS) 22.41

COATING SYSTEM

22.2.20 Coating system requirements 22.41

INSPECTION AND TESTING

22.2.21 Testing and inspection 22.42

SECTION 23
WATER RETAINING STRUCTURES

GENERAL

23.01 General requirements 23.3
23.02 Earthworks 23.3
23.03 Formwork 23.3
23.04 Reinforcement 23.3
23.05 Concrete 23.3
23.06 Joints in concrete 23.3
23.07 Drainage systems 23.3

GLOSSARY OF TERMS

23.08 Water retaining structure 23.3

MATERIALS

23.09 Sliding layers 23.3

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

23.10 Materials provided by the Employer 23.3
23.11 Equipment loaned by the Employer 23.4

SUBMISSIONS

23.12 Particulars of sliding layers 23.4
23.13 Particulars of materials and methods of construction for water retaining structures 23.4
23.14 Samples of sliding layers 23.4

STORAGE OF MATERIALS

23.15 Storage of sliding layers 23.4

DRAINAGE SYSTEMS

23.16 Drainage systems 23.5

CONSTRUCTION OF WATER RETAINING STRUCTURES

23.17 Laying sliding layers 23.5
23.18 Floor slabs of water retaining structures 23.5
23.19 Walls of water retaining structures 23.5
23.20 Roof slabs of water retaining structures 23.5
23.21 Built-in pipes in water retaining structures 23.5

PROTECTION OF WATER RETAINING STRUCTURES

23.22 Protection of water retaining structures 23.5

DEPOSITION OF FILL MATERIAL

23.23 Deposition of fill material 23.6

CLEANING AND STERILISATION OF WATER RETAINING STRUCTURES

23.24 Cleaning and sterilisation of water retaining structures 23.6
23.25 Treatment and disposal of effluent 23.6

TESTING: DRAINAGE SYSTEMS FOR WATER RETAINING STRUCTURES

23.26 Testing: drainage systems for water retaining structures 23.7
23.27 Compliance criteria: drainage systems for water retaining structures 23.7
23.28 Non-compliance: drainage systems for water retaining structures 23.8

TESTING: WATERTIGHTNESS OF ROOFS

23.29 Testing: watertightness of roofs 23.8
23.30 Compliance criteria: watertightness of roofs 23.8
23.31 Non-compliance: watertightness of roofs 23.8

TESTING: WATERTIGHTNESS OF STRUCTURES

23.32 Testing: watertightness of structures 23.8
23.33 Compliance criteria: watertightness of structures 23.9
23.34 Non-compliance: watertightness of structures 23.9

TESTING: WATER STERILITY

23.35 Samples: water sterilisation 23.10
23.36 Testing: water sterilisation 23.10
23.37 Compliance criteria: water sterilisation 23.10

APPENDIX 23.1
TREATMENT OF SLUDGE WITH MOBILE "CENTRIFUGE AND MICROFILTRATION PLANT"

23.1.1 Plant 23.11
23.1.2 Procedures 23.11

APPENDIX 23.2
SPECIFICATION OF THE MOBILE TREATMENT PLANT

23.1.3 Plant 23.12

APPENDIX 23.3
SAMPLE RECORD FOR SLUDEGE CAKE PRODUCED

APPENDIX 23.4
SAMPLING RECORD FOR FILTRATE PRODUCED BY THE MICROFILTRATION PLANT OR FINAL EFFLUENT PRODUCED BY THE MOBILE TREATMENT PLANT

SECTION 24
BUILDING WORKS

PART 1: ASPHALT ROOFING

MATERIALS

24.01 Mastic asphalt 24.3
24.02 Isolating membrane 24.3
24.03 Bitumen dressing compound 24.3
24.04 Bituminous paint 24.3

24.05 Sand 24.3
24.06 Stone chippings 24.3
24.07 Reflective paint 24.3
24.08 Metal lathing 24.3

SUBMISSIONS

24.09 Particulars of asphalt roofing 24.3
24.10 Samples of materials 24.4

STORAGE OF MATERIALS

24.11 Storage of isolating membrane, bitumen dressing compound, bituminous paint, sand, stone chippings, reflective paint and metal lathing 24.4

ASPHALT ROOFING WORK

24.12 Heating asphalt 24.4
24.13 Laying mastic asphalt 24.4
24.14 Laying isolating membrane 24.4
24.15 Forming angles 24.4
24.16 Forming skirtings 24.5
24.17 Dressing to rainwater outlets 24.5
24.18 Dressing to pipes through roofs 24.5
24.19 Finishing roof surfaces 24.5
24.20 Solar protection 24.5

TESTING: ASPHALT ROOFING

24.21 Batch: mastic asphalt 24.5
24.22 Samples: mastic asphalt 24.5
24.23 Testing: mastic asphalt 24.5
24.24 Compliance criteria: mastic asphalt 24.5

PART 2: CARPENTRY AND JOINERY MATERIALS

24.25 Timber for carpentry and joinery 24.7
24.26 Nails, screws and plugs 24.8
24.27 Wood preservative 24.8
24.28 Adhesive 24.8

SUBMISSIONS

24.29 Particulars of timber 24.8
24.30 Samples of materials 24.9

STORAGE OF MATERIALS

24.31 Storage of timber 24.9

CARPENTRY AND JOINERY WORK

24.32 Treatment to timber 24.9
24.33 Finish to timber 24.9

24.34 Framed timber 24.9
24.35 Running bonded joints 24.9
24.36 Building-in timber 24.10
24.37 Nailing 24.10
24.38 Fixing screws 24.10

TESTING: TIMBER

24.39 Batch: timber 24.10
24.40 Samples: timber 24.10
24.41 Testing: timber 24.10

PART 3: GLAZING MATERIALS

24.42 Glass 24.11
24.43 Putty 24.11
24.44 Bituminous paint 24.11

SUBMISSIONS

24.45 Samples of materials 24.11

STORAGE OF MATERIALS

24.46 Storage of glass and putty 24.11

GLAZING WORK

24.47 Glazing work 24.12

PART 4: PLUMBING

GENERAL

24.48 Licensed plumber 24.14
24.49 Taps, valves and fittings 24.14
24.49A Plumbing 24.14
24.49B Drainage 24.15
24.49C Building works with due consideration for installation of plumbing system and above ground surface water and foul water drainage systems 24.15

MATERIALS

24.50 Not used 24.15
24.51 Not used 24.16
24.52 Draw-off taps and stop valve 24.16
24.53 Not used 24.16
24.54 Sanitary appliances 24.16
24.55 Not used 24.17

SUBMISSIONS

24.56 Particulars of plumbing work 24.17

24.56A Programme 24.17
24.57 Not used 24.17

STORAGE OF MATERIALS

24.58 Not used 24.17
24.59 Storage of sanitary appliances 24.17

NOT USED

24.60 Not used 24.17

TESTING: PLUMBING AND DRAINAGE SYSTEM

24.61 Inspection, testing and commissioning of plumbing and drainage system 24.17
24.62 Not used 24.18

NOT USED

24.63 Not used 24.18
24.64 Not used 24.18

PART 5: PLASTERWORK AND OTHER FINISHES

MATERIALS

24.65 Cement, water and sand 24.19
24.66 Premixed plaster 24.20
24.67 Gypsum plaster 24.20
24.68 Lime 24.20
24.69 Stone chippings 24.20
24.70 Metal lathing 24.21
24.71 Aggregates for lightweight screeds 24.21
24.72 Vapour barrier 24.21
24.73 Aggregates for terrazzo 24.21
24.74 Aggregates for granolithic concrete 24.21
24.75 Tiles 24.21
24.76 Floor tiles 24.21
24.77 Non-homogenous floor tiles 24.21
24.78 Ceramic wall tiles 24.21
24.79 Mosaic tiles 24.21
24.80 Homogenous coved tile skirting 24.22
24.81 Homogenous wall tiles 24.22
24.82 External facing tiles 24.22
24.83 Concrete roof tiles 24.22
24.84 Tile adhesive and tile grout 24.22
24.85 Bitumen 24.23

SUBMISSIONS

24.86 Particulars of plasterwork and other finishes 24.23
24.87 Particulars of tile adhesive and tile grout 24.24
24.88 Samples of materials 24.24

DELIVERY AND STORAGE OF MATERIALS

24.89 Delivery and storage of cement, gypsum plaster and lime 24.25
24.90 Storage of tile adhesive 24.25
24.91 Storage of premixed plaster 24.25

ON SITE DELIVERY CHECK

24.92 General 24.25

TRIAL PANELS

24.93 Trial panels 24.26
24.94 Trial panels for tile adhesive 24.27
24.95 Non-compliance: trial panels 24.28
24.96 Commencement of plasterwork and other finishes 24.28
24.97 Changes in materials 24.28

PLASTERING AND RENDERING

24.98 Applying spatterdash to new concrete 24.28
24.99 Joint inspection to spatterdash 24.28
24.100 Background preparation for plastering and rendering 24.29
24.101 Preparation of hardened concrete to receive cementitious renders 24.29
24.102 Preparation of hardened concrete to receive gypsum renders 24.29
24.103 Dubbing out 24.29
24.104 Fixing steel lathing 24.30
24.105 Mixing plaster and render 24.30
24.106 Premixed plaster 24.30
24.107 Cement render 24.31
24.108 Gypsum plaster 24.31
24.109 Lime plaster 24.31
24.110 Shanghai plaster 24.31

SCREEDS, TERRAZZO AND GRANOLITHIC CONCRETE

24.111 Preparation for screeds, terrazzo and granolithic concrete 24.32
24.112 Mixing screeds, terrazzo and granolithic concrete 24.32
24.113 Screeds 24.32
24.114 Terrazzo 24.33
24.115 Granolithic concrete 24.34

TILING

24.116 Floor tiles 24.35
24.117 Wall tiles 24.36
24.118 Roof tiles 24.37

PROTECTION OF PLASTERWORK AND OTHER FINISHES

24.119 Protection of plasterwork and other finishes 24.37

TOLERANCES

24.120 Tolerances: plasterwork and other finishes 24.37

TESTING

24.121 Non-slip homogenous floor tiles 24.37
24.122 Glazed ceramic wall tiles 24.41
24.123 Unglazed vitreous mosaic wall tiles 24.44
24.124 Glass mosaic wall tiles 24.45
24.125 Homogenous coved tile skirting 24.47
24.126 Homogenous wall tiles 24.48
24.127 External facing tiles 24.50

PART 6: PAINTING

MATERIALS

24.128 Paint and associated materials 24.52
24.129 Aluminium primer 24.52
24.130 Zinc chromate primer 24.52
24.131 Lead primer 24.52
24.132 Calcium plumbate primer 24.52
24.133 Bitumastic paint 24.52
24.134 Bituminous paint 24.52
24.135 Knotting 24.52
24.136 Stopping 24.52
24.137 Rust inhibitor 24.52
24.138 Sealers 24.52
24.139 Wood preservative 24.52
24.140 Polyurethane paint 24.52
24.141 Epoxy paint 24.53
24.142 Textured paint 24.53
24.143 Plastic emulsion paint 24.53
24.144 Cement paint 24.53
24.145 Gloss paint 24.53
24.146 Volatile organic compound content 24.53
24.147 Selection of colours for paintwork 24.53

STORAGE OF MATERIALS

24.148 Storage of paint and associated materials 24.53

ON-SITE DELIVERY CHECK

24.149 Emulsion paint, synthetic paint and multi-layer acrylic paint 24.54

PAINTWORK

24.150 Preparation of surfaces for painting 24.54
24.151 Type and number of coats for painting system 24.54
24.152 Application of paint and associated materials 24.55
24.153 Health and safety 24.55

TESTING

24.154 Emulsion paint 24.57

24.155 Synthetic paint 24.58
24.156 Multi-layer acrylic paint 24.59

PART 7: BRICKWORK AND BLOCKWORK

MATERIALS

24.157 Clay bricks 24.61
24.158 Concrete bricks and blocks 24.61
24.159 Concrete hollow blocks 24.61
24.160 Brickwork reinforcement 24.61
24.161 Damp proof course 24.61
24.162 Wall ties 24.61
24.163 Mortar for brickwork and blockwork 24.62

SUBMISSIONS

24.164 Particulars of brickwork and blockwork 24.62
24.165 Samples of materials 24.62

TRIAL PANELS

24.166 Trial panels 24.62
24.167 Non-compliance: brickwork and blockwork 24.63
24.168 Commencement of brickwork and blockwork 24.63
24.169 Changes in materials 24.63

HANDLING AND STORAGE OF MATERIALS

24.170 Handling and storage of bricks and blocks 24.63

LAYING BRICKS AND BLOCKS

24.171 Type of mortar 24.63
24.172 Bond and gauge of brickwork and blockwork 24.64
24.173 Laying damp proof courses 24.64
24.174 Fixing wall ties 24.64
24.175 Finishing of joints in brickwork and blockwork 24.64

TOLERANCES

24.176 Tolerances: brickwork and blockwork 24.64

TESTING: BRICKS AND BLOCK

24.177 Batch: bricks and blocks 24.65
27.178 Samples: bricks and blocks 24.65
24.179 Testing: bricks and blocks 24.65
24.180 Compliance criteria: bricks and blocks 24.65

PART 8: METAL WINDOWS AND DOORS

MATERIALS

24.181 Materials for metal windows and doors 24.66

DESIGN AND FABRICATION OF METAL WINDOWS AND DOORS

24.182 Steel windows and doors 24.67
24.183 Fittings and furniture to steel windows and doors 24.67
24.184 Aluminium windows and doors 24.68
24.185 Fittings and furniture to aluminium windows and doors 24.70
24.186 Roller shutters and doors 24.71

SUBMISSIONS

24.187 Particulars of metal windows and doors 24.71
24.188 Samples of materials 24.71
24.189 Instruction manuals 24.71

HANDLING AND STORAGE OF MATERIALS

24.190 Handling and storage of metal windows and doors 24.71

FIXING METAL WINDOWS AND DOORS

24.191 Fixing metal windows and doors 24.72

PART 9: MASONRY

MATERIALS

24.192 Stone 24.73
24.193 Mortar 24.73
24.194 Wall ties 24.73
24.195 Damp proof course 24.73

SUBMISSIONS

24.196 Samples of materials 24.73

TRIAL PANELS

24.197 Trial panels 24.73

HANDLING AND STORAGE OF MATERIALS

24.198 Handling and storage of stone 24.73

RUBBLE STONE WALLING

24.199 Preparation of stone for rubble stone walling 24.73
24.200 Laying and jointing rubble stone walling 24.74
24.201 Pointing rubble stone walling 24.74

ASHLAR STONE WALLING

24.202 Preparation of stone for ashlar stone walling 24.75

24.203 Laying and jointing ashlar stone walling 24.75
24.204 Pointing ashlar stone walling 24.75

PROTECTION OF MASONRY

24.205 Protection of masonry 24.75

WALL TIES FOR MASONRY

24.206 Wall ties for masonry 24.75

TOLERANCES

24.207 Tolerances: masonry 24.75

SECTION 25
ENVIRONMENTAL PROTECTION

GENERAL

25.01 General requirements 25.3

WATER POLLUTION CONTROL

25.02 Water pollution control - general requirements 25.4
25.03 Marine plant and equipment 25.4
25.04 Avoidance of pollution during dredging, transporting and dumping of marine mud 25.5
25.05 Protection of water quality at water intakes and storage 25.6
25.06 Discharge into sewers, drains and water bodies 25.7
25.07 Wastewater from construction activities 25.7
25.08 Surface runoff 25.8
25.09 Protection of natural streams/rivers 25.9

NOISE CONTROL

25.10 Noise control - general requirements 25.10
25.11 Allowable noise limits 25.11
25.12 Noise mitigation measures 25.12
25.13 Construction Noise Permits 25.12

AIR POLLUTION CONTROL

25.14 Air pollution control - general requirements 25.12
25.15 Dust suppression 25.13
25.16 Smoke and exhaust control 25.15
25.17 Prior consent for pollutant emitting equipment 25.16
25.18 Odour Mitigation 25.16
25.19 Hoardings adjoining public areas 25.16

WASTE MANAGEMENT

25.20 Waste management - general requirements 25.16

25.21 Measures to reduce/minimize generation of C&D materials 25.17
25.22 Reduced use of timber in temporary works 25.17
25.23 Works involving demolition 25.17
25.24 Sorting of C&D materials 25.17
25.25 Trip ticket system 25.19
25.26 Avoidance of nuisance 25.19
25.27 Handling and disposal of waste 25.19
25.28 Chemical waste control 25.20

APPENDIX 25.1
PROFORMA FOR MONTHLY RECORDING DELIVERY AND CONSUMPTION OF ULTRA LOW SULPHUR DIESEL ON SITE

APPENDIX 25.2
SAMPLE OF WASTE FLOW TABLE

SECTION 26
PRESERVATION AND PROTECTION OF TREES

GENERAL

26.01 Definitions regarding trees 26.3
26.02 General requirements 26.3

SURVEY AND IDENTIFICATION OF EXISTING TREES

26.03 Tree Survey 26.4
26.04 Labelling of Trees 26.5

REMOVAL OF EXISTING TREES

26.05 Felling of existing trees 26.6
26.06 Transplanting of existing trees 26.6
26.07 Unplanned tree removal 26.6

PRESERVATION AND PROTECTION OF EXISTING TREES

26.08 General Precautionary Measures to Preserved Trees 26.7
26.09 Protection of preserved trees from physical damage and soil compaction 26.10
26.10 Protection of preserved trees from changes in ground levels 26.11
26.11 Protection of preserved trees from excavation including trenching 26.12
26.12 Protection of preserved trees from drilling 26.14
26.13 Protection of preserved trees from instability 26.14
26.14 Pruning of preserved trees 26.15
26.15 Control of pest and disease for preserved trees 26.15

REPAIR OF DAMAGE

26.16 Repair of damage to preserved trees and other affected plants 26.16

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 13

WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

SECTION 13

WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

GENERAL

General requirements 13.01 The works and materials specified in Clauses 13.02 and 13.03 shall comply with the sections stated, unless otherwise stated in this Section.

Earthworks 13.02 Earthworks shall comply with Section 6.

Materials for grout 13.03 Materials for grout shall comply with Section 16.

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

GLOSSARY OF TERMS

Concealed electrical conduit system 13.05 Concealed electrical conduit system is an electrical conduit system, including all bends, couplers, bushes, saddles, boxes, covers, plugs, draw wires and other conduit fittings, which is cast into concrete or fixed in chases in brickwork with a minimum cover of 20 mm or which is laid directly in the ground.

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) Anti-rust paint for concealed electrical conduit systems shall be of a proprietary type approved by the Engineer.

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

(4) Galvanizing paint for cable duct systems shall be of a proprietary type approved by the Engineer.

Fire barriers 13.09 Internal fire barriers shall be a type offering adequate fire resistance for the application. The material shall be approved by the Engineer in compliance with Fire Services Department's requirements and shall be resistant to fire, smoke, gas and water.

Cement grout for electrical and mechanical installations 13.10 The different types of cement grout for electrical and mechanical installations shall consist of Portland cement, sand and PFA in the proportions by mass stated in Table 13.1 together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the voids. The mix shall contain a non-shrink admixture of a proprietary type approved by the Engineer.

Table 13.1: Mix proportions of cement grout

Type	Mix proportions by mass		
	Cement	Sand	PFA
G1	1	-	-
G2	1	3	-
G3	1	10	-
G4	1	-	7

STORAGE OF MATERIALS

Storage of materials for conduit and cable duct systems 13.11 Materials for concealed electrical conduit systems and for cable duct systems shall be stored in accordance with the manufacturers' recommendations in a dry and weatherproof store.

HOLES AND RECESSES FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

Holes and recesses for electrical and mechanical installations

13.12 (1) Holes and recesses shall be left in structures for electrical and mechanical installations. If instructed by the Engineer, holes and recesses shall be cut in structures for electrical and mechanical installations.

(2) Holes and recesses in internal floors, stairways and platforms shall be protected with temporary covers or by other methods agreed by the Engineer until the electrical and mechanical installation starts. Holes and recesses in roofs, external walls and external floors shall be sealed with watertight temporary covers until the electrical and mechanical installation starts.

(3) Holes in structures shall be filled and made good after electrical and mechanical installations are complete. Holes left in structural elements designated as fire barriers shall be sealed to at least the same degree of fire resistance as the structural element.

FIRE BARRIERS

Fire barriers

13.13 Internal fire barriers shall be constructed in service channels, service shafts and service ducts for electrical and mechanical installations at the following locations:

(a) At points of intersection with structural elements designated as fire barriers,

(b) At 5 m centres in vertical and inclined shafts, and at intersections with floor slabs, and

(c) At termination points and open ends.

CONCEALED ELECTRICAL CONDUIT SYSTEMS

Construction of conduit systems

13.14 (1) Concealed electrical conduit systems that are shown diagrammatically in the Contract shall be constructed as stated in Clause 13.14(2) to (7).

(2) Concealed electrical conduit systems shall be mechanically and electrically continuous and shall be effectively earthed.

(3) Principal conduit runs shall be either vertical or horizontal. Tee pieces and elbows, including those with provision for inspection, shall not be used unless approved by the Engineer.

(4) Joints shall be made using coupler units into which the ends of the conduits shall be inserted and tightened. Running couplings shall not be used unless permitted by the Engineer. If permitted, the couplings shall be made by screwing each of the conduits half way into the coupler with a hexagonal lock nut against each end of the coupler.

(5) Adaptable boxes shall be provided at:

(a) Every second bend,

(b) After a bend and a straight run of 10 m or less, and

(c) Every 15 m in straight runs.

(6) Adaptable boxes for conduits installed in floor screeds shall have the lids set flush with the adjacent floor. The boxes shall be covered with the same material as the remainder of the floor and shall remain accessible at all times.

(7) The clearance between conduits entering adaptable boxes and between adjacent or parallel conduits shall be at least the nominal maximum coarse aggregate size of the concrete plus 5 mm.

Installation of conduit systems

13.15 (1) Concealed electrical conduit systems shall be arranged and installed in accordance with best trade practice and in such a manner that all cables can be drawn with ease and without damage.

(2) Bends in concealed electrical conduit systems shall be formed by using proprietary bending equipment of a type agreed by the Engineer. Connections and other work shall be carried out using purpose made equipment.

(3) Conduits shall not be bent by more than 90^0 and the internal radius at bends shall be at least 2.5 times the external diameter of the conduit. Conduits shall not be flattened at bends.

(4) Burrs and sharp edges shall be removed from the ends of conduits before installation.

(5) Concealed electrical conduit systems that are to be cast into concrete shall be fastened to the reinforcement with tying wire of the same type used for the reinforcement. The conduit systems shall not be positioned between the reinforcement and the outside face of the concrete unless permitted by the Engineer.

(6) Conduit boxes shall be of a compatible size and shall have a single extension ring of the required depth if the plaster finish exceeds 13 mm thick. Multiple extension rings shall not be used.

Terminations of conduit systems

13.16 Screw fitting couplers shall be provided at each end of conduits which terminate in distribution boards, busbar chambers, motor starters, cable ducts, boxes or similar termination points. The item at which the conduit terminates shall be drilled with an unthreaded clearance hole to receive a brass male bush. The bush shall be screwed into the coupler from the inside of the item in such a manner that the surface of the item is gripped between the coupler and the bush. The threads shall be at least half the length of the coupler.

Protection of conduit systems 13.17 (1) Concealed electrical conduit systems shall have special arrangements designed by the Contractor to permit movement of conduits to take place on each side of movement joints in structures. A separate circuit protective conductor shall be installed to maintain effective electrical continuity across the joint. The protective conductor shall have a cross-sectional area rated to suit the largest live conductor to be drawn into the conduit.

(2) Steel conduit systems laid in contact with or adjacent to other metal work shall have efficient and permanent metallic connection made between the conduit and the metal work.

(3) Underground steel conduits and conduits in contact with soil shall be painted with two coats of bituminous paint before installation.

(4) Exposed threads and damage to protective coatings of conduit systems shall be painted with two coats of anti-rust paint.

(5) Conduits shall be laid in such a manner that accumulation of condensed moisture in the conduit system is prevented. Measures shall be taken to prevent water from entering the system.

(6) Water, moisture and deleterious material shall be prevented from entering permanent and temporary terminations in concealed electrical conduit systems, including conduit boxes, by using conduit-stopping plugs of a type approved by the Engineer. Paper or rags shall not be used.

Cleaning of conduit systems 13.18 After installation, concealed electrical conduit systems shall be swabbed out with draw-in tapes and absorbent cloth of a type agreed by the Engineer. All obstructions shall be removed and draw wires shall be installed. After cleaning, exposed conduit ends shall be sealed as stated in Clause 13.17(6)**.**

CABLE DUCT SYSTEMS

Installation of cable duct system 13.19 (1) Changes in direction in cable duct systems shall be constructed in such a manner that the cables in the duct will have radii of curvature of at least 800 mm. Ducts entering draw-in pits shall be on the same horizontal plane as the draw-in pit.

(2) uPVC cable ducts shall be jointed in accordance with the manufacturer's recommendations.

(3) Steel cable ducts shall be jointed using screwed hot dip galvanized sockets and spun yarn or by an equivalent method approved by the Engineer such that the jointed pipes abut. The threads shall be painted with two coats of bituminous paint. Internal rags and burrs shall be removed to provide a smooth bore through joints in the cable duct system.

(4) Surface mounted cable ducts shall be secured by hot dip galvanized steel clamps or saddles at spacings not exceeding 3 m.

Protection of cable duct systems 13.20 (1) After jointing, exposed bare metal in cable duct systems shall be cleaned and painted with two coats of zinc chromate primer and two coats of galvanizing paint.

(2) Surface-mounted hot dip galvanized steel cable ducts shall be cleaned

and painted after fittings and jointing have been completed.

Cleaning of cable duct systems 13.21 After jointing, cable duct systems shall be cleaned internally by scrubbing with a cylindrical brush of a type agreed by the Engineer. The ends of ducts, including ends of ducts in draw-in pits and spare ducts, shall be fitted with tapered hardwood plugs to prevent water, moisture and deleterious material from entering the system and a 6 mm diameter nylon draw line shall be installed. The plugs shall be centrally drilled for the draw line and the draw line shall be secured by a knot tied on the outer face of the plug to leave at least 1500 mm of surplus line at each plug.

ELECTRICAL EARTHING SYSTEMS

Electrical earthing systems 13.22 (1) Pits and trenches for electrical earthing systems shall be excavated at positions and at the times instructed by the Engineer.

(2) After the electrical earthing systems have been installed fill material shall be deposited and compacted in the pits and trenches to a depth of 300 mm above the electrical earthing system. Fill material shall be sand or fine fill material which has been selected from the excavated material, and which is free of stones retained on a 20 mm BS test sieve. Fill material shall be compacted by handrammers in a manner approved by the Engineer.

GROUTING FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

Grouting for electrical and mechanical installations 13.23 (1) Grouting to structural steelwork, machine bases, crane rails, electrical and mechanical equipment and other electrical and mechanical installations shall comply with the requirements stated in Clauses 13.23(2) to (8).

(2) Grouting shall be carried out at the times instructed by the Engineer and shall be completed within 7 days of the instruction unless otherwise permitted by the Engineer.

(3) The permission of the Engineer shall be obtained before items or equipment are grouted. The Contractor shall inform the Engineer within 3 days, or a shorter period agreed by the Engineer, before grouting starts and shall allow the Engineer sufficient time to inspect the work that is to be grouted.

(4) Concrete surfaces shall be scabbled to remove laitance and loose material and to expose the aggregate before the item or equipment is installed in position.

(5) The voids to be grouted shall be cleaned and thoroughly wetted immediately before grouting. Excess water shall be removed by using a compressed air jet or by other methods agreed by the Engineer.

(6) Grout shall be mixed and placed by methods agreed by the Engineer.

(7) If grouting is to be carried out in two operations, holding down bolts shall be grouted into preformed pockets and sufficient time shall be allowed for the grout to cure and for the bolts to be tensioned before the remaining

voids are grouted.

(8) Exposed grout surfaces shall have a uniform, dense and smooth surface free of trowel marks and which is produced by steel trowelling the surface under firm pressure. The exposed surfaces shall be cured by either:

(a) Using a liquid curing compound applied to the surface by a low-pressure spray until a continuous visible covering is achieved, or

(b) Covering the surface with hessian or sacking. The hessian or sacking shall be lapped and securely held in position and shall be kept damp for at least 4 days.

COMPLETION AND PROTECTION OF WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

Completion of work for electrical and mechanical installations 13.24

(1) Work shall be completed to the conditions stated in Clauses 13.24(2) to (8) before structures are made available to others for electrical and mechanical installations.

(2) The structure shall be clean, dry and free of dust. Work that in the opinion of the Engineer will produce large quantities of dust shall be complete.

(3) Holes and recesses, concealed electrical conduit systems and cable duct systems required for the installation shall be complete. Concrete surfaces on which items and equipment are to be installed shall be scabbled.

(4) Plinths, trenches, louvres, openings and similar work shall be complete and shall have hardened sufficiently to allow the installation to proceed.

(5) Floors and slabs shall be complete to the specified finishes except that floor tiles shall not be laid until after the installation is complete.

(6) Plant rooms shall be complete, including fixtures and fittings, to a secure and weatherproof condition. Two sets of door keys for the plant room shall be provided for the Engineer.

(7) Paintwork and similar finishes in plant rooms shall be complete to undercoat level. Final coats shall not be applied until after the installation is complete.

(8) Temporary power supplies and connections required for the installation shall be complete. The supply shall be metered and shall be a 380V, 50Hz, 3-phase supply of 20A maximum rating. Temporary power supplies shall be provided for the periods stated in the Contract.

Protection of work for electrical and mechanical installations 13.25

(1) Structures in which electrical and mechanical installations are being carried out shall be maintained in a clean, dry condition, free of dust, during the installation.

(2) The dust level in plant rooms shall be kept to a minimum by using industrial dust extractors of a type agreed by the Engineer during and after the installation. Temporary screens shall be installed to separate dust-

affected areas from the installations or temporary covers shall be installed around the installation.

TOLERANCES

Tolerances: floors of switchgear rooms 13.26 The tolerance in floor levels for switchgear rooms shall be as follows:

(a) ± 1 mm in 1000 mm for high voltage switchgear rooms,

(b) ± 1 mm in 1000 mm for medium voltage switchgear rooms.

Tolerances: lamp standards 13.27 Lamp standards shall be within 0.1 degrees of the vertical.

INSPECTION OF WORK FOR ELECTRICAL AND MECHANICAL INSTALLATIONS

Inspection of work for electrical and mechanical installations 13.28 (1) The Contractor shall allow the Engineer to inspect the following work for electrical and mechanical installations:

(a) Completed concealed electrical conduit systems, cable duct systems, electrical earthing systems and items and equipment which are to be grouted or covered up,

(b) Items and equipment which are to be tested, and

(c) Structures that are to be made available for electrical and mechanical installations.

(2) The Contractor shall inform the Engineer three days, or such shorter period agreed by the Engineer, before work is covered up, tested or made available.

TESTING: EARTHING CONTINUITY

Testing: earthing continuity 13.29 (1) Concealed electrical conduit systems shall be tested to determine the earthing continuity. The system shall be tested:

(a) Before the system is cast in concrete or covered up,

(b) After the system is cast in concrete or covered up, and

(c) After electrical wiring that is installed by the Contractor is complete.

(2) Unless otherwise approved by the Engineer the method of testing shall comply with the Code of Practice for the Electricity (Wiring) Regulations or with BS 7671.

Compliance criteria: 13.30 The results of tests for earthing continuity shall comply with the Code of

earthing continuity		Practice for the Electricity (Wiring) Regulations or with BS 7671.

TESTING: LOAD TESTS ON BEAMS AND JOISTS

Testing: load tests on beams and joists	13.31	(1) Load tests shall be carried out on lifting beams, rolled steel joists and lifting hooks that are installed by the Contractor. (2) Testing shall be carried out by an independent testing consultant approved by the Engineer and by using methods approved by the Engineer. (3) A certificate showing the results of the load tests and signed by the testing agent shall be submitted to the Engineer within 14 days of the test.
Compliance criteria: load tests on beams and joists	13.32	The results of tests on lifting beams, rolled steel joists and lifting hooks shall comply with the Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations issued by the Labour Department.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 14

FORMWORK AND FINISHES TO CONCRETE

SECTION 14

FORMWORK AND FINISHES TO CONCRETE

GENERAL

General requirements 14.01 (1) The works and materials specified in Clauses 14.02 and 14.03 shall comply with the sections stated, unless otherwise stated in this Section. Hardwood is strictly prohibited for use in the falsework.

(2) All 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 carriageways 14.02 Surface finish to concrete carriageways shall comply with Section 10.

Cover spacers 14.03 Cover spacers for steel reinforcement shall comply with Section 15.

GLOSSARY OF TERMS

Class 14.04 Class is a term used to identify the different types and standards of formed, unformed and treated finishes.

Falsework 14.05 Falsework is a temporary structure used to support formwork and a permanent structure until the permanent structure is self-supporting.

Formed finish 14.06 Formed finish is the finish of the concrete surface produced by the use of formwork.

Formwork 14.07 Formwork is the mould against which concrete is cast and which gives the shape and finish to the concrete surface.

Permanent formwork 14.08 Permanent formwork is formwork designed to remain in position as part of the permanent work.

Profiled formwork 14.09 Profiled formwork is formwork designed to produce a ribbed or patterned finish on the concrete surface.

Sealed plywood 14.10 Sealed plywood is plywood that has been sealed with a factory-applied film of phenolic resin or plastic material.

Spatterdash 14.11 Spatterdash is a mixture of cement, coarse sand, granite fines and water, used as a rendering on concrete surfaces.

Treated finish 14.12 Treated finish is the finish of the concrete surface produced by a treatment applied to a formed or unformed finish.

Unformed finish 14.13 Unformed finish is the finish of the concrete surface produced without formwork and by working the concrete surface before the concrete has hardened.

Wood preservative 14.13A Wood preservative in permanent timber formwork shall comply with Clause 24.27.

MATERIALS

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.

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

Table 14.4: Class of finish

Description of surface		Class of finish	
		Formed	Unformed
Surfaces to be covered	- screeded	-	U2
	- rendered, plastered	F2	-
	- tiled	F2	U3
	- painted	F4	U5
Surfaces for treated finishes		F3	U3
Surfaces for pedestrian traffic		-	U4
Construction joints (for Class T1 finish)		F2	U3
Movement joints		F3	U3
Benching, screeds		F3	U5
Blinding, foundations, pile caps		F1	U1
Piers, blocks, pipe surrounds	- below FGL	F1	U1
	- above FGL	F2	U3
Manholes, chambers	- external below FGL	F1	U1
	- external above FGL	F2	U3
	- internal	F2	U3
Culverts, channels	- external below FGL	F1	U1
	- external above FGL	F2	U3
	- internal	F4	U5
Water retaining structures	- external below FGL	F2	U3
	- external above FGL	F4	U5
	- internal	F4	U5
Buildings	- external below FGL	F1	U1
	- external above FGL	F2	U3
	- internal	F4	U5
Bridges, retaining walls, walls	- below FGL	F1	U1
	- above FGL, not exposed to direct public view	F4	U5
	- above FGL, exposed to direct public view	F5	U5
	- internal, not exposed to direct public view	F2	U1

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.

SUBMISSIONS

Particulars of formwork and finishes to concrete and samples of materials 14.21 (1) Particulars and samples of the proposed materials and methods of construction for Class F4, F5, U5 and T finishes shall be submitted to the Engineer as marked 'x' in Table 14.5. The same particulars shall be submitted for other Classes of finish if required by the Engineer. Where the sheathing is timber plywood, details of the method of identifying and recording the number of uses to which the sheathing will be subjected to, including the labour and equipment that are provided for carrying out marking and recording, shall be submitted to the Engineer for approval.

(2) The particulars and samples for formed finishes shall be submitted at least 14 days before the relevant formwork, including formwork for trial panels, is fabricated. The particulars and samples for unformed and treated finishes shall be submitted at least 14 days before the relevant element, including trial panels, is concreted.

(3) In addition to drawings and calculations showing the geometry and member size and spacing of each item of formwork or falsework, the Contractor shall submit drawings showing his standard formwork and falsework details which shall include:

(a) Details of joints and seals between shutter facing boards, shutter face and concrete at construction joints and adjacent shutters at butt joints and corners to effectively prevent loss of grout and maintain accurate alignment.

(b) Details of shutter facing material.

(c) Details of fixing 'plant on' pieces onto the shutter face.

(d) Details of fixing and maintaining the alignment of waterstops.

Table 14.5: Particulars to be submitted

Particulars to be submitted		Formed finishes	Unformed finishes	Treated finishes
Formwork drawings	: Panel construction	X	-	X
	Layout and pattern of panels, joints and formwork ties	X	-	X
Method statement		-	X	X
Samples	: Formwork	X	-	-
	Formwork ties	X	-	X
	Cover spacers	X	-	X
Brand name and manufacturer's literature	: Release agent	X	-	X
	Curing compound	X	X	X
	Surface retarder	-	-	X
Programme	: Removing formwork	X	-	-
	Applying treated finishes	-	-	X
Details	: Sources of formwork, formwork ties and cover spacers	X	-	X
	Curing	X	X	X
	Filling blowholes	X	-	-
	Filling formwork tie holes	X	-	X
	Protecting finishes	X	X	X

TRIAL PANELS

Trial panels 14.22 (1) A trial panel shall be constructed for each Class F4, F5, U5 and T finish to demonstrate that the proposed materials, mix design, methods of production and methods of construction, including curing and removal of formwork, will produce the specified finish.

(2) Trial panels for Class F4 and F5 finishes shall be constructed before the relevant formwork for the permanent work is erected, and trial panels for Class U5 and T finishes shall be constructed before the relevant permanent work is concreted. The trial panels shall be constructed at least 4 weeks before the

relevant permanent work is carried out.

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

(4) Trial panels shall be constructed using the materials, mix design, methods of production and methods of construction, including curing and removal of formwork, submitted to the Engineer for approval.

(5) Trial panels shall be horizontal, vertical or inclined as appropriate and shall be constructed at locations agreed by the Engineer. Unless otherwise stated in the Contract each trial panel shall be not less than 2 m by 2 m by 300 mm thick, and shall contain reinforcement representative of the most congested reinforcement that will be used in the permanent works. Trial panels shall incorporate formwork ties and components, horizontal joints, vertical joints, chamfers, splays, rebates and other features representative of those which will be used in the permanent work.

(6) Trial panels shall be protected from damage and shall be left in position until the Engineer instructs the Contractor to remove them.

Non-compliance: trial panels 14.23 If in the opinion of the Engineer the specified finish has not been produced in the trial panel, particulars of proposed changes to the materials, mix design, methods of production or methods of construction shall be submitted to the Engineer for approval. Further trial panels shall be constructed until the specified finish is produced in the trial panel. Further trial mixes shall be made unless in the opinion of the Engineer non-compliance of the trial panel was not due to the concrete mix.

Commencement of formwork and concreting 14.24 Formwork for Class F4 and F5 finishes shall not be erected and elements with Class U5 and T finishes shall not be concreted until in the opinion of the Engineer the specified finish has been produced in the trial panel.

Changes in materials and methods of construction 14.25 Unless permitted by the Engineer, the materials, mix design, methods of production or methods of construction, including curing and removal of formwork, used to produce the specified finish in trial panels shall not be changed. The Engineer may order new trial panels to be constructed if he considers that the changes in materials and/or methods of construction proposed by the Contractor may affect the finished appearance.

STORAGE OF MATERIALS

Storage of formwork 14.26 (1) Formwork shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner, which will not result in damage or deformation to the formwork, or in contamination of the formwork. Measures to protect the formwork against drying and wetting caused by weather shall be submitted to the Engineer for approval.

(2) Formwork for Class F4 and F5 finishes shall be covered and protected from exposure to conditions that may affect the formwork.

Storage of release agents and surface retarders 14.27 Release agents and surface retarders shall be stored in sealed containers marked to identify the contents 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

shelf life has been exceeded.

DESIGN AND CONSTRUCTION OF FALSEWORK AND FORMWORK

Design and construction of falsework and formwork

14.28 (1) Falsework and formwork shall be designed and constructed to maintain the position and shape of the formwork so that the hardened concrete surface complies with the characteristics of finish stated in Table 14.1 and with any more stringent tolerances stated in the Contract. Allowance shall be made for cambers.

(2) Falsework and formwork shall be capable of being dismantled and removed without shock, disturbance, damage or loading to the concrete and in such a manner that the specified requirements for removing or leaving in position side formwork, soffit formwork and props will be achieved without disturbing other formwork or props.

(3) Formwork shall be used to form the top surface of concrete inclined at a slope exceeding 15^{o} to the horizontal unless it can be demonstrated that the specified finish will be produced without the use of formwork. Formwork to top surfaces shall be anchored to prevent flotation.

(4) The Contractor shall be responsible for the design of all proposed falsework and formwork and submit the design calculations and drawings to the Engineer at least 14 days before the relevant element is erected.

Construction of formwork

14.29 (1) Formwork shall not have any splits, cracks or other defects. The faces and edges of formwork shall be clean and formwork faces shall be free of projecting nails.

(2) Formwork that has been previously used shall be repaired and the edges resealed before it is erected. Formwork that in the opinion of the Engineer has deteriorated to an extent such that it will not produce the specified finish shall not be used for that Class or a higher Class of finish.

(3) Formwork shall be firmly supported and individual panels shall be rigid. Joints between formwork panels, stop ends and adjoining concrete shall be tight and shall not permit grout loss. Gaps shall be sealed with gaskets, filler, sealant or tape before the application of release agents.

(4) Formwork shall be cut in such a manner that reinforcement and built-in components passing through the formwork are maintained in position. The joints shall be tight and shall not permit grout loss.

(5) Formers for profiled formwork, chamfers, splays, rebates and other features shall be rigidly and evenly fixed to the formwork along the complete length and shall not permit grout loss.

(6) Formwork ties and components shall be fixed in such a manner that they do not touch reinforcement or built-in components. Formwork ties and components shall fit tightly against formwork faces and shall not permit grout loss.

(7) If required for cleaning or inspection, temporary openings shall be provided in the formwork. Temporary openings shall not be cut in any

formwork without the approval of the Engineer.

Construction of formwork for Class F2, F3, F4 and F5 finishes

14.30 (1) Formwork panels for Class F2, F3, F4 and F5 finishes shall be the same size and shall form a regular pattern approved by the Engineer. The lines of joints between panels shall be straight and continuous, horizontal and vertical, or inclined to suit the pattern of profiled formwork, and shall be coincident with construction joints and other joints and with recesses in the concrete surface. The number of make-up pieces shall be kept to a minimum.

(2) Holes left by formwork ties and components in concrete surfaces with Class F2, F3, F4 and F5 finishes shall be in line horizontally and vertically and shall form a regular pattern approved by the Engineer. Unless otherwise permitted by the Engineer, holes in profiled formwork shall be located in such a manner that the holes are completely within recesses in the concrete surface.

(3) Unless otherwise stated in the Contract or permitted by the Engineer, chamfers shall be provided for all external angles of 90° or less in concrete surfaces with Class F2, F3, F4 and F5 finishes.

(4) Formwork for curved concrete surfaces with Class F2, F3, F4 and F5 finishes shall not be made up of a series of flats unless permitted by the Engineer.

Construction of formwork for Class F4 and F5 finishes

14.31 (1) Each type of formwork for Class F4 and F5 finishes shall be obtained from one source and different types of formwork shall not be mixed unless permitted by the Engineer. Damaged formwork shall not be used unless permitted by the Engineer. Parts of steel formwork that will be in contact with concrete shall be free of rust.

(2) For concrete surfaces with Class F4 and F5 finishes, joints between formwork panels shall be sealed with foamed rubber strips. The foamed rubber strips shall be sufficiently compressible to form a grout-tight joint. The width of the resulting gap between the panels shall not be greater than 1 mm and the sealing strips shall not protrude proud of the surface of the formwork panels. Alternatively, subject to the approval of the Engineer, joints between formwork panels may be sealed with an approved filler provided that the butting edges of the panels are smooth and the resulting gap between the panels is not wider than 1 mm. Joints between formwork panels shall not be sealed by tape fixed to the formwork faces.

(3) Formwork for Class F4 and F5 finishes shall be protected from spillages, rust marks and stains.

Built-in components

14.32 Built-in components, void formers and box-outs shall be fixed in position before and during concreting. Unless permitted by the Engineer, void formers and box-outs shall not be used instead of built-in components. Polystyrene shall not be used for void formers and box-outs unless permitted by the Engineer.

APPLICATION OF RELEASE AGENTS

Application of release agents

14.33 (1) A release agent shall be used on all formwork other than permanent formwork and formwork on which a surface retarder is used to produce a Class T1 finish. The release agent shall be applied by the method and at the rate of application recommended by the manufacturer or as demonstrated to be satisfactory by use in the trial panel.

(2) Formwork faces shall be cleaned before release agents are applied. Concrete, reinforcement and built-in components shall not be contaminated by release agents.

(3) Each type of release agent used on formwork for Class F4 and F5 finishes shall be obtained from one manufacturer and different types of release agent shall not be used on formwork for the same element.

(4) Release agents shall be applied to formwork for Class F4 and F5 finishes after the formwork has been erected and before the reinforcement is fixed or, if this is not practicable, immediately before the formwork is erected. The release agent covering shall be complete and uniform.

INSPECTION OF FORMWORK AND REINFORCEMENT

Inspection of formwork and reinforcement 14.34 (1) The Contractor shall allow the Engineer to inspect the completed formwork and reinforcement, including trial panels, before carrying out any work, including fixing reinforcement adjacent to formwork and erecting formwork adjacent to reinforcement, which will make access to the formwork faces or reinforcement difficult. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before carrying out such work.

(2) The Contractor shall allow the Engineer to inspect formwork for Class F4 and F5 finishes before it is erected and shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before erecting the formwork.

REMOVAL OF FALSEWORK AND FORMWORK

Times for removal of falsework and formwork 14.35 (1) Except as stated in Clause 14.35(3), falsework and formwork shall not be loosened or removed before the minimum times stated in Table 14.6 have elapsed. The times stated are for a minimum ambient temperature of 15°C, for elements without superimposed loads and for concrete containing PC, PFAC or both PC and PFA not exceeding the PC replacement level as specified in Clause 16.14. If other conditions apply, particulars of proposed changes to the minimum times shall be submitted to the Engineer for approval.

(2) For the purpose of determining the minimum times for loosening or removing falsework and formwork, copings at the top of columns in water retaining structures shall be classified as slabs and roof slabs in water retaining structures shall be classified as beams.

(3) Falsework and formwork supporting concrete in flexure may be loosened or removed when the strength of the concrete in that element is 10 MPa or twice the stress to which it will be subjected, whichever is greater, provided that deflection which in the opinion of the Engineer is unacceptable will not result and that superimposed loads will not be applied. The strength of the concrete shall be determined from tests on test cubes which have been made with concrete from the same pour and which have been cured by the same method and under similar conditions as the concrete in the element.

Table 14.6: Minimum times for loosening or removing falsework and formwork

Type of falsework or formwork	Class F1, F2, F3 and F4 finishes		Class F5 finish
	Concrete without PFA/GGBS	Concrete with PFA/GGBS	All concrete
Vertical (non-profiled) (profiled)	12 hours 7 days	15 hours 7 days	48 hours 7 days
Inclined to top surfaces	12 hours	15 hours	48 hours
Soffits of slabs (props left in)	4 days	4 days	10 days
Soffits of beams (props left in)	7 days	7 days	14 days
Props to slabs	10 days	10 days	10 days
Props to beams	14 days	14 days	14 days
Props to cantilevers	28 days	28 days	28 days

Removal of falsework and formwork 14.36 (1) Formwork shall be removed without hammering or levering to the concrete and in such a manner that there is no shock, disturbance, damage or loading to the concrete. Side formwork shall be removed without disturbing soffit formwork and soffit formwork shall be removed without disturbing props except as provided for in Clause 14.36(2).

(2) Individual props may be removed to allow the removal of soffit formwork provided that the formwork has been designed accordingly and that each prop is replaced as soon as the formwork has been removed.

(3) Falsework and formwork for Class F5 finishes shall be loosened and removed in a continuous operation and in accordance with a consistent programme agreed by the Engineer. All formwork shall be loosened before individual panels are removed and all formwork shall be removed within the programmed period. Individual panels or make-up pieces shall not be left in position.

(4) After removal, formwork which is intended for re-use shall be cleaned, repaired and stored as stated in Clause 14.26.

UNFORMED FINISHES

Unformed finishes 14.37 (1) Unformed finishes shall be produced by the methods stated in Table 14.2.

(2) Brushing to produce a Class U4 finish shall be carried out in straight lines in a direction agreed by the Engineer. Brushing shall be carried out when the concrete has hardened sufficiently for the float marks to be removed and for the ridges to be formed without displacing the aggregate.

(3) Floating and trowelling shall not be carried out until the concrete has hardened sufficiently to allow the specified finish to be produced with the minimum amount of floating and trowelling such that excess laitance is not produced.

TREATED FINISHES

Treated finishes 14.38 (1) Treated finishes shall be produced by constructing a concrete surface with a Class F3 or U3 finish as appropriate and applying the treatment to the surface by the methods stated in Table 14.3.

(2) The treatment shall be applied in a continuous operation in accordance with a consistent programme agreed by the Engineer. Tying wire and cover spacers for reinforcement and cast-in component shall be positioned to avoid being exposed by the applied treatment.

Class T1 finish 14.39 (1) Washing and brushing to produce a Class T1 finish shall not be carried out until the concrete has hardened sufficiently for the cement matrix to be removed without disturbing the coarse aggregate. After washing and brushing have been completed and the concrete surface has hardened, the surface shall be cleaned.

(2) The cement matrix shall not be removed or the aggregate exposed by mechanical methods unless permitted by the Engineer.

(3) Class T1 finishes may be produced by using a surface retarder applied to the formwork or to the concrete surface. The surface retarder shall be applied by the method and at the rate of application recommended by the manufacturer, or as demonstrated to be satisfactory by use on the trial panel.

(4) Plywood to which a surface retarder is to be applied shall be sealed with barrier paint, polyurethane varnish or other impermeable material agreed by the Engineer. The formwork shall be removed in small sections and the coarse aggregate exposed by washing and brushing the concrete surface.

(5) Unless permitted by the Engineer, formwork to which a surface retarder has been applied shall not be re-used unless a surface retarder is to be used again on the formwork. Formwork to which a surface retarder has been applied and which is to be re-used shall be cleaned before the retarder is applied.

Class T2 and T3 finishes 14.40 Point tooling to produce Class T2 finishes and bush hammering to produce Class T3 finishes shall be carried out evenly in small areas and not in distinct lines. Tooling and hammering shall not start until at least 7 days after concreting.

Class T4 finish 14.41 Hammering or chiselling to produce a Class T4 finish shall be applied from only one direction, and only either hammering or chiselling shall be applied, on any one face. Hammering and chiselling shall not start until at least 14 days after concreting.

Class T5 and T6 finishes 14.42 Blasting to produce Class T5 and T6 finishes shall not be carried out until the concrete has hardened sufficiently for the cement matrix to be removed without disturbing the coarse aggregate. Adjacent surfaces shall be protected

from blasting and dust shall be controlled by screens and by water-spraying.

COMPLIANCE OF FINISHES

Inspection of finishes 14.43 (1) Before any subsequent work is carried out on a concrete surface, the surface shall be inspected by the Engineer to determine if the specified finish has been produced. Formed finishes shall be inspected as soon as the formwork has been removed.

(2) Blowholes or holes left by formwork ties and components shall not be filled and spatterdash or other coverings shall not be applied before the inspection. Any such filling or covering carried out before the inspection may be rejected.

Compliance of finishes 14.44 (1) Concrete surfaces shall have the characteristics stated in Tables 14.1 and 14.2 for the different Classes of formed and unformed finish before any subsequent work is carried out on the concrete surface and shall have the characteristics stated in Table 14.3 for the different Classes of treated finish.

(2) The Engineer shall determine if the specified finish has been produced and may use the trial panels as a means of comparison.

(3) Abrupt irregularities shall be measured by direct measurement. Gradual irregularities shall be measured using a 2 m long straight edge on surfaces intended to be flat and by a method agreed by the Engineer on other surfaces.

WORK ON CONCRETE SURFACES

Remedial and repair work on concrete surfaces 14.45 Remedial or repair work shall not be carried out on concrete surfaces unless permitted by the Engineer. Any such work carried out without permission may be rejected.

Filling blowholes and formwork tie holes 14.46 (1) Blowholes exceeding 3 mm in size in water retaining structures and watertight structures, and blowholes exceeding 10 mm in size in other structures shall be filled with cement mortar. The size of blowholes shall be the maximum dimension measured across the hole on the concrete surface. If the number and size of blowholes in concrete surfaces with Class F3, F4 and F5 finishes is in the opinion of the Engineer greater than in the trial panel the blowholes shall be filled, unless in the opinion of the Engineer filling is not required.

(2) Holes left by formwork ties and components shall be cleaned and filled by ramming cement mortar into the holes in layers. Holes in concrete surfaces with a Class F5 finish shall be filled to a level slightly below the concrete surface. The holes shall not be overfilled and rubbed down.

(3) Filling of blowholes and holes left by formwork ties and components shall be carried out as soon as practicable after the Engineer has inspected the finish and with the minimum interruption to curing.

Spatterdash 14.47 (1) Spatterdash shall consist of cement and coarse sand or granite fines in the proportions 1:2 by volume mixed with the minimum amount of water

necessary to achieve the consistency of a thick slurry. Spatterdash shall be thrown with a hand trowel onto the surface to a thickness not exceeding 6 mm and shall cover at least 60% of the area, which is to be plastered or rendered. Spatterdash shall be wetted one hour after application and shall be allowed to cure and harden before under coats are applied.

(2) Spatterdash shall be applied as soon as practicable after the Engineer has inspected the finish and after the concrete surface has been cleaned and wetted.

PROTECTION OF FINISHES

Protection of finishes 14.48 (1) Materials, construction plant or other vehicles shall not use or be placed on or against concrete surfaces unless permitted by the Engineer.

(2) Concrete surfaces with Class F4, F5, U5 and T finishes shall be protected from running water, spillages, rust-marks and stains by covering the surface with polyethylene sheeting or timber or by other methods agreed by the Engineer. Protection from rust-marks caused by reinforcement bars shall be by polyethylene sleeves tied to the bars or by coating the bars with cement slurry. The bars shall not be coated with oil or grease.

(3) Concrete surfaces with Class F4, F5, U5 and T finishes shall be protected from damage by securing timber battens to the surface, by erecting barriers or fences or by other methods agreed by the Engineer.

(4) Concrete surfaces with a Class F5 finish shall be protected from exposure to extreme variations in weather conditions for at least 14 days after the formwork has been removed.

CURVED FORMWORK

Curved formwork 14.49 Where curved or domed concrete surfaces are specified, the formwork shall be curved or domed accordingly. The alternative of replacing a curved or domed concrete surface with a series of small connecting planar surfaces will not be permitted unless:

(a) The concrete surface will be covered by tiles,

(b) The Contractor has demonstrated to the satisfaction of the Engineer that the irregularities on the concrete surfaces due to such alternative will not affect the final smoothness of the tiled surface, and

(c) The Engineer's approval is given.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 15

STEEL REINFORCEMENT

SECTION 15

STEEL REINFORCEMENT

GLOSSARY OF TERMS

Reinforcement connector 15.01 Reinforcement connector is a coupler or sleeve designed to transmit the force between two bars in tension or compression.

Reinforcement 15.02 Reinforcement is steel bar, wire or fabric used in its untensioned state in concrete.

MATERIALS

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 Amd 1/2025	CS2
B	Other reinforcing steel bars Grade 500 not covered by CS2 Amd 1/2025	BS 4449
C	Plain round steel bars (diameter > 12 mm) of Grade 250 not covered by CS2 Amd 1/2025	BS 4449:1997
D	Plain round steel bars (diameter ≤ 12 mm) of Grade 250 not covered by CS2 Amd 1/2025	BS 4482
E	Steel fabric sheets Amd 1/2025	BS 4483

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.

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.

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 15.10 Tying wire for reinforcement adjacent to and above Class F4 and F5 finishes and stainless steel reinforcement shall be 1.2 mm diameter stainless steel wire. 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. Tying wire for galvanized reinforcement shall be 1.6 mm diameter galvanized soft annealed steel wire. Tying wire for other reinforcement shall be 1.6 mm diameter soft annealed steel wire.

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.

SUBMISSIONS

Particulars of reinforcement

15.12 (1) The following particulars of the proposed steel reinforcement shall be submitted to the Engineer for approval Amd 3/2021:

(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 Amd 1/2025
- 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 Amd 3/2021 for each batch of reinforcement delivered to the Site and at least 14 days before fixing of the reinforcement starts.

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 Amd 3/2021:

(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 Amd 3/2021 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 Amd 3/2021 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 Amd 3/2021:

(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 Amd 3/2021 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 Amd 3/2021 for each batch of galvanized reinforcement delivered to the Site and at least 14 days before fixing of the reinforcement starts.

Particulars of reinforcement connectors

15.15 Particulars of the proposed materials and methods of installation for reinforcement connectors, including the manufacturer's literature, shall be submitted to the Engineer for approval Amd 3/2021 at least 28 days before fixing of reinforcement connectors starts.

Bending schedules

15.16 Bending schedules of reinforcement complying with BS 8666 shall be prepared by the Contractor and submitted to the Engineer for information Amd 3/2021 before bending of reinforcement starts.

Samples of materials

15.17 Samples of the following proposed materials shall be submitted to the Engineer for information Amd 3/2021 at the same time as particulars of the materials are submitted:

(a) Reinforcement,

(b) Epoxy-coated reinforcement,

(c) Galvanized reinforcement,

(d) Reinforcement connectors for tension joints and compression joints,

(e) Cover spacers and other spacers, and

(f) Tying wire, tying devices and clips.

HANDLING AND STORAGE OF MATERIALS

Handling of reinforcement

15.18 (1) Reinforcement shall not be subjected to rough handling, shock loading or dropping from a height.

(2) Nylon, rope or padded slings shall be used for lifting epoxy-coated reinforcement and galvanized reinforcement. Bundles shall be lifted with a strong back or with multiple supports to prevent abrasion.

Storage of

15.19 (1) Reinforcement shall be stored off a levelled, well drained and

reinforcement

maintained hard-standing ground on level supports and in a manner, which will not result in damage or deformation to the reinforcement, or in contamination of the reinforcement. Measures to protect the reinforcement from wetting and rusting caused by weather shall be proposed for the Engineer's approval. Reinforcement shall be stored horizontally.

(2) Different types and sizes of reinforcement shall be stored separately.

(3) Reinforcement shall not be stored on or adjacent to concrete surfaces that form part of the permanent work.

(4) Epoxy-coated reinforcement and galvanized reinforcement shall be stored on wooden or padded cribbing.

CUTTING AND BENDING REINFORCEMENT

Cutting and bending reinforcement

15.20 (1) Reinforcement shall be cut and bent in accordance with BS 8666 to the specified shapes and dimensions and shall be bent at temperatures of at least 5°C and not exceeding 100°C.

(2) Epoxy tends to become brittle at lower temperatures, additional care should be exercised when fabrication is performed during cold weather. Surfaces of bending equipment in contact with epoxy-coated reinforcement shall be fitted with nylon or plastic mandrels.

(3) Grade 500 and stainless steel reinforcement shall not be rebent or straightened after bending. Grade 250 reinforcement which projects from the hardened concrete may be bent aside and rebent provided that the internal radius of the bend is at least twice the diameter of the bar and that bending is not carried out by levering against the concrete or by other methods which in the opinion of the Engineer are likely to damage the concrete.

(4) The ends of bars to be used with reinforcement connectors for compression joints shall be sawn square with all burrs removed.

SURFACE CONDITION OF REINFORCEMENT

Surface condition of reinforcement

15.21 (1) Reinforcement shall be clean at the time of fixing and shall be free of loose mill scale, loose rust or any substance that, in the opinion of the Engineer, is likely to reduce the bond or affect the reinforcement or concrete chemically. The reinforcement shall be maintained in this condition until concrete is placed around it.

(2) If the surface condition of the reinforcement deteriorates such that it does not comply with the requirements stated in Clause 15.21(1), the reinforcement shall be cleaned or dealt with by other methods agreed by the Engineer.

Repairs to epoxy coatings and galvanized coatings

15.22 (1) If the coating to epoxy-coated reinforcement is delaminated or split at any point or if the coating to epoxy-coated reinforcement or galvanized reinforcement is damaged,

(a) at any point by an amount exceeding 25 mm^2 in area or 50 mm in length, or

(b) at more than three points in a 1 m length by amounts each even not exceeding 25 mm^2 in area or 50 mm in length,

that part of the reinforcement shall not be used in the permanent works. If the coating to epoxy-coated reinforcement or galvanized reinforcement is damaged at more than six points in the cut and bent length of a bar by amounts each even not exceeding 25 mm^2 in area or 50 mm in length, that length of bar shall not be used in the permanent work.

(2) Except as stated in Clause 15.22(1), all damaged areas and cut ends of epoxy-coated reinforcement shall be repaired using sealing material applied in accordance with the manufacturer's recommendations. The sealing material shall comply with BS ISO 14654 and shall be submitted to the Engineer for approval.

(3) Except as stated in Clause 15.22(1), all damaged areas and cut ends of galvanized reinforcement shall be repaired by materials to be approved by the Engineer. Sufficient material shall be applied to provide a coating of at least the same thickness as the galvanized coating. The Contractor shall refer to Section 6.3 and Annex C of BS EN ISO 1461 for advice on repair of damaged areas.

(4) Repairs to epoxy coatings and galvanized coatings shall be carried out within 8 hours of cutting or damage. Traces of rust shall be removed from the surface of the reinforcement before the repair is carried out.

FIXING REINFORCEMENT AND REINFORCEMENT CONNECTORS Amd 1/2025

Fixing reinforcement 15.23 (1) Reinforcement and reinforcement connectors for tension joints from each batch shall not be fixed until testing of the batch has been completed.

(2) Reinforcement shall be fixed rigidly in position and secured against displacement.

(3) A sufficient number of intersecting and lapping bars shall be tied using tying wire, tying devices or clips to prevent movement of the reinforcement. The ends of tying wire, tying devices and clips shall not encroach into the cover to reinforcement.

(4) Laps and joints in reinforcement shall be made only at the specified positions and by the specified method.

(5) Sufficient numbers of cover spacers, chairs, supports and spacers other than cover spacers shall be provided to maintain the reinforcement in the correct location and to maintain the specified cover at all positions. Cover spacers, chairs, supports and spacers other than cover spacers shall be placed at a maximum spacing of 1.5 m. Chairs, supports and spacers other than cover spacers shall be positioned adjacent to or above cover spacers and shall have at least the same cover as that specified for the reinforcement.

(6) Prefabricated reinforcement cages shall be adequately supported and braced before lifting.

(7) Reinforcement which is free-standing shall be secured in position and braced to prevent movement due to wind and other loads.

(8) For treated finishes, all reinforcement shall be positioned in such a way that the specified concrete cover can be achieved after the applied treatment.

Fixing reinforcement connectors 15.24 Reinforcement connectors shall be fixed in accordance with the manufacturer's recommendations and using equipment recommended by the manufacturer.

Welding of reinforcement 15.25 Reinforcement shall not be welded unless approved by the Engineer.

Exposed reinforcement 15.26 Reinforcement that is to be left exposed shall be protected by coating with cement slurry or by other methods agreed by the Engineer. Reinforcement shall be re-coated by the same method if in the opinion of the Engineer the original coating has begun to deteriorate.

Access over reinforcement 15.27 Reinforcement shall not be contaminated or displaced as a result of access over the reinforcement. Access shall be obtained by using planks and ladders or by other methods agreed by the Engineer.

TOLERANCES

Tolerances: reinforcement 15.28 (1) Tolerances on cutting and bending reinforcement shall comply with BS 8666 Table 5.

(2) The actual concrete cover to the outermost layer of reinforcement (including links, stirrups, surface reinforcement, etc.) shall be within 5 mm tolerance of the cover specified on the Drawings.

INSPECTION OF REINFORCEMENT

Inspection of reinforcement 15.29 The Contractor shall allow the Engineer to inspect the completed reinforcement before carrying out any work, including erecting formwork adjacent to reinforcement, which will make access to the reinforcement difficult. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before carrying out such work.

TESTING: REINFORCEMENT AND REINFORCEMENT CONNECTORS Amd 1/2025

Batch: reinforcement and reinforcement connectors Amd 1/2025 15.30 (1) For the purpose of testing, the Category A (i.e. CS2) reinforcement delivered to the Site is to be subdivided into batches in accordance with CS2.

(2) A batch of other reinforcement or reinforcement connectors is any quantity of reinforcement or reinforcement connectors of the same type, size

and grade, manufactured by the same mill, covered by the same mill and testing certificates and delivered to the Site at any one time. In addition, for epoxy-coated reinforcement and galvanized reinforcement, the coatings shall have been applied at the same coating factory and shall be covered by the same original test certificates with original signatures and official authorization chop.

Samples: reinforcement and reinforcement connectors Amd 1/2025

15.31 (1) Samples of reinforcement and reinforcement connectors for tension joints, except for epoxy-coated reinforcement, shall be provided from each batch of the material delivered to the Site and at least 14 days before fixing of the reinforcement starts. For epoxy-coated reinforcement, samples shall be provided at least 20 working days before fixing of the reinforcement starts. The number of samples to be provided from each batch shall be as stated in Table 15.1.

(2) The number of specimens in each sample shall be as follows:

Description	Number of specimens
Category A reinforcement (i.e. steel reinforcing bars covered by CS2) Amd 1/2025	In accordance with CS2 Table 10
Category B reinforcement (i.e. steel reinforcing bars of Grade 500 not covered by CS2) Amd 1/2025	In accordance with BS 4449 Cl. 8.1.2
Category C reinforcement (i.e. plain round steel bars of Grade 250 with d > 12 mm not covered by CS2) Amd 1/2025	In accordance with BS 4449:1997 Cl. 10
Category D reinforcement (i.e. plain round steel bars of Grade 250 with d ≤ 12 mm not covered by CS2) Amd 1/2025	In accordance with BS 4482 Cl. 8.1.2
Category E reinforcement (i.e. steel fabric sheets) Amd 1/2025	3 Amd 1/2025
Epoxy-coated or galvanized reinforcement	2 additional specimens
Reinforcement connectors for tension joints	3

(3) Each specimen of bar or wire reinforcement shall be at least 1 m long. Each specimen of fabric reinforcement shall be at least 1.2 m long by 1.2 m wide and shall contain at least three bars/wires in each direction. Each specimen of reinforcement connectors shall consist of one reinforcement connector joined to two lengths of bar each at least 500 mm long. The bars shall be of the same type, size and grade as the bars to which the reinforcement connector will be fixed in the permanent work.

(4) Each specimen of reinforcement shall be taken from different units in the batch. The ends of specimens shall be cut square before delivery to the laboratory.

(5) For epoxy-coated bar reinforcement, each specimen for testing epoxy coating properties shall be a 2 m length piece cut at least 1 m from the ends of a 12 m length bar. Specimens shall be selected from different bundles of the

reinforcement batch.

Table 15.1: Rate of sampling of reinforcement and reinforcement connectors Amd 1/2025

Description	Size of batch	No. of samples per batch
Reinforcement (except steel fabric sheets) Amd 1/2025	All sizes	1
Steel fabric sheets Amd 1/2025	0 – 50 tonnes Amd 1/2025	1 Amd 1/2025
	Each additional 50 tonnes or part of 50 tonnes Amd 1/2025	1 Amd 1/2025
Reinforcement connectors for tension joints	less than 100 no.	1
	100 - 500 no.	2
	exceeding 500 no.	3

Testing: reinforcement and reinforcement connectors Amd 1/2025

15.32 (1) Each sample of reinforcement shall be tested in accordance with the following requirements:

Description	Testing requirement
Category A reinforcement (i.e. steel reinforcing bars covered by CS2) Amd 1/2025	CS2 Cl. 5.1.1
Category B reinforcement (i.e. steel reinforcing bars of Grade 500 not covered by CS2) Amd 1/2025	BS 4449 Cl. 8.1.2 with methods in Cl. 9
Category C reinforcement (i.e. plain round steel bars of Grade 250 with d > 12 mm not covered by CS2) Amd 1/2025	BS 4449:1997 Cl. 10
Category D reinforcement (i.e. plain round steel bars of Grade 250 with d ≤ 12 mm not covered by CS2) Amd 1/2025	BS 4482 Cl. 8.1.2 with methods in Cl. 9

(2) Each sample of steel fabric sheets (Category E) shall be tested in accordance with BS 4483 Cl. 8.1.2 with methods in Cl. 9 with following modifications:-

(a) The number of tests shall be as stated in Table 15.2; and

(b) The mass shall be measured as mass of fabric per square metre.

Amd 1/2025

(3) Each additional specimen as required in Clause 15.31(2) of epoxy-coated reinforcement shall be tested to determine the thickness, adhesion and continuity of the coating in accordance with Clause 15.33.

(4) Each additional specimen as required in Clause 15.31(2) of galvanized reinforcement shall be tested to determine the thickness of coating in accordance with BS EN ISO 1461 for compliance.

(5) Each sample of reinforcement connectors for tension joints shall be tested to determine the tensile properties in accordance with Clause 15.35.

(6) The number of tests on each sample shall be as stated in Table 15.2.

Testing: epoxy coating 15.33

(1) The thickness test shall be in accordance with Methods 7A, 7B and 7C of BS EN ISO 2808. For bars/wires of 12 mm diameter or below, only instruments which operate on magnetic flux principle (Methods 7B and 7C) can be used. For bars of 16 mm diameter or above, instruments which operate on either magnetic flux principle (Methods 7B and 7C) or magnetic pull-off principle (Method 7A) can be used. All measuring instruments shall be calibrated to an accuracy of ±5%.

(2) For thickness test, five recorded measurements shall be obtained approximately evenly spaced along each side of the test specimen (a total of ten recorded measurements per bar). A single recorded thickness measurement is the average of three individual reading obtained in between the ribs of three consecutive deformations.

(3) The adhesion and continuity tests shall be in accordance with BS ISO 14654.

Table 15.2: Number of tests on each sample of reinforcement and reinforcement connectors Amd 1/2025

Description	**Type and number of tests**								
	Tensile properties	Bend performance	Mass	Chemical composition (product analysis)	Bond property	Weld shear	Pitch dimension	Thickness, adhesion and continuity	Thickness and uniformity
Reinforcement (except steel fabric sheets)	In accordance with Clause 15.32(1)					-	-	-	-
Steel fabric sheets - sheet - longitudinal bar/wire - transverse bar/wire	- 3 3	- 1# 1#	3 - -	- - -	- - -	2# - -	- 1# 1#	- - -	- - -
Epoxy coating	-	-	-	-	-	-	-	2	-
Galvanized coating	-	-	-	-	-	-	-	-	2
Reinforcement connectors for tension joints	3	-	-	-	-	-	-	-	-

Note #: Tests to be carried out on one of the three specimens collected for Category E reinforcement as per Clause 15.31(2)

Amd 1/2025

Compliance criteria: reinforcement

15.33A (1) For Category A (i.e. CS2) reinforcement, if the results of the tests performed on the test specimens meet the requirements specified in CS2 Cl. 5.1.2, the batch shall be deemed to comply with the requirements.

(2) For Category B (i.e. Grade 500) reinforcement, if the results of the tests performed on the test specimens meet the requirements specified in BS 4449 Cl. 8.1.3.1 and 8.1.3.2 (for bond property, relative rib area only, other surface geometry parameters are optional.), the batch shall be deemed to comply with the requirements.

(3) For Category C (i.e. plain round steel bars, Grade 250 & d > 12 mm) reinforcement, if the results of the tests performed on the test specimens meet the requirements specified in BS 4449:1997 Cl. 5, 6, 8.2 and 11, the batch shall be deemed to comply with the requirements.

(4) For Category D (i.e. plain round steel bars, Grade 250 & d ≤ 12 mm) reinforcement, if the results of the tests performed on the test specimens meet the requirements specified in BS 4482 Cl. 8.1.3.1 and 8.1.3.2, the batch shall be deemed to comply with the requirements.

(5) For Category E (i.e. steel fabric sheets) reinforcement, the batch shall be deemed to comply with the requirements if the results of the tests performed on the test specimens meet the requirements as stated in Table 15.3. Amd 1/2025

Table 15.3: Specified test requirement / tolerance on steel fabric sheet

Type of Tests	Requirement / Tolerance
Pitch dimension	BS 4483 Cl. 7.3.2
Tensile properties	BS 4483 Cl. 8.1.3.1
Bend performance	BS 4483 Cl. 8.1.3.2
Weld shear	BS 4483 Cl. 8.1.3.2
Mass per square metre of steel fabric sheet with diameter of bars / wires in either direction greater than 8mm	± 4.5% of nominal mass
Mass per square metre of steel fabric sheet with diameter of bars / wires in both directions less than or equal to 8 mm	± 6.0% of nominal mass

Amd 1/2025

Compliance criteria: epoxy coating to reinforcement

15.34 The results of tests for thickness, adhesion and continuity of epoxy coatings to reinforcement shall comply with all the following requirements:

(a) Coating thickness
At least 90% of all recorded thickness measurements of coating shall be within the specified range. Thickness measurements below 0.13 mm shall be considered cause for rejection.

(b) Coating adhesion:
The adhesion test shall comply with the requirements in BS ISO 14654. The surface of the bent test piece shall not exhibit cracking, disbonding or ductile tearing when viewed under well-lit conditions using normal or corrected vision.

(c) Coating continuity

The continuity test shall comply with the requirements in BS ISO 14654. The continuity of the coating shall be free of holes, voids, cracks and damaged areas discernible to a person with normal or corrected vision.

Compliance criteria: reinforcement connectors for tension joints

15.35 The results of tensile properties tests on specimens of reinforcement connectors for tension joints shall comply with the following requirements:

(a) The tensile strength shall exceed 287.5 MPa for grade 250, 540 MPa for grade 500B and 575 MPa for grade 500C reinforcement.

(b) When a test is made of a representative gauge length assembly comprising reinforcement of the size, grade and profile to be used and a reinforcement connector for tension joints of the precise type to be used, the permanent elongation after loading to 0.6 times of the specified characteristic strength and unloading shall not exceed 0.1 mm. The gauge length shall span over the reinforcement connector.

Non-compliance: reinforcement

15.36 For Category A (i.e. CS2) reinforcement, if the result of any test fails, the acceptance of retests shall be considered in accordance with CS2 Cl. 5.1.4.

15.37 For other reinforcement not covered by CS2, if the result of any test fails, two additional test specimens shall be taken from different reinforcement of the same batch and be subjected to the test or tests which the original specimen failed. For properties other than chemical composition (product analysis), the batch shall be considered as not complying with the specified requirements for the properties if the result of any additional test fails. For chemical composition (product analysis), the batch shall be considered as not complying with the specified requirements of the property if the result of any additional test fails unless it is demonstrated by alternative method as accepted in CS2 Cl. 6.3. If all of the additional test specimens pass the retests, the batch shall be deemed to comply with the requirements. Otherwise the batch of reinforcement shall be rejected and removed from the Site.

Non-compliance: epoxy coatings

15.38 For each test specimen fails to meet the coating thickness, coating adhesion or coating continuity requirements, two additional test specimens shall be taken from the same batch and be subjected to the test or tests which the original specimen failed. If all of the additional test specimens pass the retests, the batch from which they have been taken shall be deemed to comply with the specified requirements for the properties. Otherwise this batch shall be rejected and removed from the Site.

Non-compliance: galvanized coatings

15.39 (1) If the result of any test for thickness of galvanized coatings to reinforcement does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be as stated in Table 15.1.

(2) The number of specimens in each additional sample shall be as follows:

(i)	Galvanized bar/wire reinforcement	4
(ii)	Galvanized fabric reinforcement	2
(iii)	Galvanized reinforcement connectors for tension joints	4

(3) The number of tests on each additional sample shall be four.

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

Non-compliance: reinforcement connectors

15.40 (1) If the result of any test for tensile properties of reinforcement connectors for tension joints does not comply with the specified requirements as stated in Clause 15.35, additional samples shall be provided from the same batch and additional tests as stated in Clause 15.35 shall be carried out. The number of additional samples shall be as stated in Table 15.1.

(2) The number of specimens in each additional sample shall be six.

(3) The number of tests on each additional sample shall be six.

(4) The batch shall be considered as not complying with the specified requirements for tensile properties if the result of any additional test does not comply with the specified requirements as stated in Clause 15.35.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 16

CONCRETE AND JOINTS IN CONCRETE

SECTION 16

CONCRETE AND JOINTS IN CONCRETE

PART 1: CONCRETE WORKS

GENERAL

Sprayed concrete 16.01 Sprayed concrete shall comply with Section 7 except as stated in this Section.

Designation of concrete mixes 16.02 (1) Designed mix concrete shall be designated by the grade strength in MPa followed by the nominal maximum aggregate size in mm and the suffix D.

(2) Standard mix concrete shall be designated by the grade strength in MPa followed by the nominal maximum aggregate size in mm and the suffix S.

(3) Designed mix concrete or standard mix concrete of the same grade strength but with different constituents, workability or other properties shall be designated as such by the addition of a suitable description. If the grade of concrete is designated by one number only, the number shall be the grade strength in MPa.

GLOSSARY OF TERMS

Mix constituents 16.03 (1) Cementitious content is the combined mass of cement, Pulverised Fuel Ash (PFA) or Ground Granulated Blastfurnace Slag (GGBS), and the dry mass of Condensed Silica Fume (CSF) per cubic metre of compacted concrete. PFA, GGBS and CSF are referred to as supplementary cementitious materials in this GS.

(2) Water content is the total mass of the free water contained in the aggregates plus the mass of the added mixing water plus the mass of water contained in any admixtures or additives used.

Water/cement ratio is the ratio of the water content divided by the cementitious content.

Grade 16.04 Grade is a term used to identify the different concrete mixes in terms of grade strength or in terms of grade strength and nominal maximum aggregate size.

Grade strength 16.05 Grade strength is the compressive strength of concrete stated in the Contract. For designed mix concrete, compliance with the grade strength shall be ascertained in accordance with Clause 16.61.

MATERIALS

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.

Water 16.09 (1) Water for concrete and for curing concrete shall be clean fresh water taken from the public supply.

(2) Non-saline water from other sources may be used subject to the Engineer's approval, provided that it can be demonstrated that the water is neutral in PH value, free from suspended solids and liquid contaminants non-miscible with water. It shall be tested and comply with BS EN 1008.

(3) Wash water from concrete mixer washout operations (recycled water) may be used for mixing concrete of grade strength not exceeding 35MPa provided that:

(a) The density of the recycled water shall not exceed 1030 kg/m^3.

(b) The limits for the time of setting (h:min), expressed as deviation from those for control mix, shall comply with Table 16.8. The control mix shall be of the same mix design but clean fresh water shall be used.

(c) The chemical limits of the recycled water shall not exceed those specified in Table 16.8.

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.

CONCRETE

Concrete mix 16.12 (1) Concrete shall be a designed mix unless the Engineer permits the use of a standard mix. Designed mixes shall be designed by the Contractor.

(2) 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. Should the Contractor wish to use designed mix concrete with a designed slump value less than 75 mm in reinforced elements, the Engineer may require the Contractor to demonstrate that such concrete can be satisfactorily placed and compacted in trial sections simulating the appropriate sections of the Works.

(3) Cement, PFA, GGBS, aggregates, water and admixtures for concrete shall comply with Clauses 16.06 to 16.10.

(4) SRPC shall only be used if stated in the Contract. PFA shall not be used with SRPC.

(5) PFA shall not be used in addition to PFAC.

(6) Either PFA, GGBS, or a combination of PFA and GGBS Amd 2/2026 shall be used in concrete of all pile caps and substructure construction where the concrete member is thicker than 750 mm.

(7) When GGBS is used in conjunction with PFA, the proportions of GGBS and PFA shall refer to Clause 16.14(7). In any case, GGBS shall not be used in conjunction with PFAC. Amd 2/2026

(8) Unless with the prior approval of the Engineer, the reactive alkali content of the concrete, expressed as the total Amd 1/2023 equivalent sodium oxide (Na_2O) content per cubic metre of concrete defined in sub-clause (9) of this Clause, shall not exceed 3.0 kg.

(9) The total Amd 1/2023 equivalent sodium oxide (Na_2O) content of the concrete shall be determined in accordance with the following expression:

$$\text{Total equivalent Amd 1/2023 } Na_2O \text{ content} = A + B + C$$

where A is the sum of the Amd 1/2023 alkali content (expressed as equivalent Na_2O) of cement, admixtures and water,

B is equal to 1/6 of the Amd 1/2023 alkali content of PFA (expressed as equivalent Na_2O) or 1/2 of the Amd 1/2023 alkali content of GGBS (expressed as equivalent Na_2O).

If the proportion of PFA and GGBS is less than 20% and 25% of the total cementitious content respectively, the value of B shall be equal to the Amd 1/2023 alkali content of PFA or GGBS expressed as equivalent Na_2O, and

C is equal to 0.76 times the chloride ion (Cl^-) content of the aggregate.

(a) The Amd 1/2023 alkali content of the cementitious materials shall be determined in accordance with BS EN 196-2 and shall be taken as the average of the latest 25 daily determinations of equivalent sodium oxide plus twice the standard deviation of the results.

(b) The Amd 1/2023 alkali content of admixtures shall be determined in accordance with BS EN 480-12 Amd 1/2023.

(c) The Amd 1/2023 alkali content of water shall be determined in accordance with BS EN 1008.

(d) The Amd 1/2023 alkali content of the PFA shall be determined in accordance with BS EN 196-2 and shall be taken as the average of the latest 25 weekly determinations plus twice the standard deviation of the results.

(e) The Amd 1/2023 alkali content of the GGBS shall be determined in accordance with BS EN 196-2 and shall be taken as the average of the latest 25 weekly determinations plus twice the standard deviation of the results.

(f) The chloride ion contents of aggregates shall be measured in accordance with CS3.

Chloride content of concrete 16.13 The maximum total chloride content of concrete, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the concrete mix, shall be as stated in Table 16.1. If the concrete is of more than one of the types stated, then the lower value of maximum chloride content shall apply.

Table 16.1: Maximum total chloride content of concrete

Type of concrete	**Maximum total chloride content (%)**
Prestressed concrete. Steam-cured structural Concrete	0.1
Concrete with reinforcement or other embedded metal	0.35
Concrete made with SRPC	0.2

Cementitious content of designed mix concrete 16.14 (1) The minimum cementitious content of designed mix concrete of Grade 20 or above using 20 mm nominal maximum aggregate size shall be as stated

in Table 16.2. The minimum cementitious contents shall be increased by 40 kg/m^3 for 10 mm nominal maximum aggregate size and decreased by 30 kg/m^3 for 40 mm nominal maximum aggregate size.

(2) Unless otherwise approved by the Engineer, the maximum cementitious content of designed mix concrete for water retaining structures and water tight structures shall be 450 kg/m^3 for concrete containing either PFA, GGBS, PFAC, or a combination of PFA and GGBS, Amd 2/2026 and 400 kg/m^3 for concrete containing PC only. The minimum cementitious content of designed mix concrete for water retaining structures shall be 325 kg/m^3 and maximum water/cement ratio shall be 0.5. Unless otherwise approved by the Engineer, the maximum cementitious content of designed mix concrete other than for water retaining structures and water tight structures shall be 550 kg/m^3.

(3) The cementitious content of designed mix concrete may be varied during routine production at the discretion of the Contractor by an amount not exceeding 20 kg/m^3, provided that the total cementitious content is not less than the specified minimum value and does not exceed the specified maximum value.

(4) When only Amd 2/2026 PFA is incorporated in the concrete as a separate cementitious material, its proportion shall not exceed 35% of the total cementitious content for normal concrete. If other conditions apply, particulars of proposed changes to the proportion of PFA shall be submitted to the Engineer for approval. Unless otherwise approved by the Engineer, the maximum water/cement ratio of designed mix concrete for permanent reinforced concrete structures shall be as stated in Table 16.2A. Amd 2/2026

(5) When only Amd 2/2026 PFA is used in construction of pile caps and substructures, the PFA content shall constitute at least 25% of the total Amd 2/2026 cementitious content in the concrete.

(6) When only Amd 2/2026 GGBS is incorporated in the concrete as a separate cementitious material, its proportion shall be between 35% and 75% of the total cementitious content for normal concrete. If other conditions apply, particulars of proposed changes to the proportion of GGBS shall be submitted to the Engineer for approval. Unless otherwise approved by the Engineer, the maximum water/cement ratio of designed mix concrete for permanent reinforced concrete structures shall be as stated in Table 16.2A. Amd 2/2026

(7) When both PFA and GGBS are incorporated in the concrete as separate cementitious materials, their combined proportion shall not exceed 65% of the total cementitious content, and the PFA proportion shall not exceed 20%. Unless otherwise approved by the Engineer, the maximum water/cement ratio of designed mix concrete for permanent reinforced concrete structures shall be as stated in Table 16.2A. Amd 2/2026

Table 16.2: Minimum cementitious content of designed mix concrete of Grade 20 or greater with 20 mm nominal maximum aggregate size

Grade strength (MPa)	20	25	30	35	40	45	50
Minimum cementitious content (kg/m^3)	270	290	310	330	350	375	400

Table 16.2A: Maximum water/cement ratio of designed mix concrete for permanent reinforced concrete structures containing either PFA, GGBS, or a combination of PFA and GGBS

Separate cementitious material	% of total cementitious content	Design concrete grade strength	Maximum water/cement ratio
PFA only	≤ 25%	Grade 35 or above	0.50
		Below Grade 35	0.55
	> 25% and ≤ 35%	Grade 35 or above	0.45
		Below Grade 35	0.50
GGBS only	≥ 35% and ≤ 50%	Grade 35 or above	0.50
		Below Grade 35	0.55
	> 50% and ≤ 75%	Grade 35 or above	0.45
		Below Grade 35	0.50
PFA and GGBS combined	≤ 40% (*)	Grade 30 or above	0.50
		Below Grade 30	0.55
	> 40% and ≤ 65% (*)	Grade 30 or above	0.45
		Below Grade 30	0.50

Remarks (*): proportion of PFA shall not exceed 20% of the total cementitious content. Amd 2/2026

Standard mix concrete 16.15 Standard mix concrete shall comply with the following requirements:

(a) Cement shall be PC or PFAC.

(b) The total mass of dry aggregate to be used with 100 kg of PC or with 110 kg of PFAC shall be as stated in Table 16.3.

(c) The percentage by mass of fine aggregate to total aggregate shall be as stated in Table 16.4.

(d) Admixtures other than water-reducing admixtures shall not be used unless permitted by the Engineer.

Table 16.3: Mass of total aggregate for standard mix concrete

Grade strength (MPa)	**Nominal maximum aggregate size (mm)**	**40**	**20**	**10**
	Range of measured slump value (mm)	**85-170**	**75-150**	**65-130**
10	Mass of total aggregate (kg)	800	690	-
20		550	500	400
25		490	440	360
30		440	380	300

Table 16.4: Percentage by mass of fine aggregate to total aggregate for standard mix concrete

Grade strength (MPa)	Grading of fine aggregate (CS3)	Nominal maximum aggregate size (mm)	40	20	10
10	C, M or F	Percentage by mass of fine aggregate to total aggregate (%)	30 - 45	35 - 50	-
20, 25 or 30	C		30 - 40	35 - 45	45 - 55
	M		25 - 35	30 - 40	40 - 50
	F		25 - 30	25 - 35	35 - 45

No-fines concrete 16.16 No-fines concrete shall comply with the following requirements:

(a) Cement shall be PC or PFAC.

(b) The nominal maximum aggregate size shall be 20 mm. Not more than 15% by mass shall be retained on a 20 mm BS test sieve and not more than 10% by mass shall pass a 10 mm BS test sieve.

(c) The aggregate:cement ratio by mass shall be at least 10 and shall not exceed 15.

(d) The cementitious content shall be such that each particle of aggregate is coated with cement paste but the compacted concrete has an open texture that permits the flow of water through the hardened concrete.

SUBMISSIONS

Particulars of materials for concrete 16.17 (1) The following particulars of the proposed cement, PFA, GGBS and aggregates shall be submitted to the Engineer for approval Amd 3/2021:

(a) A certificate issued within Amd 3/2021 6 months for each type of cement showing the manufacturer's name, the date and place of manufacture and showing that the cement complies with the requirements stated in the Contract and including results of tests for:
- Composition
- Chemical requirement
- Compressive strength at 2, 7 and 28 days
- Initial setting time
- Soundness

(b) A certificate issued within Amd 3/2021 6 months for PFA showing the source of the PFA and showing that the PFA complies with the requirements stated in the Contract and including results of tests required in either Clause 14.1 of BS 3892:Part 1 or Clauses 5.2 and 5.3 of BS EN 450-1.

(c) If “high-lime PFA” as stated in Clause 16.07 is used, the

certificates that accompany delivery of "high-lime PFA" shall mention that the PFA is high-lime.

(d) Certificates/documents issued within Amd 3/2021 6 months for each nominal maximum aggregate size in accordance with Clause 6.2.2 of CS3 and other test certificates showing the compliance of requirements as stated in the Contract (e.g. Los Angeles value, aggregate impact value, drying shrinkage, sulphur content).

(e) A certificate issued within Amd 3/2021 6 months for GGBS showing the manufacturer's name, the date and place of manufacture and showing that the GGBS complies with the requirements stated in the Contract and including results of tests for:

- 7-day and 28-day activity indexes of a 50 % combination of the GGBS with 50 % of test cement, determined in accordance with BS EN 15167-1. The test cement shall conform to BS EN 197-1 and shall be subject to the following restrictions:
  - It shall be a type CEM I, of strength 42.5N or higher;
  - The Blaine fineness shall be at least 300 m^2/kg;
  - The tricalcium aluminate shall be between 6% and 12%; and
  - The alkali (Na_2O equivalent) content shall be between 0.5% and 1.2%.
- Initial setting time of a 50 % combination of the GGBS with 50 % of test cement;
- Initial setting time of the test cement and its 7-day and 28-day strength;
- Chemical oxide composition of the GGBS, comprising the contents of calcium oxide (CaO), silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), magnesium oxide (MgO), titanium dioxide (TiO_2) and manganese oxide (Mn_2O_3);
- Total content of alkalis determined in accordance with BS EN 196-2, or other method agreed by the Engineer, and expressed as equivalent sodium oxide;
- Fineness value determined in accordance with the air permeability method in BS EN 196-6;
- Relative density determined in accordance with BS EN 196-6;
- Glass content and the method used for its determination; and
- The method(s) of rapid cooling used to produce the granulated blastfurnace slag(s) during the manufacture of the GGBS (Rapid cooling includes quenching in water (granulation) and projecting through water and air (pelletisation)).

(2) The following particulars of the proposed admixtures shall be submitted to the Engineer for approval Amd 3/2021:

(a) Manufacturers' literature,

(b) Description of physical state, colour and composition,

(c) Recommended storage conditions and shelf life,

(d) Method of adding to the concrete mix,

(e) Any known incompatibility with other admixtures or cement,

(f) Recommended dosage,

(g) Effects of under-dosage and over-dosage, and

(h) A certificate issued within Amd 3/2021 6 months for each type of admixture showing the manufacturer's name, the date and place of manufacture and showing that the admixture complies with the requirements stated in the Contract and including results of tests for:
- Uniformity
- Chloride content.

(3) The following particulars of the proposed curing compound shall be submitted to the Engineer for approval Amd 3/2021:

(a) Manufacturer's literature,

(b) Description of physical state, colour and composition,

(c) Recommended storage conditions and shelf life,

(d) Method of application,

(e) Recommended rate of application, and

(f) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the curing compound complies with the requirements stated in the Contract and including results of tests for efficiency index.

(4) If recycled water is used for mixing concrete, results of the tests specified in Clause 16.51 and Table 16.8 shall be submitted to the Engineer for approval Amd 3/2021.

(5) The particulars, including certificates, shall be submitted to the Engineer for approval Amd 3/2021 at least 14 days before the first delivery of the material to the Site, and thereafter each time the source is changed.

Particulars of concrete mix 16.18 (1) The following particulars of each proposed designed concrete mix shall be submitted to the Engineer for approval Amd 3/2021:

(a) Quantity of each constituent per batch and per cubic metre of compacted concrete, with required tolerances on quantities of aggregates to allow for minor variations in grading, silt content etc. The maximum permitted variations Amd 4/2022 in the quantity of fine and coarse aggregates Amd 4/2022 shall be ± 20 kg Amd 4/2022 per 100 kg of cementitious content. In the event that the approved fine aggregate content is adjusted, the approved coarse aggregate content shall be adjusted accordingly to keep the approved aggregate/cementitious content ratio unchanged. The same is for the adjustment of the approved coarse aggregate content. Amd 4/2022

(b) Grading of coarse and fine aggregates,

(c) Workability after the addition of superplasticisers, in terms of designed slump value or designed flow value,

(d) Method of placing concrete,

(e) Method of controlling the temperature of the concrete, if required,

(f) Test or trial mix data for designed mix concrete of the same grade and with similar constituents and properties, if available, and

(g) Test data for designed mix concrete of the same or other grade produced in the plant or plants proposed to be used, if available.

(h) Test certificates issued within Amd 3/2021 6 months giving the results of tests required in Clauses 16.12(9).

(i) Calculation of the reactive alkali content of the concrete for the designed concrete mix.

(j) Documentation of a quality system to control the reactive alkali content in the concrete.

(2) The particulars shall be submitted to the Engineer for approval Amd 3/2021 at least 7 days before trial mixes are made or, if trial mixes are not required, at least 7 days before the mix is placed in the permanent work.

(3) Test certificates giving the results of tests required in Clause 16.12(9) and Table 16.7 shall be submitted at quarterly intervals unless agreed otherwise by the Engineer. The test certificates shall be accompanied by calculations to demonstrate that the concrete continues to comply with the requirement on reactive alkali content limit given in Clause 16.12(8) during the period of delivery of the approved concrete mix to the Site. If the reactive alkali content limit was found to have been exceeded, the Contractor shall submit the relevant test certificates and calculations to the Engineer together with his remedial proposals for approval Amd 3/2021.

Particulars of ready-mixed concrete supplier 16.19 The name of the suppliers and the location of each plant, including a back-up plant, from which the Contractor proposes to obtain ready-mixed concrete shall be submitted to the Engineer for approval Amd 3/2021 at least 14 days before trial mixes are made or, if trial mixes are not required, at least 14 days before the ready-mixed concrete is placed in the permanent work.

Particulars of batching and mixing plant 16.20 Particulars of the proposed batching and mixing plant to be used on the Site, including a layout plan and the output of the plant, shall be submitted to the Engineer for approval Amd 3/2021 at least 7 days before the plant is delivered to the Site.

Particulars of precast concrete units 16.21 (1) The following particulars of the proposed precast concrete units shall be submitted to the Engineer for approval Amd 3/2021:

(a) Details of precasting yards,

(b) A certificate showing the manufacturer's name, the date and place of manufacture, the identification numbers of the precast concrete units and including results of tests for:
- Compressive strength of concrete cubes at 28 days
- Routine tests, including loading tests, carried out at the

precasting yards,

(c) Details of lifting points and methods of handling, and

(d) Procedure for testing precast units.

(2) The particulars, other than certificates, shall be submitted to the Engineer for approval Amd 3/2021 at least 14 days before the first delivery of the precast concrete units to the Site. The certificates shall be submitted for each batch of precast concrete units delivered to the Site.

Particulars of construction joints 16.22 Particulars of the proposed positions and details of construction joints in concrete which are not stated in the Contract shall be submitted to the Engineer for approval at least 14 days before the relevant elements are concreted.

TRIALS

Trial mix concrete 16.23 (1) Trial mixes are not required for designed mix concrete of Grade 20 and below, or for standard mix concrete.

(2) For designed mix concrete of higher than Grade 20, the Engineer may require Plant Trials and/or Laboratory Mix Trials to be carried out in accordance with Table 16.4A. Amd 2/2024

(3 Amd 2/2024) Plant Trials and Laboratory Mix Trials shall be completed at least 35 days before the concrete mix is placed in the permanent work.

(4 Amd 2/2024) The Contractor shall inform the Engineer at least 24 hours before conducting Plant Trials or Laboratory Mix Trials.

Table 16.4A: Plant Trials and/or Laboratory Mix Trials for designed mix concrete of higher than Grade 20

Trial required	No test data submitted/ Test data submitted do not in the opinion of the Engineer demonstrate the suitability of the proposed plant and mix design	Test data submitted in accordance with Clause 16.18 accepted by the Engineer			
		same grade and with similar constituents and properties		different grade or with different constituents and properties	
		same plant	different plant	same plant	different plant
Plant Trials in accordance with Clause 16.24	Yes	No	Yes	No	Yes
Laboratory Mix Trials in accordance with Clause 16.25	Yes	No	No	Yes	Yes

Amd 2/2024

Plant Trials 16.24 (1) Plant Trials shall be made using the plant or plants proposed and the mix designs and constituents submitted to the Engineer for approval Amd 3/2021.

(2) One batch of concrete of a proposed designed mix shall be made on each of three days in each plant proposed to be used. The batch shall be at least 60% of the mixer's nominal capacity. If the concrete is batched in a central plant and mixed in a truck mixer, three different truck mixers shall be used.

(3) Three samples of concrete shall be provided from each batch at approximately 1/6, 1/2 and 5/6 of the discharge from the mixer. Each sample shall be of sufficient size to perform a slump test or a flow table test, and make two test cubes. The method of sampling shall be as stated in CS1.

(4) Each sample taken in accordance with Clause 16.24(3) shall be tested to determine its slump value or its flow value in accordance with CS1.

(5) Two test cubes shall be made from each sample taken in accordance with Clause 16.24(3) and stored, cured and tested to determine the compressive strength at 28 days in accordance with CS1.

(6) The size of the test cube shall be 100 mm for concrete with the maximum aggregate size not exceeding 20 mm and shall be 150 mm with the maximum aggregate size exceeding 20 mm.

Laboratory Mix Trials 16.25 (1) Laboratory Mix Trials shall be made in the Contractor's laboratory using the mix designs and constituents submitted to the Engineer for approval Amd 3/2021.

(2) Laboratory Mix Trials shall be carried out in accordance with Section 11 of CS1. Three separate batches shall be made, each of sufficient size to provide samples for two slump tests or two flow table tests, and to make six test cubes.

(3) Two slump tests or two flow table tests in accordance with CS1 shall be performed on separate specimens from each batch of Laboratory Trial Mix concrete.

(4) Six test cubes shall be made from each batch of Laboratory Trial Mix concrete, stored, cured and tested for compressive strength at 28 days in accordance with CS1.

(5) The size of the test cube shall be 100 mm for concrete with the maximum aggregate size not exceeding 20 mm and shall be 150 mm with the maximum aggregate size exceeding 20 mm.

Compliance criteria: Plant Trials 16.26 The results of tests on concrete taken from Plant Trials in accordance with Clause 16.24 shall comply with the following requirements:

(a) The average of the nine measured slump values shall be within +/- 20mm or +/- 25%, whichever is the greater, of the designed slump value. The average of the nine measured flow values shall be within +/- 50mm of the designed flow value.

(b) The range of the three measured slump values for each batch of concrete shall not exceed 20% of the average of the three measured

slump values for that batch. For flow table tests, the range of the three measured flow values for each batch of concrete shall be within 70mm.

(c) The average compressive strength at 28 days of the 18 test cubes shall exceed the Grade strength by at least 12 MPa for 100 mm test cubes or 10 MPa for 150 mm test cubes. The compressive strength of each individual test cube shall exceed the Grade strength by at least 5 MPa for 100 mm test cubes or 4 MPa for 150 mm test cubes.

(d) The range of the compressive strength of the six test cubes from each batch of concrete shall not exceed 20% of the average compressive strength of the six test cubes from that batch.

Compliance criteria: Laboratory Mix Trials 16.27 (1) When test data relating to the proposed plant or plants submitted in accordance with Clause 16.18 show that the plant standard deviation exceeds 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes, or in the absence of acceptable data, the results of tests on Laboratory Mix Trial concrete shall comply with the following requirements:

(a) The average of the six measured slump values shall be within +/- 20mm or +/- 25%, whichever is the greater, of the designed slump value. The average of the six measured flow values shall be within +/- 50mm of the designed flow value.

(b) The average compressive strength at 28 days of the 18 test cubes shall exceed the Grade strength by at least 14 MPa for 100 mm test cubes or 12 MPa for 150 mm test cubes, and the compressive strength of each individual test cube shall exceed the Grade strength by at least 7 MPa for 100 mm test cubes or 6 MPa for 150 mm test cubes.

(2) When test data relating to the proposed plant or plants submitted in accordance with Clause 16.18 show that the plant standard deviation does not exceed 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes and the data are acceptable to the Engineer, the results of tests on Laboratory Mix Trial concrete shall comply with the following requirements:

(a) The average of the six measured slump values shall be within +/- 20 mm or +/- 25%, whichever is the greater, of the designed slump value. The average of the six measured flow values shall be within +/- 50mm of the designed flow value.

(b) The average compressive strength at 28 days of the 18 test cubes shall exceed the Grade strength by at least 10 MPa for 100 mm test cubes or 8 MPa for 150 mm test cubes, and the compressive strength of each individual test cube shall exceed the Grade strength by at least 3 MPa for 100 mm test cubes or 2 MPa for 150 mm test cubes.

Trial lengths and trial panels 16.28 Trial lengths required in accordance with Clauses 10.23 to 10.26 and trial panels required in accordance with Clauses 14.22 and 14.23 shall be constructed for each concrete mix as appropriate.

Non-compliance: trial mix concrete 16.29 (1) If the result of any test for workability or compressive strength of laboratory mix trial and plant trial concrete does not comply with the specified

requirements for the property, particulars of proposed changes to the materials, mix design or methods of production shall be submitted to the Engineer. Further laboratory mix trials or plant trials shall be made until the result of every test complies with the specified requirements for workability and compressive strength of laboratory mix trial and plant trial concrete.

(2) If trial lengths or trial panels are constructed using the non-complying trial mix, further trial lengths or trial panels shall be constructed unless in the opinion of the Engineer the changes to the materials, mix design or methods of production will not affect the results of the previous trial lengths or trial panels.

Approved concrete mix 16.30 (1) A concrete mix that complies with the specified requirements for laboratory mix trials, plant trials and for trial lengths or trial panels shall become an approved concrete mix. The designed slump value or designed flow value used to produce an approved concrete mix shall become the approved slump value or approved flow value.

(2) If laboratory mix trials or plant trials are not required, a concrete mix submitted as stated in Clause 16.18 and which complies with the specified requirements for trial lengths or trial panels shall become an approved concrete mix. The designed slump value or designed flow value of the concrete mix shall become the approved slump value or approved flow value.

Commencement of concreting 16.31 Concrete shall not be placed in the permanent work until the concrete mix has been approved by the Engineer.

Changes in materials and methods of construction 16.32 Unless permitted by the Engineer, the materials, mix design, methods of production or methods of construction used to produce an approved concrete mix shall not be changed except that the variations of cementitious Amd 4/2022 content as stated in Clause 16.14(3), and variations in aggregate quantities within the required Amd 4/2022 tolerances in Clause 16.18(1)(a) Amd 4/2022, will be allowed.

HANDLING AND STORAGE OF MATERIALS

Storage of cement, PFA and GGBS 16.33 (1) Cement in bags shall be stored in a dry, weatherproof store sheltered on the top and 3 sides with a raised floor. Each delivery shall be identified and kept separate and shall be used in the order of delivery.

(2) Bulk cement, PFA and GGBS shall be kept dry. Cement, PFA and GGBS of different types and from different sources shall be stored in separate silos clearly marked to identify the different contents of each.

Handling and storage of aggregates 16.34 (1) Aggregates shall not be handled or stored in a manner that will result in mixing of the different types and sizes or in segregation or contamination of the aggregates.

(2) Different types and sizes of aggregates shall be stored in separate hoppers or in separate stockpiles. The stockpiles shall have well drained concrete floors and shall have dividing walls of sufficient height to keep the different aggregates separate.

Storage of admixtures and curing compounds 16.35 Admixtures and curing compounds shall be stored in sealed containers marked to identify the contents 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 shelf life has been exceeded.

Handling and storage of precast concrete units 16.36 (1) The identification number, date of casting and lifting points shall be marked on precast concrete units in a manner agreed by the Engineer.

(2) Precast concrete units shall be lifted and supported only at the designed lifting points and shall not be subjected to rough handling, shock loading or dropping.

(3) Precast concrete units shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner that will not result in damage or deformation to the units or in contamination of the units. Precast concrete units and the lifting points shall be protected from damage/rusting and damaged units shall not be used in the permanent works unless permitted by the Engineer.

BATCHING AND MIXING CONCRETE

Batching concrete 16.37 (1) Measuring and weighing equipment for batching concrete shall be maintained in a clean, serviceable condition. The equipment shall be zeroed daily and calibrated when the equipment is set up on the Site and at a frequency of at least once per month. The accuracy of the measuring equipment shall be within 3% of the quantity of cementitious materials, total aggregates or water being measured and within 5% of the quantity of admixtures being measured.

(2) The quantities of cement, PFA, GGBS and fine and coarse aggregate shall be measured by mass except that cement supplied in bags may be measured by using a whole number of bags in each batch. The mass of aggregates shall be adjusted to allow for the free moisture content of the aggregates.

(3) Separate weighing equipment shall be used for cementitious material and aggregates.

(4) The quantity of water shall be adjusted for the free moisture content of the aggregates and shall be measured by mass or volume.

(5) Liquid admixtures shall be measured by mass or volume and powdered admixtures shall be measured by mass.

Mixing concrete 16.38 (1) The quantities of concrete mixed and the speed of operation of a mixer shall comply with the manufacturer's recommendations.

(2) A mixer shall not be loaded in excess of its rated capacity and shall be emptied before being re-charged. A mixer that has been out of use for more than 30 minutes shall be cleaned before fresh concrete is mixed in it. Mixers shall be cleaned whenever there is a change in the type of cement being used.

(3) Mixing times or the number and rate of revolutions of mixer drums shall not be less than those recommended by the manufacturer unless it is

demonstrated in the production of concrete that a shorter time or fewer or slower revolutions are adequate. Constituents shall be thoroughly mixed and admixtures shall be uniformly distributed throughout the concrete.

(4) Water shall be added to truck mixed concrete at the batching plant and shall not be added in transit. Water shall not be added at the Site unless approved by the Engineer.

(5) Water shall not be added to partially hardened concrete.

TRANSPORTATION OF CONCRETE

Transportation of concrete 16.39 (1) Concrete shall not be transported in a manner that will result in contamination, segregation, loss of constituents or excessive evaporation.

(2) Concrete batched off the Site shall be transported to the Site in purpose-made agitators operating continuously or in truck mixers.

RECORDS OF CONCRETE

Records of concrete 16.40 (1) Delivery notes shall be provided for each delivery of concrete to the Site. The delivery notes shall be kept on the Site and shall be available for inspection by the Engineer at all times. Delivery notes shall contain the following details:

(a) Serial number of delivery note,

(b) Date,

(c) Name and location of batching and mixing plant,

(d) Registration number of delivery vehicle,

(e) Name of purchaser,

(f) Name and location of the Site,

(g) Designation of concrete mix and approved slump value or approved flow value,

(h) Sources of constituents,

(i) Quantity of concrete, and

(j) Time of introduction of water to the concrete.

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

(a) Date,

(b) Designation of concrete mix and approved slump value or

approved flow value,

(c) Total quantity of each concrete mix produced that day,

(d) Serial number of delivery note,

(e) Arrival time of delivery vehicle,

(f) Time of completion of discharge,

(g) Quantity of water added at the Site,

(h) Position where concrete is placed,

(i) Results of flow table tests or slump tests,

(j) Details of test cubes made, and

(k) Temperature of concrete if a restriction on the temperature is stated in the Contract.

(3) Certificates/documents issued within 6 months showing the sources of constituents mentioned in sub-clause (1)(h) of this Clause shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. Amd 3/2021

PLACING AND COMPACTING CONCRETE

Placing concrete 16.41 (1) The permission of the Engineer shall be obtained before concrete is placed in any part of the permanent work. If placing of concrete is not started within 24 hours of permission having been given, permission shall again be obtained from the Engineer. The Contractor shall inform the Engineer before concreting starts and shall allow the Engineer sufficient time to inspect the work that is to be concreted.

(2) Unless otherwise permitted by the Engineer, the temperature of fresh concrete when placed in position shall not exceed 30 ℃ for mixes of grade strength greater than 20 MPa. The Contractor shall submit for approval details of the proposal to ensure that this temperature will not be exceeded.

(3) Concrete shall be placed and compacted in its final position within 2½ hours of the introduction of cement to the concrete mix.

(4) Concrete that in the opinion of the Engineer is no longer sufficiently workable shall not be placed in the permanent work.

(5) Concrete shall not be placed in water other than by tremie or in bags.

(6) Concrete shall be placed as close as practicable to its final position and shall not be moved into place by vibration. Trunking or chutes shall be used to place concrete which will fall more than 2.7 m unless otherwise permitted by the Engineer. Trunking or chutes, where being used, shall be clean and used in such a way to avoid segregation and loss of constituents of the concrete mix.

(7) Concrete shall be placed in such a manner that the formwork, reinforcement or built-in components are not displaced.

(8) Unless otherwise permitted by the Engineer, concrete other than concrete placed by tremie shall be placed in horizontal layers to a compacted depth of not more than 450 mm if internal vibrators are used and to a compacted depth of not more than 150 mm in other cases.

(9) Concrete shall be placed continuously within the element to be concreted. Fresh concrete shall not be placed against concrete that has been in position for more than 30 minutes unless in the opinion of the Engineer the concrete already placed is sufficiently workable and the permission of the Engineer has been obtained. If permission is not obtained, a construction joint shall be formed as stated in Clause 16.45. Concrete shall not be placed against the concrete already placed for at least 24 hours unless permitted by the Engineer.

Placing concrete by pumping

16.42 (1) Concrete pumps shall be operated and maintained in accordance with the manufacturer's recommendations. The pumps and pipelines shall be maintained in a clean condition. Internal surfaces of pipelines shall not be aluminium. Joints in pipelines shall be tightly fixed and shall not permit grout loss.

(2) Concrete pumps shall be positioned such that pipelines are as short and straight as practicable and require as little repositioning as practicable. Bends in pipelines shall be arranged in such a manner that the concrete, formwork, reinforcement or built-in components are not disturbed.

(3) Pipelines shall be lubricated by passing cement grout or concrete through the pipeline before the concrete is pumped. The initial discharge of pumped concrete shall not be placed in the permanent work.

Placing concrete by tremie

16.43 (1) Tremies used to place concrete shall be securely supported in position and the joints shall be watertight. A temporary seal of a type agreed by the Engineer shall be used to keep the water and the concrete separate at the start of concreting. Concrete for tremie placing shall be self-compacting, free flowing and cohesive.

(2) After the concrete is flowing, the tremie shall be raised in a manner agreed by the Engineer. The lower end of the tremie shall be kept immersed in the concrete to a depth of at least 1 m. Water, mud and other deleterious material shall be prevented from entering the tremie after concreting has started.

(3) The Contractor should include in his method statement a contingency plan of necessary measures that shall be taken to cater for any incident that the tremie pipe might become blocked or removed from the concrete.

(4) Concrete placed by tremie shall be placed above the specified level by an amount that is sufficient to allow for the removal of contaminated concrete. Contaminated concrete shall be removed.

Compacting concrete

16.44 (1) Concrete shall be compacted to form a dense homogeneous mass.

(2) Unless otherwise permitted by the Engineer, concrete shall be compacted by means of internal vibrators of suitable diameter. A sufficient

number of vibrators shall be maintained in serviceable condition on the Site to ensure that spare equipment is available in the event of breakdown.

(3) Vibrators shall be used in such a manner that vibration is applied continuously and systematically during placing of the concrete until the expulsion of air has practically ceased. Vibrators shall not be used in a manner that will result in segregation. Internal vibrators shall be inserted to the full depth of the concrete placed and shall be withdrawn slowly.

(4) Vibration shall not be applied by way of the reinforcement, and contact between internal vibrators and formwork, reinforcement or built-in components shall be avoided as far as possible. Concrete shall be vibrated in such a manner that the formwork, reinforcement or built-in components will not be displaced.

(5) Concrete that has been in position for more than 30 minutes shall not be vibrated except as stated in Clause 16.41(8).

(6) No-fines concrete shall be compacted using a minimum amount of punning.

CONSTRUCTION JOINTS

Construction joints 16.45 (1) Construction joints in concrete shall be formed only at the specified positions and by the specified method unless otherwise approved by the Engineer. The position and details of construction joints which are not stated in the Contract shall be arranged in such a manner that the possibility of the occurrence of shrinkage cracks is minimized.

(2) Construction joints shall be normal to the axis or plane of the element being constructed unless otherwise permitted by the Engineer.

(3) Waterstops shall be provided at construction joints in water retaining structures and watertight structures.

(4) Laitance and loose material shall be removed from the surface of construction joints and the aggregate shall be exposed by a method agreed by the Engineer. The work shall be carried out as soon as practicable after the concrete has hardened sufficiently for the cement matrix to be removed without disturbing the coarse aggregate. The surface of the construction joint shall be cleaned after the matrix has been removed.

(5) The surface of the construction joint shall be clean and dry when fresh concrete is placed against it.

CURING CONCRETE

Curing concrete 16.46 (1) Concrete shall be protected against harmful effects of weather, running water and drying out by one of the following methods:

Method 1 : A liquid curing compound shall be applied to the concrete surface by a low-pressure spray until a continuous visible covering is achieved. The

application rate shall be applied as recommended by the manufacturer. For textured surfaces and fluted surfaces, the application rate shall be adjusted to ensure that full covering is achieved. Covering the adjoining reinforcement or formwork shall be avoided.

Method 2 : The concrete surface shall be covered with hessian, sacking, canvas or other absorbent material agreed by the Engineer or with a layer of fine aggregate at least 25 mm thick. The hessian, sacking, canvas, absorbent material or fine aggregate shall be kept constantly wet.

Method 3 : The concrete surface shall be covered with polyethylene sheeting. Concrete surfaces which have become dry shall be thoroughly wetted before the sheeting is placed.

Method 4 : Unformed concrete surfaces shall be covered with polyethylene sheeting until the concrete has hardened sufficiently for water curing to be carried out. Water curing shall be carried out by spraying the concrete surface continuously with cool water or by ponding immediately after the sheeting is removed. If in the opinion of the Engineer water curing is impracticable, Method 2 shall be used instead of water curing.

(2) Method 1 shall not be used on concrete surfaces against which concrete will be placed or which will have a Class T1 finish or which will be painted or tiled.

(3) Method 1, 2, 3 or 4 shall be carried out on unformed concrete surfaces immediately after the concrete has been compacted and finished. Method 1, 2 or 3 shall be carried out on formed concrete surfaces immediately after the formwork has been removed.

(4) Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

(5) Hessian, sacking, canvas, absorbent material and polyethylene sheeting shall be lapped and securely held in position in such a manner that the concrete surface will not be damaged.

(6) Cold water shall not be applied to concrete surfaces or formwork intermittently in large quantities.

(7) The different methods of protection shall be maintained for the minimum periods stated in Table 16.5 after the concrete has been placed. The minimum periods may be reduced by the number of days during which formwork is left in position.

Table 16.5: Minimum periods of protection for concrete

Type of structure	Method of protection	Minimum period of protection (days)	
		Concrete not containing PFA, GGBS or PFAC	Concrete containing PFA, GGBS or PFAC
Water retaining structures and water tight structures	1	7	7
	2, 3 or 4	7	9
Others	1	7	7
	2, 3 or 4	4	5

INSTALLATION OF PRECAST CONCRETE UNITS

Installation of precast concrete units 16.47 (1) Contact surfaces between in-situ concrete and precast concrete units shall be prepared as stated in the Contract. Dimensional tolerances shall be checked before the precast concrete units are lifted into position.

(2) Temporary supports and connections shall be provided as soon as practicable during installation of precast concrete units.

(3) Final structural connections shall be completed as soon as practicable after the precast concrete units have been installed.

(4) Levelling devices that have no load bearing function in the finished structure shall be slackened, released or removed after the precast concrete units have been installed.

LOADING OF CONCRETE

Loading of concrete 16.48 (1) Loads which will induce a compressive stress in the concrete exceeding one-third of the compressive strength of the concrete at the time of loading or exceeding one-third of the grade strength, whichever is less, shall not be applied to concrete. Allowance shall be made for the weight of the concrete in determining the loading. The strength of the concrete and the stresses produced by the loads shall be assessed by a method agreed by the Engineer.

(2) Loads from materials not forming part of the permanent work or from construction plant or other vehicles shall not be applied to no-fines concrete.

TESTING: CEMENT, PFA, GGBS, AGGREGATE, ADMIXTURE, CURING COMPOUND, RECYCLED WATER

Batch: cement, PFA, 16.49 A batch of cement, PFA, GGBS, aggregate, admixture or curing compound is

GGBS, aggregate, admixture, curing compound

any quantity of cement, PFA, aggregate, admixture or curing compound of the same type, manufactured or produced at the same time in the same place, covered by the same certificates and delivered to the Site, or stored at the ready-mixed concrete plant, at any one time.

Samples: cement, PFA, GGBS, aggregate, admixture, curing compound

16.50 (1) One sample of each type of cement, PFA, GGBS, aggregate, admixture and curing compound shall be provided at the same time as particulars of the material are submitted to the Engineer.

(2) The size of each sample and the method of sampling shall be as stated in Table 16.6.

Testing: cement, PFA, GGBS, aggregate, admixture, curing compound, recycled water

16.51 (1) Each sample of cement, PFA, GGBS, aggregate, admixture and curing compound shall be tested to determine the properties stated in Table 16.7.

(2) The method of testing and acceptance criteria shall be as stated in Table 16.7.

(3) The maximum total chloride content of concrete shall be determined on the basis of the results of tests for chloride content of each constituent.

(4) The sampling and testing for acceptance inspection at delivery shall be as stated in National Annex NB of BS EN 197-1. The methods of taking and preparing samples of cement shall be as stated in BS EN 196-7.

(5) If recycled water is used for mixing concrete, tests shall be carried out according to the methods and frequency stated in Table 16.8.

Table 16.6: Size of samples and method of sampling cement, PFA, GGBS, aggregate, admixture and curing compound

Material	Size of sample	Method of sampling
Cement	20 kg	BS EN 196-7
PFA	20 kg	BS EN 196-7
GGBS	20 kg	BS EN 196-7
Coarse aggregate	25 kg for physical and chemical tests; 25 kg for assessment of potential alkali-reactivity	CS3
Fine aggregate	10 kg for physical and chemical tests; 10 kg for assessment of potential alkali-reactivity	CS3
Admixture (powdered)	1 kg	BS EN 934-2
Admixture (liquid)	1 L	BS EN 934-2
Curing compound	5 L	BS EN 934-2

Table 16.7: Testing cement, PFA, GGBS, aggregate, admixture and curing compound

Material	Property	Testing Method and Acceptance Criteria
PC, SRPC, PFAC	Composition	BS EN 197-1
	Chemical properties	BS EN 196-2
	Compressive strength at 2, 7 and 28 days	BS EN 196-1
	Initial setting time	BS EN 196-3
	Soundness	BS EN 196-3
PFA	Chemical composition	BS EN 196-2
	Physical tests	BS 3892:Part 1 or BS EN 450-1
GGBS	Composition	BS EN 197-1
	Chemical requirements	BS EN 196-2
	Fineness	BS EN 196-6
	Relative density	BS EN 196-6
	Activity index	BS EN 15167-1 and BS EN 196-1
	Initial setting time	BS EN 196-3
Coarse aggregate and fine aggregate	Grading Fines content Oven-dried particle density Potential alkali-reactivity Presence of organic substances	CS3
Fine aggregate	Water-soluble chloride ion content	CS3
Coarse aggregate	Flakiness index Elongation index (natural aggregate) Ten per cent fines value Water absorption Magnesium sulphate soundness value (natural aggregate) Water-soluble chloride ion content (natural aggregate) Foreign materials content (recycled aggregate) Acid-soluble chloride ion content (recycled aggregate) Acid-soluble sulphate content (recycled aggregate) Los Angeles Value (when required)	CS3
Admixture	Chloride content	BS EN 934-2
Curing compound	Efficiency index	Appendix 16.1

Table 16.8: Recycled water testing for each batching plant

Description	Limits	Test method	Test frequency
Physical test			
(a) Density test for recycled water (b) Initial setting time of cement with recycled water (time of set, deviation from control, h:min)	≤ 1030 kg/m^3 From 1:00 earlier to 1:30 later	Note 1 BS EN 196-3	At least once per day Once every 3 months for the first year and thereafter at half-yearly intervals
Chemical test for recycled water			For all tests: (i) Once per week for the first 2 months (i) Once per month for the next 12 months thereafter (ii) In case of a weekly or monthly test indicates that the limits are exceeded, the water shall immediately be suspended for use in concrete mixing until two sets of consecutive test results taken from the same source are satisfactory. In such case, the testing frequency shall be maintained at or reverted back to once per week until two sets of consecutive test results are satisfactory. (iv) The testing frequency shall be subject to review after the 12-month period for the monthly test
(a) Chloride content (as $C1^-$): - prestressed concrete steam-cured structural concrete	500 ppm	APHA 4500-C1-B	
- concrete with reinforcement or other embedded metal	1,000 ppm	APHA 4500-Cl-B	
(b) Sulphate content (as SO_4)	3,000 ppm	APHA 4500-SO42-C	
(c) Acid-soluble alkali content	600 ppm	BS EN 1008	

Notes:
1. Test method to be proposed by the Contractor for the acceptance of the Engineer.
2. Laboratories accredited by HOKLAS for the relevant tests shall be used, if available, in which case results shall be issued on HOKLAS endorsed test reports.

TESTING: CONCRETE - GENERAL REQUIREMENTS

Batch: concrete 16.52 A batch of concrete is any quantity of concrete produced in one cycle of operations of a batch mixer, or conveyed ready-mixed in a delivery vehicle, or discharged during one minute from a continuous mixer.

Reduction of testing frequency 16.53 The number of tests for workability or compressive strength of standard mix concrete may be reduced if in the opinion of the Engineer the standard of quality control is satisfactory.

TESTING: CONCRETE - WORKABILITY

Samples: workability of concrete 16.54

(1) One sample of concrete shall be provided from each batch of concrete to determine the workability of the concrete.

(2) The size of each sample and the method of sampling shall be in accordance with CS1.

(3) The first 0.3 cu. m. concrete discharged from the truck before taking concrete sample for slump test can be used in the Works after the measured slump value is accepted by the Engineer as in Clause 16.56.

Testing: workability of concrete 16.55

(1) Each sample of concrete taken as stated in Clause 16.54 shall be divided into two specimens. Each specimen shall be tested to determine the workability of the concrete in accordance with CS1. Selection of the testing method is given in the table below:

Normal Workability (designed slump value from 20 mm to 200 mm)	**High Workability (designed flow value from 340 mm to 600 mm)**
Slump Test (For designed slump value > 175 mm and ≦ 200 mm, see the Note to Clause 2.1.1 of CS1)	Flow Table Test (See Note below)

Note: For concrete with a flow value greater than 600mm, the Engineer shall specify the workability testing method.

(2) The average of the two workability values shall be calculated and referred to as the average measured slump value or average measured flow value.

Compliance criteria: workability of concrete 16.56

(1) The average measured slump value of the two specimens taken from one sample of standard mix concrete shall be within the appropriate range of measured slump value stated in Table 16.3.

(2) The average measured slump value of the two specimens taken from one sample of designed mix concrete shall be within +/- 25 mm or +/- 33% of the designed slump value, whichever is the greater, up to the limit of +/- 50 mm.

(3) The average measured flow value of the two specimens taken from one sample of designed mix concrete shall be within +/- 60 mm of the designed flow value.

Non-compliance: workability of concrete 16.57

A batch of concrete shall be considered as not complying with the specified requirements for workability if the result of any test for workability, carried out on a sample taken from the batch, does not comply with the specified requirements for workability. Concrete that failed to comply with the specified requirements for workability shall not be placed in the permanent works.

TESTING: CONCRETE - COMPRESSIVE STRENGTH

Samples: compressive strength of concrete 16.58

(1) For each concrete mix, one sample of concrete shall be provided from each amount of concrete as stated in Table 16.9 or from the amount of concrete produced each day, whichever is less.

(2) If the Contractor requests, or if the Engineer instructs, that the concrete be tested for compressive strength at ages other than 28 days, additional samples shall be provided. The number of additional samples shall be as stated in Clause 16.58(1).

(3) The size of each sample and the method of sampling shall be in accordance with CS1. If a superplasticising admixture is included in the concrete mix, the samples shall be taken after the superplasticiser is added and after the concrete is remixed.

Table 16.9: Rate of sampling of concrete

Type of structure	Amount of concrete
Masts Cantilevers 3 m or more in length Columns Shear walls Prestressed elements Other critical elements	10 m^3 or 10 batches, whichever is less
Solid rafts Pile caps Mass concrete	100 m^3 or 100 batches, whichever is less
Other types	25 m^3 or 25 batches, whichever is less

Testing: compressive strength of concrete 16.59

(1) Two test cubes shall be made from each sample of concrete taken as stated in Clause 16.58. Each pair of test cubes shall be tested to determine the compressive strength at 28 days.

(2) The method of making test cubes shall be in accordance with CS1.

(3) The method of storing test cubes shall be in accordance with CS1. Test cubes which are cured on the Site shall be delivered to the testing laboratory at least 48 hours before the tests are due to be carried out.

(4) The method of testing shall be in accordance with CS1.

(5) For the purpose of assessing compliance of designed mix concrete as stated in Clauses 16.61 and 16.62, the average of the two compressive strengths of the pair of test cubes shall be calculated and referred to as the test result.

(6) The size of the test cube shall be 100 mm for concrete with the maximum aggregate size not exceeding 20 mm and shall be 150 mm with the maximum aggregate size exceeding 20 mm.

Non-compliance: compressive strength of standard mix concrete 16.60 If the result of any test for compressive strength at 28 days of standard mix concrete is less than the grade strength, the Engineer may instruct that tests as stated in Clauses 16.63 to 16.66 are carried out on concrete cores or on samples taken from the hardened concrete.

Compliance criteria: compressive strength of designed mix concrete 16.61 (1) The results of tests for compressive strength at 28 days of designed mix concrete shall comply with the following requirements:

(a) Each test result shall not be less than the grade strength by more than the appropriate amount stated in Column A of Table 16.10, and,

(b) The average of any four consecutive test results, or the average of the first two or first three test results if less than four test results are available, shall exceed the grade strength by at least the appropriate amount stated in Column B of Table 16.10.

Table 16.10: Compliance criteria for compressive strength of designed mix concrete

Grade strength (MPa)	**Compliance criteria**	**Column A**		**Column B**	
		Maximum amount by which each test result may be below the grade strength (MPa)		**Minimum amount by which the average of any four consecutive test results shall be above the grade strength (MPa)**	
		100 mm cubes	150 mm cubes	100 mm cubes	150 mm cubes
20 or greater	C1	2	3	7	5
	C2	2	3	5	3
below 20	C3	2	2	3	2

(2) If there is a period exceeding 14 days between any two consecutive test results in any group of four consecutive test results and if agreed by the Engineer, the test results immediately before and immediately after the period may be treated separately for the purpose of Clause 16.61(1)(b). For bored piles, if a pile consists of at least four test results and if agreed by the Engineer, the test results of that pile may be treated individually for the purpose of Clause 16.61(1)(b). Amd 2/2026

(3) If the difference between the compressive strengths of two test cubes made from one sample of designed mix concrete exceeds 15% of the test result:

(a) The higher of the compressive strengths of the two test cubes shall be used to assess compliance as stated in Clause 16.61(1)(a), and

(b) The test result for that sample shall not be used to assess compliance as stated in Clause 16.61(1)(b) and shall not be used to calculate the standard deviation.

(4) For designed mix concrete with grade strength of less than 20 MPa,

compliance criteria C3 shall apply.

(5) For designed mix concrete with a grade strength of 20 MPa or greater, until 40 test results are available either:

(a) Compliance criteria C1 shall apply, or

(b) If in the opinion of the Engineer there is sufficient evidence that the standard of quality control using similar materials and plant is such that the standard deviation for at least 40 test results will not exceed 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes, compliance criteria C2 shall apply.

(6) For designed mix concrete with a grade strength of 20 MPa or greater, the standard deviation and Amd 4/2025 the coefficient of variation of test results shall be calculated after every test result for each designed mix using the last 40 test results judged by the same compliance criteria. The acceptance criteria shall depend on the calculated standard deviation and the coefficient of variation Amd 4/2025 as follows:

(a) For 100 mm test cubes, if the standard deviation does not exceed 5.5 MPa, compliance criteria C2 shall apply to subsequent test results. If the standard deviation exceeds 5.5 MPa, compliance criteria C1 shall apply to subsequent test results.

(b) For 150 mm test cubes, if the standard deviation does not exceed 5 MPa, compliance criteria C2 shall apply to subsequent test results. If the standard deviation exceeds 5 MPa, compliance criteria C1 shall apply to subsequent test results.

(c) When both of Amd 4/2025the following situations occur Amd 4/2025, no further concreting of permanent works should be allowed until an investigation of the materials, mix design, methods of production, sampling and testing has been carried out and measures, which in the opinion of the Engineer will result in restoring a steady and satisfactory production of the concrete mix, have been taken:

(i) Amd 4/2025The standard deviation exceeds 8.5 MPa for 100 mm test cubes or 8 MPa for 150 mm test cubes; and Amd 4/2025

(ii) Amd 4/2025The coefficient of variation exceeds 14%.

(7) If the compliance criteria are changed from C1 to C2 or from C2 to C1, the new compliance criteria shall apply from the 35th day after making the last pair of test cubes in the set of 40 on which the decision to change was based. For the purpose of Clause 16.61(1)(b), test results immediately before and immediately after the change shall be treated separately.

Non-compliance: compressive strength of designed mix concrete 16.62 (1) A batch of designed mix concrete shall be considered as not complying with the specified requirements for compressive strength if the test result for the pair of test cubes made from a sample taken from the batch does not comply with the requirements stated in Clause 16.61(1)(a).

(2) The batches of designed mix concrete from which the first and last samples in any group of four consecutive test results were taken and all intervening batches shall be considered as not complying with the specified requirements for compressive strength if the group of four consecutive test

results does not comply with the requirements stated in Clause 16.61(1)(b).

(3) If designed mix concrete is considered as not complying with the specified requirements for compressive strength, the Engineer may instruct that tests as stated in Clauses 16.63 to 16.66 are carried out on concrete cores or on samples taken from the hardened concrete.

TESTING: HARDENED CONCRETE

Samples: hardened concrete and concrete cores 16.63

(1) The number of samples, including cores, of hardened concrete to be provided for testing shall be as stated in the Contract or, if testing is to be carried out as a result of the concrete not complying with the specified requirements, shall be as instructed by the Engineer. In the latter case, all the concrete being investigated shall be divided as instructed by the Engineer into separate test locations. The number of samples taken from each location shall be as instructed by the Engineer and the quality of concrete at each location shall be assessed separately. The positions from which the samples are taken shall be as instructed by the Engineer.

(2) The size of samples and the method of sampling shall be in accordance with CS1.

Testing: concrete cores 16.64

(1) Each concrete core shall be inspected for evidence of segregation of the constituents and for the presence of voids. Specimens selected from each core shall be tested to determine the compressive strength.

(2) The method of preparing and inspecting concrete cores and of testing the cores to determine the compressive strength shall be in accordance with CS1. Concrete cores shall not be tested for compressive strength until the concrete has reached an age of 28 days.

Compliance criteria: concrete cores 16.65

(1) The concrete core shall be considered as non-compliant if it exhibits honeycombing which means interconnected voids arising from, for example, inadequate compaction or lack of mortar.

(2) The results of tests for compressive strength of concrete cores shall be interpreted in accordance with BS 6089. Adjustments to the measured strength in respect of the age of the core when tested shall not be made unless permitted by the Engineer. The estimated in-situ cube strength of each core specimen shall be calculated in accordance with CS1. For any set of cores representing a test location, the average estimated equivalent cube strength shall be at least 85% of the specified grade strength, and each individual estimated equivalent cube strength shall be at least 75% of the specified grade strength.

Analysis of hardened concrete 16.66

(1) Each sample of hardened concrete shall be tested to determine the properties or the composition of the concrete as stated in the Contract or, if testing is to be carried out as a result of the concrete not complying with the specified requirements, shall be tested as instructed by the Engineer.

(2) Tests on hardened concrete shall be carried out within 14 days of the Engineer's instruction for the test.

(3) The method of testing shall be in accordance with CS1.

TESTING: PRECAST UNITS

Batch: precast units 16.67 A batch of precast units is any quantity of precast units, including prestressed units, of the same type and size, of the same concrete mix, manufactured in the same place, covered by the same certificates and delivered to the Site at any one time.

Samples: precast units 16.68 The number of precast units to be provided for testing from each batch shall be as stated in the Contract.

Testing: precast units 16.69 (1) Load tests shall be carried out to determine the deflection and recovery of each precast unit, including prestressed units, provided for testing and to determine the resistance to cracking of each prestressed unit provided for testing.

(2) Load tests shall be carried out in accordance with a procedure agreed by the Engineer. The age at which the units are to be tested, the test load, the points at which the loads are to be applied and the points at which the unit is to be supported shall be as stated in the Contract.

(3) The method of testing shall be as stated in Appendix 16.2.

(4) Post-tensioned units shall not be tested until at least 7 days after the ducts have been grouted.

Compliance criteria: precast units 16.70 The results of load tests on precast units shall comply with the requirements stated in the Contract.

PART 2: JOINTS IN CONCRETE

GENERAL

General requirements 16.71 (1) The works and materials specified in Clauses 16.72 and 16.73 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.

Joints in concrete carriageways 16.72 Joints in concrete carriageways shall comply with Section 10.

Construction joints 16.73 Construction joints in concrete shall comply with Section 16.

MATERIALS

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 16.75 Joint filler shall be of a proprietary type approved by the Engineer and shall be a firm, compressible, single-thickness, non-rotting filler. Joint filler for joints in water retaining structures and watertight structures shall be non-absorbent.

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.

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.

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

SUBMISSIONS

Particulars of materials for joints 16.81 (1) The following particulars of the proposed materials for joints shall be submitted to the Engineer for approval Amd 3/2021:

(a) Manufacturer's literature and a certificate for joint filler showing the manufacturer's name, the date and place of manufacture and showing that the joint filler complies with the requirements stated in the Contract and including results of tests for:
- Disintegration and shrinkage
- Recovery value and reduction in mass
- Extrusion,

(b) Manufacturer's literature and a certificate for bitumen emulsion showing the manufacturer's name, the date and place of manufacture and showing that the bitumen emulsion complies with the requirements stated in the Contract,

(c) Manufacturer's literature for joint sealant, including details of the method and time required for mixing the different components, and a certificate showing the manufacturer's name, the date and place of manufacture and showing that the sealant complies with the requirements stated in the Contract and including results of tests as appropriate for:
- Rheological properties
- Plastic deformation
- Adhesion and tensile modulus
- Application life
- Adhesion in peel
- Loss of mass after heat ageing
- Staining
- Transverse butt joint movement range
- Extension

- Flow
- Penetration
- Degradation,

(d) Manufacturer's literature and a certificate for bearing strip for sliding joints showing the manufacturer's name, the date and place of manufacture and showing that the strips comply with the requirements stated in the Contract and including results of tests for:
- Vertical load
- Coefficient of friction,

(e) Manufacturer's literature for waterstops, including details of intersections, reducers and junctions, and a certificate showing the manufacturer's name, the date and place of manufacture and showing that the waterstops comply with the requirements stated in the Contract and including results of tests for:
- Density
- Hardness
- Tensile strength
- Elongation at break point
- Water absorption
- Softness number of PVC waterstops, and

(f) Particulars of primers and caulking material for joint sealant and of bond breaker tape.

(2) The particulars, including certificates, shall be submitted to the Engineer for approval Amd 3/2021 at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the Site.

Samples of materials 16.82 Samples of the following proposed materials shall be submitted to the Engineer for information Amd 3/2021 at the same time as particulars of the material are submitted:

(a) Joint filler,

(b) Bond breaker tape,

(c) Bearing strip for sliding joints, and

(d) Waterstops, including intersections, reducers and junctions.

STORAGE OF MATERIALS

Storage of materials for joints 16.83 (1) Bitumen emulsion, joint sealant and primer for joint sealant shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions which may affect the material. The materials shall be stored in accordance with the manufacturers' recommendations and shall not be used after the recommended shelf life has been exceeded.

(2) Joint filler, bond breaker tape and waterstops shall be stored in accordance with the manufacturers' recommendations in a dry weatherproof store with a raised floor. Absorbent joint filler shall be stored in sealed

plastic bags and shall not be exposed to moisture or air.

(3) Bearing strip for sliding joints supplied in rolls of 5 m length or less shall be unrolled immediately after delivery and shall be stored flat at full length on an even surface. Bearing strip supplied in rolls of more than 5 m length may be left in the original packing. Bearing strip shall be stored in accordance with the manufacturer's recommendations and shall be protected from mechanical damage and creasing. The two layers of strip shall be kept free from deleterious material.

FORMING JOINTS

Forming joints 16.84 (1) Materials for joints shall be used in accordance with the manufacturers' recommendations or as otherwise stated in the Contract.

(2) Joint filler shall be cut to size before fixing and shall be securely fixed in position to the existing concrete surface before concreting. There shall be no gaps between the joint filler and formation.

(3) Waterstops shall be securely fixed in position to formwork in such a manner that compaction of the concrete will not be affected. In-situ joints in waterstops shall be made using methods and equipment recommended by the manufacturer. Exposed waterstops shall be protected from exposure to conditions that may affect the waterstop and shall be kept free from rust, hydrocarbons and other deleterious material.

(4) Joints shall be formed in straight lines perpendicular to the surface of the concrete unless otherwise stated in Contract.

Forming grooves 16.85 (1) Grooves for joint sealant shall be straight and shall be perpendicular to the surface of the concrete. The bottom of the groove shall be flat and shall be parallel to the surface of the concrete.

(2) Grooves shall be formed by using timber or other approved formers and shall not be formed by cutting back or raking out the joint filler. The grooves shall be located over the joint filler such that the upper surface of the joint filler is entirely contained in the groove.

Protection of grooves 16.86 Before permanent sealing, grooves for joint sealant shall be protected from contamination by a temporary sealing strip or cover or by other methods agreed by the Engineer.

Sealing joints 16.87 (1) The permanent sealing of joints shall be carried out at least 7 days after concreting unless otherwise permitted by the Engineer.

(2) Immediately before permanent sealing, timber formers, temporary seals, dirt and loose material shall be removed from the groove and the sides of the groove shall be cleaned and roughened by water jetting, sand blasting or by other methods agreed by the Engineer.

(3) Caulking material shall be firmly packed in the bottom of the groove if the joint sealant is not required to extend to the bottom of the groove.

(4) Bond breaker tape shall be fixed continuously and evenly along the bottom of the groove for the full width and length of the groove.

(5) Concrete surfaces within 75 mm of the edges of the joint shall be masked with tape before the primer is applied and until the sealing of the joint is complete.

(6) Primer for the joint sealant shall be applied to the sides of the groove in accordance with the manufacturer's recommendations.

(7) Joint sealant shall be applied between the minimum and maximum drying times of the primer recommended by the manufacturer. The components of the sealant shall be thoroughly mixed in accordance with the manufacturer's recommendations using a power operated paddle mixer for sufficient time to produce a homogeneous mass without entrapped air. The sealant shall be dispensed into the groove as soon as practicable after mixing and within the time recommended by the manufacturer.

(8) The groove shall be clean and dry at the time of applying the primer and joint sealant.

(9) Excess joint sealant shall be removed by using a purpose made finishing tool such that the finished surface of the sealant is between 4 mm and 6 mm below the face of the concrete.

TOLERANCES

Tolerances: joints 16.88 (1) The best-fit straight line of straight joints shall be within 25 mm of the specified line. The line of straight joints shall be within 10 mm of the best-fit straight line.

(2) The best-fit curved line of curved joints shall be as agreed by the Engineer and shall be within 25 mm of the specified line. The line of curved joints shall be within 10 mm of the best-fit curved line.

(3) Joints shall be continuous across intersections of joints to within 5 mm of the best fit straight lines or best fit curved lines of each joint.

(4) The depth of grooves for joint sealant shall be within 3 mm of the specified depth.

TESTING: MATERIALS FOR JOINTS

Batch: joint filler, joint sealant, waterstops 16.89 A batch of joint filler, joint sealant or waterstop is any quantity of joint filler, joint sealant or waterstop of the same type, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: joint filler, joint sealant, waterstops 16.90 (1) One sample of each type of joint filler, joint sealant or waterstop shall be provided at the same time as particulars of the material are submitted to the Engineer. Unless otherwise permitted by the Engineer, one sample of each type of material shall be provided from each batch of the material delivered to the Site. Unless otherwise permitted by the Engineer, one sample of mixed joint sealant shall be provided on each day that joints are sealed.

(2) The size of each sample of joint filler shall be sufficient to permit all tests stated in Appendix 16.3 to be carried out.

(3) Samples of unmixed joint sealant and primers for joint sealant shall be taken from sealed containers delivered to the Site. Samples of mixed joint sealant shall be taken immediately before the sealant is applied to the joint. The method of sampling shall be as stated in BS 2499, Appendix A. The size of each sample shall be as follows:

(a) Unmixed joint sealant : 1 kg

(b) Mixed joint sealant : 1.5 kg

(c) Primer for joint sealant : 1 L.

(4) The size of each sample of waterstop shall be 1 m.

Testing: joint filler, joint sealant, waterstops 16.91 (1) If required by the Engineer, samples of joint filler shall be tested to determine the disintegration and shrinkage, the recovery value and reduction in mass and the extrusion. The method of testing shall be in accordance with Appendix 16.3.

(2) If required by the Engineer, samples of joint sealant shall be tested to determine the properties stated in Table 16.13. The method of testing shall be as stated in Table 16.13.

(3) If required by the Engineer, samples of waterstop shall be tested to determine the properties stated in Table 16.14. The method of testing shall be as stated in Table 16.14.

Table 16.13: Testing joint sealant

Type of joint sealant	Properties to be tested	Method of testing
Polysulphide-based sealant Polyurethane-based sealant	Rheological properties Plastic deformation Adhesion and tensile modulus Application life Adhesion in peel Loss of mass after heat ageing Staining	BS 4254
Hot-applied bitumen rubber sealant	Extension Flow Penetration Degradation	BS 2499

Table 16.14: Testing waterstops

Property	Method of testing	
	Rubber waterstops	**PVC waterstops**
Density	BS ISO 2781	BS EN ISO 1183-1
Hardness	BS ISO 48	ASTM D 2240
Tensile stress-strain properties	BS ISO 37 and BS ISO 2285	BS 2782:Part 3, Methods 320A to 320F
Water absorption	BS 903:Part A18	BS EN ISO 62
Softness number	-	BS 2782:Part 3, Method 365A

Compliance criteria: joint filler

16.92 The results of tests on joint filler shall comply with the following requirements:

(a) None of the three specimens in the weathering test shall show any sign of disintegration or shrinkage.

(b) Each of the four specimens in the compression and recovery test shall have a recovery value of at least 70%, and the reduction in mass of each of the two new specimens shall not exceed 1%.

(c) The extrusion of the free edge of the specimen shall not exceed 6 mm as determined by the extrusion test.

APPENDIX 16.1

DETERMINATION OF THE EFFICIENCY INDEX OF CURING COMPOUNDS

Scope 16.1.1 This method covers the determination of the efficiency index of membrane forming curing compounds for concrete.

Materials 16.1.2 The following materials are required:

(a) Portland cement complying with BS EN 197-1, specially selected for testing admixtures and identified as 'CAA/BS EN 934-2 Reference Portland Cement'. The cement shall be stored in an airtight container.

(b) Oven-dry natural sand with a rounded particle shape complying with BS 882 and with the grading stated in Table 16.1.1.

(c) Petroleum jelly, mineral oil or a propriety release agent.

Table 16.1.1: Grading of sand

BS test sieve	Percentage by mass passing
1.18 mm	100
600 μm	90 - 100
300 μm	12 - 40
150 μm	0 - 6

Apparatus 16.1.3 The following apparatus is required:

(a) Moulds constructed of corrosion resistant metal. The moulds shall be watertight, tapered and constructed so as to prevent distortion and shall have the following dimensions:

- Internal size (top) : 150 mm (0mm to +5 mm) x 300 mm (0mm to +5 mm)
- Internal size (bottom) : 145 mm (0mm to +5 mm) x 295 mm (0mm to +5 mm)
- Internal depth : 50 mm ± 2 mm
- Side and end slope : 5% ± 1%
- Top flange width : at least 12 mm

(b) A balance readable and accurate to 0.1 g.

(c) A cabinet complying with BS 2648 capable of storing specimens

at a temperature of 38°C ± 1°C and at a relative humidity of 35% ± 5%. The cabinet shall have three perforated or mesh shelves each capable of supporting two specimens during test so as to ensure a clear space of at least 40 mm on all sides of individual specimens. The cabinet shall be equipped to circulate air over the specimens at an approximate rate of 0.5 m/s.

(d) Spray equipment, such as the Wagner model W320 electric spray gun, designed to permit the curing compound to be aspirated and applied evenly to the specimen.

(e) An electrically driven mixer complying with BS EN 1015-2 and having a nominal capacity of 12 kg.

(f) A vibrating table or a vibrating hammer with a 40 mm square foot or a compacting bar made of non-absorbent material, approximately 200 mm long and with a 40 mm square foot.

(g) A metal screed, 148 mm long, of L-shaped Section 50 mm x 25 mm with the shorter side having a sharpened leading edge. The screed shall be supported across the top of the mould by a 200 mm long rigid member that can slide on the flanges of the mould while holding the screed horizontal. The height of the screed shall be adjustable to give a uniformly flat surface finish to the mortar 7 mm ± 1 mm below the top of the mould.

(h) A metal tray with sides at least 3 mm high and an area equal to the surface area of the specimen.

(i) A hydrometer complying with BS 718.

(j) A float, 250 mm x 140 mm ± 5 mm.

(k) A medium soft 50 mm paint brush.

Procedure: preparation of specimens

16.1.4 The procedure for preparation of the specimens shall be as follows:

(a) Three pairs of specimens shall be prepared, each pair comprising one test specimen and one control specimen.

(b) Mixing shall be carried out in a room having a temperature of 27°C ± 3°C. The materials shall be brought to room temperature before mixing. A mortar mix shall be prepared comprising one part by mass of cement, three parts by mass of sand and 0.44 parts by mass of water.

(c) The sand and cement shall be placed in the mixer and mixed for 1 minute. The water shall be added and mixing continued for a further 4 minutes.

(d) The two moulds shall be cleaned, lightly coated with the petroleum jelly, mineral oil or release agent and weighed to the nearest 0.1 g (m_1).

(e) The specimens shall be prepared 20 minutes after completion of mixing and shall be cast in pairs.

(f) A layer of mortar approximately 25 mm deep shall be placed in each mould and tamped 50 times with the compacting bar. A second layer of mortar, sufficient to overfill the moulds slightly, shall be placed in each mould and tamped 50 times with the compacting bar. Indentations formed by tamping shall be filled and the surface shall be levelled by vigorous compaction by manual methods. Alternatively, each layer shall be compacted by using the vibrating table or vibrating hammer and levelled using the float.

(g) A uniform surface, free from undulations and surface defects, shall be produced using the minimum number of passes of the metal screed working along the length of the mould in both directions. The finished surface shall be 7 mm ± 1 mm below the top of the mould.

(h) The surface shall be brushed lightly with the paint-brush to give an even texture.

(i) The moulds and specimens shall each be weighed to the nearest 0.1 g (m_2) immediately before the curing compound is applied.

Procedure: determination of efficiency index

16.1.5 The procedure for determination of the efficiency index shall be as follows:

(a) A sample of the curing compound shall be taken by the method for sampling admixtures in accordance with BS EN 934-2, Appendix A.

(b) The sample shall be agitated thoroughly and the relative density determined at room temperature with the hydrometer. The mass required to give the coverage rate stated in Clause 16.1.5(c) shall be calculated from the relative density. The mass of the curing compound applied shall be within ± 0.5 g of that required to give the specified coverage rate.

(c) The curing compound shall be applied at the coverage rate recommended by the manufacturer, or at a rate of 0.2 L/m^2 ± 0.01 L/m^2 if no rate is recommended.

(d) The curing compound shall be applied to the test specimen one hour after the specimen has been prepared, using the spray equipment or in accordance with the manufacturer's recommendations. The curing compound shall be shaken well before and during application. The spray gun shall be held so that the nozzle is as near vertical as possible and at a height that will result in uniform application and minimum overspray. The specimen shall be coated uniformly by applying several layers over the whole surface until the specified coverage is reached, checked by repeated weighing. Over spray shall be wiped from the exposed faces and edges of the mould. The whole application procedure shall be completed in not more than 2 minutes.

(e) The test specimen and the control specimen shall each be weighed to the nearest gram (m_3) and placed immediately on the lowest shelf of the cabinet. After the second pair of specimens has been prepared and weighed, the first pair shall be moved up one shelf and the second pair placed on the lowest shelf. After the third

pair of specimens has been prepared and weighed, the first two pairs shall be moved up one shelf and the third pair placed on the lowest shelf.

(f) The total time for making the specimens, coating the test specimen and placing the pair in the cabinet shall not exceed 2 hours.

(g) The specimens shall be kept in the cabinet for 72 hours ± 15 minutes after application of the curing compound. Each specimen shall be weighed to the nearest 0.1 g at 24 hours ± 15 minutes and 48 hours ± 15 minutes. Each specimen shall be weighed to the nearest 0.1 g (m_4 and m_5) at 72 hours ± 15 minutes.

(h) The metal tray shall be weighed to the nearest 0.1 g (m_6) and coated with the same quantity ± 0.5 g of curing compound used on the test specimen. The coated tray shall be weighed to the nearest 0.1 g (m_7) and placed in the cabinet for 72 hours ± 15 minutes after application of the curing compound. The tray shall be removed from the cabinet and weighed to the nearest 0.1 g (m_8).

Calculation

16.1.6 (1) The proportion of solvent lost (V) by the curing compound during the test period shall be calculated from the equation:

$$V = \frac{(m_7 - m_8)}{(m_7 - m_6)}$$

where:

- m_6 is the mass of the tray (g)
- m_7 is the mass of the tray after coating (g)
- m_8 is the mass of the tray after 72 hours in the cabinet (g)

(2) The loss of water from the test specimen (W_t) and the loss of water from the control specimen (W_c) shall be calculated for each pair of specimens from the equation:

$$W_t = \frac{(m_3 - m_4) - V(m_3 - m_2)}{(m_2 - m_1)} \times 100\%$$

$$W_c = \frac{(m_2 - m_5)}{(m_2 - m_1)} \times 100\%$$

where:

- m_1 is the mass of the mould (g)
- m_2 is the mass of the mould and test or control specimen as appropriate (g)
- m_3 is the mass of the mould and test specimen after coating (g)

- m_4 is the mass of the mould and test specimen after 72 hours in the cabinet (g)

- m_5 is the mass of the mould and control specimen after 72 hours in the cabinet (g)

(3) The efficiently index (E') of the curing compound shall be calculated for each test specimen from the equation:

$$E' = \frac{(W_c - W_t)}{W_c} \times 100\%$$

The efficiency index (E) of the curing compound shall be calculated as the average of E' for the three test specimens.

Reporting of results 16.1.7 The following shall be reported:

(a) Details of the sample of curing compound including identification, source, size, date received and age at test.

(b) The method of compacting the mortar.

(c) The method of applying the curing compound and the type of spray gun used.

(d) The rate of application of the curing compound to the nearest 0.01 L/m^2.

(e) The duration of the test.

(f) The efficiency index of the curing compound to the nearest 0.1%.

(g) That the test method used was in accordance with this Specification.

APPENDIX 16.2

DETERMINATION OF THE DEFLECTION, RECOVERY AND RESISTANCE TO CRACKING OF PRECAST UNITS

Scope 16.2.1 This method covers the determination of the deflection and recovery of precast units, including prestressed units, and the resistance to cracking of prestressed units by means of a load test.

Equipment 16.2.2 The following equipment is required:

(a) Rigid supports.

(b) Test loads.

(c) Equipment for measuring the loads applied, readable and accurate to 2% of the specified test load.

(d) Equipment for measuring the deflection and recovery, readable and accurate to 0.5 mm.

Procedure 16.2.3 The procedure shall be as follows:

(a) The precast unit shall be supported at the specified points of support.

(b) The upward deflection at mid-span due to the prestressing force in a prestressed unit and the deflection at mid-span due to the self-weight of a non-prestressed unit shall be measured.

(c) The specified test load shall be applied at the specified loading points in not less than ten approximately equal increments.

(d) The specified test load shall be maintained for 5 minutes and removed in not less than five approximately equal decrements.

(e) The deflection at mid-span shall be measured for each load increment and each load decrement and 5 minutes after the loads have been removed.

(f) Steps (c) to (e) shall be repeated.

(g) Load-deflection graphs shall be plotted.

Reporting of results 16.2.4 The following shall be reported:

(a) Details of the precast unit, including place of manufacture.

(b) The age of the concrete in the precast unit at the time of the test.

(c) The loads applied to the nearest 2% of the specified test load.

(d) The deflections measured to the nearest 0.5 mm.

(e) The load-deflection graphs.

(f) Details of any cracks.

(g) That the test method used was in accordance with this Specification.

APPENDIX 16.3

DETERMINATION OF THE RECOVERY VALUE AND REDUCTION IN MASS, AND THE EXTRUSION OF JOINT FILLER

Scope

16.3.1 This method covers the determination of the recovery value and reduction in mass of joint filler by the compression and recovery test, and the extrusion of joint filler by the extrusion test.

Apparatus

16.3.2 The following apparatus is required:

(a) Equipment for measuring the plan dimensions of the joint filler, accurate to 0.5 mm.

(b) Equipment for measuring the thickness of the joint filler, accurate to 0.1 mm.

(c) A balance, accurate to 0.1% of the specimen mass.

(d) A compression test machine complying with BS EN ISO 7500-1 with auxiliary platens 100 mm x 100 mm and a minimum thickness of 13 mm.

(e) An extrusion mould open on one side only and rigidly fixed to a base plate. The mould shall be 100 mm x 100 mm (+0.5 mm, -0 mm) internally and shall be of sufficient depth to test the specimen. The mould shall be provided with a close fitting pressure plate that shall fit without binding and with a horizontal measuring dial gauge or device readable and accurate to 0.1 mm.

Procedure: compression and recovery test

16.3.3 The procedure for determination of the recovery value and reduction in mass by the compression and recovery test shall be as follows:

(a) Four specimens from the sample shall be prepared, each 100 mm x 100 mm (± 2.5 mm).

(b) The thickness (t_1) of the four specimens shall be measured to the nearest 0.1 mm, and two specimens shall be weighed to within 0.1% of their mass (m_1).

(c) Each specimen shall be subjected to three applications of load in the compression test machine at 24-hour intervals. During each application of load the specimen shall be compressed to 50% of its original thickness at a rate of strain of 1.3 mm per minute. The load required to achieve the compression shall be at least 0.07 N/mm^2 and shall not exceed 10 N/mm^2. The load shall be released immediately the specified amount of compression is reached.

(d) After the third application of load, a recovery period of 30 minutes shall be allowed and the thickness (t_2) of each specimen shall be measured to the nearest 0.1 mm.

(e) The two previously weighed specimens shall be re-weighed to

within 0.1% of their mass (m_2).

Procedure: extrusion test

16.3.4 The procedure for determination of the extrusion by the extrusion test shall be as follows:

(a) One 100 mm x 100 mm (± 0.5 mm) specimen shall be prepared.

(b) The thickness of the specimen shall be measured to the nearest 0.1 mm.

(c) The specimen shall be placed in the extrusion mould and subjected to one application of load as stated in Clause 16.3.3(c). The extrusion at the open side of the mould shall be measured to the nearest 0.1 mm with the gauge or device when the specimen is compressed to 50% of the original thickness and before the load is released.

Calculation

16.3.5 (1) The recovery value (R) of each specimen shall be calculated from the equation:

$$R = t_2/t_1 \times 100\ \%$$

where:

- t_1 is the original thickness of the specimen (mm)
- t_2 is the thickness of the specimen after the third application of load (mm)

(2) The reduction in mass (M) of each specimen shall be calculated from the equation:

$$M = (m_1 - m_2)/m_1 \times 100\ \%$$

where:

- m_1 is the original mass of the specimen (g)
- m_2 is the mass of the specimen after the third application of load (g)

Reporting of results

16.3.6 The following shall be reported:

(a) Type and source of filler.

(b) The recovery values to the nearest 0.5%.

(c) The reductions in mass to the nearest 0.1%.

(d) The extrusion to the nearest 0.1 mm.

(e) That the test methods used were in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 17

PRESTRESSING

SECTION 17

PRESTRESSING

GENERAL

Materials for grout 17.01 Materials for grout for prestressing systems shall comply with Section 16 except as stated in this Section.

GLOSSARY OF TERMS

Duct 17.02 Duct is a void formed in the concrete to accommodate a prestressing tendon.

Prestressing components 17.03 Prestressing components are the components used in a prestressing system, including anchorages, grips, tendon deflectors, couplers, wedges, swages, nuts and other devices used to grip the prestressing tendon.

Prestressing tendon 17.04 Prestressing tendon is:

(a) An individual steel wire, wire strand or alloy steel bar in a duct, or

(b) An individual steel wire, wire strand or alloy steel bar not in a duct, or

(c) A group of steel wires or wire strands in a duct

used in a prestressing system.

Sheath 17.05 Sheath is a tube or lining which is used to form a duct and which is left in place.

MATERIALS

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. Amd 1/2024

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.

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.

SUBMISSIONS

Particulars of prestressing systems

17.11 (1) The following particulars of the proposed prestressing systems shall be submitted to the Engineer:

(a) Details of the prestressing system, including prestressing tendons, prestressing components, sheaths and tensioning apparatus,

(b) Sequence of prestressing and ends of prestressing tendons from which prestress will be applied if not stated in the Contract,

(c) Calculated values of:
- Each type of loss of prestress
- Prestressing tendon forces
- Extensions of prestressing tendons and details of the method of measuring the extensions,

(d) A certificate showing that the tensioning apparatus has been tested and calibrated by an agent approved by the Engineer within a period of two years before the apparatus is to be used,

(e) Any alterations to the reinforcement or additional reinforcement

required to allow for primary bursting effects,

(f) Details of corrosion protection required for the prestressing system, including type of grease for unbonded strand and the type of corrosion inhibitor to be adopted, and

(g) Details of the format of tensioning schedules and of reports of tensioning operations, grouting operations and testing of duct friction.

(2) Calculations for loss of prestress due to creep shall be based on the information stated in the Contract.

(3) The particulars shall be submitted to the Engineer for approval at least 8 weeks before the approval is required.

Particulars of prestressing tendons 17.12 (1) The following particulars of the proposed prestressing tendons shall be submitted to the Engineer:

- A certificate from the manufacturer showing the manufacturer's name, the date and place of manufacture and showing that the prestressing tendons comply with the requirements stated in the Contract and including details of:
  - Cast analysis
  - Diameter, cross-sectional area and unit mass
  - Results of tests for mechanical properties, including the characteristic breaking load, characteristic 0.1% proof load, elongation at maximum load, relaxation and modulus of elasticity,
  - Results of tests for ductility of prestressing wires.

(2) The particulars shall be submitted to the Engineer for each batch of prestressing tendons delivered to the Site and at least 28 days before installation of the prestressing tendons starts.

Particulars of grout mix and grouting procedure 17.13 (1) The following particulars of the proposed grout mix and grouting procedure for prestressing systems shall be submitted to the Engineer:

(a) Water: cement ratio by mass,

(b) Admixture: a certificate not older than 6 months showing the manufacturer's name, the date and place of manufacture and that the admixture complies with the requirements stated in the Contract and BS EN 934:Part 2 or Part 4 as appropriate including the manufacturer’s test results,

(c) Details of mixing and grouting equipment,

(d) Method of quality control during grout injection, and

(e) Details of grouting trials.

(2) The particulars shall be submitted to the Engineer at least 7 days before trial mixes for grout are made.

Samples of materials 17.14 Samples of the following proposed items shall be submitted to the Engineer at

the same time as particulars of the prestressing systems are submitted:

(a) Prestressing tendons,

(b) Prestressing components,

(c) Sheaths, and

(d) Grout vents and taps.

TRIALS

Trial mixes for grout 17.15 (1) A trial mix for grout for prestressing systems shall be made to demonstrate that the proposed materials, grout mix and methods of production will produce grout which complies with the specified requirements.

(2) The trial mixes shall be completed at least 35 days before the grout mix is used in the permanent works.

(3) The Contractor shall inform the Engineer at least 24 hours, or such shorter period as may be agreed by the Engineer, before making trial mixes.

(4) Trial mixes shall be made using the materials, grout mix and methods of production submitted to the Engineer.

Samples: trial mixes for grout 17.16 (1) One sample of grout shall be provided from the trial mix to determine the amount of bleeding and volume change of the grout. The method of sampling shall be as stated in Clause 17.59(2).

(2) One sample of grout shall be provided from the trial mix to determine the crushing strength of the grout. The method of sampling shall be as stated in Clause 17.62(2).

(3) One sample of grout shall be provided from the trial mix to determine the fluidity of the grout. The sample shall be protected from rain before the tests for fluidity are carried out.

Testing: trial mixes for grout 17.17 (1) Each sample of grout taken as stated in Clause 17.16(1) shall be tested to determine the amount of bleeding and volume change. The method of testing shall be as stated in Clause 17.60.

(2) Each sample of grout taken as stated in Clause 17.16(2) shall be tested to determine the crushing strength. The method of testing shall be as stated in Clause 17.63.

(3) Each sample of grout taken as stated in Clause 17.16(3) shall be tested to determine the fluidity immediately after mixing and 30 minutes after mixing. The method of testing shall be as stated in Clause 17.66.

Non-compliance: trial mixes for grout 17.18 (1) If the result of any test for amount of bleeding, volume change, crushing strength or fluidity of trial mixes for grout does not comply with the specified requirements for the property, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further trial mixes shall be made until the result of every test complies with the specified requirements for the property.

(2) If grouting trials are carried out using the non-complying trial mix, further grouting trials shall be carried out unless in the opinion of the Engineer the changes to the materials, grout mix or methods of production will not affect the results of the previous grouting trials.

Grouting trials 17.19 (1) Grouting trials for grout for prestressing systems shall be carried out to demonstrate that the proposed materials, grout mix, methods of production and methods of construction will produce a grouted duct which complies with the specified requirements. The number and details of grouting trials shall be as stated in the Contract.

(2) Grouting trials shall be completed at least 21 days before installation of the prestressing components in the permanent works.

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

(4) Grouting trials shall be carried out using the materials, grout mix, methods of production and methods of construction submitted to the Engineer.

(5) The profile of ducts and the method of support for grouting trials shall be as agreed by the Engineer. Vents shall be provided in ducts and tendons shall be pulled tight.

(6) Grouting trials that do not form part of the permanent work shall be removed.

(7) The grouting trial shall incorporate all relevant parts and components as if these will be used in the actual prestressing system.

Testing: grouting trials 17.20 Three sections selected by the Engineer shall be cut from the grouted duct and inspected not less than 2 hours after the grout used in the grouting trial has achieved its final set. Each of the three cut sections shall be 300 mm long in length. The external sheath from the cut sections shall be removed for inspection.

Compliance criteria: grouting trials 17.21 The sections of grouted duct cut in grouting trials shall be completely filled, and the prestressing tendon shall be completely surrounded with grout.

Non-compliance: grouting trials 17.22 If the result of any test on sections of grouted duct cut in grouting trials does not comply with the specified requirements for the test, or if in the opinion of the Engineer any aspect of the grouting procedure as demonstrated by the grouting trial is unsatisfactory, particulars of proposed changes to the materials, grout mix, methods of production or methods of construction shall be submitted to the Engineer. Further grouting trials shall be carried out until the result of every test on sections of grouted duct complies with the specified requirements for the test and until in the opinion of the Engineer every aspect of the grouting procedure is satisfactory. Further trial mixes for grout shall be made unless in the opinion of the Engineer non-compliance of the grouting trial was not due to the grout mix.

Approved grout mix 17.23 A grout mix that complies with the specified requirements for trial mixes for grout and for grouting trials shall become an approved grout mix.

Commencement of grouting 17.24 Grouting shall not proceed until the grout mix has been approved by the Engineer.

Changes in materials and methods of construction 17.25 The materials, grout mix, methods of production or methods of construction used to produce an approved grout mix shall not be changed, unless permitted by the Engineer.

HANDLING AND STORAGE OF MATERIALS

Handling of prestressing tendons 17.26 Prestressing tendons shall not be subjected to rough handling, shock loading or dropping from a height.

Handling of prestressing components 17.27 Prestressing components shall be handled in accordance with the manufacturers' recommendations.

Storage of materials for prestressing systems 17.28 (1) Each prestressing tendon shall be tagged with a number to identify the coil or bundle number of the prestressing tendon used.

(2) Prestressing tendons and sheaths shall be stored in a dry and weatherproof store and in a manner that will not result in damage or deformation to the materials or in contamination of the materials.

(3) Different types and sizes of prestressing tendons, prestressing components and sheaths shall be stored separately.

(4) Prestressing tendons, prestressing components and sheaths shall not be stored on or adjacent to concrete surfaces that form part of the permanent work.

(5) Prestressing tendons, prestressing components and sheaths shall be protected from exposure to conditions that may affect the material.

SURFACE CONDITION OF MATERIALS FOR PRESTRESSING SYSTEMS

Surface condition of materials for prestressing systems 17.29 (1) Prestressing tendons, prestressing components and sheaths shall be clean at the time of installation and shall be free of loose mill scale, loose rust, pitting, grease or any substance which in the opinion of the Engineer is likely to reduce the bond or affect the prestressing tendons, prestressing components, sheaths, concrete or grout chemically. The prestressing tendons, prestressing components and sheaths shall be maintained in this condition until concrete or grout is placed around them.

(2) If the surface condition of the prestressing tendons, prestressing components or sheaths deteriorates such that it does not comply with the requirements stated in Clause 17.29(1), the prestressing tendons, prestressing components or sheaths shall be cleaned or dealt with by other methods agreed by the Engineer.

INSTALLATION OF PRESTRESSING SYSTEMS

Installation of prestressing systems 17.30 (1) Prestressing operations shall be carried out in such a manner that persons and property are not endangered by any sudden release of the energy stored in a stressed prestressing tendon.

(2) Prestressing tendons, prestressing components and sheaths shall be accurately located and maintained in the correct position during all operations. Supports shall be placed at a maximum spacing of 600 mm.

Installation of prestressing tendons 17.31 (1) Prestressing tendons from each batch shall not be installed until testing of the batch has been completed.

(2) Steel wires, wire strands and alloy steel bars that will be tensioned in one operation shall be taken from the same batch.

(3) Individual steel wires and wire strands in the same duct shall not be twisted together. Strands that have become unravelled shall not be used.

(4) Unless permitted by the Engineer, alloy steel bars that have become bent shall not be straightened. Small adjustments for straightness may be made provided that the straightening is carried out at the ambient temperature by non-mechanical methods and provided that no force is applied on the threaded portion. Bars that have become bent in the threaded portion shall not be used.

(5) Prestressing tendons which have been damaged mechanically or by work-hardening or heating shall not be used. After manufacture, prestressing tendons shall not be welded and heat treatment, work-hardening, galvanizing and other metallic coatings shall not be applied.

Cutting prestressing tendons 17.32 Prestressing tendons shall be cut using either a high-speed abrasive cutting wheel or a friction saw or by other methods agreed by the Engineer. Flame cutting shall not be used.

Joints in prestressing tendons 17.33 Joints in prestressing tendons shall be made using couplers fixed in accordance with the manufacturer's recommendations.

Use of prestressing components 17.34 Prestressing components shall be used in accordance with the manufacturers' recommendations.

Installation of sheaths 17.35 At the time of tensioning, sheaths shall be free of dents or other irregularities that may affect tensioning.

Joints in sheaths 17.36 Joints in sheaths shall be securely taped to prevent penetration of the duct by concrete or grout. Joints in adjacent sheaths shall be staggered by at least 300 mm. Use of joints shall be kept to a minimum where practicable. Joints shall be formed using sleeve connectors and adequately sealed against ingress of any material.

Installation of grout vents and taps 17.37 (1) Grout vents and taps shall be provided at the following positions:

(a) All crests of the prestressing tendon profile and 400 mm on each side of each crest,

(b) All low points of the prestressing tendon profile,

(c) All anchorages and couplers for joints in prestressing tendons, Amd 1/2024

(d) Intervals not exceeding 15 m.

(e) Beyond each intermediate crest in the direction of grout flow at the point where the duct is one half diameter lower than the crest (but not further than 1 m), and elsewhere as required by the Engineer.

(f) Deviators for external prestressing tendons.

(g) For external tendons, in case the vents cannot be placed because of encroachment upon the diaphragm/deviator block, vents should be installed on both sides of the diaphragm/deviator block. For anchorage locations, vents should be provided at the other side of the diaphragm. Amd 1/2024

(2) Vents shall not be placed at positions where they will be blocked by the prestressing tendons after tensioning.

(3) Vents at high points shall extend to a minimum of 500 mm above the highest point on the duct profile.

TENSIONING OF PRESTRESSING TENDONS

Tensioning of prestressing tendons

17.38 (1) Apparatus for tensioning of prestressing tendons shall be of a type such that a controlled total force is imposed gradually and such that excessive secondary stresses are not induced in the prestressing tendons and prestressing components or in the structure or element to which prestress is being applied.

(2) Prestressing tendons shall be securely attached to jacks and tensioning apparatus.

(3) Steel wires or wire strands that are tensioned simultaneously shall be approximately the same length between anchorage points.

(4) The force in the prestressing tendons during tensioning shall be measured by direct reading load cells or obtained indirectly from pressure gauges fitted in the hydraulic system. Load measuring devices shall be accurate to within 2%.

(5) The extension of prestressing tendons and any movement of prestressing tendons in the gripping devices shall be measured during tensioning. The elongation of prestressing tendons shall be measured to an accuracy of 2% or 2 mm, whichever is the more accurate.

(6) Tensioning apparatus and load measuring devices shall be calibrated before tensioning starts and at regular intervals agreed by the Engineer. The calibration certificate shall be obtained from an approved testing laboratory once every 6 months.

(7) The force in the prestressing tendons shall not be transferred to the concrete until the concrete has reached the specified transfer strength.

(8) The capacity of pressure gauges, when used together with the load cell as a load indicator, shall be sufficient in capacity such that the working pressure lies within the central half of the range of the gauge.

(9) The time for transfer will be determined by the successful testing of a batch of minimum 3 test cubes. If the initial batch of any individual cube tested indicates that the concrete has not attained the required strength, a further batch of cubes shall be tested at a later date. This process shall be repeated until a batch of cubes successfully passes the strength test.

Pretensioning

17.39 (1) The stress in prestressing tendons shall be fully maintained during the period between pretensioning and transfer of stress. Transfer of stress shall take place gradually to minimise shock or damage to the transmission length and shall be carried out in conjunction with the release of any hold-down and hold-up forces in tendon deflectors.

(2) In the long-line method of pretensioning, locator plates shall be distributed throughout the length of the bed to ensure that the steel wires or wire strands are maintained in the correct positions during concreting. Units that are made in line shall be free to slide in the direction of their length to permit transfer of the prestressing force to the concrete along the whole line.

(3) Moulds used in the individual mould system of pretensioning shall be sufficiently rigid to provide the reaction to the prestressing force without

excessive distortion.

(4) Tendon deflectors in contact with pretensioned prestressing tendons of single steel wire or wire strand shall have a radius of at least five times the prestressing tendon diameter for steel wire and at least ten times the prestressing tendon diameter for wire strand. The total angle of deflection shall not exceed 15°. If a system is used such that friction develops between prestressing tendons and tendon deflectors, the friction force shall be determined by a test procedure agreed by the Engineer and any necessary allowance shall be made.

(5) The tendons shall be covered with sleeves of PVC or other approved material where these materials are specified as debonded from the concrete. Tape ends of the sleeves to the tendon shall prevent the ingress of grout.

(6) When the temperature of the pretensioning steel is below 10°C at the time of tensioning, steel elongation computations shall allow for the increase in temperature of the steel between the time of tensioning and the time when the concrete takes its initial set.

(7) The tendons shall be trimmed to flush with the face of the concrete and apply the specified protection to their ends.

(8) The precast prestressed members shall be indelibly marked to show the specific information related to its manufacturer.

Post-tensioning 17.40 (1) A tensioning schedule shall be submitted to the Engineer for approval at least 48 hours before each post-tensioning operation starts. The schedule shall include the proposed sequence of tensioning the prestressing tendons, the required prestressing loads and the calculated extensions of the prestressing tendons.

(2) Spacers used with post-tensioned steel wire or wire strand, which are not tensioned simultaneously, shall be sufficiently rigid to ensure that they will not be displaced during successive tensioning operations.

(3) If both ends of the prestressing tendon are free to move, a demonstration shall be carried out before post-tensioning starts to show that all prestressing tendons are free to move in the ducts.

(4) Post-tensioning shall be carried out in such a manner that the stress in the prestressing tendons increases at a gradual and steady rate. The sequence of tensioning prestressing tendons and the ends of prestressing tendons from which prestress will be applied shall be as stated in the Contract or as approved by the Engineer.

(5) For each element of a structure being stressed, post-tensioning of the prestressing tendons shall be carried out until the required prestress to that element has been reached. Tensioning of each prestressing tendon shall be carried out continuously until the required tendon loads or extensions have been reached. If tensioning is stopped for more than 2 days, particulars of any proposals for remedial or other work shall be submitted to the Engineer for approval and tensioning shall not recommence until the approved work has been carried out.

(6) Measurement of extensions shall not commence until any slack in the prestressing tendon has been taken up. If the design permits, the draw-in of

prestressing tendons at the non-jacking end shall also be measured. For each post-tensioning stage, the tensioning shall be applied in increments of load and the extensions shall be measured at each increment. The average measured total extension of the prestressing tendons in each post-tensioning stage shall be within 5% of the average calculated total extension of prestressing tendons of the corresponding post-tensioning stage. The measured total extension of individual prestressing tendons in each post-tensioning stage shall be within 10% of the calculated total extension of individual prestressing tendons of the corresponding post-tensioning stage.

(7) If the tendon deflector in contact with a post-tensioned prestressing tendon has a radius of less than 50 times the diameter of the prestressing tendon or if the total angle of deflection exceeds 15°, the loss of strength of the prestressing tendon shall be determined by a test procedure agreed by the Engineer and any necessary allowance shall be made.

(8) Post-tensioned prestressing tendons shall be cut at a distance from the anchorage of at least one diameter or 10 mm, whichever is greater. Unless otherwise permitted by the Engineer the tendons shall not be cut until at least 1 day after stressing, if the tendon is to be cut before grouting, or alternatively, at least 3 days after grouting.

Protection of external prestressing tendons and anchorages

17.41 External prestressing tendons and anchorages shall be protected in their permanent positions from mechanical damage or corrosion until the permanent protection is applied.

Records of tensioning operations

17.42 Records of tensioning operations shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 24 hours of each tensioning operation. The report shall contain the following details:

(a) Location of tensioning operations,

(b) Coil, heat and bundle numbers of strand used,

(c) Date and time of starting and completing tensioning operations,

(d) Weather conditions,

(e) Technical personnel supervising or carrying out tensioning operations,

(f) Prestressing tendon reference numbers,

(g) Tensioning apparatus identification,

(h) Measured extensions,

(i) Pressure gauge or load cell readings, and

(j) Amount of draw-in.

INSPECTION OF PRESTRESSING SYSTEMS

Inspection of prestressing systems

17.43 The Contractor shall allow the Engineer to inspect the completed prestressing system before carrying out any work, including concreting and grouting,

which will make access to the prestressing system difficult. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before carrying out such work.

GROUTING OF PRESTRESSING SYSTEMS

Grouting equipment 17.44

(1) Grout for prestressing systems shall be mixed by a machine capable of producing a homogeneous colloidal grout and of keeping the grout in slow continuous agitation after mixing and until the grouting operation starts.

(2) Grouting equipment shall be capable of continuous operation with little variation of pressure and shall include a system of recirculating the grout when grouting is not in progress.

(3) Grout pumps shall be fitted with a safety valve to prevent the build-up of excessive pressure. The connection of the pump to the duct shall be by a screw connector or other positive method. Baffles to the pump shall be fitted with 1.18 mm sieve strainers. Suction circuits shall be airtight.

(4) Grouting equipment shall be thoroughly washed through with clean water after every series of grouting operations and at the end of use each day.

(5) Grout pumps shall be fitted with a safety valve to prevent pressure from rising above 2 MPa at any point within the grouting system including the sheaths.

Grouting effectiveness 17.45

(1) Amd 1/2024 Grouting of prestressing tendons shall be effective such that the duct and anchorage are Amd 1/2024 completely filled, and the prestressing tendon is completely surrounded, with grout. Vacuum-assisted grouting shall be adopted. For vacuum-assisted grouting, a negative pressure of no less than 0.75 bar shall be maintained within the tendon duct for at least one minute before the injection of grout and throughout the whole grouting operation. Amd 1/2024

(2) For external prestressing tendons, to inspect the quality of grout at ducts, hammer sounding or other equivalent inspection methods shall be conducted at all grouted tendons. The Contractor shall submit for approval by the Engineer a detailed method statement for hammer sounding (or other equivalent inspection methods), outlining the operation and type of apparatus to be used. In the case of suspected void within the grouted ducts, drilling of holes on sheathing and remedial measures shall be conducted. The Contractor shall submit for approval by the Engineer a detailed method statement for the drilling and remedial works.

(3) The quality of grouting at anchorages and deviators shall also be inspected. Such inspection can be conducted in form of visual inspections of the grouting condition at grout vents and inspection holes. If suspected abnormalities are found, further verification by drilling through the grout vents or pre-installed inspection holes and borescope inspections shall be carried out. The Contractor shall submit for approval by the Engineer a detailed method statement for the drilling and remedial works.

(4) The inspection of the quality of grout detailed in sub-clauses (2) and (3) shall be conducted by an experienced person from an organization independent of the main contractor and prestressing works contractor, and

shall possess at least three years of experience in the inspection of grouting quality at ducts.

(5) Records on the inspection on quality of grouting, inspection of grouting condition at ducts, anchorages and deviators, and the subsequent remedial and reinstatement works, shall be submitted to the Engineer. Amd 1/2024

Grout injection 17.46 (1) The permission of the Engineer shall be obtained before prestressing tendons are grouted. If grouting is not started within 24 hours of permission having been given, permission shall again be obtained from the Engineer.

(2) Grouting of prestressing tendons shall be carried out as soon as practicable, and not more than 5 days, after tensioning of the prestressing tendons. In case grouting cannot be carried out within 5 days after tensioning of the prestressing tendons, temporary corrosion protection measures should be implemented. The Contractor shall submit proposal of corrosion protection measures to the Engineer for approval before commencement of tendon prestressing works. Amd 1/2024

(3) A check shall be made to ensure that the ducts, vents, inlets and outlets are capable of accepting injection of grout. This shall be done by blowing through the system with dry, oil-free air and testing each vent in turn.

(4) All ducts shall be kept free of standing water at all times and shall be thoroughly clean and dry before grouting.

(5) All anchorages shall be sealed by caps and fitted with grouting connections and vents. Sealing of anchorages shall be protected against damage at all times.

(6) Grout shall be used within 30 minutes of mixing unless a retarder is incorporated in the grout. If a retarder is used, the time shall be determined by a test procedure agreed by the Engineer.

(7) The grout pressure applied shall be as low as practicable and shall not exceed 1 MPa. Grout shall be injected from one end and at the lower end of ducts. Grout injection shall be continuous and steady and shall be at a rate that will avoid grout segregation and trapping air in the duct. Grout shall be allowed to flow from each of the grout vents until its consistency is equivalent to that of the grout injected. After the last grout vent has been closed, the pressure shall be maintained at 0.5 MPa for 5 minutes. The injection vent shall then be closed under pressure.

(8) If there is any blockage or breakdown or if the grout injection is interrupted, the duct shall immediately be thoroughly washed with clean water and blown dry with oil-free compressed air. Re-grouting shall start as soon as practicable.

(9) Grouted ducts shall not be subject to shock or vibration within 24 hours of grouting.

(10) The level of grout in grout vents shall be inspected and made good as agreed by the Engineer. Making good shall not be carried out until at least 2 days after grouting.

(11) In addition to the grouting trials stated in Clause 17.19(1), the Contractor shall select and propose for the Engineer's approval an external

prestressing tendon to be completed first, and demonstrate to the Engineer that the workmanship and quality of the grouting works for the tendon is satisfactory. Hammer sounding or other equivalent inspection methods shall be conducted in accordance with Clause 17.45 to inspect the quality of grouting. The Contractor shall not commence the grouting works for the remaining external tendons without the prior agreement of the Engineer.

(12) If the Contractor fails to demonstrate that the workmanship and quality of the grouting works for the tendon is satisfactory, or if in the opinion of the Engineer any aspect of the grouting procedure as demonstrated by the Contractor is unsatisfactory, remedial measures and/or particulars of proposed changes to the method of grouting shall be submitted by the Contractor to the Engineer. Further grouting of external tendons shall not be carried out until in the opinion of the Engineer the remedial measures and/or every aspect of the grouting procedure is satisfactory.

(13) The Contractor shall employ on the Site in connection with execution of grouting works for prestressing systems an experienced site personnel who is required to supervise, witness and take record of the whole grouting process of each tendon. The site personnel shall record the sequence of work and check against the prescribed method statement. Any anomaly shall be recorded and investigated. The record shall be countersigned by a supervising engineer and submitted to the Engineer within 3 days of each grouting operation.

(14) The supervising engineer shall be a holder of a recognized degree in civil/structural engineering with 5 years of relevant experience in tendon prestressing works.

(15) The following particulars of the proposed supervising engineer for grouting works shall be submitted to the Engineer:

(a) Name,

(b) Copy of Hong Kong Identity Card,

(c) Details of qualifications, including copies of certificates, and

(d) Details of previous experience.

(16) The particulars shall be submitted to the Engineer for approval at least 8 weeks before the approval is required. Amd 1/2024

Records of grouting operations

17.47 Records of grouting operations for prestressing systems shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 3 days of each grouting operation. The report shall contain the following details:

(a) Location of grouting operations,

(b) Date and time of starting and completing grouting operations,

(c) Weather conditions,

(d) Technical personnel supervising or carrying out grouting operations,

(e) Prestressing tendon reference numbers,

(f) Grout mix, including any admixtures,

(g) Grout injection pressure,

(h) Volume of grout used, and

(i) Details of any interruptions and topping up.

TOLERANCES

Tolerances: sheaths 17.48 The line of sheaths shall be within 5 mm of the specified line.

TESTING: PRESTRESSED UNITS

Testing: prestressed units 17.49 Testing of prestressed units shall comply with Section 16.

TESTING: PRESTRESSING TENDONS

Batch: prestressing tendons 17.50 A batch of prestressing tendons is any quantity of prestressing tendons of the same type, size and grade, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: prestressing tendons 17.51 (1) Samples of prestressing tendons shall be provided from each batch of prestressing tendons delivered to the Site and at least 28 days before installation of the prestressing tendons starts. The number of samples to be provided from each batch shall be as stated in Table 17.1.

(2) The number of specimens in each sample shall be 15.

(3) Each specimen shall be 1.5 metres long and straight.

(4) Each specimen shall be taken from different coils or bars in the batch. The ends of specimens shall be cut square without unravelling of wires before delivery to the laboratory.

Table 17.1: Rate of sampling prestressing tendons

Description	Size of batch	No. of samples per batch
Steel wire	0 - 50 tonnes	1
	Exceeding 50 tonnes	1 for each 50 tonnes or part thereof
Wire strand and alloy steel bar	0 - 100 tonnes	1
	Exceeding 100 tonnes	1 for each 100 tonnes or part thereof

Testing: prestressing tendons 17.52

(1) Each specimen of prestressing tendons shall be tested to determine the characteristic breaking load, characteristic 0.1% proof load, elongation at maximum load, diameter, cross-sectional area, unit mass and modulus of elasticity. Each specimen of prestressing wire shall also be tested to determine the ductility.

(2) Except that tests shall be carried out on specimens having a temperature of between 5°C and 30°C, the method of testing shall be in accordance with the following:

High tensile steel wire and strand for the prestressing of concrete : BS 5896

Hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete : BS 4486

Compliance criteria: characteristic breaking load, characteristic 0.1% proof load 17.53

(1) The standard deviations of the results of tests for characteristic breaking load and characteristic 0.1% proof load, expressed as equivalent stress values, of prestressing tendons shall not exceed the following:

(a) Tensile strength : 55 MPa

(b) 0.1% proof stress : 60 MPa.

(2) The statistical interpretation of the test results shall be in accordance with BS ISO 16269:Part 6, Form A of Annex B and BS 2846:Part 4, Table E, both for a one-sided tolerance interval of 0.95 and for a confidence level of 0.95.

Non-compliance: elongation, diameter, cross-sectional area, unit mass, modulus of elasticity, ductility 17.54

(1) If the result of any test for elongation at maximum load, diameter, cross-sectional area, unit mass, modulus of elasticity or ductility of prestressing tendons does not comply with the specified requirements for the property, one additional sample shall be provided from the same batch and additional tests for the property shall be carried out.

(2) The number of specimens in the additional sample shall be 15.

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

TESTING: DUCT FRICTION

Testing: duct friction 17.55 (1) The number and details of tests to determine the duct friction in prestressing systems shall be as stated in the Contract. The method of testing shall be as stated in Clause 17.55(2) to (4).

(2) Prestressing tendons shall be tensioned from one end and the tendon force shall be measured at both the jacking and non-jacking ends.

(3) The tendon force at the non-jacking end shall be measured by a load-measuring device of a type approved by the Engineer. A direct-reading load cell or a dummy jack is considered to be suitable as a load-measuring device. The load-measuring device shall be sufficiently rigid to ensure that the movement of the prestressing tendon at the non-jacking end under the specified tendon force is not excessive. The deflection of the load-measuring device shall be measured to an accuracy of 0.5 mm. A load-measuring device with a deflection exceeding 10 mm under the maximum load shall not be used.

(4) The prestressing tendon shall be tensioned to the specified tendon force in equal increments and the tendon extensions at the jacking end and the tendon force and tendon movement at the non-jacking end shall be measured to within 5 mm. The number of load increments shall be suited to the tensioning operation but shall be at least five.

Compliance criteria: duct friction 17.56 The force at the non-jacking end of the prestressing tendon determined in the duct friction test shall be within +10% and -5% of the calculated value.

Records of duct friction tests 17.57 Reports of duct friction tests shall be submitted to the Engineer within 3 days of each test. The report shall contain the following details:

(a) Details stated in Clause 1.42(1),

(b) Prestressing tendon reference numbers,

(c) Graph showing tendon forces at jacking end against tendon forces at non-jacking end, and

(d) Comparison between the calculated tendon forces at the non-jacking end and the measured values.

TESTING: GROUT - GENERAL REQUIREMENTS

Batch: grout for prestressing systems 17.58 A batch of grout for prestressing systems is any quantity of grout produced in one cycle of operations of a mixer.

TESTING: GROUT - BLEEDING AND VOLUME CHANGE

Samples: bleeding and volume change of grout 17.59

(1) For each grout mix one sample of grout shall be provided from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser, to determine the amount of bleeding and volume change of the grout.

(2) Samples shall be provided and tested immediately after the grout has been mixed. Samples shall be protected from rain before the tests for amount of bleeding and volume change are carried out.

Testing: bleeding and volume change of grout 17.60

Each sample of grout taken as stated in Clause 17.59 shall be divided into three specimens. Each specimen shall be tested to determine the amount of bleeding and volume change of the grout by the wick-induced method in accordance with BS EN 445.

Non-compliance: bleeding and volume change of grout 17.61

If the result of any test for amount of bleeding or volume change of grout for prestressing systems does not comply with the specified requirements for the property, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further trial mixes shall be made and further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT - CRUSHING STRENGTH

Samples: crushing strength of grout 17.62

(1) For each grout mix one sample of grout shall be provided from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser, to determine the crushing strength of the grout.

(2) Samples shall be provided not more than 1 hour after the grout has been mixed and shall be protected from rain before test cubes are made.

Testing: crushing strength of grout 17.63

(1) Two 100 mm test cubes shall be made from each sample of grout taken as stated in Clause 17.62. Each pair of test cubes shall be tested to determine the crushing strength at 7 days.

(2) The method of making, curing and testing the test cubes, and the calculation of the test results, shall be as stated in Clause 16.59(2), (3), (4) and (5), except that compaction of the grout is not required.

Non-compliance: crushing strength of grout 17.64

If the result of any test for crushing strength of grout for prestressing systems does not comply with the specified requirements for crushing strength, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further trial mixes shall be made and further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT – FLUIDITY

Samples: fluidity of grout

17.65 (1) For each grout mix one sample of grout shall be provided from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser, to determine the fluidity of the grout.

(2) Samples shall be provided and tested immediately after the grout has been mixed. Samples shall be protected from rain before the tests for fluidity are carried out.

Testing: fluidity of grout

17.66 Each sample of grout taken as stated in Clause 17.65 shall be tested to determine the fluidity of the grout by the cone method in accordance with BS EN 445.

Non-compliance: fluidity of grout

17.67 If the result of any test for fluidity of grout for prestressing systems does not comply with the specified requirements for the property, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer. Further trial mixes shall be made and further grouting trials shall be carried out unless otherwise permitted by the Engineer.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 18

STEELWORK

SECTION 18

STEELWORK

GENERAL

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.

Specialist contractors 18.02

(1) Steelwork shall be fabricated and erected by specialist contractors in the 'Structural Steelwork' category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works.

(2) For highway works, hot-dip galvanizing shall be carried out by specialist contractors in 'Class V: Hot dip galvanizing' of the 'Specialized Operations for Highway Structures' category of the List of Approved Suppliers of Materials and Specialist Contractors for Public Works.

SCOPE

Requirements 18.03 The scope shall be as stated in Clause 1 of BS EN 1090:Part 2.

NORMATIVE REFERENCES

Requirements 18.04

(1) Normative references shall be as stated in Clause 2 of BS EN 1090:Part 2 and Clause 18.04(2).

(2) Refer to Appendix 1.1 for normative references not given in BS EN 1090:Part 2.

TERMS AND DEFINITIONS

Requirements 18.05 Terms and definitions shall be as stated in Clause 3 of BS EN 1090:Part 2 and Clauses 18.06 to 18.07.

Inspection lot for mechanical fasteners 18.06 Inspection lot for mechanical fasteners shall be as defined in BS EN ISO 3269.

Constructor 18.07 The term 'constructor' used in BS EN 1090:Part 2 is equivalent to the term 'Contractor' used in this Section.

SPECIFICATIONS AND DOCUMENTATION

Requirements 18.08 Specifications and documentation shall comply with Clause 4 of BS EN 1090:Part 2 and Clauses 18.09 to 18.10.

Execution specification – Execution classes 18.09

(1) For highway works, the execution class shall be EXC3 unless otherwise specified in the Contract.

(2) For other works, the execution class shall be EXC2 unless otherwise specified in the Contract.

Contractor's documentation – Quality plan 18.10

(1) A quality plan for the execution of the works is required and shall include the items recommended in Annex C of BS EN 1090:Part 2.

(2) The execution records shall include the Contractor's drawings (including electronic files) for the execution of all components.

(3) The Contractor's drawings (including electronic files) shall include the unique component mark information.

(4) Records of testing undertaken to prove product conformity shall be treated as execution records.

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 products – General 18.13 Flat rolled stainless steels shall be grade 1.4401 to BS EN 10088:Part 4.

Structural steel products – Surface conditions 18.14 Imperfections such as cracks, shell and seams shall be repaired.

Structural steel products – Additional properties 18.15

(1) Unless otherwise specified in the Contract, internal discontinuity quality class S1 of BS EN 10160 shall be used for cross plates in welded cruciform and welded tee joints transmitting primary tensile stresses through the plate thickness on a band of width four times the thickness of the plate each side of the proposed attachment.

(2) Flange or web plates close to bearing diaphragms and/or single sided bearing stiffeners, where attached by welding, shall be checked for conformance to BS EN 10160 internal discontinuity quality class S1 in the areas specified in Clause 5.3.4 of BS EN 1090:Part 2.

(3) The precautions necessary to avoid lamellar tearing in tee, cruciform and corner joints, whether or not improved deformation properties to BS EN 10164 Amd 3/2022 have been specified for the through plates, shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts. The guidance on suitable precautions given in BS EN 1011-2 and PD 6695-1-10 shall be followed. Amd 3/2022

Welding consumables 18.16 Welding consumables and the procedures used shall be such that the mechanical properties of the deposited weld metal shall not be less than the respective minimum values of the parent metal being welded.

Mechanical fasteners – Terminology 18.17 The 'part turn method' of tightening of preloaded fasteners is similar to the 'combined method' in BS EN 1090:Part 2. However it is restricted to Grade 8.8 assemblies of all k-classes (K2, K1 and K0). Amd 3/2022 It has reduced torque values in the first step and higher nut rotation values in the second step (see Clause 18.51(4)).

Mechanical fasteners – Structural bolting assemblies for non-preloaded applications 18.18 Stainless steel bolts and nuts shall be grade A4 and property class 80 to BS EN ISO 3506:Part 1 and Part 2.

Mechanical fasteners – Structural bolting assemblies for preloading 18.19

(1) The following products shall be used for preloaded bolting assemblies using all tightening methods stated in BS EN 1090:Part 2 and this Section, except the HRC method:

(a) bolting assemblies conforming to BS EN 14399:Part 3 (HR type); and

(b) nuts fully Amd 3/2022 lubricated by the manufacturer after the nuts have been tapped (and, if relevant, after any coating passivation process has been completed). Lubricant coatings which are permanently liquid and could risk contamination of faying surfaces shall not be used. Amd 3/2022

(2) Electroplated property class 10.9 Amd 3/2022 bolting assemblies shall not be used.

(3) Cleaning of property class 10.9 bolting assemblies Amd 3/2022 prior to hot-dip galvanizing shall be by a mechanical process such as Amd 3/2022 blast cleaning and not by pickling.

(4) Nuts of property class 10 shall be used with bolts of property class 8.8.

(5) Bolts of property class 10.9 shall not be used for assemblies tightened by the part turn method (see Clauses 18.17, 18.51(3) and 18.51(4)).

Mechanical fasteners – Foundation bolts 18.20 Reinforcing steels shall not be used for foundation bolts subject to Amd 3/2022 applied tension forces.

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.

Expansion joints for bridges 18.24 Expansion joints shall conform to the requirements specified in Section 20 and on the Drawings.

Structural bearings 18.25 Structural bearings shall conform to the requirements specified in Section 20 and on the Drawings.

PREPARATION AND ASSEMBLY

Requirements 18.26 Preparation and assembly shall comply with Clause 6 of BS EN 1090:Part 2 and Clauses 18.27 to 18.31.

General 18.27 (1) Heating or thermal cutting processes which give off toxic or irritant gases shall not be used. Heating or thermal cutting shall not be carried out within 2 m of lead-based, cadmium or carbonaceous coatings.

(2) Appropriate measures as stated in Clause 18.33(2) shall be taken to counteract shrinkage or distortion due to thermal cutting or heat treatment.

Identification 18.28 Hard stamps, punched or drilled marks shall not be used unless approved by the Engineer.

Handling and storage 18.29 (1) Steelwork shall not be subject to rough handling, shock loading or dropping from a height.

(2) During handling and transport of coated steelwork, the steelwork shall be separated from wires and lashings by rubber padding in such a manner that the coatings are not damaged or discoloured. Free ends shall be stiffened, measures shall be taken to prevent permanent distortion and machined surfaces and faying surfaces shall be protected.

(3) Steelwork shall not be lifted from the painting bed until the last applied coating is sufficiently dry or cured for handling.

(4) Rivets, bolts, nuts, washers, screws and small plates and articles shall be packed in containers marked to identify the contents.

(5) Steelwork shall be stored off the ground on level supports in well drained areas in a manner which will not result in damage or deformation to the steelwork or coatings, or in contamination of the steelwork or coatings. Packings shall be placed between steelwork that is stacked.

(6) Covered places in which steelwork is stacked shall be ventilated.

(7) Different types and sizes of steelwork shall be stored separately.

(8) Steelwork shall not be stored on or adjacent to concrete surfaces that form part of the permanent work.

(9) Steelwork shall be protected from exposure to conditions that may affect the steelwork or coatings.

(10) Wet paint films, steelwork surfaces that are to be primed or overcoated and joint surfaces that are to be assembled shall be protected from exposure to conditions which may affect the film or surface. Undercoats which contain anatase titanium dioxide shall be protected from exposure to direct sunlight.

(11) Except as stated in Clauses 18.29(12) and 18.29(13), steelwork shall be stored in an enclosed workshop and protected from conditions which may affect the steelwork after the steelwork has been cleaned as stated in Appendix 18.1 until the following times:

(a) when the second undercoat to painted steelwork has hard dried;

(b) when the coating process to hot-dip galvanized, electroplated, sherardized or thermally metal sprayed steelwork has been completed;

(c) when the sealer to thermally metal sprayed and sealed steelwork has been completely absorbed; and

(d) when the first undercoat to thermally metal sprayed and painted steelwork has hard dried.

(12) Primed steelwork surfaces may be exposed outside the enclosed workshop for a period not exceeding two weeks.

(13) Micaceous iron oxide undercoats to steelwork may be exposed outside the enclosed workshop for the minimum period necessary to move the steelwork from one part of the workshop to the other. The undercoat surfaces shall be covered when the steelwork is being moved.

Assembly 18.30 (1) Drifting to align holes, other than those for fitted bolts or fitted pins, shall be carried out in such a way that the elongation does not exceed the values specified in Table B.8 of BS EN 1090:Part 2 as follows:.

(a) tolerance class 1 for non-preloaded connected parts; and

(b) tolerance class 2 for preloaded connected parts.

(2) Connections for temporary components shall not result in the removal or addition of permanent material, or introduction of permanent stress concentrating details. Any filling of permitted temporary holes by welding shall be subject to qualification of the procedure(s) and the welder(s) using the preparation(s) and material thickness(es) to be used in production, and to specific testing Amd 3/2022.

(3) A record of the details of any connections for temporary components shall be provided and shall form part of the execution documentation (see Clause 4.2.4 of BS EN 1090:Part 2 and Clause 18.10). Amd 3/2022

Assembly check 18.31 (1) Trial assembly shall be undertaken were required by the Engineer or as specified in the Contract. Amd 3/2022

(2) Where a full or staged trial assembly is undertaken, the correction of hole alignment by reaming of bolted splices, selection of pack thicknesses, correction of weld preparation fit-up and correct positioning of temporary alignment cleats shall be carried out during the trial assembly Amd 3/2022.

(3) The following shall be taken into account, where applicable Amd 3/2022:

(a) support of the assembly parts shall Amd 3/2022 minimise self-weight stresses, where the unstressed camber profile is being checked Amd 3/2022;

(b) correct Amd 3/2022 alignment of assembly parts shall be re-established Amd 3/2022 in staged trial assembly including correct relative levels of bearing Amd 3/2022;

(c) Amd 3/2022 differential temperature distribution Amd 3/2022 throughout the steelwork shall be controlled or allowed for Amd 3/2022 if exposed to direct sunlight when surveys are made; Amd 3/2022

(d) unique marking for identification and orientation of individual members shall be used; Amd 3/2022

(e) all shop welding and bolting shall be complete; Amd 3/2022

(f) every bolt hole shall be proved with a bolt of identical size to those to be used at the site; Amd 3/2022

(g) lack of fit between components shall not be corrected by bolt tensioning; and Amd 3/2022

(h) the position and level of all bearings and primary control points shall be surveyed at the trial erection. Amd 3/2022

WELDING

Requirements 18.32 Welding shall comply with Clause 7 of BS EN 1090:Part 2 and Clauses 18.33 to 18.45.

General 18.33

(1) Welding processes which give off toxic or irritant gases shall not be used. Welding shall not be carried out within 2 m of lead-based, cadmium or carbonaceous coatings.

(2) Pre-setting, pre-bending, skip welding, back-step techniques and other measures shall be taken as necessary to counteract shrinkage or distortion due to welding, gouging, thermal cutting or heat treatment.

(3) Permanent welds that are not specified on the Drawings shall not be permitted.

Qualification of welding procedures and welding personnel – Qualification of welding procedures: General 18.34

(1) The Contractor's compliance with the requirements for qualification of welding procedures stated in Clause 7.4.1 of BS EN 1090:Part 2 shall be endorsed by the approved inspection authority or testing consultant.

(2) All reports of welding procedure tests shall be examined by the approved inspection authority or testing consultant.

(3) For Amd 3/2022 tack welds, the Amd 3/2022 welding procedure specification (WPS) shall include the special deposition conditions and the tests stated in Clause 18.34 (6). Amd 3/2022

(4) The tolerances on cross section and length of the tack weld and any subsequent profiling requirements, such as feathering of ends, shall be specified in the WPS. Amd 3/2022

(5) To qualify the procedure for a tack weld where it is to be incorporated in the joint, the maximum permitted cross section of tack weld shall be used in the qualification test. The positions of the ends of the tack weld shall be marked on the test piece. Amd 3/2022

(6) Macroscopic examination and hardness testing shall be carried out within the tack weld length. This test is not required if the original test for qualifying the complete weld includes the tack weld tested as described in this paragraph. Amd 3/2022

Qualification of welding procedures and welding personnel – Qualification of welding procedures: Validity of a welding procedure qualification

18.35 Welding production tests shall be carried out in accordance with the relevant standard of qualification for the process concerned.

Qualification of welding procedures and welding personnel – Welders and welding operators: General

18.36 Welding shall be carried out by welders who possess a valid welding certificate for the appropriate category of welding. A welder shall cease to carry out welding if the requirements stated in Clause 9 of BS EN ISO 9606:Part 1 are not satisfied.

Qualification of welding procedures and welding personnel – Welding coordination

18.37 Welding coordinators shall not act as examiners for qualification of the welders/operators.

Preparation and execution of welding – Joint preparation: General

18.38 For EXC1, prefabrication primers (shop primers) may be left on the fusion faces only if they do not adversely affect the welding process. For EXC2, EXC3 and EXC4, prefabrication primers shall not be left on the fusion faces or heat affected zone, unless welding procedure tests in accordance with BS EN ISO 15614:Part 1 or BS EN ISO 15613 have been completed satisfactorily using such prefabrication primers. The prefabrication primers adjacent to the welds shall be made good after welding.

Preparation and execution of welding – Assembly for welding

18.39 (1) The guidance on preparation, assembly and welding of joints in hollow sections given in Annex E of BS EN 1090:Part 2 shall be applied. Amd 3/2022

Amd 3/2022

Amd 3/2022

(2) For the assembly of hollow section components where access to the joint for welding is restricted, a pre-production welding test conforming to BS EN ISO 15613 shall be conducted using the tolerances on preparation and fit-up that give the most restricted access, to demonstrate that the required penetration can be achieved. Amd 3/2022

Preparation and execution of welding – Temporary attachments

18.40 (1) Temporary welded attachments shall not be used unless permitted by the Engineer.

(2) The removal of temporary welded attachments by cutting, gouging or chipping shall not be permitted, except that thermal cutting may be used provided that the finished cut surface is at least 3 mm proud of the permanent member surface. Remnants of temporary materials proud of the permanent member surface shall be removed by grinding parallel to the member axis. The ground surface shall be visually inspected in accordance with BS EN ISO 17637 and for steel grades ≥ S355 shall be subjected to non-destructive testing (NDT). Chipping and gouging are not permitted on steel grades ≥ S460 or on components subject to fatigue, unless otherwise specified in the Contract.

Preparation and execution of welding – Butt welds: General

18.41 (1) Butt welds shall be complete penetration butt welds made between fusion faces.

(2) Butt welds in each component part shall be completed before the final assembly of built-up assemblies.

(3) Where a weld surface is required to be ground or machined flush, this shall be executed prior to non-destructive testing.

Preparation and execution of welding – Butt welds: Single sided welds

18.42 Permanent steel backing shall only be used if specified on the Drawings.

Preparation and execution of welding – Stud welding

18.43 The comprehensive quality requirements with reference to Table B.1 of BS EN ISO 14555 shall be adopted.

Preparation and execution of welding – Slot and plug welds

18.44 The depth-to-minimum width ratio of the slot or plug hole shall not exceed that used for the welding procedure qualification test.

Preparation and execution of welding – Execution of welding

18.45 (1) Precautions shall be taken to avoid stray arcing, and if stray arcs do occur outside the weld fusion face, the surface of the steel shall be lightly ground and checked. For EXC2, EXC3 and EXC4, visual checking shall be supplemented by penetrant or magnetic particle testing for all steel grades.

(2) Precautions shall be taken to avoid weld spatter. For EXC2, EXC3 and EXC4, weld spatter shall be removed for all steel grades.

MECHANICAL FASTENING

Requirements 18.46 Mechanical fastening shall comply with Clause 8 of BS EN 1090:Part 2 and Clauses 18.47 to 18.54.

Use of bolting assemblies – General 18.47

(1) The threads of nuts for preloaded bolts shall not be lubricated unless approved by the Engineer. If the use of lubricant is approved, the lubricant shall be applied at the place of manufacture and shall only be applied to the nut threads. The bearing surfaces of the nuts and the faying surfaces shall not be contaminated with the lubricant.

(2) Lubricant for lubricating nut threads of preloaded bolts shall be of a wax-based type approved by the Engineer. Machine oil and other free-flowing lubricants shall not be used.

(3) The bolt load meter for measuring bolt shank tension in tightening of preloaded bolts shall be calibrated by a laboratory approved by the Engineer before tightening starts and at regular intervals agreed by the Engineer. During re-calibration, a replacement calibrated bolt load meter shall be provided on the Site. Calibration results shall be submitted to the Engineer at least one week before the bolt load meter is used.

Use of bolting assemblies – Bolts 18.48 For non-preloaded bolts, the end of the bolt shall not project beyond the outer face of the nut by more than one nominal bolt diameter after tightening.

Use of bolting assemblies – Washers 18.49 Washers shall be placed under the nut or the bolt head in non-preloaded assemblies whichever is rotated.

Preparation of contact surfaces in slip resistant connections 18.50

(1) All surfaces which overlap each other in the final assembled connection excluding any painted edge strip around the perimeter of the connection stated in Appendix 18.3 shall be deemed to be 'contact surfaces'.

(2) The specified surface treatment applied to the friction surfaces shall be maintained until the surfaces are brought together and the connection assembled.

Tightening of preloaded bolting assemblies – General 18.51

(1) At the snug tight stage, the exposed surfaces of the components being connected shall be aligned within 1 mm where they emerge from beneath the cover plate(s) at the joint plane. This is subject to the tolerances of thickness difference between the two components (including any packing plates) in Clause 8.1 of BS EN 1090:Part 2 also being met. If this tolerance Amd 3/2022 is exceeded, the cover plate(s) shall be removed and corrective Amd 3/2022 steel packing plates shall be installed Amd 3/2022.

(2) Where a connection is designed to transfer applied tensile forces through a flanged and bolted end plate, as a minimum, the area of the mating surfaces in direct line with the tension member cross section shall be in contact when all bolts are snug tight. Any remaining gaps in this zone shall be filled by steel shims prior to the application of the remaining preload. The following shall apply: Amd 3/2022

(a) If necessary, bolts can be partially slackened to enable shims to be inserted. Amd 3/2022

(b) The shims shall not be loose in the final snug tight stage. Amd 3/2022

(c) In the event of a tapering gap, use of a purpose machined tapered steel shim is permitted. Amd 3/2022

(d) As an alternative to Clause 18.51(2)(c), flat (parallel) steel shims of not less than 0.1mm and of not more than 0.2mm thick shall be inserted to refusal, in steps until the gap in the contact zone is filled, followed by retightening to the snug tight stage. Amd 3/2022

(e) If sealing of the joint is required, the remaining gaps shall be filled with a corrosion protection medium compatible with the corrosion protection to be applied to the joint after final tightening of the bolting assemblies. Amd 3/2022

(3) The part turn method may be used for tightening preloaded bolting assemblies if:

(a) the bolts are property class 8.8 and assemblies conform to Clause 18.19;

(b) the required nominal minimum preloading force is not in excess of the values specified in Table 18 of BS EN 1090:Part 2; and

(c) the joint fit-up confirms to Clause 18.51(1) or 18.51(2), whichever is applicable.

(4) The part turn method is the same as the combined method in Clause 8.5.4 of BS EN 1090:Part 2 except that:

(a) the k-class of the bolting assemblies shall comply with Clause 18.17 Amd 3/2022;

(b) in the first tightening step, the nut shall be tightened to a specified torque as given in Table 18.1; and

(c) in the second tightening step, the nut shall be tightened to a specified turn as given in Table 18.2.

(5) The torque method shall not be used for the tightening of preloaded bolting assemblies.

Tightening of preloaded bolting assemblies – Torque reference values 18.52 The torque reference values in Clause 8.5.2a)2) of BS EN 1090:Part 2 shall be amended as follows:

$M_{r,1} = k_m \, d \, F_{p,C}$ with k_m for k-class K1.

Tightening of preloaded bolting assemblies – Combined method 18.53 (1) For property classes 8.8 and 10.9 bolting assemblies to BS EN 14399:Part 3 (see Clause 18.19), the further rotation values in Table 21 of BS EN 1090:Part 2 shall be amended as follows for the same thickness ranges:

(a) replace 60° by 90° (1/4 turn);

(b) replace 90° by 120° (1/3 turn); and

(c) replace 120° by 180° (1/2 turn).

(2) Calibration tests shall be carried out daily with the torque wrenches in accordance with Annex H of BS EN 1090:Part 2 and the torque for the first tightening step shall be adjusted accordingly. Any assembly lots that fail to conform to this test shall be discarded.

(3) The simplification $0.75\ M_{r,1} = 0.094\ d\ F_{p,C}$ and Table 20 in Clause 8.5.4 of BS EN 1090:Part 2 shall not be used.

Tightening of preloaded bolting assemblies – HRC method 18.54

(1) The preload shall be checked on sample assemblies for each assembly lot within seven days prior to use, in accordance with Annex H of BS EN 1090:Part 2. Any assembly lots showing values of preload below the minimum specified value shall be discarded.

(2) The first tightening step shall be repeated until the shear wrench outer socket has stopped turning on all bolting assemblies in a joint.

ERECTION

Requirements 18.55

Erection shall comply with Clause 9 of BS EN 1090:Part 2 and Clauses 18.56 to 18.60.

Survey – Reference system 18.56

The reference temperature shall be 20°C unless otherwise specified in the Contract.

Supports, anchors and bearings – Setting out and suitability of supports 18.57

(1) Foundation bolts for steelwork shall be held firmly in the set position during fixing. Measures shall be taken to ensure that the full movement tolerances are achieved and the bolts are not displaced during concreting. Bolts and nuts, including the threads, shall be protected against damage, corrosion and contamination.

(2) Foundation bolt pockets shall be kept dry and clean. Tubes that are cast in concrete for grouting bolt pockets shall be securely fixed and sealed to prevent ingress of grout during concreting.

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

(4) Installation of structural bearings shall conform to the requirements specified in Section 20 and on the Drawings.

Supports, anchors and bearings – Temporary supports 18.58

(1) The material, size, position and cover of packs, shims and other supporting devices for steelwork which are to be embedded shall be as approved by the Engineer.

(2) Levelling nuts or other devices providing temporary support shall be slackened off before final tensioning of foundation bolts where a post-tensioning force is specified, to allow the post-tensioning force to be transferred to the foundations.

(3) In the case of exposed steelwork and irrespective of bedding material, the minimum finished cover to steel packings or other steel temporary support devices left in position shall be 50 mm.

Supports, anchors and bearings – Grouting and sealing 18.59 Column bases for each portion of steelwork shall not be bedded or grouted until the portion has been aligned, levelled, plumbed and permanently connected. Spaces below the steel shall be dry, clean and free of rust immediately before bedding or grouting.

Erection and work at site – Erection methods: Fit-up and alignment 18.60

(1) Steelwork shall be erected in such a manner that the alignment and levels of the steelwork comply with the tolerances stated in Clause 18.66. Allowance shall be made for the effects of temperature on the steelwork.

(2) Measures shall be taken to ensure that the steelwork will remain stable before temporary supports and fastenings are slackened or removed for aligning, levelling, plumbing or other purposes. The temporary supports and fastenings shall be re-tightened or replaced as soon as the adjustments are complete and at the end of each continuous period of working.

(3) Permanent connections shall be made as soon as a sufficient portion of the steelwork has been aligned, levelled and plumbed. Temporary supports and fastenings shall be replaced by permanent connections progressively and in such a manner that the parts connected are securely restrained in the aligned position at all times.

(4) Permanent connections for each portion of steelwork shall be completed not more than 14 days after the portion has been erected.

(5) The use of shims shall be avoided where possible by suitable controls on preparation, assembly and weld distortion and, if necessary, by machining.

(6) Where steel shims are needed to correct the fit between members, particularly in preloaded tension joints (see Clause 18.51), and where gaps are variable across the interface, flat (parallel) steel shims may be used as an alternative to a purpose machined tapered steel shim. The gap shall be filled by insertion of shims of not less than 0.1 mm and not more than 0.2 mm thick from the widest gap position until refusal. The excess material shall be cut off on completion.

SURFACE TREATMENT

Requirements 18.61 Surface treatment shall comply with Clause 10 of BS EN 1090:Part 2 and Clauses 18.62 to 18.65.

General 18.62

(1) Treatment of surfaces to receive corrosion protection shall also comply with Appendices 18.1 to 18.4.

(2) The requirements for the execution of corrosion protection in Annex F of BS EN 1090:Part 2 shall be supplemented by those as stated in Appendices 18.1 to 18.4 and specified in the Contract.

(3) The performance specification for corrosion protection required by Clause F.1.2 of BS EN 1090:Part 2 shall be as stated in Appendices 18.1 to 18.4 and specified in the Contract.

(4) The prescriptive requirements for corrosion protection required by Clause F.1.3 of BS EN 1090:Part 2 shall be as stated in Appendices 18.1 to 18.4 and specified in the Contract.

(5) The requirements for corrosion protection of surfaces in preloaded bolting assemblies required by Clause F.4 of BS EN 1090:Part 2 shall be as stated in Appendix 18.3 and specified in the Contract.

Preparation of steel substrates for paints and related products 18.63 (1) The requirements stated in Clause 10.2 of BS EN 1090:Part 2 shall also apply to products subject to hot-dip galvanizing or metal spraying.

(2) All surfaces shall meet the requirements of preparation grade P3 to BS EN ISO 8501:Part 3 unless otherwise specified in the Contract.

Sealing of spaces 18.64 (1) The internal treatment system to be provided to enclosed spaces that are to be sealed by welding or provided with internal protective treatment shall be as stated in Appendices 18.1 to 18.4 and specified in the Contract.

(2) Where spaces are to be fully enclosed by sealing welds to prevent the ingress of moisture, weld imperfections involving surface breaking voids otherwise permitted under the welding specification shall be sealed using an appropriate weld repair. Amd 3/2022

Repairs after cutting or welding 18.65 (1) Protective treatment on edges and adjacent surfaces which have been damaged by cutting or after welding Amd 3/2022 shall be restored in accordance with the original specification.

(2) Where post-galvanising welding is necessary, the reinstatement of zinc coating on affected areas shall comply with Clauses 18.65(3) to 18.65(5).

(3) The zinc coating shall be ground off the mating surfaces directly before welding. Immediately after welding, the surface of the weld area shall be prepared for the restoration of the zinc coating. The zinc coating shall be restored by either:

(a) application of two coats of an organic zinc rich paint (zinc content at least 95%) to an overall dry film thickness greater than 100 μm; or

(b) pre-heating to 315°C and application of proprietary metallic repair stick or powder to a thickness greater than 100 μm.

(4) If re-coating does not take place within 4 hours of welding, the weld areas shall be blast cleaned to grade Sa 3 to BS EN ISO 8501:Part 1 and coated with zinc by thermal metal spraying to a minimum coating thickness of 100 μm.

(5) After reinstatement of the zinc coating, the full specified paint system shall be applied to the repaired area in such a manner that each new paint coat overlaps the existing paint by at least 50 mm all round the affected part.

GEOMETRICAL TOLERANCES

Requirements 18.66 Geometrical tolerances shall comply with Clause 11 of BS EN 1090:Part 2 and Clauses 18.67 to 18.69.

Tolerance types 18.67

(1) Steelwork shall be erected to within the tolerances stated in Clauses 11.2 and 11.3 of BS EN 1090:Part 2 and Clauses 18.67(2) to 18.67(8) after aligning, levelling, plumbing and making the permanent connections. The tolerances permitted shall be the smaller of the values determined in accordance with Clauses 11.2 and 11.3 of BS EN 1090:Part 2 and Clauses 18.67(2) to 18.67(8) as appropriate.

(2) The level of the top of base plates and the level of the lower end of vertical or raking components in a pocket base shall be within 10 mm of the specified level.

(3) The thickness of bedding shall be within one-third of the nominal thickness or 10 mm, whichever is less, of the specified nominal thickness.

(4) The line of vertical or raking components other than in portal frames shall be within 1 in 600 and within 10 mm of the specified line in every direction.

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

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

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

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

Essential tolerances – Erection tolerances: Full contact bearing 18.68 Where full contact end bearing is specified, the maximum gap between the two surfaces shown in Table B.19 of BS EN 1090:Part 2 shall be limited to 0.5 mm. In the case of fitted web stiffeners, the gap shall also be limited to a maximum of 0.25 mm over 60% of the fitted area.

Functional tolerances – Tabulated values 18.69

(1) The functional tolerance class 1 shall be adopted except in the following cases in Annex B of BS EN 1090:Part 2 where class 2 shall be adopted unless otherwise specified in the Contract:

(a) nos. 1 to 6 in Table B.1 at bearing and bearing stiffener locations; and

(b) nos. 3 and 4 in Table B.6.

(2) For no. 3 in Table B.23 of Annex B of BS EN 1090:Part 2, the deviation ($\triangle_y$, $\triangle_z$) at the tip of foundation bolts shall be within ±5 mm of the specified position.

(3) For no. 4 in Table B.23 of Annex B of BS EN 1090:Part 2, the vertical protrusion ($+\triangle_p$) and horizontal protrusion ($+\triangle_x$) of foundation bolts shall not be more than 25 mm from the specified position.

INSPECTION, TESTING AND CORRECTION

Requirements 18.70 Inspection, testing and correction shall comply with Clause 12 of BS EN 1090:Part 2 and Clauses 18.71 to 18.82.

General 18.71 (1) Defective components for steelwork shall not be used in the permanent work unless repair of the defects is permitted by the Engineer. If permitted, defective components shall be repaired by methods agreed by the Engineer.

(2) Fabricated steelwork shall not be:

(a) covered with protective coatings, concrete or other materials,

(b) erected, or

(c) dispatched from the place of fabrication if fabricated off the Site

until the steelwork, including any repaired areas, complies with the specified test and inspection requirements and has been approved by the Engineer.

(3) Defects that have been repaired and adjoining areas that in the opinion of the Engineer may have been affected by the repair shall be re-tested as instructed by the Engineer.

Constituent products and components – Constituent products 18.72 (1) The Contractor shall provide samples from each batch of steelwork for tensile tests and impact tests as follows:

(a) A batch of steelwork is the amount of steelwork specified in the Contract and which is completed or delivered to the fabrication yard or Site at any one time.

(b) The Contractor shall submit to the Engineer a list of the parts or material groups included in each batch at least 14 days before testing starts.

(c) Samples for testing shall be provided from each batch of steelwork within 3 days after delivery of the batch to the fabrication yard or to the Site. The rate of sampling and the position and direction of the samples shall be in accordance with the relevant standard of the steel supplied for use in the works. The test unit shall be as defined in the relevant standard of the steel supplied for use in the works and shall not exceed 40 tones.

(d) Samples to be tested shall be selected by the Engineer if testing is to be carried out in Hong Kong and shall be selected by the approved inspection authority or testing consultant if testing is not to be carried out in Hong Kong.

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

(f) The Engineer shall inform the Contractor of the samples selected for testing at least 7 days before testing starts.

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

(h) The tensile test and impact test shall be carried out on each sample of steel in accordance with BS EN ISO 6892:Part 1 and BS EN ISO 148:Part 1 respectively in conjunction with the relevant standard of the steel supplied for use in the works.

(i) If the result of any test does not comply with the specified requirements for the test, the test shall be carried out on additional samples from the batch. The number of additional tests shall be twice the number of original tests.

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

(k) If the result of every additional test complies with the specified requirements for the test, only those parts the samples from which have failed in the original tests shall be considered as not complying with the specified requirements for the test.

(l) Reports of the tests carried out shall be prepared. The reports shall be treated as execution records and shall form part of the execution documentation (see Clause 4.2.4 of BS EN 1090:Part 2 and Clause 18.10).

(2) The Contractor shall verify that mechanical fasteners conform to the requirements of the product standard to which the mechanical fasteners have been manufactured. Reports of the verification undertaken shall be prepared and submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts. The reports shall be treated as execution records and shall form part of the execution documentation (see Clause 4.2.4 of BS EN 1090:Part 2 and Clause 18.10). The verification shall include:

(a) obtaining evidence of certification of the quality of the mechanical fasteners such as the manufacturer's declaration of performance under a CE mark, manufacturer's certificates and test reports from the manufacturer or suppliers; and

(b) review of the mechanical fastener documentation to confirm authenticity, relevance, accuracy and completeness.

(c) inspection and sample testing of the mechanical fasteners in accordance with BS EN ISO 3269 to confirm that the dimensional characteristics and mechanical, physical and functional properties comply with the product standard to which the mechanical fasteners have been manufactured. Amd 3/2022

(3) In addition to the requirements of Clause 18.72(2), the Contractor shall provide samples as selected by the Engineer for suitability testing of mechanical fasteners supplied for use in the works. For each inspection lot of mechanical fasteners, three fasteners shall be drawn at random by the Engineer and tested in accordance with the suitability test relevant to the product standard to which the mechanical fasteners have been manufactured. The mechanical fasteners that have been tested shall be discarded. In the event of a mechanical fastener not meeting the requirements of the suitability test, all mechanical fasteners in the associated inspection lot shall be discarded. The suitability testing shall be reported in accordance with the relevant standard. The reports shall be treated as execution records and shall form part of the execution documentation (see Clause 4.2.4 of BS EN 1090:Part 2 and Clause 18.10).

(4) The tests stated in Clauses 18.72(1) and 18.72(3) shall be carried out by the approved inspection authority or testing consultant.

Manufacturing: geometrical dimensions of manufactured components

18.73 (1) The inspection and test plan shall identify all dimensions which could be at risk of non-conformity. Checks shall be made during execution and action shall be taken to ensure that any non-conformity is corrected at the earliest opportunity. All such dimensions shall be checked before the steelwork is dispatched to the Site. Components in the neighbourhood of site connections shall be re-checked once the connections are complete.

(2) If the correction of a non-conformity is not practicable, proposed modifications to the steel structure to compensate for the non-conformity shall be approved by the Engineer in advance of implementation.

(3) Repair of local dents in hollow sections by means of welded cover plates shall not be undertaken unless approved by the Engineer.

Welding – General

18.74 (1) Inspection and testing of welds shall be carried out by the approved inspection authority or testing consultant.

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

(3) The methods to be used for non-destructive testing of welds shall be appropriate for the joint geometry, material and production requirements and shall be as agreed by the Engineer. Welds shall be dressed to facilitate ultrasonic testing.

Welding – Inspection after welding: Routine inspection and testing

18.75 (1) All welded joints shall be subjected to inspection and testing as follows:

(a) 100% visual inspection in accordance with BS EN ISO 17637 throughout the entire welded length;

(b) supplementary NDT with the extent as specified in Table 24 of BS EN 1090:Part 2; and

(c) for EXC2 and EXC3 welds, the extent of supplementary NDT as specified in Table 24 of BS EN 1090:Part 2 shall be amended as follows:

(i) EXC2 – replace 0% and 5% by 10%; and

(ii) EXC3 – replace 5% by 10%.

(2) Clause 12.4.2.3 of BS EN 1090:Part 2 shall be amended as follows:

(a) page 89 – delete the last sentence of the second last paragraph; and

(b) page 89 – delete the last paragraph.

(3) Welds for steelwork that has been fabricated and tested by NDT at the fabrication yard shall be visually inspected in accordance with BS EN ISO 17637 when the steelwork is delivered to the Site. 5% of the welds in those steelwork shall be examined by the magnetic particle testing method.

Welding – Production tests on welding

18.76 For EXC3 and EXC4, production tests shall be carried out.

Mechanical fastening – Inspection and testing of preloaded bolted connections: Inspection during and after tightening

18.77 (1) The inspection during and after tightening for the part turn method shall conform to the requirements for the combined method stated in Clause 12.5.2.4c) of BS EN 1090:Part 2.

(2) For the part turn method, the inspection and testing requirements stated in Clause 12.5.2.6 of BS EN 1090:Part 2 shall apply except as follows:

(a) for EXC3 and EXC4, the first step shall be checked but using the same torque conditions as given in Table 18.1; and

(b) for inspection after the second step, rotation angle values given for the combined method shall be replaced with:

(i) 0^{o} (in lieu of 15^{o}); and

(ii) 60^{o} (in lieu of 30^{o}).

Erection – Inspection of trial erection

18.78 (1) The following checks shall be carried out during trial erection, where applicable, in addition to those that are specified in the Contract:

(a) dimensions critical to assembly to other parts of the structure;

(b) overall horizontal and vertical alignment and twist;

(c) evidence of correct re-establishment of alignment of units in staged trial erection;

(d) temperature differentials in box girders;

(e) fit-up of bolted joints and site welding preparations;

(f) alignment of bolt holes; and

(g) identification marks of members and their orientation, including packer plates.

Erection – Survey of geometrical position of connection nodes: Survey methods and accuracy

18.79 For EXC3 and EXC4, the survey of the completed structure shall include recording of dimensional checks at acceptance of the structure.

Erection – Survey of geometrical position of connection nodes: Location and frequency

18.80 Account shall be taken of the deflection effects due to temporary equipment supported by, or supporting, the erected structure and any non-steelwork dead weight which is in place at the time of measurement of the positional accuracy of the steelwork.

Inspection authority and testing consultant

18.81 (1) Inspection and testing of steelwork that are specified in the Contract to be carried out by an approved inspection authority or testing consultant shall be carried out by an inspection authority or a testing consultant employed by the Contractor subject to the approval by the Engineer.

(2) The employment of the approved inspection authority or testing consultant shall comply with Clause 1.40 and the following requirements:

(a) The inspection authority and testing consultant shall be accredited by HOKLAS/HKIAS or equivalent as agreed by the Engineer. The qualifications of the inspection authority and testing consultant and his staff shall be submitted to the Engineer for approval.

(b) The Contractor shall require the approved inspection authority or testing consultant to send all documentation, including inspection and test reports, issued by the inspection authority or testing consultant directly to the Engineer in sealed envelopes.

(c) The Contractor shall require the approved inspection authority or testing consultant to submit to the Engineer for approval the inspection and test plan for the works to be supervised/inspected/tested by the inspection authority or testing consultant as well as any subsequent changes, and to certify compliance with the inspection and test plan.

(d) The Contractor shall require the approved inspection authority or testing consultant to submit to the Contractor and the Engineer simultaneously site records on any non-compliance with the Contract requirements.

(e) The Contractor shall require the approved inspection authority or testing consultant to certify to the Engineer that the works supervised/inspected/tested by the inspection authority or testing consultant have been constructed/fabricated in accordance with the Contract requirements.

(3) Notwithstanding the requirements in Clause 18.81(2), the employment of the approved inspection authority or testing consultant shall not relieve the Contractor of any duties or liabilities under the Contract.

Inspection and test reports 18.82 (1) Reports of inspection and testing of steelwork carried out by the approved inspection authority or testing consultant shall be submitted to the Engineer at least 7 days before approval of the parts of steelwork examined is required. The reports shall contain the following details:

(a) procedures tested and exact locations examined in the steelwork;

(b) results of examination compared to the required values, with any non-complying results highlighted;

(c) any tearing, cracking or other defects found; and

(d) conclusion as to the overall testing results (compliance/non-compliance) of the parts of steelwork examined by the approved inspection authority or testing consultant.

(2) The reports shall be certified by the approved inspection authority or testing consultant who carried out the inspection and testing.

SUBMISSIONS

Quality documentation 18.83 The quality documentation stated in Clause 4.2.1 of BS EN 1090:Part 2 shall be submitted to the Engineer for approval at least 10 weeks before fabrication of the steelwork starts.

Quality plan 18.84 The quality plan stated in Clause 18.10 and Clause 4.2.2 of BS EN 1090:Part 2 shall be submitted to the Engineer for approval at least 10 weeks before fabrication of the steelwork starts.

Particulars of fabrication yard 18.85 The particulars of the proposed fabrication yard shall be submitted to the Engineer for approval at least 10 weeks before fabrication of the steelwork starts.

Particulars of constituent products supplied for use in the works

18.86 The inspection documents stated in Clause 5.2 of BS EN 1090:Part 2 for the constituent products supplied for use in the works shall be submitted to the Engineer for approval at least 4 Amd 2/2021 weeks before delivery of the constituent products to the Amd 2/2021 fabrication yard or site Amd 2/2021.

Particulars of welding procedures

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

(a) welding plan stated in Clause 7.2 of BS EN 1090:Part 2;

(b) documentation endorsed by the approved inspection authority or testing consultant to show that the proposed welding procedures have complied with the requirements for qualification of the welding procedures stated in Clause 7.4.1 of BS EN 1090:Part 2 and Clause 18.34(1); and

(c) certificates and test records of all tests and trials related to welding of steelwork endorsed by the approved inspection authority or testing consultant.

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

Particulars of cutting, shaping and holing procedures

18.88 The particulars of the proposed cutting, shaping and holing procedures (see Clauses 6.4 to 6.6 of BS EN 1090:Part 2) shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts.

Particulars of vent holes for hot-dip galvanizing

18.89 The particulars of the proposed method of plugging vent holes required for hot-dip galvanizing hollow or box sections shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts.

Particulars of workshop drawings

18.90 (1) Two sets of drawings of the steelwork shall be submitted to the Engineer. The drawings shall show details of the following:

(a) steelwork and welds, including any stud welds, marked with the relevant welding procedures and welding sequence to be employed to minimize contraction stresses and distortion;

(b) joints or welds necessary for the fabrication, delivery and erection of steelwork which are not specified on the Drawings;

(c) locations and method of removal of any temporary welded attachments proposed by the Contractor;

(d) edges of steelwork to be formed by thermal cutting or shearing procedures with the edges marked with the procedures to be used; and

(e) parts of steelwork to be worked by hot processes with the parts marked with the processes to be used.

(2) The drawings shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts. Drawings shall not be approved until all procedures and details shown on the drawing have been approved by the Engineer.

(3) A print and an electronic copy (.pdf and .dgn or equivalent format) of the approved drawings shall be submitted to the Engineer at least 7 days before fabrication of the steelwork starts.

Particulars of delivery of steelwork 18.91 (1) The following particulars of steelwork fabricated off the Site shall be submitted to the Engineer:

(a) expected and actual arrival dates;

(b) name of carrier;

(c) duplicate copies of bill of lading and packing list for steelwork transported by sea; and

(d) duplicate copies of delivery note and a list showing the marking and weight of each component for steelwork transported by land.

(2) The particulars of expected arrival date and name of carrier shall be submitted to the Engineer at least 14 days before the due date. Other particulars shall be submitted to the Engineer within 3 days after delivery of the steelwork to the Site.

Particulars of method of erecting steelwork 18.92 (1) The erection method statement stated in Clauses 9.3 and 9.6.1 of BS EN 1090:Part 2 and the following particulars shall be submitted to the Engineer:

(a) sequence and method of erection of steelwork;

(b) method of lifting and handling the components;

(c) method of preventing damage to protective coatings on steelwork during handling;

(d) procedure for aligning, levelling and plumbing steelwork, including temporary supports and method of making beddings for column bases; and

(e) sequence of casting concrete bonded to the steelwork.

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

Inspection and test plan 18.93 The inspection and test plan stated in Clause 12 of BS EN 1090:Part 2 and Clause 18.81(2)(c) shall be submitted to the Engineer for approval at least 6 weeks before fabrication of the steelwork starts.

Particulars of method of non-destructive testing 18.94 The particulars of the proposed methods for carrying out non-destructive testing on welds shall be submitted to the Engineer for approval at least 6 weeks before the tests start.

Particulars of welders 18.95 (1) Welding certificates endorsed by the approved inspection authority or testing consultant shall be submitted to the Engineer to show that each proposed welder has been approved in accordance with BS EN ISO 9606:Part 1. The extent of approval of the welder shall be appropriate to the categories of welds that the welder will carry out.

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

Particulars of welding coordination personnel 18.96

(1) Documentation endorsed by the approved inspection authority or testing consultant shall be submitted to the Engineer to show that qualifications of the proposed welding coordination personnel have complied with the requirements stated in Clause 7.4.3 of BS EN 1090:Part 2.

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

Particulars of inspection authority and testing consultant 18.97

The names of the proposed inspection authority and testing consultant stated in Clause 18.81 shall be submitted to the Engineer for approval at least 4 weeks before the inspection authority or testing consultant commences work.

Particulars of paint 18.98

(1) The following particulars of the proposed paints and associated products shall be submitted to the Engineer:

(a) particulars of manufacturer;

(b) duplicate copies of the manufacturer's data sheets including temperature, humidity and other conditions at the workshop or on the Site under which the paint is to be applied; and

(c) manufacturer's product specifications, product range and technical information.

(2) The particulars shall be submitted to the Engineer for approval at least 6 weeks before the painting starts.

Samples of materials 18.99

(1) A sample of blast cleaned steel plate shall be submitted to the Engineer for approval at least 14 days before blast cleaning starts. The sample shall be 150 mm x 150 mm x 6 mm and shall be enclosed in a sealed, colourless, transparent wrapping. The grade of steel and the method of blasting shall be representative of those that will be used in the permanent work.

(2) Two samples of painted tin plates for each paint system shall be submitted to the Engineer for approval at least 14 days before painting starts. Each plate shall be 150 mm x 75 mm x 1 mm and shall have smooth edges and 10 mm corner radii. The plates shall be brush cleaned and painted on one face with the paint system in such a manner that each coat is stepped back from the underlying coat in equal strips. The degree of gloss of the finishing coat shall be as agreed by the Engineer.

(3) Samples of each type of nut, bolt, washer, stud and rivet shall be provided within 3 days after the material is delivered to the Site.

APPENDIX 18.1

PREPARATION OF STEELWORK SURFACES

Cleaning of steelwork and coated surfaces 18.1.1 (1) Soil, concrete and other adherent matter shall be removed immediately from steelwork or coated surfaces and the surfaces shall be made good by methods agreed by the Engineer.

(2) Dust, soot, grit, detritus, metallic or other loose particles shall be removed by vacuuming after steelwork surfaces have been blast cleaned or before coated surfaces are washed or steam cleaned.

(3) Oil and grease shall be removed by emulsion cleaners, by steam cleaning or by high pressure water jets before removing rust and mill scale or overcoating. Oil and grease shall not be removed with turpentine or other solvents. If steam cleaning is used, steam cleaning shall be carried out after the greasy deposits have been removed by scraping and a detergent shall be added to the feed water of the steam generator.

(4) Salts, chemicals, corrosion or paint degradation products, including rust-spotting on blast cleaned surfaces and zinc salts on zinc coatings or zinc-rich paints, shall be removed by washing with detergent solution before coating steelwork surfaces or overcoating. The blast cleaned surface shall be tested for soluble contamination in accordance with BS EN ISO 8502:Part 6.

(5) The final shop coats on external surfaces shall be thoroughly washed with a detergent solution at the Site before being overcoated.

(6) Unless otherwise permitted by the Engineer, finished coated surfaces shall be cleaned not more than 14 days before handover of the steelwork.

(7) Cleaning agents to be used shall be as agreed by the Engineer. Surfaces that have been cleaned using cleaning agents shall be rinsed with fresh water to remove all traces of the cleaning agent.

(8) Cleaning tools shall be of a type that will not result in damage to the surfaces being cleaned. Wire brushes and brooms shall not be used for cleaning coated surfaces.

Cleaning of bolts, nuts and washers 18.1.2 Bolts, nuts and washers for steelwork shall be kept free of dirt and deleterious material. Oil and grease on bolts, nuts and washers, other than approved lubricants for nuts of preloaded bolts, shall be removed before assembling and coating the exposed parts of assembled bolts, nuts and washers.

Removal of rust and mill scale from steelwork 18.1.3 (1) Bare metal surfaces of steelwork which are to be painted or metal coated shall be treated before rust and mill scale are removed in accordance with the following requirements:

(a) burrs, arrises and serrations shall be smoothed by grinding or filing; and

(b) weld spatter, weld slag and raised metal laminations shall be removed by grinding or chipping and the surface shall be made good.

(2) Rust and mill scale shall be removed from steelwork which is to be metal coated in factories by a pickling process which is compatible with the metal coating process.

(3) Rust and mill scale shall be removed from steelwork which is to be thermally metal sprayed by blast cleaning to grade Sa 3 to BS EN ISO 8501:Part 1 Amd 3/2022.

(4) Rust and mill scale shall be removed from steelwork which is to be painted by blast cleaning as stated in Clause 18.1.4 unless the use of acid-pickling, mechanical cleaning or flame cleaning as stated in Clauses 18.1.5 to 18.1.7 has been approved by the Engineer.

Blast cleaning of steelwork

18.1.4 (1) Except as stated in Clause 18.1.3(3), blast cleaning of steelwork shall be carried out to grade Sa 2½ to BS EN ISO 8501:Part 1 using chilled iron abrasive.

(2) Chilled iron grit shall be graded in accordance with BS EN ISO 11124:Part 2. The maximum size of grit shall be G070 for use in automatic-impeller-type equipment and shall be G050 for manual or compressed air equipment. The difference in level between a peak and the adjacent trough of the blasted surface profile shall not exceed 0.1 mm.

(3) Non-metallic abrasives with a maximum particle size not exceeding 1 mm shall not be used other than with portable equipment. The abrasives shall comply with BS EN ISO 11126.

(4) Abrasives shall not contain materials that may contaminate the steel surfaces. Sand containing salt or excessive amounts of silt shall not be used. Contaminants shall be removed from recovered abrasives before re-use.

(5) Blast cleaning shall be carried out in a fully enclosed space separated from the place of painting. The enclosed space shall be fitted with dust extractors and filters to prevent the dispersal of dust outside the enclosed space.

Acid-pickling of steelwork

18.1.5 (1) Acid-pickling of steelwork shall be carried out by the Footner process in accordance with Clauses 14.3.2 and 16.2.2 of BS 5493. The first priming coat of paint shall be applied as soon as the steel has dried and is still warm.

(2) Excess acid or other chemicals used in the pickling process shall be removed from steelwork that has been prepared by pickling before the application of the metal coating. Pickling shall not be carried out for longer than is necessary to remove the rust and mill scale.

Mechanical cleaning of steelwork

18.1.6 Mechanical cleaning of steelwork shall be carried out using carborundum grinding discs or other power-driven tools followed by steel wire brushing and dusting to remove all loosened material which is not firmly bonded to the metal surface. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall not be carried out. Visible peaks and ridges shall be removed. Pneumatic chipping hammers shall not be used.

Flame cleaning of steelwork

18.1.7 (1) Flame cleaning of steelwork shall not be carried out at the following locations:

(a) within 2 m of preloaded bolting assemblies, cold worked high tensile steel and surfaces already coated with paint or cadmium, lead-based or carbonaceous materials;

(b) on sections thinner than 0.5 mm.

(2) Flame cleaning shall be carried out without distorting the steelwork and without adversely affecting the properties of the steel. The temperature of the steel surface being flame cleaned shall not exceed 200°C.

(3) Loose materials shall be removed from the flame-cleaned surface by wire brushing followed by blowing dry air or vacuuming. The priming coat shall be applied when the surface temperature of the steel is between 35°C and 40°C. Surfaces with temperatures of less than 35°C shall be reheated.

Approval of surface preparation

18.1.8 Surfaces shall not be coated until the cleaning and preparation of the surfaces have been approved by the Engineer.

Metal coatings to steelwork

18.1.9 (1) Galvanized coatings shall be applied by hot-dip galvanizing in accordance with BS EN ISO 1461. The coating thickness shall comply with BS EN ISO 1461.

(2) Thermal metal spraying shall comply with BS EN ISO 2063. The coating thickness shall be at least 100 μm. The sprayed metal shall be pre-treated with product CP1 and sealed with product CP3C in accordance with BS 5493.

(3) Hot-dip galvanized coatings of fasteners shall comply with BS EN ISO 10684. The coating thickness shall comply with BS EN ISO 10684.

(4) Electroplated zinc and cadmium coatings of fasteners shall comply with BS EN ISO 4042. The coating thickness shall be at least 5 μm.

(5) Allowance for the thickness of the metal coating shall be made in the sizes of the threads of metal coated fasteners in accordance with BS EN ISO 10684 or BS EN ISO 4042 as appropriate. Metal-coated preloaded bolts and nuts shall not be tapped oversize unless approved by the Engineer.

(6) Metal coatings that will be overcoated with paint shall not be passivated.

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

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

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.

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.

Application of paint to steelwork 18.2.3 (1) Surfaces that are to be painted shall be dry immediately before paint is applied.

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

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

(4) Each coat in the paint system shall be sufficiently dry or cured before the next coat is applied. The time between the applications of successive coats shall be within the limits recommended by the manufacturer and the limits stated in Clause 18.2.5.

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

Working conditions for painting 18.2.4 (1) Paint shall not be applied to steelwork under the following conditions:

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

(b) for outdoor work, during periods of inclement weather including fog, frost, mist and rain or when condensation has occurred or is likely to occur on the metal;

(c) when the surface temperature of the metal to be painted is less than 3°C above the dew point of the ambient air; and

(d) when the amount of dust in the air or on the surface to be painted is in the opinion of the Engineer excessive.

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

Priming and overcoating time limits 18.2.5 (1) Blast cleaned steel shall be primed or metal coated within 4 hours after blast cleaning.

(2) Primed steel surfaces shall be overcoated within 8 weeks after priming.

(3) Second undercoat shall be applied within 72 hours after application of the first undercoat.

(4) Sealer or etch primer to thermally sprayed metal shall be applied within 4 hours after spraying. The etch primed surfaces shall be overcoated within 72 hours after priming.

(5) Etch primer to galvanized steelwork shall be applied within 14 days after delivery of the steelwork to the Site. The etch primed surfaces shall be overcoated within 48 hours after priming.

(6) Overcoats to two-pack paint of the epoxide or polyurethane type shall be applied within 48 hours after application of the two-pack paint. If it is not possible to overcoat within 48 hours, the two-pack paint shall be abraded to produce a roughened surface and shall be given a flash coat of primer of a type approved by the Engineer. The primer shall be allowed to dry for at least 4 hours before application of the next coat of the system.

Stripe coats to steelwork 18.2.6 Immediately after the first undercoat of the paint system to steelwork has dried, a stripe coat of undercoat paint shall be applied by brush to edges, corners, crevices, exposed parts of bolts, nuts, rivets and welds. Another stripe coat of finishing paint shall be applied in the same manner after the last undercoat has dried.

Paint coats to steelwork 18.2.7 (1) The dry film thickness of the paint coats to steelwork shall be measured using a magnetic dry film thickness gauge or other apparatus approved by the Engineer. The total dry film thickness shall be measured at spacings of approximately 1.0 m. Individual dry film thicknesses of less than 80% of the nominal dry film thickness are not acceptable. Individual values between 80% and 100% of the nominal dry film thickness are acceptable provided that the overall average (mean) is equal to or greater than the nominal dry film thickness. If the measured dry film thicknesses do not comply with the requirements, repair work shall be carried out as stated in Clause 18.2.9.

(2) Care shall be taken to achieve the nominal dry film thickness and to avoid areas of excessive thickness. The maximum dry film thickness shall not be greater than 3 times the nominal dry film thickness. For products or systems which have a critical maximum dry film thickness and in special cases, information given in the manufacturer's technical data sheet shall be observed.

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

(4) Each coat of paint shall be free of embedded foreign matter, mechanical damage and surface defects, including bittiness, blistering, brush marks, bubbling, cissing, cracking, cratering, dry spray, floating, pinholing, rivelling, runs, sagging, spotting and spray mottle as stated in BS EN ISO 4618. The finished paintwork system shall have an even and uniform appearance.

(5) Each coat of paint shall adhere firmly to the substrate without blistering, chipping, flaking or peeling. Adhesion pull-off tests shall be carried out in accordance with BS EN ISO 4624.

Etch primers and blast primers 18.2.8 Etch primers and blast primers shall not be applied on phosphated steel and shall not be overcoated with zinc-rich primers.

Repairs to damaged areas of paint 18.2.9 (1) Areas of paint to steelwork that have been damaged shall be cleaned to bare metal or to the metal coating. The edges of the undamaged paint shall be bevelled.

(2) The full specified paint system shall be restored in such a manner that each new paint coat overlaps the existing paint by at least 50 mm all round the affected part.

Painting trials 18.2.10 (1) A painting trial shall be carried out for each paint system that will be applied to areas exceeding 100 m^2 to demonstrate that the proposed materials and methods of application will produce a painted surface that complies with the specified requirements.

(2) Painting trials shall be carried out at the place where painting to the permanent work will be carried out and using the employees and equipment which will be used to carry out painting to the permanent work.

(3) Painting trials shall be carried out on blast cleaned steel.

(4) If the painted surface produced in a painting trial does not comply with the specified requirements for the paintwork, the cause of failure shall be established by the Contractor and particulars of proposed changes shall be submitted to the Engineer. Proposed changes to the paint formulation, other than an adjustment in the amount of thinners, shall be carried out at the paint manufacturer's works before the final painting trial and before the first batch of paint is delivered.

(5) Painting shall not commence until the painted surface produced in painting trials complies with the specified requirements for paintwork.

(6) Unless permitted by the Engineer, the materials and methods of application used in a painting trial that complies with the specified requirements shall not be changed.

APPENDIX 18.3

TREATMENT OF JOINTS IN STEELWORK

Preloaded bolting assemblies

18.3.1 (1) In steelwork painted only overall:

The primer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The outer surfaces and edges of site joint material shall also be given a coat of the primer.

(2) In steelwork with thermally sprayed metal coating at joints only and painted overall:

The thermally sprayed metal coating shall be applied to the contact surfaces of the joints and to the outer surfaces and edges of joint material. The thermally sprayed metal coating on the contact surfaces of the parent material shall be taken 10 mm to 15 mm outside the perimeter of the joints. The primer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The thermally sprayed metal coating on the outer surfaces and edges of site joint material shall be given a coat of sealer.

(3) In steelwork with thermally sprayed metal coating overall and sealed only or painted overall:

The thermally sprayed metal coating shall be applied to the contact surfaces of the joints and to the outer surfaces and edges of joint material. The sealer applied to the parent material shall be taken 10 mm to 15 mm inside the perimeter of the joints. The thermally sprayed metal coating on outer surfaces and edges of site joint material shall also be given a coat of sealer.

(4) In steelwork hot-dip galvanized only or hot-dip galvanized and painted overall:

All material at joints shall be hot-dip galvanized. When an adhesion promoter and a first undercoat are applied before a joint is made, they shall be taken 10 mm to 15 mm inside the perimeter of the joint; these coats shall also be applied to edges and outer surfaces of the joint material.

(5) The thickness of a protective paint coat applied to the outer surfaces of joint material prior to assembly of any preloaded bolts shall not exceed 50 μm dry film thickness.

Non-preloaded bolting assemblies

18.3.2 (1) Blast primer for painted steelwork or thermally sprayed metal coating plus sealer for metal sprayed steelwork shall be applied to the joint and parent material of shop-bolted joints. Joints for painted steelwork shall be assembled after the first undercoat of the painting system has been applied to the contact surfaces and while the undercoat is still wet.

(2) Surfaces of the parent and joint material of site-bolted joints shall be coated with the same protective system as the parent material.

Welded joints

18.3.3 Welds and steelwork surfaces that have been affected by welding shall be coated with the same protective system as the parent material.

Joints made after coating of the parent material

18.3.4 (1) Hot-dip galvanizing or thermal metal spraying to steelwork shall not be carried out until all welds for the steelwork that is to be galvanized or thermally metal sprayed have been completed.

(2) At preloaded bolting assemblies, successive coats of paint on the parent material, with the exception of the primer or first coat of paint, shall be stepped back at 30 mm intervals commencing 10 mm from the perimeter of the joint.

(3) At welded joints, thermally sprayed metal coating on the parent material shall be kept clear of the weld by a distance of at least 15 times the thickness of the steel in the area to be welded, with a minimum of 150 mm and maximum of 300 mm from the joint. The restricted area shall be masked during metal spraying. Successive coats of paint on the parent material shall be stepped back at 30 mm intervals commencing at least 150 mm from the joint, or from the edge of the thermally sprayed metal coating.

(4) The parent material, joint material, exposed parts of bolts, nuts and washers, welds and weld affected areas shall be cleaned, prepared and brought up to the same protective system as the adjoining surfaces not more than 14 days after the joints have been made.

Sealing of joints

18.3.5 (1) The different parts of joints in steelwork shall be dry immediately before the joints are assembled.

(2) Fine gaps around the perimeter of bolted joints and load indicator gaps of preloaded bolts in steelwork painted overall shall be sealed by successive brush application of the same paint system as the parent material. All wider gaps shall be sealed with a proprietary sealant approved by the Engineer.

APPENDIX 18.4

TREATMENT OF SPECIAL SURFACES IN STEELWORK

Hollow steel sections 18.4.1 (1) The ends of hollow steel sections shall be sealed by welding mild steel plates over the open ends. The plates shall be at least 5 mm thick.

(2) Vent holes drilled in hollow steel sections prior to hot-dip galvanizing shall be plugged after hot-dip galvanizing and before application of any painting.

Bearing surfaces for bridge bearings 18.4.2 Dirt, oil, grease, rust and mill scale shall be removed from the metal bearing surfaces for bridge bearings. The surfaces shall be masked with tape or other methods agreed by the Engineer and shall not be primed or painted until the bonding agent has been applied.

Uncoated steelwork surfaces 18.4.3 The coated surfaces of steelwork coated over part of the surface shall be protected from rust that may form on the uncoated surfaces. Temporary coatings that may affect the bond between concrete and uncoated surfaces against which the concrete is to be placed shall be removed and the uncoated surfaces shall be cleaned before the concrete is placed. The coating system shall extend 50 mm, or 75 mm for steel piles, into areas against which concrete is to be placed.

Table 18.1: Torque values for the part turn method – step one Amd 2/2021

Bolt diameter d (mm)	12 Amd 3/2022	14 Amd 3/2022	16	18 Amd 3/2022	20	22	24	27	30	36 Amd 3/2022
Torque value M (Nm)	40 Amd 3/2022	60 Amd 3/2022	80	110 Amd 3/2022	160	210	270	340	460	810 Amd 3/2022

Table 18.2: Rotation values for the part turn method – step two

Bolt diameter (mm)	**Grip length A) (mm)**	**Rotation (Degrees)**
12 Amd 3/2022 to 22	$t \leq 115$	180 (1/2 turn)
	$115 < t \leq 275$	270 (3/4 turn)
24 to 36 Amd 3/2022	$t \leq 160$	180 (1/2 turn)
	$160 < t \leq 350$	270 (3/4 turn)
A) Equal to nominal thickness, t, in Table 21 of BS EN 1090:Part 2		

ACKNOWLEDGEMENTS

Certain requirements in this Section are based upon the documents listed below. The information in these documents is licensed under the terms of the Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence).

(1) Series 1800, Structural Steelwork, Volume 1, Specification for Highway Works, Manual of Contract Documents for Highway Works, April 2021 Amd 3/2022.

(2) Series 1900, Protection of Steelwork against Corrosion, Volume 1, Specification for Highway Works, Manual of Contract Documents for Highway Works, August 2014.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 19

HANDRAILING, LADDERS, STAIRS AND FLOORING

SECTION 19

HANDRAILING, LADDERS, STAIRS AND FLOORING

GENERAL

General requirements 19.01 The works and materials specified in Clauses 19.02 to 19.06 shall comply with the sections stated, unless otherwise stated in this Section. Hot dip galvanization shall comply with BS EN ISO 1461.

Fencing 19.02 Fencing shall comply with Section 4.

Pedestrian guardrailing 19.03 Pedestrian guardrailing shall comply with Section 11.

Materials for grout 19.04 Materials for grout shall comply with Section 16.

Steelwork 19.05 Steelwork, including protective treatment, shall comply with Section 18.

Vehicular parapets 19.06 Vehicular parapets shall comply with Section 20.

MATERIALS

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 19.08 Stainless steel for handrailing, ladders, stairs and flooring shall be Grade 1.4301 complying with BS EN 1090:Part 2, Table 4 or BS EN 10095. Stainless steel tubes shall be longitudinally welded tubes complying with BS EN 10296:Part 2. Tubes for handrails shall be polished.

Aluminium 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.

Cement mortar 19.11 (1) Mortar for grouting fixing bolts shall consist of 1 part of Portland cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the bolt holes. The mix shall contain a non-shrink admixture.

(2) Resin grout shall be of a proprietary type approved by the Engineer and shall contain a non-shrink admixture.

(3) Mortar for building in curbs for metal flooring shall consist of 1 part of cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for the work. The mix shall contain a non-shrink admixture.

DESIGNED BY CONTRACTOR

Designed by Contractor 19.12 Handrailing, ladders, stairs and flooring which are to be designed by the Contractor shall comply with the following requirements:

(a) Handrailing shall be capable of withstanding a horizontal loading of 740 N/m. The deflection of handrailing shall not exceed 1 in 200 at mid-span.

(b) Stairs shall be designed for a live loading of 5 kPa.

(c) Flooring shall be designed for a live loading of 5 kPa. The deflection of flooring shall not exceed 1/200 of the span.

FABRICATION OF HANDRAILING, LADDERS, STAIRS AND FLOORING

Fabrication of steelwork 19.13 Steelwork for handrailing, ladders, stairs and flooring shall be fabricated in accordance with BS EN 1090:Part 2.

Galvanizing to steel 19.14 (1) All steel that is to be galvanized shall be hot dip galvanized in accordance with BS EN ISO 1461.

(2) Galvanizing to steel shall be applied after welding, drilling and cutting are complete.

Welding steel 19.15 (1) Welds to steel for handrailing, ladders, stairs and flooring shall be full depth fillet welds. The welded surface shall be clean and flush before application of the protective coating. Welds to steel for handrailing, ladders, stairs and flooring shall be full depth fillet welds. The welded surface shall be clean and flush before application of the protective coating.

(2) Steel shall not be welded after hot dip galvanizing unless permitted by the Engineer and if permitted, the welded areas shall be free from scale and slag and shall be treated with appropriate coating system approved by the Engineer, which is compatible with the protective system of the parent material.

Fabrication of handrailing 19.16 Handrailing shall be discontinued at movement joints in structures. The spacing between standards shall be regular and shall not exceed 1.6 m. Curved handrailing shall not be made up of a series of straights.

Fabrication of ladders 19.17 (1) Ladders shall comply with BS 4211

(2) Steel ladders shall be hot-dip galvanized.

(3) Aluminium ladders shall be Grade EN AW-6082 aluminium.

(4) Rungs, extended stringers, safety cages and brackets shall be welded to the stringers of ladders.

(5) Rungs on aluminium ladders shall have longitudinal grooves and pressed aluminium alloy caps shall be fixed to open ends.

Fabrication of stairs 19.18 Stairs shall comply with BS 5395:Part 1.

Fabrication of flooring 19.19 (1) The shape of each panel of flooring shall be such that the panel can be easily removed. The mass of each panel shall not exceed 40 kg. Where intermediate supports are provided to support flooring they shall be capable of being removed to provide the specified clear opening.

(2) Curbs shall be provided in concrete surfaces for flooring.

(3) Cut-outs in flooring shall be neatly shaped and shall be provided with toe plates. Cut-outs in open mesh flooring shall be trimmed with edge bars welded to the bearing bars. The clearance between the edge of cut-outs and the component passing through the cut-out shall not exceed 30 mm.

(4) The bearing bars in open mesh flooring shall be welded to the nosing bars. The transverse bars shall be rivetted or welded to the bearing bars. Panels of open mesh flooring shall be secured with adjustable fixing clips.

(5) Chequer plate flooring shall have a non-slip pattern of a type approved by the Engineer and shall be provided with lifting holes. The flooring shall be secured to curbs by countersunk screws.

Fabrication of toe plates 19.20 Toe plates shall be fixed to handrail standards by brackets and shall be bolted or welded to stairs and flooring.

Fabrication of safety chains 19.21 (1) Safety chains shall comply with BS EN 818:Part 1 and shall be capable of withstanding a breaking force of 30 kN and a proof force of 15 kN.

(2) Steel safety chains shall be 8 mm nominal size, Grade M4 non-calibrated chain Type 1 and shall be hot-dip galvanized.

(3) The links of stainless steel safety chains shall be welded and shall have an internal length exceeding 45 mm and an internal width of between 12 mm and 18 mm. Fins caused by welding shall be removed.

(4) Hot dip galvanized hooks on chains shall be fitted with a sprung securing device.

SUBMISSIONS

Particulars of handrailing, stairs, ladders and flooring 19.22 (1) The following particulars of the proposed handrailing, ladders, stairs and flooring shall be submitted to the Engineer:

(a) Details of manufacturer's name and place of manufacture,

(b) An original certificate bearing the chop of the manufacturer showing that the materials comply with the requirements stated in the Contract,

(c) Drawings showing layout and details of handrailing, including positions of the different types of standards,

(d) Drawings showing details of ladders, stairs, toe plates and safety chains,

(e) Drawing showing layout and details of flooring, including positions and sizes of panels and supports,

(f) Details of methods of fixing and of rag, indented, expansion and resin bonded bolts, including manufacturer's literature, and

(g) Design details in accordance with Clause 19.12.

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

Samples of materials 19.23 (1) The following samples of the proposed handrailing, ladders, stairs and flooring shall be submitted to the Engineer at least 14 days before the relevant work starts:

(a) Handrails,

(b) Standards,

(c) Ladders, including rungs,

(d) Toe plates,

(e) Flooring and curbs,

(f) Safety chains, and

(g) Rag, indented, expansion and resin bonded bolts.

(2) The details of samples shall be as instructed by the Engineer.

STORAGE OF MATERIALS

Storage of handrailing, ladders, stairs and flooring 19.24 Handrailing and flooring shall be stored on level supports in a dry weatherproof store and in a manner that will not result in damage or deformation to the materials or in contamination of the materials. Handrailing, ladders, stairs and flooring shall be protected from damage and damaged handrailing, ladders, stairs and flooring shall not be used in the permanent work unless permitted by the Engineer.

INSTALLATION OF HANDRAILING, LADDERS, STAIRS, AND FLOORING

Installion of handrailing, ladders and stairs 19.25 (1) Handrailing shall be installed to a smooth alignment to the Engineer’s satisfaction.

(2) Handrail standards, flanges, ladders and stairs shall be bolted to metalwork and shall be fixed to concrete using rag, indented, expansion or resin bonded bolts. The bolts shall be fitted into pockets left in the concrete and the pockets shall be filled with cement mortar or resin grout.

Installation of flooring 19.26 (1) Flooring and curbs shall be flush with the adjoining surfaces.

(2) Curbs shall be fitted into rebates left in the concrete and the rebates shall be filled with cement mortar.

(3) Flooring shall be closely butted and the gap between panels and curbs, adjacent panels and other surfaces shall not exceed 10 mm.

TOLERANCES

Tolerances: handrailing, ladders, stairs and flooring 19.27 Handrailing, ladders, stairs and flooring shall comply with the following requirements:

(a) The position and height of handrailing shall be within 10 mm of the specified position and height.

(b) The level of the top rung of ladders and the top tread of stairs shall be within 75 mm of the specified level.

(c) The level of flooring and curbs shall be within 3 mm of the specified level.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 20

BRIDGEWORKS

SECTION 20

BRIDGEWORKS

PART 1: WATERPROOFING

MATERIALS

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.

SUBMISSIONS

Particulars of waterproofing systems

20.04 (1) The following particulars of the proposed waterproofing systems shall be submitted to the Engineer:

(a) Manufacturer's literature and a certificate for prefabricated sheeting showing the manufacturer's name, the date and place of manufacture and showing that the prefabricated sheeting complies with the requirements stated in the Contract and including results of tests for:
- Tensile strength
- Pliability
- Puncture resistance
- Elongation,

(b) Manufacturer's literature and a certificate for bentonite panels showing the manufacturer's name, the date and place of manufacture and showing that the bentonite panels comply with the requirements stated in the Contract and including results of tests for permeability,

(c) Manufacturer's literature and a certificate for bituminous paint showing the manufacturer's name, the date and place of manufacture and showing that the bituminous paint complies with the requirements stated in the Contract and including results of tests for viscosity,

(d) Particulars of primers and mastic for prefabricated sheeting, bentonite joint seal and bentonite granules and primers for bituminous paint, and

(e) Methods of laying prefabricated sheeting and bentonite panels.

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

Samples of materials for waterproofing systems

20.05 Samples of the following proposed materials for waterproofing systems shall be submitted to the Engineer at the same time as particulars of the material are submitted:

(a) Prefabricated sheeting, and

(b) Bentonite panels.

DELIVERY AND STORAGE OF MATERIALS

Delivery of bentonite panels

20.06 Bentonite panels shall be delivered in original unbroken packages bearing the manufacturer's label.

Storage of materials for waterproofing systems 20.07 (1) Prefabricated sheeting and bentonite panels shall be stored in accordance with the manufacturers' recommendations in a dry weatherproof store with a raised floor.

(2) Bituminous paint shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions that may affect the bituminous paint. The bituminous paint shall be stored in accordance with the manufacturer's recommendations and shall not be used after the recommended shelf life has been exceeded.

INSTALLATION OF WATERPROOFING SYSTEMS

Installation of waterproofing systems 20.08 (1) Surfaces on which waterproofing systems will be laid shall be clean, dry and free from voids, loose aggregate, sharp protrusions, projecting tying wire, release agents and other substances which are likely to damage or affect the waterproofing system.

(2) Waterproofing systems shall be laid in accordance with the manufacturer's recommendations.

(3) Before waterproofing systems are laid on concrete surfaces, the concrete surface shall have been cured for at least 7 days and shall be cleaned with a broom and sealed with one coat of primer. Primed surfaces shall not be covered until the solvent constituent has evaporated. Water shall be allowed to evaporate from primers containing bituminous emulsion before the surface is covered. Primed surfaces shall be protected from contamination.

Installation of prefabricated sheeting 20.09 (1) Prefabricated sheeting shall be laid one sheet at a time from low points and drains towards high points. The sheeting shall be firmly and tightly brought into contact with the primer or underlying sheeting.

(2) Laps shall be formed at joints between individual sheets of prefabricated sheeting. Unless otherwise approved by the Engineer, end laps shall be at least 150 mm and side laps shall be at least 100 mm. Joints shall be arranged in such a manner that the number of layers of sheeting at any joint does not exceed three.

(3) The perimeter of prefabricated sheeting laid each day shall be sealed with a trowelled bead of mastic.

(4) A double layer of prefabricated sheeting shall be laid around pipes, posts or other components, which pass through the sheeting, and the edges shall be sealed with a trowelled bead of mastic.

Installation of bentonite panels 20.10 (1) Bentonite panels shall not be laid in water or during wet weather.

(2) Immediately before bentonite panels are laid on a surface, joints and cracks in the surface shall be sealed with bentonite joint seal.

(3) Polyethylene sheeting shall be laid below and above bentonite panels to prevent prehydration. Laps of at least 100 mm shall be formed at joints in the sheeting.

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

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

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

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

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

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

Bituminous paint waterproofing systems

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

PART 2: BRIDGE BEARING

GLOSSARY OF TERMS

Schedule of bearings 20.12 Schedule of bearings is the schedule of bearings stated in the Contract.

Type of bridge bearing 20.13 Type of bridge bearing is a term used to identify bridge bearings of exactly the same design and same capacity for all bearing loads, movements and rotations.

MATERIALS

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 sliding bearings 20.18 Stainless steel sliding surfaces of sliding bearings which are attached to backing plates by mechanical fasteners instead of continuous welding along the edges shall be bonded to the backing over the full area and supplemented with peripheral sealing if necessary. Mechanical fixing only stated in Clause 7.2.1 of BS EN 1337:Part 2 shall not be used.

Design of elastomeric bearings 20.19 The performance requirements for the shear modulus of elastomeric bearings at low temperatures and very low temperature stated in Clauses 4.3.1.2 and 4.3.1.3 respectively of BS EN 1337:Part 3 shall not apply.

Design of guides for bridge bearings 20.20 The clearance between guides and complementary sliding surfaces of a guided bearing shall not exceed 1 mm.

Design of fixings for bridge bearings 20.21 (1) Except for elastomeric bearings, bridge bearings, including bearings that are not required to provide horizontal restraint, shall be fixed to the superstructure and substructure with mechanical fixings or by other methods approved by the Engineer. The friction between the bearing and the superstructure or substructure may be used to resist the horizontal forces provided that a factor of safety of at least 2 is applied to the proven coefficient of friction and that the worst combination of vertical load and horizontal load is considered.

(2) The ultimate capacity of the mechanical fixings for bridge bearings shall not be less than the worst combination of loading at ultimate limit state stated in the schedule of bearings.

Protective coatings to bridge bearings 20.22 Metal components of bridge bearings shall be protected against corrosion by a protective coating complying with, and selected in accordance with, BS EN ISO 14713. For the purpose of selecting the coating system, the corrosivity shall be classified as 'CX' and the durability class shall be 'very high (VH)' (more than 20 years).

Marking of bridge bearings 20.23 (1) Bridge bearings shall be marked by the manufacturer either with the type numbers stated in the schedule of bearings or with the manufacturer's own type or other numbers. A schedule shall be provided which relates the manufacturer's own type or other numbers to the type numbers stated in the schedule of bearings.

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

SUBMISSIONS

Particulars of bridge bearings 20.24 (1) The following particulars of the proposed bridge bearings shall be submitted to the Engineer:

(a) Details of type of bridge bearings, including materials, and the name and address of the manufacturer,

(b) Design calculations, including (i) calculations of bearing stresses above and below the bearings, (ii) calculations for bursting or other necessary additional or revised reinforcement, and (iii) calculations to show that the bearings comply with the requirements of BS EN 1337,

(c) Shop drawings and drawings of any additional or revised reinforcement details,

(d) A certificate for each type of bridge bearing showing the manufacturer's name, the date and place of manufacture and showing that the bridge bearings comply with the requirements stated in the Contract and BS EN 1337,

(e) Values of stiffness in compression and in shear of elastomeric bearings,

(f) Details of fixings to superstructures and substructures,

(g) Details of protective coatings,

(h) Methods of installation, and

(i) Programme of manufacture, testing and delivery, including name and address of testing laboratory.

(j) Certificates, reports, etc. showing that the bridge bearings comply with the test requirements stated in BS EN 1337 including but not limited to the following tests:
- Friction tests
- Load tests
- Tests on elastomers
- Quick compressive tests
- Stiffness tests.

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

STORAGE OF MATERIALS

Storage of bridge bearings 20.25 Bridge bearings shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner that will not result in damage or deformation to the bearings or in contamination of the bearings.

INSTALLATION OF BRIDGE BEARINGS

Installation of bridge 20.26 (1) Bridge bearings shall be installed as recommended in BS EN 1337:Part

bearings

11 and as stated in Clauses 20.26(2) to (7).

(2) Bridge bearings that have been pre-assembled shall not be dismantled unless approved by the Engineer.

(3) The levels of substructures stated in the Contract on which bridge bearings will be installed shall be adjusted to suit the thickness of the bearing so that the superstructure will be at the specified level after completion.

(4) Bridge bearings, other than elastomeric bridge bearings, shall be set level on substructures using only a thin layer of cementitious mortar, unless the Engineer permits the bearings to be set on plinths. If setting on plinths is permitted, the plinths shall be constructed of cementitious mortar or grout, unless otherwise approved by the Engineer, and the thickness of such plinths shall be at least 25 mm and shall not exceed 40 mm. If approved by the Engineer, the plinths may be constructed of chemical resin mortar, having a thickness of at least 5 mm and not exceeding 10 mm. The thickness of mortar joint stated in Clause 6.6 of BS EN 1337:Part 11 shall not apply.

(5) Elastomeric bearings shall be set directly on the substructure. A thin layer of cementitious mortar may be used to level the surface if the substructure is concrete. Elastomeric bearings shall not be set in position by grouting between the substructure and the underside of the bearing.

(6) The top surface of bridge bearings that will support precast concrete or other prefabricated beams shall be covered with a thin layer of cementitious mortar immediately before the beam is placed. The beam shall be temporarily supported on folding wedges or by other methods agreed by the Engineer until the mortar has achieved sufficient strength to transmit the weight of the beam to the bearings. The temporary supports shall then be removed.

(7) Temporary locking devices for bridge bearings shall be removed before post-tensioned superstructures are stressed. Temporary locking devices for other types of superstructures shall be removed at times agreed by the Engineer.

TOLERANCES

Tolerances: bridge bearings

20.27 (1) The centreline of bridge bearings shall be within 3 mm of the specified position.

(2) The level of bridge bearings shall be within 0.0001 times the adjacent span or the lesser of the adjacent spans or within 5 mm of the specified level, whichever is less.

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

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

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

TESTING: BRIDGE BEARINGS - GENERAL REQUIREMENTS

Batch: bridge bearings 20.28 A batch of bridge bearings is any quantity of bridge bearings of the same type fabricated by the same manufacturer and which for the purpose of testing elastomeric bearings contains the same type of elastomer.

Testing: bridge bearings 20.29 (1) Bridge bearings shall be tested by the Contractor at a laboratory approved by the Engineer.

(2) The Contractor shall inform the Engineer of the date and place of testing at least 28 days before testing starts.

(3) The specified procedures for testing bridge bearings shall not be changed unless permitted by the Engineer.

(4) The reports of tests on bridge bearings shall include load/deflection graphs and shall be submitted to the Engineer for approval at least 28 days before installation of the bridge bearings starts.

TESTING: FRICTION TEST FOR BRIDGE BEARINGS

Samples: friction test for bridge bearings 20.30 One sample of bridge bearing shall be provided from each batch of sliding bearings and from each batch of other types of bridge bearings which contain sliding parts.

Testing: friction test for bridge bearings 20.31 (1) The friction test shall be carried out on each sample of bridge bearing provided as stated in Clause 20.30 to determine the coefficient of friction, flatness, bonding properties and resistance to mechanical damage. The method of testing shall be in accordance with Appendix 20.1.

(2) The friction test shall be carried out at room temperature.

Compliance criteria: friction test for bridge bearings 20.32 The results of friction tests for bridge bearings shall comply with the following requirements:

(a) The coefficient of friction in any test position shall not exceed 0.04.

(b) The flatness of the stainless steel shall be within the specified limits after testing.

(c) The bond to the backing plate shall be unaffected by the friction test.

(d) The PTFE shall be free from mechanical damage after testing.

TESTING: BRIDGE BEARINGS OTHER THAN ELASTOMERIC BEARINGS

Samples: bridge 20.33 One sample of bridge bearing shall be provided from each batch of bridge

bearings other than elastomeric bearings bearings other than elastomeric bearings.

Testing: bridge bearings other than elastomeric bearings 20.34 Vertical load tests and horizontal load tests shall be carried out on each sample of bridge bearing provided as stated in Clause 20.33. The test loads shall be the serviceability limit state loads. If stated in the Contract, additional tests with test loads up to the ultimate limit state loads shall be carried out. The method of testing shall be in accordance with Appendix 20.2.

Compliance criteria: bridge bearings other than elastomeric bearings 20.35 The results of tests on bridge bearings other than elastomeric bearings shall comply with the requirements stated in Appendix 20.2.

TESTING: ELASTOMERIC BEARINGS

Samples: elastomeric bearings 20.36 (1) Except as stated in Clause 20.36(2), one sample of elastomeric bearing shall be provided from each batch of elastomeric bearings for testing by the "Quick Compressive Test".

(2) Samples shall not be provided for the "Quick Compressive Test" if in the opinion of the Engineer there is sufficient evidence that tests have been carried out within the previous 18 months on identical materials and that the results of the tests comply with the specified requirements for the test.

(3) Two samples of elastomeric bearings shall be provided from each batch of ten or part thereof of elastomeric bearings to determine the stiffness in compression and stiffness in shear.

Testing: elastomeric bearings 20.37 (1) Each sample of elastomeric bearing provided as stated in Clause 20.36(1) shall be tested to determine the physical and weathering properties of the elastomer and the bond of the elastomer to metal. The method of testing shall be the "Quick Compressive Test" in accordance with Clause 4.3.3.2 of BS EN 1337:Part 3.

(2) One sample of elastomeric bearing provided as stated in Clause 20.36(3) shall be tested to determine the stiffness in compression and the other sample shall be tested to determine the stiffness in shear.

(3) The method of testing to determine the stiffness in compression shall be in accordance with Annex H of BS EN 1337:Part 3. The method of testing to determine the stiffness in shear shall be in accordance with Annex F of BS EN 1337:Part 3.

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

(a) There shall be no evidence of surface flaws in the bearings during or after the test.

(b) There shall be no irregularities in the deflected shape of laminated bearings during or after the test.

(c) The stiffness in compression shall be within 20% of the value quoted by the manufacturer and approved by the Engineer.

(d) The stiffness in shear shall be within 20% of the value quoted by the manufacturer and approved by the Engineer.

PART 3: VEHICULAR PARAPETS

MATERIALS

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.

SUBMISSIONS

Samples of materials for vehicular parapets 20.42 Samples of the proposed posts and rails for vehicular parapets shall be submitted to the Engineer at least 14 days before installation of the parapets starts.

STORAGE OF MATERIALS

Storage of vehicular parapets 20.43 Vehicular parapets shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner that will not result in damage or deformation to the parapets or in contamination of the parapets.

INSTALLATION OF VEHICULAR PARAPETS

Installation of vehicular parapets 20.44 (1) Vehicular parapets shall be installed to a smooth alignment and with the posts vertical.

(2) Grouting shall be carried out by setting the vehicular parapets in position and grouting the gap between the vehicular parapets and the structure. Vehicular parapets shall be held in position until connections and fixings are complete and until the fixings have gained sufficient strength.

TOLERANCES

Tolerances: Vehicular parapets 20.45 Vehicular parapets shall be within 10 mm of the specified position and height.

TESTING OF VEHICULAR PARAPETS

Batch: Vehicular parapets 20.46 (1) A batch of vehicular parapets is the amount of parapet materials stated in the Contract and which is completed or delivered to the fabrication yard or Site at any one time.

(2) The Contractor shall submit to the Engineer a list of the parts of vehicular parapets included in each batch at least 14 days before testing starts.

Samples: Vehicular parapets for testing 20.47 (1) Samples shall be selected from positions that in the opinion of the Engineer or the approved inspection authority or testing consultant are representative of the batch as a whole.

(2) The Engineer shall inform the Contractor of the samples selected for testing at least 7 days before testing starts.

Testing: Vehicular parapets 20.48 (1) The relevant tests stated in Clauses 20.49 to 20.52 shall be carried out on each batch of vehicular parapets.

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

Testing: Parapets Materials 20.49 (1) The tensile test and Charpy impact test of materials for vehicular parapets shall be carried out in accordance with BS EN ISO 6892:Part 1 and BS EN ISO 148:Part 1 respectively in conjunction with the relevant standard of the material supplied for use in the works. The frequency of tests and results of material tests shall conform to the relevant standard stated in Tables 2 and 3 of BS EN 1090:Part 2 for steel parapets and Table 4 of BS EN 1090:Part 3 for aluminium parapets.

(2) Vehicular parapet material which has not been tested for quality grade by the manufacturer shall not be accepted.

Testing: Fasteners 20.50 (1) The tensile test of stainless steel fasteners for vehicular parapets shall be carried out in accordance with BS EN ISO 3506:Part 1 and Part 2 or equivalent approved by the Engineer.

Testing: Welded components of Vehicular parapets 20.51 (1) Inspection and testing of welds for components of vehicular parapets on each batch shall be carried out after cleaning and before application of hot-dip galvanizing and other protective treatment. De-burring, dressing, grinding, machining and peening shall be carried out after the visual inspection for cracks, surface pores and joint fit-up and before other inspections and tests are carried out.

(2) All welds shall be visually inspected for vehicular parapets in accordance with BS EN ISO 17637 or equivalent approved by the Engineer. Non-destructive testing shall be carried out on a proportion of welds after visual inspection.

(3) Non-destructive testing of welds for components of vehicular parapets shall comply with the following: -

(a) For the components of vehicular parapets which are butt welded or fillet welded with nominal leg length greater than 12mm, 10% of welds for each type of components shall be examined by ultrasonic testing in accordance with BS EN ISO 17640 or equivalent approved by the Engineer.

(b) 10% of the welds other than sub-clause 20.51(3)(a) shall be tested as follows:

- Magnetic particle method to joints in steel parapet in accordance with BS EN ISO 17638 or equivalent approved by the Engineer or

- Liquid penetrant method to welds in aluminium parapet in accordance with BS EN ISO 3452:Part 1 or equivalent approved by the Engineer.

(4) The compliance criteria for welds to be inspected, examined and tested shall be in accordance with BS 6779:Part 1 Clauses 9.4.3.1.2 to 9.4.3.1.4. For the butt welds to be tested the individual pores shall also be less than 2.5mm diameter and the localized pores shall be less then 3% by the area. The width of defect of buried slag shall be less than 1.5mm. Linear groups of inclusions are acceptable provided that adjacent groups shall be separated by a distance of at least 4 times and 6 times the length of longest defect for parent metal thickness less than 20mm and larger than 20mm respectively.

(5) If non-conformities are found as stated in sub-clause 20.51(4), the test

shall be carried out on additional samples from the batch. The number of additional tests shall be twice the number of original tests.

(6) The batch shall be considered as not complying with the compliance criteria for the test if the result of any additional test does not comply with the compliance criteria for the test.

(7) If the whole batch is not in compliance, the Contractor may propose to carry out 100% testing on the batch at his own costs.

(8) If the result of every additional test complies with the compliance criteria for the test, only those parts the samples from which have failed in the original tests shall be considered as not complying with the compliance criteria for the test.

(9) Welds for vehicular parapets that have been fabricated and tested by non-destructive testing at the fabrication yard shall be visually inspected for cracks when the vehicular parapets are delivered to the Site. If welding quality of the vehicular parapets is in doubt, 5% of the welds shall be tested by the magnetic particle testing method in accordance with BS EN ISO 17638 or equivalent approved by the Engineer. The surface protection of vehicular parapets shall be made good to the satisfaction of the Engineer after the tests.

(10) Inspection and testing of vehicular parapets shall be carried out by an approved inspection authority or testing consultant in accordance with Clause 18.81.

Testing: Metal vehicular parapet posts 20.52 (1) Destructive static testing of metal vehicular parapet posts on each batch shall be carried out in accordance with the procedures stated in Annex E of BS 6779:Part 1. The frequency of destructive testing shall be as follows:

No. of posts per batch	No. of posts to be tested per batch
<150	1 (The Engineer may waive this testing requirements if satisfactory tests within 3 months are provided)
150-300	1
> 300	1 for each 300 posts or remaining part thereof

(2) The results of test on post shall comply with the following criteria:

(a) The post shall sustain a moment of 1.05 times its theoretical moment of resistance (product of nominal yield stress and plastic modulus) at its critical section without failure.

(b) The material thickness, effective weld throat sizes and external dimensions of the post shall be within the tolerances.

(3) In the event that any of the acceptance criteria as stated in sub-clause 20.52(2) are not met, further two posts shall be selected from the same batch of posts and tested. If any further test fails to meet the acceptance criteria, the whole batch shall be rejected.

PART 4: MOVEMENT JOINTS

GENERAL

Movement joints formed in place 20.53 Movement joints formed in place shall comply with Section 16 except as stated in this Section.

GLOSSARY OF TERMS

Fabricated movement join 20.54 Fabricated movement joint is a manufactured assembly, including nosings, designed to carry traffic smoothly over a movement joint and to seal the joint against the ingress of water and debris.

Movement joint 20.55 Movement joint is a permanent joint or hinge throat that allows expansion, contraction or angular rotation to occur.

Movement joint formed in place 20.56 Movement joint formed in place is a movement joint formed during construction of a structure to permit adjacent structural elements to move relative to each other without damage.

MATERIALS

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

20.63 (1) Fabricated movement joints shall be a proprietary type approved by the Engineer.

(2) Fabricated movement joints shall be capable of withstanding the following loads, either separately or in combination:

(a) Vertically: two 112.5 kN wheel loads, 1 m apart, each spread over a contact area giving an average pressure of 1 MPa and applied in such a manner as to produce the worst possible effect, and

(b) Horizontally: a traction force of 75 kN/m run of the joint applied perpendicular to the alignment of the joint, together with any forces arising from strain of the joint.

Allowance for additional loading due to impact is not necessary.

(3) Fabricated movement joints shall be capable of accommodating the movements and rotations stated in the Contract without damaging the joint and without loading the supporting structure with forces which arise from strain of the joint exceeding 5 kN/m run of the joint.

(4) Fabricated movement joints shall either be watertight or shall be provided with a drainage layer or channel to collect water passing through the joint and to divert the water away from the underlying structure.

(5) Facilities shall be provided in fabricated movement joints for easy clearance of grit or silt entering slots, grooves or channels forming or associated with the joint.

(6) Surfaces of fabricated movement joints, which will be exposed at finished road level, shall be treated to provide a resistance to skidding not less than that of the adjacent road surface.

(7) Fabricated movement joints shall not impair the riding quality of the road surface for vehicular traffic and the passage of vehicular traffic shall not cause undue noise or vibration. The size of gaps, including gaps sealed with flexible material, on the riding surface of the joint shall not exceed 65 mm.

(8) The passage of pedestrians and cyclists shall not be impeded or endangered by fabricated movement joints.

Design of fixings for fabricated movement joints

20.64 (1) The holding down and fixing arrangements for fabricated movement joints shall be capable of withstanding the loads stated in Clause 20.63(2). The diameter of bolts fixed as double row bolts on one side shall be at least 12 mm and the diameter of other holding down bolts and studs shall be at least 16 mm.

(2) Fixings for fabricated movement joints shall be compatible with the reinforcement in the underlying concrete. Any revisions to the reinforcement required to suit the fixings shall be designed by the Contractor and submitted to the Engineer for approval.

SUBMISSIONS

Particulars of movement joints

20.65 (1) The following particulars of the proposed movement joints shall be submitted to the Engineer:

(a) Details of type of movement joint and the name and address of the manufacturer,

(b) Design calculations and drawings,

(c) Details of fixings, including the size, length and spacing of holding down bolts and any necessary revisions to the reinforcement,

(d) Details of materials for making good adjoining road surfaces and nosings, including reinforcement, jointing and curing details,

(e) Programme of manufacture, testing and delivery, and

(f) For fabricated movement joints, a written undertaking from the supplier that he will install the proposed movement joint.

(2) The particulars shall be submitted to the Engineer at least 28 days before construction of the movement joint starts.

STORAGE OF MATERIALS

Storage of fabricated movement joints

20.66 Fabricated movement joints shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner that will not result in damage or deformation to the movement joint or in contamination of the movement joint.

INSTALLATION OF FABRICATED MOVEMENT JOINTS

Installation of fabricated movement joints

20.67 (1) Fabricated movement joints shall be installed in accordance with the manufacturer's recommendations. The installation shall be carried out by the supplier of the movement joint.

(2) The vertical faces of recesses in bridge decks for fabricated movement joints shall be formed by saw-cutting. Holding-down bolts shall be cast into the concrete for direct mounting of the joints unless the Engineer permits the bolts to be grouted. If grouting is permitted, the grouting shall be carried out by setting the movement joint in position and grouting the gap between the movement joint and the structure. Rebates and pockets for subsequent trimming to line and level or for holding-down bolts shall not be used unless permitted by the Engineer.

(3) The bedding to fabricated movement joints shall be formed such that there shall be no gaps between the joint and the bedding.

(4) Relative movement between components and supports of a fabricated movement joint shall be prevented during installation of the joint and during placing and hardening of concrete and mortar under the components. Joint

components shall be free to move longitudinally relative to each other.

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

Road surface adjoining fabricated movement joints 20.68 (1) The gap between fabricated movement joints and the adjoining road surface or nosing shall be made good after installation of the joint with material that has properties as similar as practicable to those of the material in the adjoining road surface.

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

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

Protection of fabricated movement joints 20.69 (1) The permission of the Engineer shall be obtained before construction plant or other vehicles cross a fabricated movement joint or the adjacent road surface.

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

CONSTRUCTION OF MOVEMENT JOINTS FORMED IN PLACE

Forming movement joints 20.70 Gaps forming part of movement joints formed in place shall be filled with joint filler fixed in position with adhesive. The edge of the joint filler shall be covered with bond breaker tape or a PVC capping strip.

Forming grooves 20.71 Grooves for joint sealant and compression seals for movement joints formed in place shall be formed by saw cutting.

Sealing grooves 20.72 Grooves for movement joints formed in place shall be sealed with joint sealant or with a compression seal.

TOLERANCES

Tolerances: fabricated movement joints 20.73 The surface of fabricated movement joints shall be at least 1 mm, and not more than 3 mm, below the surrounding road surface.

APPENDIX 20.1

FRICTION TEST FOR BRIDGE BEARINGS

Scope

20.1.1 This method covers the determination of the coefficient of friction, flatness, bonding properties and resistance to mechanical damage of bridge bearings by means of a friction test.

Equipment

20.1.2 The following equipment is required:

(a) Compression testing rig.

(b) Test loads.

(c) Equipment for measuring the loads applied, readable and accurate to within 2% of the measured load.

(d) Equipment for measuring movement, readable and accurate to 0.01 mm.

(e) Lubricant of the same type as will be used in service.

Procedure

20.1.3 The procedure shall be as follows:

(a) The PTFE surface of the bearing shall be lubricated with the lubricant.

(b) Two sets of sliding surfaces shall be mounted back to back between the platens of the compression testing rig with the stainless steel sliding surfaces in the centre. A vertical load equal to the permanent load stated in the schedule of bearings shall be applied for 1 hour.

(c) A horizontal load shall then be applied steadily and without shock to the pair of stainless steel sliding surfaces and shall be increased at a rate of 0.2% of the vertical load per minute until movement occurs between the sliding surfaces. The maximum horizontal load sufficient to cause movement of at least 25 mm between the stainless steel and PTFE sliding surfaces at a rate not exceeding 50 mm/min shall be recorded.

(d) The loads shall be removed.

(e) The sliding surfaces shall be removed from the rig and inspected.

Calculation

20.1.4 The coefficient of friction shall be calculated from the equation:

Reporting of results

20.1.5 The following shall be reported:

(a) Name of bearing manufacturer.

(b) Details of bearing and sliding surfaces.

(c) The vertical load applied.

(d) The maximum horizontal force applied.

(e) The total movement and rate of movement at the maximum horizontal force applied.

(f) The coefficient of friction to two significant figures.

(g) Details of any damage to the sliding surfaces.

(h) That the test method used was in accordance with this Specification.

APPENDIX 20.2

LOAD TEST FOR BRIDGE BEARINGS OTHER THAN ELASTOMERIC BEARINGS

Test loads 20.2.1 The test loads shall be as follows:

(a) Both vertical and horizontal loads, where applicable, shall be applied to the bearing in the most adverse combinations. Where load transfer due to tilting of the bearing can occur, it shall be taken into account.

(b) Load tests to check the performance of a bearing at the serviceability limit state shall be carried out using the serviceability design load effects on the bearing multiplied by the partial factor for the material property, γ_M.

(c) Load tests to check the performance of a bearing at the ultimate limit state shall be carried out using the ultimate design load effects on the bearing multiplied by γ_M.

Loading and unloading procedure 20.2.2 The loading and unloading procedure shall be as follows:

(a) Before recording measurements, the bearing shall be bedded in by applying a load equal to the serviceability limit state load and then releasing it.

(b) The test loads shall then be applied in increments.

(c) The rate of loading shall be slow enough to avoid any adverse shock effects.

(a) The maximum load shall be maintained until any obvious short-term creep has ceased.

(b) The load shall then be removed in decrements.

(c) Load deflection measurements shall be made at each increment and decrement.

Serviceability limit state load tests 20.2.3 For serviceability limit state load tests:

(a) After complete unloading, the amount of set shall be checked and, if significant, the loading and unloading cycle repeated. If the set is shown to be progressive, the bearing shall be deemed not to comply with the requirements.

(b) After being tested, the bearing shall be dismantled as necessary for inspections

(c) A bearing is considered to have passed a serviceability limit state load test provided that there is no visible damage or permanent deformation of any part due to loading cycles subsequent to the initial bedding-in cycle.

Ultimate limit state load tests 20.2.4 For ultimate limit state load tests:

(a) Where a bearing is to be test loaded to both serviceability and ultimate limit states, it shall be tested for serviceability first and be dismantled as necessary for inspection before being tested for the ultimate limit state. In such cases, it shall have a second bedding-in cycle before the second load test.

(b) A bearing may be considered to have passed an ultimate limit state load test if it supports the test load.

(c) Bearings tested for the ultimate limit state shall not be further used.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 21

MARINE WORKS

SECTION 21

MARINE WORKS

GENERAL

General requirements 21.01 The works and materials specified in Clauses 21.02 to 21.08 shall comply with the sections stated, unless otherwise stated in this Section.

Pipes and fittings 21.02 Pipes and fittings, including gaskets, internal linings, external coatings and anticorrosion tape, for submarine outfalls shall comply with Section 5.

Fill material 21.03 Fill material for marine works shall comply with Section 6.

Public filling area 21.04 Reclamation in form of public filling area shall comply with Section 6 except the requirements for compaction of public fill.

Formwork 21.05 Formwork and finishes to concrete shall comply with Section 14.

Steel reinforcement 21.06 Steel reinforcement shall comply with Section 15.

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.

Joints in concrete 21.08 Joints in concrete in seawalls shall comply with Section 16 and shall also comply with Appendix 21.2 entitled "Specification for Reinforced Concrete in Marine Environment".

GLOSSARY OF TERMS

Reclamation 21.09 Reclamation is the formation of land over an area of foreshore, sea-bed, tidal inlet or river, including the adjoining areas, by the deposition of fill material to the limits stated in the Contract.

Marine structures 21.10 Marine structures are seawalls, revetments, breakwaters, jetties, quay walls, dolphins, docks, slipways, beacons, lighthouses, landing steps for berthing of vessels and other similar structures.

Final surface of any work 21.11 Final surface of any work is the surface to which the work is to be finished.

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.

SUBMISSIONS

Particulars of marine works 21.25 (1) The following particulars of the proposed marine works shall be submitted to the Engineer for approval:

(a) Any conditions or restrictions imposed by the Director of Marine and other authorities, including copies of applications, licences, permits and correspondence, and

(b) Details of methods for controlling marine traffic,

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before marine works start.

Particulars of dredging 21.26 (1) The following particulars of the proposed methods of dredging shall be submitted to the Engineer for information:

(a) Any conditions or restrictions imposed by the Director of Environmental Protection and other authorities for disposal of dredged material, including copies of applications, marine dumping permits and correspondence,

(b) Type and capacity of dredgers,

(c) Methods of anchorage and positioning of dredgers,

(d) Sequence and rate of working,

(e) Details of silt curtain for dredging as stated in Clause 21.54, including manufacturer's literature, and

(f) Arrangements for the transportation and disposal of dredged material.

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

Particulars of transportation of imported fill material 21.26A (1) The following particulars of fill material imported from sources outside Hong Kong shall be submitted to the Engineer for approval:

(a) Expected departure and arrival dates,

(b) Name of vessel,

(c) Routing of delivery vessel, and

(d) Vessel position tracking and monitoring arrangement.

(2) The particulars shall be submitted to the Engineer for information at least 24 hours before the commencement of transportation of fill material to the Site.

Particulars of deposition of fill material 21.27 (1) The following particulars of the proposed materials and methods of deposition of fill material shall be submitted to the Engineer for approval:

(a) Details of construction plant and transport,

(b) Sources and properties as required in accordance with Clauses 21.12 and 21.13, of each type of fill material,

(c) Details of silt curtain for filling as stated in Clause 21.56, including manufacturer's literature,

(d) Details of refuse containment booms as stated in Clause 21.49,

(e) Methods of deposition and compaction of fill material,

(f) Methods of controlling moisture content of fill material, and

(g) Sequence and rate of working.

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

(a) Layout plan showing the pumpline alignments and positions of the discharge points,

(b) Calculations of the rate and duration of discharge, and

(c) Details of containment bunds and tailwater drainage systems.

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

Particulars of lifting seawall blocks, copings and wave deflectors

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

Particulars of rock armour and rock for underlayer

21.29 Particulars of the proposed methods and devices to be used for placing and weighing rock armour and rock for underlayer of rock armour and the testing certificates shall be submitted to the Engineer for approval at least 14 days before commencement of the deposition of rock armour and rock for underlayer.

Particulars of slip joints

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

(a) Details of joint filler, including manufacturer's literature, and

(b) Method of fixing and application of the materials.

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

Particulars of timber for fendering systems

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

(a) Species and grade of timber,

(b) Name and address of timber supplier, and

(c) Method of pressure treatment and amount of net retention.

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

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

Particulars of rubber fenders

21.32 (1) The following particulars of the proposed rubber fenders shall be submitted to the Engineer for approval:

(a) Manufacturer's literature, including a list of physical properties of the rubber for the fenders, and

(b) A report on compression load tests and characteristic load-deflection and energy-deflection curves.

(2) The particulars shall be submitted to the Engineer for approval of the source and type of rubber fenders at least 30 days before the first delivery of the rubber fenders to the Site.

(3) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the rubber fenders, including the rubber used in manufacturing the fenders, comply with the requirements stated in the Contract, shall be submitted for each batch of rubber fenders delivered to the Site.

Particulars of plastic fenders

21.33 The following particulars of the proposed plastic fenders shall be submitted to the Engineer for approval:

(a) Manufacturer's literature including a list of physical properties of plastic fender in accordance with Table 21.6,

(b) Composition of plastic materials and type of fibreglass bar,

(c) Workshop drawing of the proposed plastic fender,

(d) The Contractor shall provide the latest test certificates, not more than 1 year, in accordance with Table 21.6, and

(e) A certificate showing the manufacturer's name, the date and place of manufacture and complying with the requirements stated in the Contract.

Particulars of submarine outfalls

21.34 (1) The following particulars of the proposed materials and methods of construction for submarine outfalls shall be submitted to the Engineer for approval:

(a) Methods of lifting, laying, jointing and testing pipes,

(b) Manufacturer's literature, and

(c) A certificate for pipes and pipe joints showing the manufacturer's name, the date and place of manufacture and showing that the pipes comply with the requirements stated in the Contract and including the results of load tests.

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

Particulars of demolition of marine structures

21.35 (1) The following particulars of the proposed methods of demolition of marine structures shall be submitted to the Engineer for approval:

(a) Details of construction plant,

(b) Method and sequence of demolition, and

(c) Arrangement for on-site sorting of demolition debris.

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

TRANSPORTATION, HANDLING AND STORAGE OF MATERIALS

Storage of fill material and dredged material

21.36 Fill material and dredged material shall not be stockpiled on the foreshore, seabed or riverbed within the Site unless permitted by the Engineer.

Transportation of imported fill material

21.36A (1) Imported fill material for marine works which is provided by the Contractor from sources outside the Site shall not be transported in a manner that will result in contamination, unauthorised loading or leakage of material.

(2) All vessels transporting imported fill material to the Site shall be equipped with a tracking device (Global Positioning System (GPS) or equivalent system approved by the Engineer) for real time tracking and monitoring of their travel routings, speed, anchorage points, etc. The Contractor shall provide means of access by software or an equivalent mobile application to the vessels' GPS tracking devices for the Engineer to monitor the real time movement of the vessels. Unless otherwise permitted by the Engineer, the Contractor shall ensure that a back-up positioning system is available on board each vessel so that the monitoring will not be disrupted when the tracking device is out of service for any reason.

(3) The Contractor shall monitor the transportation of imported fill material from its source to the Site, and shall produce and/or keep logs and other records to demonstrate compliance with sub-clause (1) of this Clause. The Contractor shall submit on a daily basis copies of such logs and records to the Engineer, in a manner and format agreed by the Engineer, for checking.

(4) The Contractor shall make all necessary arrangements with and obtain the necessary approvals from the relevant local or overseas authorities for the tracking and monitoring arrangements.

Handling and storage of fill material

21.37 (1) Fill material shall not be handled or stored in a manner that will result in segregation, deterioration, erosion or instability of the material.

(2) Different types of fill material shall be kept separate from each other.

Handling and storage of precast concrete seawall blocks, copings and wave deflectors

21.38 (1) Precast concrete seawall blocks, copings and wave deflectors shall be stored in such a manner that identification markings can be easily seen.

(2) Precast concrete seawall blocks, copings and wave deflectors shall be stored on level supports and in a manner which will not result in damage or deformation to the units or in contamination of the units. The units shall be protected from damage and damaged units shall not be used in the permanent work unless permitted by the Engineer.

Handling and storage of timber fenders

21.39 (1) Timber for fendering systems shall be stored off levelled, well-drained and maintained hard-standing ground on level supports and shall be protected from exposure to conditions which may cause reduction in the moisture content in the material.

(2) Timber which is treated with preservatives shall not be stored on or adjacent to concrete surfaces that form part of the permanent work.

(3) Safety precautions as recommended by the timber treatment company shall be observed in the handling of treated timber. Treated wood offcuts shall be buried in a suitable location, or burnt in an open area and the ashes buried.

(4) Safety precautions as recommended by the supplier of wood preservatives shall be observed in the handling of the wood preservatives.

Handling and storage of rubber fenders and fittings

21.40 (1) Rubber fenders and fittings shall be left in their original packing until required for placing. All rubber surfaces shall be protected against damage.

(2) Rubber fenders shall be handled with nylon slings of a size agreed by the Engineer or by other methods agreed by the Engineer.

Handling and storage of plastic fenders

21.41 (1) Plastic fender for fendering systems shall be stored off levelled, well drained and maintained hard-standing ground on level supports.

(2) Identification shall be marked on the surface of ends including the following information:

(i) Name of manufacturer and model number,

(ii) Place and date of manufacture, and

(iii) Unique serial number.

GENERAL MARINE WORKS REQUIREMENTS

Notification of marine works

21.42 Before commencing marine works, the Contractor shall provide the Engineer with evidence that the Director of Marine has been notified of the proposed works in accordance with Section 70 of the Shipping and Port Control Regulations, Chapter 313.

Marking of marine works

21.43 Marine works and any part of the Site in which marine works are carried out shall be marked with flags, marker buoys and lights in accordance with the International Association of Lighthouse Authorities Maritime Buoyage System (current edition as adopted by Marine Department) for Region A and in a manner agreed by the Engineer. Red flags shall be at least 0.6 m square and marker buoys shall be of a type, size and colour approved by the Engineer. Lights shall be either fixed red lights or quick flashing yellow lights visible all round the horizon at a distance of at least 2 km.

Marine traffic and waterfront operations

21.44 (1) Marine traffic and the operation of public and private concerns in areas adjacent to the Site shall not be obstructed by the activities of the Contractor.

(2) The Contractor shall make all arrangements with and obtain the

necessary approvals from the Director of Marine and any other relevant authority for temporary marine traffic arrangements and control.

Temporary tide gauges 21.45 (1) Temporary tide gauges shall be mounted vertically and firmly on rigid supports at locations agreed by the Engineer at all times during execution of the marine works and shall be calibrated, levelled and fixed to give tidal readings within an accuracy of 20 mm.

(2) Temporary tide gauges shall be made of 50 mm thick hardwood or other replacement material approved by the Engineer and shall be at least 250 mm by 3200 mm in size. The gauges shall be painted on the marked faces with alternate 100 mm stripes in red and white and shall be marked and numbered in black at 0.5 m intervals over the tidal range from 0.0 m C.D. to +3.0 m C.D. The painting applied shall consist of one primary coat, one undercoat and one finishing coat.

Work boats 21.46 (1) Work boats shall be motorised boats equipped with a rain shelter and capable of carrying at least six passengers.

(2) Work boats shall be licensed under the Merchant Shipping (Launches and Ferry Vessels) Regulations, Chapter 281 and shall be manned and maintained in good seaworthy condition.

(3) Work boats shall be kept available for use by the Engineer for supervision, inspection and measurement during normal working hours and at other times when the Contractor is working.

Silt curtains 21.47 (1) The Contractor shall provide silt curtains during all kind of works that may affect the water bodies adjacent to the Site as detailed on the Drawings or as required by the Engineer. The Contractor shall be responsible for designing, agreeing with the Engineer, installing and properly maintaining the silt curtains throughout the duration of the above works. The Contractor shall, not later than 3 weeks before the commencement of the relevant works, submit details of silt curtains to be used, including dimensions, exact locations and method of installation and removal, to the Engineer for approval.

(2) Silt curtains shall be formed by using tough, abrasion-resistant and permeable membranes suitable for the purpose, supported on floating booms in such a way as to ensure that the passage of turbid water to the surrounding water shall be restricted. The permeable membranes shall be of a type with properties approved by the Engineer.

(3) The boom of the silt curtains shall be formed and installed in such a way that tidal rise and fall are accommodated, and that the ingress of turbid waters is limited. Removal and reinstallation of such curtains during typhoon conditions shall be agreed with the Engineer and the Director of Marine.

(4) The Contractor shall carry out regular inspections to ensure that the silt curtains are adequately moored and marked to avoid any danger to marine traffic. The Contractor shall promptly repair any damage to the silt curtains to the satisfaction of the Engineer.

(5) The Contractor shall be responsible for re-positioning of the silt curtains to suit the construction programme.

Removal of floating 21.48 Floating debris within the Site arising from any source shall be collected and

debris

disposed of by the Contractor at regular intervals agreed by the Engineer. Floating debris shall be prevented from dispersing outside the Site.

Refuse containment booms and floating refuse for use of inert construction and demolition material in reclamation

21.49 (1) If inert construction and demolition material is used as fill material in reclamation, refuse containment booms as detailed on the Drawings shall be provided and installed before dumping of fill material into the sea commences.

(2) The Contractor shall provide sinker blocks and lit marker buoys as agreed by the Engineer to ensure that the booms are visible above the water line and are securely anchored. The lights on the marker buoys shall comply with the following requirements unless otherwise stated in the Contract:

(a) In the type of quick flashing yellow lights visible all round the horizon at a distance of at least 2 km, and

(b) The maximum spacing between the lights shall be 30 m.

(3) Details of the proposed lights on the marker buoys shall be submitted to the Engineer for approval before installation starts.

(4) The Contractor shall properly maintain and operate the booms to the satisfaction of the Engineer throughout the progress of the reclamation and shall replace the same when they are under repair or beyond repair.

(5) The refuse containment booms shall revert to the Contractor upon the completion of reclamation or at such earlier date as instructed by the Engineer.

(6) The Contractor shall provide light mechanized marine craft with crew and labour as agreed with the Engineer for collecting floating refuse and preventing floating refuse within the Site from drifting into public waters. Floating refuse collected shall be disposed off-site in accordance with the requirements of Trip-ticket System as stated in Section 1.

(7) The Contractor shall make due allowance in programming the reclamation works for the provision, installation, operation and maintenance of the refuse booms and the regular collection of the floating refuse throughout the process of reclamation.

Surveys for marine works

21.50 (1) Surveys for dredging and deposition of fill material shall be carried out using echo sounders of 200 kHz to 220 kHz frequency or by other methods agreed by the Engineer.

(2) The initial survey for dredging shall be carried out within 30 days before dredging starts.

(3) The final survey for dredging shall be carried out within 30 days after dredging has been completed.

(4) The initial survey for deposition of fill material shall be taken as being the same as the final survey for dredging, or the final survey for the underlying layer of fill material as appropriate, except as stated in Clause 21.50(5).

(5) If the final survey for dredging or the final survey for the underlying layer of fill material was carried out more than 30 days before deposition of the next layer of fill material starts, the initial survey for deposition of fill material shall be carried out within 30 days before deposition of the layer of fill material starts.

(6) The final survey for deposition of fill material for the first layers, intermediate layers, and final layers of underwater foundations shall be carried out within 30 days after deposition of fill material has been completed. The final survey for final layers other than those of underwater foundations shall be carried out at least 30 days and not more than 90 days after deposition of fill material has been completed.

Fill material allowed to become unsuitable or to deteriorate

21.51 (1) Fill material which has been used or is required for use in the permanent work and which is allowed to become unsuitable such that in the opinion of the Engineer it no longer complies with the specified requirements for that type of material shall be replaced or dealt with by methods agreed by the Engineer.

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

(3) Disposal of the unsuitable fill material shall be in accordance with the Contractor's Waste Management Plan.

Concreting in locations affected by tides

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

DREDGING

Commencement of dredging

21.53 The permission of the Engineer shall be obtained before dredging starts in any area.

Dredging

21.54 (1) Dredging shall be carried out in such a manner and sequence that semi-fluid or disturbed seabed or foundation material will not accumulate in dredged areas.

(2) Dredging shall be carried out with due care in the vicinity of existing structures.

(3) During dredging, samples shall be taken from the dredged materials for inspection and determination of the sand content. The Contractor shall notify the Engineer if there is any sudden or significant change in the properties of dredged material.

(4) Dredged material shall be disposed of by the Contractor in the dumping ground stated in the Contract.

(5) Silt curtains shall be provided as stated in Clause 21.47 before dredging commences so as to minimize water quality impact on surrounding environment.

DEPOSITION OF FILL MATERIAL BELOW +2.5 m PD

Commencement of deposition of fill material

21.55 The permission of the Engineer shall be obtained before deposition of fill material starts in any area.

Deposition of fill material

21.56 (1) Fill material shall be deposited in a manner and sequence such that minimum lateral displacement of the underlying material will be induced and such that slopes are stable at all times.

(2) The methods and construction plant used for deposition of fill material shall be such that segregation of the material does not result. Fill material shall not be deposited by end-tipping unless permitted by the Engineer.

(3) Fill material for blanketing layers and drainage layers shall be deposited uniformly by a method agreed by the Engineer.

(4) Silt curtains shall be provided as stated in Clause 21.47 before filling activities commence so as to minimize water quality impact on surrounding environment.

Deposition of fill material in dredged trenches

21.57 (1) The first layer of fill material in dredged trenches for seawalls, revetments and breakwaters shall be deposited as soon as practicable after the dredged profile has been agreed by the Engineer. The dredged trench shall be substantially free from silt and debris before deposition of fill material starts.

(2) Subsequent layers of fill material shall be deposited as soon as practicable after the profile of the underlying layer of fill material has been agreed by the Engineer.

Deposition of rock fill material adjacent to structures and utilities

21.58 (1) Rock fill material deposited adjacent to or above structures, piles or pedestals shall be hand packed or placed by a method approved by the Engineer.

(2) Rock fill material deposited around utilities, including pipes for submarine outfalls, shall be hand packed or placed by a method approved by the Engineer and shall be brought up to the specified level equally on both sides.

(3) Rock fill material deposited directly on geotextile shall be deposited in such a manner that the geotextile is not ruptured.

DEPOSITION OF ROCK ARMOUR AND ROCK FOR UNDERLAYER

Deposition of rock armour and rock for underlayer

21.59 (1) Each piece of rock armour shall be placed individually and shall not be deposited by tipping, dumping or dropping.

(2) Rock armour and rock for underlayer for breakwaters, revetments and similar structures shall be deposited by working from the bottom to the top of a section in such a manner and sequence that the individual rock pieces interlock and do not segregate. The interstices shall be kept free from small fragments of rock.

(3) Rock armour and rock for underlayer deposited directly on geotextile shall be deposited in such a manner that the geotextile is not ruptured.

LEVELLING AND COMPACTION OF FILL MATERIAL

Levelling of rock fill material in underwater foundations 21.60 The top surface of rock fill material in foundations for structures or pipes shall be thoroughly tamped with a concrete block weighing at least 10 t dropped through a height of at least 300 mm or by other methods agreed by the Engineer. The voids at the top of the foundation shall be filled with rock fill material (Grade 75).

CONSTRUCTION OF MARINE STRUCTURES

Construction of seawall blocks, copings and wave deflectors 21.61 (1) Formwork or moulds for precast concrete seawall blocks, copings and wave deflectors shall not be loosened or removed in less than 12 hours after completion of concreting.

(2) Precast concrete seawall blocks, copings and wave deflectors shall be marked with the date of casting, identification reference and orientation in the structure. The letters and figures used for marking shall be at least 75 mm high and shall be sufficiently durable to be legible until the unit is placed in the final position.

(3) Key holes in precast concrete seawall blocks, copings and wave deflectors shall be kept free from soil, aggregates, concrete and other materials before and after the blocks are set in position.

Setting of seawall blocks 21.62 (1) Seawalls constructed with precast concrete seawall blocks shall be constructed in layers between slip joints. The blocks shall be set in close contact with each other. Packing pieces shall not be used unless permitted by the Engineer.

(2) The permission of the Engineer shall be obtained before the next layer is placed on each completed layer of blocks.

Facing stones to seawalls and revetments 21.63 (1) Facing stones to seawalls and revetments shall be built up one course at a time. The stones shall be thoroughly washed and cleaned with fresh water before placing and shall be set in 1:3 cement mortar. In vertical concrete seawalls there shall be at least one header stone to each square metre of facework. Header stones shall be staggered in alternate courses.

(2) Concrete backing behind facing stones shall be placed as soon as each course of facing stones has been completed.

Slip joints in seawalls 21.64 (1) Slip joints in seawalls shall be straight and vertical and shall be perpendicular to the face of the seawall. The joints shall extend through the seawall from the coping down to the foundation.

(2) Joint filler shall be cut to size before fixing and shall be securely fixed in position to the existing surface with adhesive. Concrete to the adjacent section of seawall shall be placed directly against the joint filler.

Filling of channels in seawall blocks 21.65 The channels in precast concrete seawall blocks and backing to seawalls shall be filled with rock pieces of sizes between 20 mm to 40 mm.

Concrete copings to seawalls 21.66 Concrete copings to seawalls shall be constructed in lengths of at least 5 m and not more than 10 m.

Bermstones for marine 21.67 (1) Bermstones shall be placed as soon as practicable after toe blocks have

structures

been set in position or fill material has been deposited at the toe of marine structures.

(2) Bermstones shall be set in close contact with each other and with the structure. The longitudinal axis of bermstones shall be perpendicular to the alignment of the structure on plan.

Bagged concrete 21.68 (1) Bagged concrete shall consist of hessian or canvas bags filled to approximately 70% full with Grade 30/10 concrete.

(2) The bags shall be filled and the open ends tied or sewn up immediately before placing.

(3) The bags shall be placed in brick bond fashion and flattened into position. The open ends of the bags shall be directed away from the outside surface and the spaces between bags and between layers of bags shall be kept as small as practicable. Bags shall not be disturbed after placing.

Cutting and jointing timber for fendering systems 21.69 (1) The finished surfaces of timber for fendering systems shall be free from irregularities. The timber shall not be cut by force splitting.

(2) Timber which is to be pressure treated with preservatives shall be machined to the specified dimensions, sizes and shapes before treatment.

(3) Drilling of holes and cutting of notches and recesses in timber shall be completed before painting and installation starts.

(4) Pieces of timber shall not be jointed to form a member for the fendering system unless otherwise stated in the Contract.

(5) Unless otherwise permitted by the Engineer pressure treated timber shall not be cut or drilled for holes after the treatment process. If cutting or drilling is permitted, surfaces exposed by cutting or drilling shall be field-treated as stated in Clauses 21.69(6) and 21.69(7).

(6) Exposed surfaces of timber treated with creosote shall be field-treated by brushing, spraying or dipping with hot creosote.

(7) Exposed surfaces of timber treated with CCA salts shall be field-treated by brushing or dipping with either a 100 g/L solution of the wood preservative or a solution suitable for after-fabrication treatment as recommended in BS 4072.

Painting to timber fendering systems 21.70 (1) Timber members in fendering systems shall be painted with two coats of bituminous paint before installation.

(2) Steel fittings for fendering systems, other than the threaded portions of bolts, nuts and other fittings, shall be painted with one coat of primer and two coats of bituminous paint before installation. The minimum thickness of each coat shall be 300 μm.

(3) Bolt heads, shanks and nuts on the outer face of timber fendering systems shall be recessed into notches at a distance of 25 mm below the surface of the fenders. The notches shall be filled flush with the surface with a sealant composed of one part of bitumen and two parts of cement.

Installation of rubber 21.71 Timber or steel base templates shall be used to position anchor bolts for rubber

fenders fenders.

TRIALS FOR SUBMARINE OUTFALLS

Trials for submarine outfalls 21.72 (1) A trial shall be carried out to demonstrate that the proposed methods of lifting, laying and jointing pipes for submarine outfalls, including jointing of riser pipes to the diffuser pipes, comply with the specified requirements. The trial shall include a demonstration by a method agreed by the Engineer that the joints between the riser pipes and the diffuser pipes are sufficiently strong to withstand the forces which will be applied during construction of the submarine outfall.

(2) The trial shall be carried out at least 14 days before pipelaying starts.

Results of trials for submarine outfalls 21.73 If in the opinion of the Engineer the proposed methods of lifting, laying and jointing pipes as demonstrated by the submarine outfall trial do not comply with the specified requirements, particulars of proposed changes shall be submitted to the Engineer for approval. Further trials shall be carried out until in the opinion of the Engineer the methods are satisfactory.

Commencement of pipe-laying for submarine outfalls 21.74 Pipe-laying for submarine outfalls shall not start until in the opinion of the Engineer, the methods of lifting, laying and jointing pipes as demonstrated by the submarine outfall trial are satisfactory.

CONSTRUCTION OF SUBMARINE OUTFALLS

Laying of submarine outfall pipes 21.75 (1) Pipes for submarine outfalls shall be marked with fluorescent paint such that the sequence of laying will be seen on underwater photographs. The letters and numbers used for marking shall be at least 100 mm high and shall be painted in orange on a white background.

(2) Before submarine outfall pipes are laid, a guide rail of mild steel channel or other material agreed by the Engineer, painted with fluorescent paint, shall be laid on the levelling stones to provide a visible aid for laying pipes.

(3) During construction of submarine outfalls, the open ends of the outfall pipes and riser pipes shall be temporarily capped by a method agreed by the Engineer to prevent the entry of silt or fill material.

Marker blocks for submarine outfalls 21.76 (1) Concrete marker blocks for submarine outfalls shall be placed on top of the fill material along the alignment of the pipeline as soon as deposition of fill material has been completed.

(2) Concrete marker blocks shall be marked with fluorescent paint. The letters and numbers used for marking shall be at least 100 mm high and shall be painted in orange on a white background.

(3) Concrete marker blocks shall be linked by coloured nylon ropes of at least 25 mm diameter.

Diffuser pipes for submarine outfalls 21.77 Epoxy resin joints between riser pipes and diffuser pipes shall be made in dry conditions.

Diffuser caps for submarine outfalls

21.78 (1) Diffuser caps shall be placed on top of the open ends of riser pipes and precast end plates shall be placed on the open end of the outfall within 7 days after the pipeline has been tested.

(2) Marker buoys shall be tied to the diffuser caps with 1 m long nylon ropes of 6 mm diameter.

DEMOLITION OF MARINE STRUCTURES

Demolition of marine structures

21.79 (1) Demolition shall be carried out by methods approved by the Engineer.

(2) Demolition shall be carried out in such a manner and sequence that will facilitate recovering as much reusable and recycled material as possible.

(3) The Contractor shall take measures to sort out and separate the demolition debris on site to recover the reusable and/or recyclable material before disposal.

TOLERANCES

Tolerances: dredging

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

Tolerances: deposition of fill material

21.81 (1) The final surface of deposition and compaction of fill material, measured perpendicular to the specified surface, shall comply with the following requirements:

(a) Top surfaces to receive levelling stones shall be not more than 75 mm above, and not more than 250 mm below, the specified surface.

(b) Top surfaces of levelling stones shall be within 25 mm of the specified surface for foundations of structures and shall be within 50 mm of the specified surface for submarine outfalls.

(c) Other top surfaces shall be within 250 mm of the specified surface.

(2) There shall be no abrupt change in level of the finished surface of reclamation and levelling stones.

Tolerances: precast concrete seawall blocks and copings

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

Tolerances: timber fendering systems

21.83 (1) The dimensions of members of timber fendering systems shall be within 5 mm of the specified dimensions.

(2) The levels and positions of timber fendering systems shall comply with the following requirements:

(a) The top level of blocks for landings and steps shall be within 5 mm of the specified level.

(b) The top level of other members shall be within 10 mm of the specified level.

(c) The horizontal position perpendicular to the berthing face of the fendering system shall be within 10 mm of the specified position.

(d) The horizontal position parallel to the berthing face of the fendering system shall be within 25 mm of the specified position.

Tolerances: rubber fenders

21.84 (1) The dimensions of rubber fenders and bolt holes shall comply with the following requirements:

(a) The bolt hole diameter shall be within 2 mm of the specified diameter.

(b) The bolt pitch shall be within 4 mm of the specified pitch.

(c) The height, length and width of rubber fenders shall be within +4% and -2% of the specified dimensions.

(d) The thickness of fender sections shall be within +8% and -5% of the specified thickness.

(2) The positions of rubber fenders shall comply with the following requirements:

(a) The centrelines shall be within 25 mm of the specified positions on the face of the supporting structures.

(b) The inclination shall not deviate by more than 1 in 50 from the specified inclination.

Tolerances: plastic fenders

21.85 The dimensions of plastic fender shall be within the allowable tolerance specified by the manufacturer.

Tolerances: submarine outfalls

21.86 (1) The horizontal alignment of submarine pipelines shall be within 250 mm of the specified alignment.

(2) The invert level of submarine outfalls shall be within 50 mm of the specified level.

(3) There shall be no abrupt change in alignment or level of the submarine outfall.

TESTING: DREDGED MATERIAL

Samples: dredged material

21.87 (1) Areas being dredged shall be divided into a grid at 15 m intervals. One sample of dredged material shall be provided from each point on the grid at 2 m depth intervals. Additional samples shall be provided from positions instructed by the Engineer if there appears to be any change in the quality of the dredged material.

(2) The mass of each sample shall be at least 1 kg. The method of sampling shall be as agreed by the Engineer.

Testing: dredged material

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

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

Batch: fill material for marine works

21.89 A batch of fill material for marine works is any quantity of fill material for marine works of the same type and which in the opinion of the Engineer has similar properties throughout.

Samples: fill material for marine works

21.90 (1) Except for public fill as stated in Section 6, one sample of each type of fill material for marine works shall be provided at the same time as particulars of the material are submitted to the Engineer for approval. Unless otherwise agreed by the Engineer, one sample of each type of fill material for marine works shall be provided from each batch.

(2) The size of samples and the method of sampling shall be as stated in Clause 6.71.

(3) When the material is delivered to the site, 1 sample shall be taken from each 5,000 m^3 or part thereof of each batch of each type of fill material for marine works.

Testing: fill material for marine works

21.91 (1) Each sample of fill material shall be tested to determine the particle size distribution, plasticity index and coefficient of uniformity.

(2) The method of testing shall be in accordance with the following:

Particle size distribution	: Clause 6.72(3)
Plasticity index	: Test Method 6.1 of Geospec 3
Coefficient of uniformity	: Clause 6.72(4)

Non-compliance: fill material for marine works

21.92 (1) If the result of any test for particle size distribution, plasticity index or coefficient of uniformity of fill material for marine works does not comply with the specified requirements for the property, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.

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

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

Batch: rock armour 21.93 A batch of rock armour is any quantity of rock armour of the same type and which in the opinion of the Engineer has similar properties throughout.

Samples: rock for rock armour 21.94 (1) One sample of each proposed type of rock for rock armour shall be provided at the same time as particulars of the material are submitted to the Engineer for approval.

(2) If instructed by the Engineer, a representative sample of each type of rock for rock armour, broken down into appropriate sizes, shall be provided for testing under Clause 21.95.

Testing: rock for rock armour 21.95 (1) Each sample of rock for rock armour taken as stated in Clause 21.94(2) shall be tested to determine the specific gravity, water absorption, aggregate impact value, ten percent fines value, aggregate abrasion value and soundness.

(2) The method of testing shall be in accordance with the following:

Relative density	: CS3
Water absorption	: CS3
Aggregate impact value	: CS3
Ten percent fines value	: CS3
Aggregate abrasion value	: BS EN 1097-8
Soundness	: BS 6349:Part 1 and BS EN 1367-2

Samples: rock armour 21.96 (1) One sample piece of each type of rock armour shall be provided for the dropping test from each 100 pieces or part thereof of that type delivered to the Site.

(2) One sample piece of each type of rock armour of the specified minimum size and one piece of the specified maximum size shall be provided near the deposition location for checking the sizes of material at all times during the deposition of rock armour.

(3) The sample pieces of the specified minimum and maximum sizes shall be mounted on individual plinths at locations agreed by the Engineer. The design and details of the plinths shall be prepared by the Contractor and agreed by the Engineer.

(4) When the material is delivered to the site, 1 bulk sample of rock armour consisting of not less than 50 pieces of randomly selected rock armour shall be taken from each 5,000 m3 or part thereof each batch.

Testing: rock armour

21.97 (1) Each sample piece of rock armour taken as stated in Clause 21.96(1) shall be tested by the dropping test to determine the resistance to fracture.

(2) The dropping test shall be carried out with the largest cross-section of the specimen horizontal. The specimen shall be dropped from a vertical height to the underside of the specimen of 1.5 m, onto a steel plate. The steel plate shall be at least 20 mm thick and shall be firmly bedded on a level concrete base.

(3) Each piece of the rock armour taken from the bulk sample as stated in Clause 21.96(4) shall be weighed individually to the accuracy of 2% of the specified minimum weight.

Non-compliance: rock for rock armour

21.98 (1) If the result of any test for specific gravity, water absorption, aggregate impact value, ten percent fines value, aggregate abrasion value or soundness of rock for rock armour does not comply with the specified requirements for the property, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.

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

Non-compliance: dropping test

21.99 (1) If a sample piece of rock armour fractures as a result of the dropping test, nine additional sample pieces of rock armour from the same group of 100 pieces or part thereof shall be tested. If any one of these sample pieces fracture as a result of the dropping test, every piece of rock armour in the same group shall be tested. Only those pieces of rock armour passing the dropping test shall be used.

(2) A specimen is deemed to fracture if:

(a) Cracking occurs after dropping, or

(b) The difference in masses of the original specimen and the largest single piece after dropping exceeds 1% of the mass of the original specimen.

Non-compliance: weighing test

21.100 (1) If the bulk sample does not comply with the specification, 2 additional bulk samples shall be provided from the same batch and additional weighing tests shall be carried out.

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

Testing: rock for underlayer

21.101 The sampling, testing and compliance criteria of rock for underlayer of rock armour shall be the same as those of the rock armour as specified in Clauses 21.93 to 21.100 except that no dropping test is required.

TESTING: TIMBER FOR FENDERING SYSTEMS

Batch: timber for fendering systems

21.102 A batch of timber for fendering systems is any quantity of timber for fendering systems of the same grade and species and from the same source, covered by the same test certificates and bills of lading.

Samples: timber for fendering systems

21.103 One sample of timber for fendering systems shall be provided at the same time as particulars of the material are submitted to the Engineer for approval. Unless otherwise permitted by the Engineer, six samples shall be provided from each batch of timber for fendering systems delivered to the Site.

Testing: timber for fendering systems

21.104 (1) For fendering systems delivered to the site, the samples shall be provided in pairs taken from three separate balks of timber. Each sample shall be 1000 mm x 50 mm x 50 mm and shall be cut with the longest dimension parallel to the grain and the two shorter dimensions tangential and radial to the growth rings.

(2) Each sample of timber for fendering systems shall be tested to determine the oven dry density, static bending at rupture, modulus of elasticity under bending, hardness, compressive stress parallel to grain at maximum load and shear stress parallel to grain at maximum load.

(3) The method of testing, including the Janka indentation test for hardness, shall be in accordance with BS 373 except that the specimens shall be tested at a moisture content of at least 25%.

Compliance criteria: Janka indentation test, test for shear stress parallel to grain at maximum load

21.105 The results of Janka indentation tests and tests for maximum shear parallel to grain of timber for fendering systems shall comply with the following requirements:

(a) Each of the results of Janka indentation tests on the end face, radial face and tangential face shall comply with the requirements stated in Table 21.4.

(b) Each of the results of tests for shear parallel to grain on the radial face and tangential face shall comply with the requirements stated in Table 21.4.

Non-compliance: timber for fendering systems

21.106 (1) If the result of any test for oven dry density, static bending at rupture, modulus of elasticity under bending, hardness, compressive stress parallel to grain at maximum load or shear stress parallel to grain at maximum load, of timber for fendering systems does not comply with the specified requirements for the property, three additional pairs of samples shall be provided from the same batch and additional tests for the property shall be carried out.

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

TESTING: RUBBER FENDERS

Batch: rubber fenders 21.107 A batch of rubber fenders is any quantity of rubber fenders of the same type and from the same source, covered by the same test certificates.

Samples: rubber fenders 21.108 Unless otherwise permitted by the Engineer, one sample shall be provided from each 50 rubber fenders or part thereof delivered to the Site.

Testing: rubber fenders 21.109 (1) Each sample of rubber fenders shall be compression load tested either at a laboratory approved by the Engineer or at the manufacturer's workshop in the presence of the representative of a Government body or other organisation approved by the Engineer.

(2) Each sample of rubber fenders shall be subjected to three complete load cycles at a rate of 200 mm ± 20 mm per minute to 50% deflection. The results of the test shall be shown on a load-deflection curve and on an energy-deflection curve.

Compliance criteria: rubber fenders 21.110 The result of compression load tests on rubber fenders shall comply with the following requirements:

(a) The sample shall not show any visible sign of cracks or permanent deformation in shape.

(b) The height of each sample one minute after releasing the third compression load shall be at least 95% of the original height.

(c) The recovery in height shall be as stated in Clause 21.110(b) for the repeated compression test.

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

Non-compliance: rubber fenders 21.111 (1) If the result of any compression load test on rubber fenders does not comply with the specified requirements stated in Clause 21.110, two additional samples shall be provided from the same batch and additional tests for the property shall be carried out.

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

TESTING: PLASTIC FENDERS

Batch: plastic fenders 21.112 A batch of plastic fenders is any quantity of plastic fenders of the same type and from the same source, covered by the same test certificates.

Samples: plastic fenders 21.113 Test samples shall be selected by the Engineer at a sampling rate of 1 sample per batch of 50 plastic fenders.

Testing: plastic fenders 21.114 (1) Each sample of plastic fenders shall undergo the loading test in

accordance with Appendix 21.1.

(2) After testing, the Contractor shall deliver the test samples to the storage shed or other areas as instructed by the Engineer.

Compliance criteria: plastic fenders

21.115 (1) The test result of loading test shall comply with the requirements of Table 21.6.

(2) If the test result of loading test does not comply with the requirements of Table 21.6, 2 additional test samples from the same batch shall be selected by the Engineer for additional loading test in accordance with Appendix 21.1.

(3) The batch shall be considered as not complying with specified requirements if the result of any additional loading test fails to comply with such requirements.

TESTING: SUBMARINE OUTFALLS

Testing: submarine outfalls

21.116 (1) Submarine outfalls shall be tested to determine if there is any blockage or leakage.

(2) Precast end plates and diffuser caps shall be removed before the outfall is tested.

(3) The outfall shall be cleaned by high velocity water jets or by other electromechanical methods agreed by the Engineer. Riser pipes and diffuser pipes shall be cleaned by high capacity grit suction pumps or by other methods agreed by the Engineer.

(4) The outfall shall be tested for blockages by pulling a mandrel approved by the Engineer through the outfall between manholes and between manholes and the end of the outfall. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.

(5) Riser pipes and diffuser pipes shall be tested for blockages and leakage by pumping dyed water through the outfall and inspecting the discharge plume at each riser pipe. Precast end plates shall be replaced before the test is carried out.

Compliance criteria: submarine outfalls

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

Non-compliance: submarine outfalls

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

APPENDIX 21.1

LOADING TEST FOR PLASTIC FENDERS

Scope

21.1.1 This method covers the determination of the flexural properties of plastic fenders.

Equipment

21.1.2 The following equipment is required:

(a) Loading machine.

(b) Equipment for measuring the loads applied shall be accurate to within 2% of the maximum load to be measured.

(c) Dial gauges for measuring deflection shall be accurate to 0.1 mm.

(d) Supports shall be cylindrical rods with diameter not less than 25 mm and the length of cylindrical rods shall be longer than the width of test sample by at least 100 mm.

Procedure

21.1.3 The procedure shall be as follows:

(a) Test sample shall be placed on the supports in accordance with Figure 21.1.

(b) Loading shall be applied to the test sample at increment of 10 kN until the specified loading is reached. Both readings of the applied loading and dial gauges shall be recorded.

(c) After loading, the test sample shall be inspected. Any defects shall be recorded and reported in the test report.

Reporting of results

21.1.4 The following shall be reported:

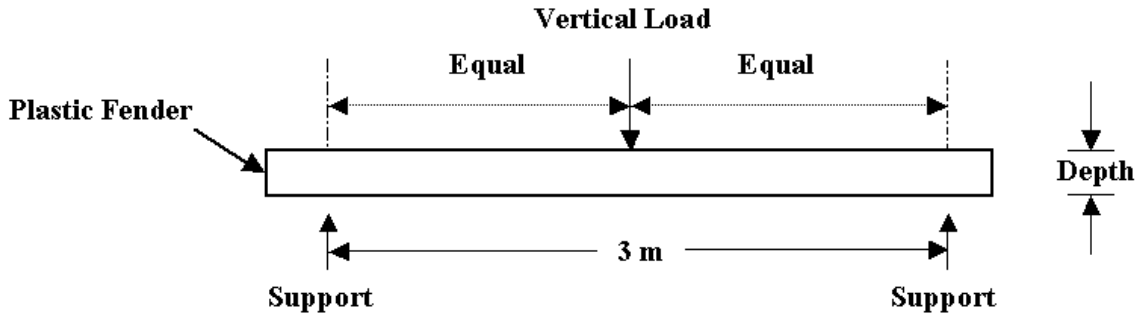
(a) The vertical load applied.

(b) The vertical deflection during the loading test.

(c) The load against deflection curve.

(d) Record of defects after the loading test.

Figure 21.1 – Arrangement of loading test for plastic fenders**:**



Notes:

1) Load is applied to the major axis of the test sample.
2) Two dial gauges are provided at mid span of the test sample to measure the deflection during testing.
3) The mean value of deflection is calculated based on the reading of the dial gauges.

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

MATERIALS

Mix constituents 21.2.1 Clause 16.03 – Sub-clause (1) is replaced by (1) below: -

(1) Cementitious content is the combined mass of cement, Pulverised Fuel Ash (PFA) or Ground Granulated Blastfurnace Slag (GGBS), and the dry mass of Condensed Silica Fume (CSF) per cubic metre of compacted concrete. PFA, GGBS and CSF are referred to as supplementary cementitious materials in this Specification.

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 21.2.6 Clause 16.13(2) is added below: -

concrete

(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.

SUBMISSIONS

Particulars of materials for concrete

21.2.8 Clause 16.17 - The first sentence of sub-clause (1) is deleted and replaced by:

"The following particulars of the proposed cement, PFA, GGBS, CSF and aggregate shall be submitted to the Engineer for approval:"

The results of the following test is added at the end of Sub-clause (1)(d): -

" - sodium sulphate soundness"

Sub-clause (1)(f) is added below: -

(f) A certificate issued within Amd 3/2021 6 months for CSF showing the source of the CSF and showing that the CSF complies with the requirements stated in the Contract.

Particulars of ready-mixed concrete supplier

21.2.9 Clause 16.19 is replaced by the following: -

"The Contractor shall arrange for the Engineer or Engineer's Representative to inspect the supplier's plant or plants if required before and/or during the period of supply. The name of the supplier, the type of plant, and the location of each plant, including a back-up plant, from which the Contractor proposes to obtain ready-mixed concrete shall be submitted to the Engineer for approval at least 14 days before trial mixes are made or if trial mixes are not required, at least 14 days before the ready-mixed concrete is placed in the permanent works."

Particulars of precast concrete units

21.2.10 Clause 16.21 – New sub-clauses (3) to (6) are added below: -

(3) The following particulars of the precast concrete units shall be submitted to the Engineer for approval at least 21 days before the casting work starts:

(a) Layout of the precasting yard,

(b) Methods and sequence of casting and placing the units,

(c) Methods of testing for checking continuity of steel reinforcement before and after casting, and

(d) Methods and details of handling and storage of the precasting units.

(4) Precast concrete units shall be stored on level supports and in a manner which will not result in damage or deformation to the units or in contamination of the units. The units shall be protected from damage and any damaged units shall be replaced or repaired to the satisfaction of the Engineer.

(5) Particulars of the proposed method and devices to be used for lifting and setting of the precast concrete units shall be submitted to the Engineer for approval at least 14 days before the lifting works starts.

(6) Contact surfaces between precast concrete units shall be prepared as stated in the Contract. Dimensional tolerances shall be checked in accordance with the new Clause 16.97 in paragraph 21.2.25 of this Specification. Discrepancies in dimensions of the units shall be rectified by a method approved by the Engineer before the units are lifted into position.

HANDLING AND STORAGE OF MATERIALS

Storage of cement, PFA, GGBS and CSF

21.2.11 Clause 16.33 – New sub-clause (3) is added below: -

(3) Cement and supplementary cementitious materials from different sources shall not be used in the same pour and may only be used in the same structure with the Engineer's prior approval.

BATCHING AND MIXING CONCRETE

Batching concrete

21.2.12 Clause 16.37 – Sub-clause (2) is replaced by the following:

(2) The quantities of cement, supplementary cementitious materials and fine and coarse aggregate shall be measured by mass except that cement supplied in bags may be measured by using a whole number of bags in each batch. The mass of aggregates shall be adjusted to allow for the free moisture content of the aggregates.

Mixing concrete

21.2.13 Clause 16.38 – New sub-clause (6) is added below: -

(6) Remixing of partially hardened concrete with or without additional cement, PFA, aggregate or water is prohibited.

TRANSPORTATION OF CONCRETE

Transportation of Concrete

21.2.14 Clause 16.39 – New sub-clause (3) is added below: -

(3) Particulars shall be submitted to the Engineer for approval at least 14 days before placement of concrete regarding the method of transporting concrete from the production plant to the Site and the methods of handling concrete for placement on the Site.

RECORDS OF CONCRETE

Records of concrete

21.2.15 Clause 16.40 – New sub-clause (1)(k) is added below: -

(k) time of introduction of cement and supplementary cementitious materials to the mix.

PLACING AND COMPACTING CONCRETE

Placing concrete

21.2.16 Clause 16.41 – New sub-clauses (10) to (16) are added below: -

(10) All areas in which concrete is to be placed shall be clean and free from standing water immediately before the placing of the concrete, except for concrete placed under water.

(11) Unless otherwise permitted by the Engineer, rock or earth surfaces on which concrete, unless the concrete is placed by tremie, is to be placed shall be prepared after site clearance in accordance with the following requirements:-

(a) Topsoil, grass and other organic matter shall be removed.

(b) Soft spots, boulders loose/ shattered/ unsound rock fragments and other materials which in the opinion of the Engineer are unsuitable

or unstable shall be removed.

(12) Concreting to structures below +2.5 m CD shall be carried out in the dry at low tides using formwork with watertight joints or an equivalent method accepted by the Engineer.

(13) On completion of concreting below +2.5 m CD, the top of the concrete shall be adequately covered to prevent washout of cement paste as the water level rises or falls.

(14) No concrete shall be placed in flowing water.

(15) The Contractor shall be responsible for setting and maintaining forms sufficiently within the tolerances, and shall ensure that the work is completed within the specified tolerances. Concrete work falling outside the tolerances shall be remedied or replaced by and at the expense of the Contractor.

(16) The swellable waterstop shall be kept in dry conditions for at least 48 hours prior to casting the pile connection holes.

Compacting Concrete 21.2.17 Clause 16.44 – New sub-clauses (7) to (9) are added below: -

(7) Concrete shall be compacted and in its final position within 2.5 hours of the introduction of water to mixture and within 30 minutes of discharge from agitator, truck mixer and static mixer.

(8) An internal vibrator shall operate at not less than 10,000 cycles per minute.

(9) Concrete shall not be subjected to vibration between 4 hours and 24 hours after compaction.

CURING CONCRETE

Curing concrete 21.2.18 Clause 16.46 – Sub-clauses (1) and (2) are replaced by the following and sub-clauses (3) and (7) are deleted: -

(1) After final set has taken place the concrete shall be cured for at least 7 days. All exposed surfaces shall be protected from the sun and wind immediately after the initial set has occurred and the concrete shall be kept moist by light water spray or other suitable means until curing methods are applied. Surfaces from which formwork has been removed before 7 days shall be cured for the remaining period.

(2) The following curing methods are acceptable:

(a) Moist Curing
Concrete shall be covered by canvas, hessian or polyethylene sheeting and kept continuously moist. Where polyethylene sheeting is used, all edges of the sheeting shall be securely fastened so that no air circulation can occur. Concrete surfaces which have become dry shall be thoroughly wetted before the sheeting is placed. Alternatively, exposed surfaces can be cured by flooding or continuous sprinkling. Formwork left in position shall be kept continuously wet.

(b) Curing Compounds
Curing compounds shall comply with Clause 16.11 and methods of applications shall be submitted for the approval of the Engineer prior to concrete placement. 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.

TESTING: CONCRETE – COMPRESSIVE STRENGTH

Testing: compressive strength of concrete

21.2.19 Clause 16.59 – Sub-clause (3) is replaced by the following: -

(3) Test cubes which are cured on the Site shall be delivered to the testing laboratory as specified by the Engineer at least 36 hours before the tests are due to be carried out. The Contractor shall provide an on-site covered curing tank of internal dimension 2200 x 1200 x 900 mm deep with lock for storage of test cubes. The curing tank shall be made of galvanized steel coated with epoxy/tar paint and fitted with bottom drain, water inlet, overflow facilities and lifting lugs. The curing tank shall be thermostatically controlled within the range 27°C ± 3°C and be completed with an impeller type circulation device of suitable design to maintain a temperature gradient of better than 0.5°C. The temperature control mechanism shall be equipped with both heating and cooling system. All mechanisms shall be suitably protected from damage. The tank base shall be fitted with mesh racks, suitably treated to prevent corrosion, which allow water circulation beneath the cubes. The rack shall be constructed in at least 3 sections for ease of handling and removal.

PART 2: JOINT IN CONCRETE

MATERIALS

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°C to +70°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.

MISCELLANEOUS

Blinding concrete

21.2.24 New clause 16.93 is added below: -

Blinding concrete shall be grade 10/20 and shall be cast in bays with vertical joint properly formed.

Construction tolerances

21.2.25 New Sub-clause 16.94 is added below: -

(1) Unless otherwise specified, the dimensional tolerances for concrete construction shall comply with BS 5606:1990. Verification of tolerances shall be made by measurement made as close as practicable to 28 days after casting the appropriate element of structure for in situ construction or at the time of incorporation into the Works in the case of precast units.

(2) Unless otherwise specified, the tolerances for insitu concrete in the finished work shall be :

(a) Variation from plumb in any 3 m: 6 mm
Variation from plumb in any 12 m: 18 mm

(b) Variation of level or lateral position of any point from its level or lateral position indicated or completed: 12 mm

(c) Variation in slab and wall thickness: +6 mm, -3 mm

(d) Variation of level or lateral position of any point, for machinery installation, from its level or lateral position indicated or completed: +5 mm, -12 mm

(3) Unless otherwise specified, the tolerances for precast concrete construction in the completed work shall be:

(a) Length

Up to 2 m	±6 mm
2 m to 6 m	±9 mm
Over 6 m	±12 mm

(b) Cross section width or height

Up to 2 m	±4 mm
2 m to 6 m	±6 mm
Over 6 m	±8 mm

(c) Cross section thickness or depth

Up to 0.5 m	±6 mm
Above 0.5 m	±8 mm

(d) Straightness or bow (deviation from intended line)

Up to 3 m	±6 mm
3 m to 6 m	±8 mm

(e) Length

Up to 1.2 m	±6 mm
1.2 m to 1.8 m	±9 mm
Over 1.8 m	±12 mm

(f) Gap

The gaps between adjacent units shall not exceed 15 mm ±5 mm.

(4) Discrepancies in dimensions of the concrete construction works shall be rectified by methods approved by the Engineer. If the said concrete construction works cannot be rectified to the satisfaction of the Engineer, the concrete construction works shall be removed and reconstructed. Any additional expenses incurred thereon shall be borne by the Contractor.

Use of displacers 21.2.26 New Sub-clause 16.95 is added below: -

"Where their use is approved, displacers shall be clean and dry and carefully placed into the concrete as pouring proceeds. There shall be at least 225 mm between any two pieces, or between the displacers and the face of the concrete. The mass of displacers in any one pour of concrete shall not exceed 20% of the total mass of that pour."

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.

REINFORCED CONCRETE IN MARINE ENVIRONMENT

Reinforced Concrete in Marine Environment 21.2.29 New Sub-clause 16.98 is added below: -

"For avoidance of doubt, concrete of Grade 45/20 or above in a marine works contract is regarded as Reinforced Concrete in Marine Environment and the specification contained in this Appendix shall apply."

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 22

WATER SUPPLY PIPEWORKS

SECTION 22

WATER SUPPLY PIPEWORKS

GENERAL

General requirements	22.01	The works and materials specified in Clauses 22.02 to 22.05 shall comply with the sections stated, unless otherwise stated in this Section.
Drainage works	22.02	Drainage works shall comply with Section 5.
Earthworks	22.03	Earthworks shall comply with Section 6.
Formwork	22.04	Formwork and finishes to concrete shall comply with Section 14.
Concrete	22.05	Concrete shall comply with Section 16.

GLOSSARY OF TERMS

Fitting	22.06	Fitting is a component fitted to a pipe for jointing or connecting or for changing the direction or bore of a pipe.
Flexible joint	22.07	Flexible joint is a connection between pipes and fittings that provides angular deflection or axial movement or a combination of both in service without impairing the efficiency of the connection.
Mechanical joint	22.08	Mechanical joint is a flexible joint in which an elastomeric joint ring is located in the socket and the joint sealed by applying pressure to the joint ring by means of a gland bolted to the socket.
Nominal size	22.09	Nominal size (DN) is a numerical designation of size, which is common to all components in a pipework system. The nominal size is stated as a convenient round number in millimetres and is related to, but not normally the same as, the actual internal diameter of the pipeworks. "dn" designates the nominal size of tees and tapers that are less than DN.
Push-in joint	22.10	Push-in joint is a flexible joint in which an elastomeric joint ring is located in the socket and the joint is effected by entering the spigot through the joint ring into the socket.
Special fitting	22.11	Special fitting is a fitting that is made from a manipulated or fabricated pipe.
Thin- walled pipe	22.12	Thin-walled pipe is a pipe, including pipes of DN 1200 or greater, which has a ratio of nominal size to wall thickness, excluding linings and coatings, exceeding 125.

MATERIALS

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 as stated in Clause 22.73. 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 35ºC 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 and the details shown in Drawing No. WSD 1.21 of the standard drawing of Water Supplies Department. Amd 2/2025

(5) Tolerance for pipe thickness shall comply with Clause 7.7 of BS EN 10224:2002. No negative tolerance is allowed. Amd 2/2025

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.

DI 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.

Polyethylene pipes and fittings 22.16 Polyethylene (PE) pipes and fittings shall comply with BS EN 12201-1, BS EN 12201-2 and BS EN 12201-3.

Not used 22.17 Not used.

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) Steel puddle flanges shall be separated into 180° segments.

(4) 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.

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.

(2) Bolts and nuts shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

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

Elastomeric joint rings 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.

(4) Bituminous tapes shall be stored in a cool dry place away from the sun's rays. No dirt or grits shall be allowed to stick on the edge of the tape before applying the tape for pipe protection.

(5) The following particulars of the proposed anticorrosion tape for water supply pipeworks shall be submitted to the Engineer:

(a) Manufacturer’s literature for anticorrosion tape, and

(b) Certificate for anticorrosion tape showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests in accordance with the Contract.

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

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	Self	0.5	N/A

strength to JIS Z 1902 (N/mm)	Steel	0.5	N/A
Dielectric strength (2 layers) (kV)		15	30
Elongation (at break) (%)		-	260
Temperature range(^{0}C)	Wrapping	-5 to +55 Amd 1/2022	+5 to +50
	In service	-20 to +70 Amd 1/2022	-20 to +75

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

Polyethylene sheeting 22.26 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

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.

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

Materials provided by the Employer 22.28 (1) The following materials for water supply pipeworks included in Contracts entered into with Water Supplies Department will be provided by the Employer and shall be used in the permanent works:

(a) Full, half and quarter length pipes with plain, flanged and spigot and socket ends,

(b) Ring flanges, puddle flanges, slip-on type couplings, flange adapters, collars, expansion joints, detachable joints, elastomeric joint rings, nuts and bolts,

(c) Blank flanges and caps other than those required for pressure tests,

(d) Bends, tees and tapers,

(e) Steel pipes for the fabrication of gusseted steel bends and tees,

(f) Primer, bitumen based composition and woven glass cloth for repairs to joints in steel pipes with bitumen coating provided by the Employer other than materials for protection of steel flanged joints, slip-on type couplings and flange adapters, and

(g) Gate valves, air relief valves, butterfly valves and non-return valves, including all winding gear, operating motors and control equipment.

(2) The materials shall be obtained from the locations and at the times stated in the Contract.

(3) Water and sterilising chemicals for cleaning, sterilising and testing pipelines as stated in Clauses 22.73 and 22.81 will be provided by the Employer for one set of tests. The water and sterilising chemicals shall be obtained from the locations stated in the Contract or from other locations agreed by the Engineer and shall be mixed by the Contractor.

Equipment loaned by the Employer

22.29 The continuous pressure recorder and purpose made charts for pressure tests on pipelines for water supply pipeworks as stated in Appendix 22.1 will be loaned by the Employer.

INSPECTION OF MANUFACTURE

Inspection of manufacture and testing

22.30 (1) The manufacture and testing of pipes, joints, fitting and valves for water supply pipeworks other than materials provided by the Employer shall be inspected by an independent inspection authority approved by the Engineer.

(2) The inspections shall be carried out at the manufacturer's works or at other locations stated in the Contract or instructed by the Engineer. The facilities and equipment required for inspections shall be provided by the Contractor.

SUBMISSIONS

Particulars of independent inspection authority

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

Particulars of pipes, joints and fittings

22.32 (1) The following particulars of the proposed pipes, joints and fittings for water supply pipeworks shall be submitted to the Engineer:

(a) Manufacturer's literature, including details of:
- Manufacturing process
- Pressure and temperature ratings
- Permissible values of straight draws and angular deflection of flexible joints
- Recommendations for handling, storage, laying, jointing and

repair
- Drilling and tapping equipment for connections to pipes,

A certificate for each material showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests required in accordance with the relevant British Standard,

(b) Three copies of drawings showing details of the pipes, joints and fittings, including the materials used and the mass of each item, and

(c) A certificate of inspection of the manufacture and testing signed by the approved independent inspection authority.

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

Particulars of welding 22.33 (1) The following particulars of the proposed materials and methods of construction for welding joints in steel pipes for water supply pipeworks shall be submitted to the Engineer:

(a) Details of welders, including names, copies of Hong Kong Identity Cards and details of previous experience,

(b) Details of format of records,

(c) Details of welding procedures, including welding plant, method of welding, materials, manufacturer and size of electrodes, number of runs and current strength,

(d) Procedures for nitrogen gas tests on joints, and

(e) Valid certificate of competency in accordance with BS 2633, Clause 11 for each welder, issued by an authority approved by the Engineer.

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

Particulars of pressure tests 22.34 (1) The following particulars of the proposed procedures for pressure tests on pipelines for water supply pipeworks shall be submitted to the Engineer:

(a) Test equipment and method of setting up the equipment,

(b) Calibration certificates for pressure gauges,

(c) Procedure for carrying out the test, and

(d) Programme for testing.

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

TRIALS

Welding trials 22.35 (1) Unless otherwise permitted by the Engineer, trials shall be carried out to demonstrate the competency of each proposed welder who will be employed to weld joints in steel pipes for water supply pipeworks.

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

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

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

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

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

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

Pipe jointing trials 22.36 (1) Trials shall be carried out to demonstrate that the pipes, joints and fittings for water supply pipeworks fit correctly.

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

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

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

Trials for drilling and tapping 22.37 (1) Trials shall be carried out to demonstrate that the proposed equipment and methods of drilling and tapping pipes for water supply pipeworks will produce connections that comply with the specified requirements.

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

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

TRANSPORT, HANDLING AND STORAGE OF MATERIALS

Transport, handling and storage of pipes, joints and fittings

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

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

(3) Not used

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

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

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

Handling of pipes and fittings

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

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

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

Storage of pipes

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

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

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

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

Transport of thin walled pipes

22.41 When being transported, thin-walled pipes shall be supported on three rubber-covered saddles shaped such that the pipes are supported over at least one-

quarter of the circumference. The pipes shall be securely fixed in position at each saddle by straps tightened by turnbuckles. One saddle shall be placed at the mid-point of the length of the pipe and the other two saddles shall be placed at distances of one-fifth of the length of the pipe from each end of the pipe.

Handling and storage of thin walled pipes 22.42 (1) When being handled and stored, thin walled pipes shall be protected from deformation by means of at least two screw jack cruciform struts with rubber-padded ends shaped to fit the circumference of the pipes. The struts shall be fitted inside the pipes. Any temporary struts fixed by the manufacturer shall be left in position until the cruciform struts have been fixed.

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

(3) Thin-walled pipes shall not be rolled.

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

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

Storage of valves 22.43 Valves, including power operated valves and associated electrical and control equipment, shall be stored in accordance with the manufacturer's recommendations in a weatherproof store.

ACCESS TO PIPELINES

Access to pipelines 22.44 (1) Rubber wheeled trolleys shall be provided to obtain access inside pipelines exceeding DN 500 for water supply pipework in order to joint pipes, repair joints, coatings and linings and inspect the pipeline. Persons entering pipelines shall wear clean soft-soled footwear.

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

SETTING OUT OF PIPELINES

Setting out of pipelines 22.45 (1) Both horizontal and vertical alignment shown on the Drawings are indicative only. The exact alignment shall be determined by the Engineer on site in accordance with the procedure set out in this Clause.

(2) Three weeks before commencing trench excavation of a section of pipeline, the Contractor shall set out on site such section of pipeline based on

the indicative information given on the Drawings and shall proceed to conduct the underground utilities survey. When this has been carried out, the Contractor shall prepare his proposal of inspection pits excavation and submit the same to the Engineer for agreement two weeks before commencing trench excavation all in accordance with Clause 1.25(6). The agreed inspection pits excavation shall be completed within one week to provide the remaining one week as float time for the Engineer to inspect and, if found necessary, adjust the indicative alignment to suit topography and obstruction in accordance with sub-clause (3) of this Clause.

(3) The Engineer may order excavation of inspection pits after initial setting out or after the completion of the excavation of inspection pits proposed by the Contractor at locations that may deviate from the proposed indicative alignment to ascertain the final alignment. The inspection pits so ordered shall be payable under the Bills of Quantities. The Contractor shall exercise his best endeavour to complete such inspection pits excavation before the scheduled commencement date for trench excavation.

(4) The method of setting out shall be a centre line peg with suitable offset at every change in horizontal alignment and a slight rail mounted on two posts at 30m maximum or at every change in vertical alignment or any other appropriate methods agreed by the Engineer.

(5) Following the setting out and adjustments, if any, the existing ground levels shall be recorded and agreed.

(6) The chainages shown on the Drawings for mainlaying works are nominal only and should only be used as a means of reference. The measured distance between the chainages assigned to any two points will not necessarily be that given by the difference in those chainages.

LAYING AND BEDDING PIPES

Laying pipes 22.46 (1) The Engineer shall be allowed to inspect trenches, bedding, pipes, joints, fittings and valves before pipelaying for water supply pipeworks starts. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before pipelaying starts in any part of the permanent work.

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

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

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

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

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

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

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

Laying steel pipes 22.47 Steel pipes with welded joints for water supply pipeworks shall be spot welded to the adjacent pipe to which they will be jointed immediately after laying. Steel pipes manufactured with longitudinal or spiral welds shall be aligned in such a manner that the welds are staggered from pipe to pipe by at least 15° of arc.

Laying pipes with flexible joints 22.48 The degree of the curve of pipes for water supply pipeworks with flexible joints, which are to be laid to a curve, shall be equally distributed over all joints within the curved section. The deflection at a completed joint shall not exceed 3° or three-quarters of the maximum deflection recommended by the manufacturer whichever is less.

Installation of valves 22.49 (1) Operating gear and associated fittings shall be installed and fixed at the same time as valves for water supply pipeworks are installed. After installation, valves shall be cleaned inside and outside and left in a closed position.

(2) Extension keys and clamps shall be fixed to valves in valve chambers if the vertical distance between the top of the valve spindle and the finished ground level exceeds 600 mm. The length of extension keys shall be such that the top of the extension key is not more than 300 mm below the finished ground level.

Bedding pipes 22.50 (1) Surfaces on which pipes for water supply pipeworks will be laid shall be cleaned and objects that may damage the pipes shall be removed before pipes are laid.

(2) The bottom of trenches on which pipes will be laid directly shall be shaped to support the pipes uniformly along the length of the barrel. Holes shall be dug to prevent pipes resting on the sockets and to allow the pipes to be jointed.

CUTTING AND DRILLING PIPES

Cutting pipes 22.51 (1) Pipes for water supply pipeworks shall be cut and the ends shall be prepared in accordance with the manufacturer's recommendations. Purpose-made equipment recommended by the manufacturer and agreed by the Engineer shall be used for cutting the pipes.

(2) Cut ends of pipes shall be square and even, without damage to the pipe or coating. Cut ends, including cut ends of the piece not immediately required, shall be trimmed and chamfered to suit the type of joint and in such

a manner that elastomeric joint rings will not be damaged by the cut end.

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

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

Drilling pipes 22.52 (1) Pipes for water supply pipeworks shall be drilled for small diameter connections using purpose made drilling and tapping equipment.

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

JOINTING PIPES

Jointing pipes 22.53 (1) Pipes for water supply pipeworks shall be jointed in accordance with the manufacturer's recommendations and using jointing equipment and jointing materials recommended by the manufacturer and agreed by the Engineer.

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

(3) All joints in pipelines shall be watertight.

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

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

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

(7) Bolt holes in flanged joints shall be orientated symmetrically about the vertical diameter with no bolt-holes on the vertical diameter. Elastomeric joint rings shall be the correct size and shall not protrude into the bore of the

pipe. The rings may be temporarily fixed to the face of the flange using a minimum amount of adhesive of a type recommended by the manufacturer. Jointing compound or paste shall not be used.

DI pipes with push-in joints

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

DI pipes with mechanical joints

22.55 (1) DI pipes with mechanical joints for water supply pipeworks shall be jointed as stated in Clauses 22.55(2) to (4).

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

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

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

Welding joints in steel pipes

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

(2) Butt welding shall not be used for jointing plain-ended pipes other than for gusseted bends unless approved by the Engineer. If approved, the ends of the pipes shall be prepared in accordance with BS EN 10224 and BS 2633 and welding shall be carried out in accordance with BS 4515-1.

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

(a) Date,

(b) Names of welders,

(c) Location of welding operation, and

(d) Electrodes used in making each weld.

Steel pipes with spigot and socket joints

22.57 (1) Steel pipes with spigot and socket joints for water supply pipeworks shall be jointed as stated in Clause 22.57(2) to (6).

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

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

(4) A double-run convex fillet weld shall be used for pipes not exceeding DN 900 and a triple-run convex fillet weld shall be used for pipes exceeding

DN 900. The leg length of the fillet as deposited shall be at least the same as the full thickness of the pipe wall. The actual throat depth shall not be less than seven-tenths, and shall not exceed nine-tenths, of the minimum leg length as deposited.

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

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

Steel pipes with welded steel collar joints 22.58 Steel pipes with welded steel collar joints for water supply pipeworks shall be jointed by leaving a gap not exceeding 75 mm between the ends of the pipes to be jointed. A split steel collar shall be placed centrally around the ends of the pipes. The collar shall be at least the same thickness as the pipe wall and shall be approximately 300 mm long. The end of each pipe shall be fillet welded to the collar as stated in Clause 22.57.

Steel pipes with couplings and flange adapters 22.59 (1) Steel pipes with slip-on type couplings and flange adapters for water supply pipeworks shall be jointed as stated in Clause 22.59(2) to (4).

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

(a) Epoxy or plastics based coating of a proprietary type approved by the Engineer.

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

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

Not used 22.60 Not used.

Not used 22.61 Not used.

Not used 22.62 Not used.

MAKING FLANGED JOINTS

Making flanged joints 22.63 (1) Further to Clause 22.53(6), both pipes and/or fittings to be joined together shall be independently supported and properly aligned. After placing the gasket in position, the bolts shall be tightened in the sequence as shown in Sketch No. 22.1 to avoid severe overstressing of the flange. If it is necessary to dismantle the flanged joint, the bolts shall be slackened in the reverse sequence to that used for tightening.

(2) When flanges other than polyethylene flanges are tightened, the bolts

shall be tightened with a torque not exceeding the corresponding value specified in Table 22.4(a), (b) or (c) as appropriate. If the joint is not sealed after applying the specified torque, then the bolts shall be tightened with the torque increased by 10%. This procedure will be repeated until the joint is sealed. A final tightening shall then be applied with a further 10% increase in torque.

(3) When polyethylene flanges are tightened, the bolt torque shall be in accordance with manufacturer's recommendations or in the absence of such recommendations to the limits as shown in Table 22.4 (d). Bolts shall be tightened by means of a torque wrench.

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

Protection to steel flanged joints, slip-on type couplings and flange adapters

22.64 (1) Steel flanged joints, slip-on type couplings and flange adapters in steel pipes for water supply pipeworks shall be protected as stated in Clauses 22.64(2) to (4). Protection shall be carried out after jointing is complete.

(2) The joint, including bolts and nuts, shall be cleaned to remove all moisture, dirt, oil, grease and deleterious material. Bolts and nuts shall be painted with two coats of bituminous paint and the joint shall be coated with primer. Mastic filler shall be applied in such a manner that all depressions, corners and voids between the bolts and nuts are filled and a smooth surface is available on which to apply the anticorrosion tape.

(3) At least two layers of anticorrosion tape shall be applied to all parts of the joint and to the adjacent pipe for at least 200 mm beyond each end of the joint. The tape shall be applied in accordance with the manufacturer’s recommendations and shall be wrapped spirally around the joint and pipe with at least 55% overlap per spiral.

(4) The tape shall be moulded manually after application to take up the contours of the parts being protected.

Table 22.4(a): Approximate bolt torques (PN 10 Flanged Joints)

Using rubber, cork, or paper millboard gaskets (3 mm thick only)

Nominal Size DN (mm)	**Approximate Bolt Torque (Nm)**		
	To seal at 5 bar	**To seal at 10 bar**	**To seal at 16 bar**
80	55	55	55
100	55	60	65
150	90	90	95
200	95	105	110
250	90	95	105
300	95	105	115
350	90	100	110
400	125	135	150
450	120	130	145
500	125	135	155
600	160	180	220
700	160	185	235
800	200	240	325
900	200	240	330
1000	240	310	430
1100	240	315	440
1200	290	395	555
1400	335	470	670
1600	425	610	875

Table 22.4(b): Approximate bolt torques (PN 16 Flanged Joints (DN 80 - 600))

Using rubber, cork, or paper millboard gaskets (3 mm thick only)

Nominal size DN (mm)	**Approximate Bolt Torque (Nm)**				
	To seal at 5 bar	**To seal at 10 bar**	**To seal at 16 bar**	**To seal at 20 bar**	**To seal at 25 bar**
80	55	55	55	60	60
100	55	60	65	65	65
150	90	90	95	100	110
200	85	90	90	95	105
250	115	125	130	140	145
300	120	130	145	150	170
350	115	130	140	150	160
400	145	160	175	190	215
450	140	155	170	185	210
500	170	190	215	235	275
600	215	245	290	340	405

Table 22.4 (c): Approximate bolt torques (PN 16 Flanged Joints (DN 700 - 1600))

Using rubber, cork, or paper millboard gaskets (thickness up to and including 3 mm)

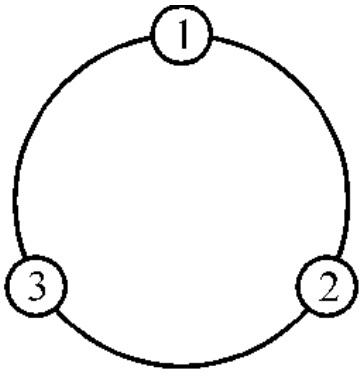
Nominal size DN (mm)	**Approximate Bolt Torque (Nm)**				
	To seal at 5 bar	**To seal at 10 bar**	**To seal at 16 bar**	**To seal at 20 bar**	**To seal at 25 bar**
700	235	280	370	430	510
800	290	375	505	590	695
900	290	380	515	610	720
1000	350	485	670	790	940
1100	350	490	680	805	965
1200	450	650	910	1090	1305
1400	475	730	1040	1245	1500
1600	600	945	1350	1630	1970

Table 22.4 (d): Typical bolt torques for polyethylene flanges

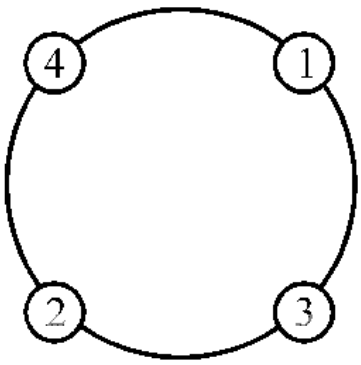
Nominal PE Size (mm)	**Equivalent Size of Metal Flange (mm)**	**No. of Bolts**	**Torque Required (Nm)**
63	50	4	35
90	80	8	35
125	100	8	35
180	150	8	60
250	250	12	100

Bolt tightening sequence

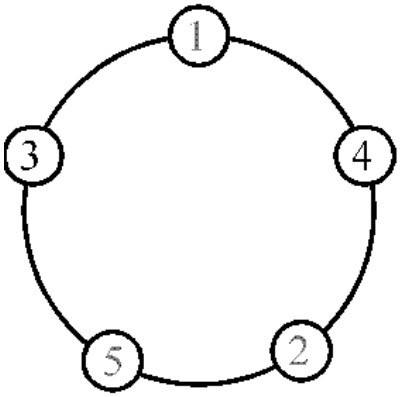
Sketch No. 22.1



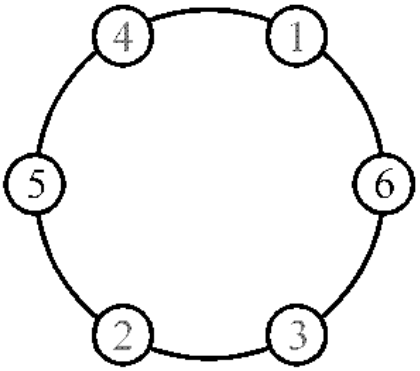
3 BOLTS



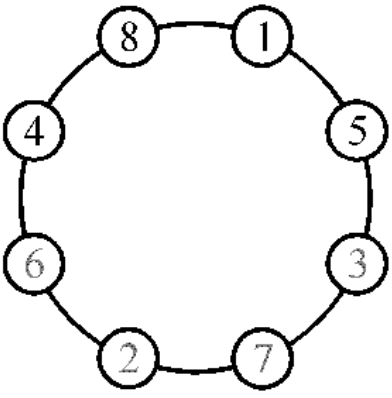
4 BOLTS



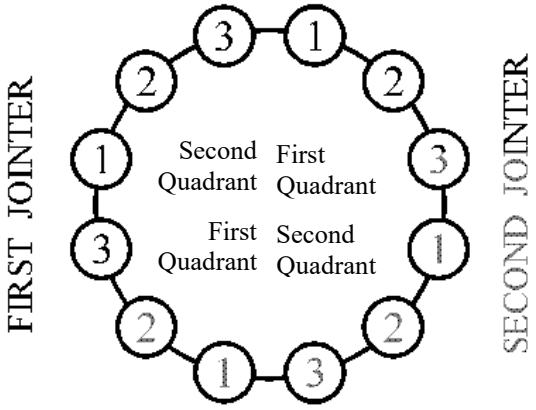
5 BOLTS



6 BOLTS



8 BOLTS



12 BOLTS OR MORE

For sizes having 12 bolts or more, it is recommended two jointers work simultaneously on diametrically opposite bolts. Each jointer tightens the first nut in the first quadrant then the first nut in the second quadrant, returns to the second nut in the first quadrant and so on.

REPAIRS TO JOINTS, COATINGS AND LININGS

Repairs to joints, coatings and linings

22.65 (1) Joints and damage to coatings and linings of pipes, joints and fittings for water supply pipeworks shall be repaired as stated in Clauses 22.65 to 22.68.

(2) Unless otherwise approved by the Engineer, repairs to joints, coatings and linings shall be carried out using materials of the same type and grade as in the pipe, joint or fitting.

(3) External repairs shall be completed before internal repairs are carried out.

(4) Internal repairs and adjacent areas shall be washed with potable water after the repair is complete.

Repairs to DI pipes with bitumen coatings

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

Internal repairs to DI pipes with cement mortar lining

22.67 (1) Internal repairs to joints and linings of DI pipes with cement mortar linings shall be carried out as stated in Clause 22.67(2) to (4). 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 14901-1.

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

(3) The cement mortar shall be worked into the area to be repaired and compacted to the same thickness as the adjacent lining. The cement mortar shall be finished to a smooth uniform surface.

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

Not used

22.68 Not used.

THRUST AND ANCHOR BLOCKS

Thrust and anchor blocks

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

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

BED, HAUNCH AND SURROUND

Concrete bed, haunch and surround 22.70

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

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

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

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

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

TOLERANCES

Tolerances: pipelines 22.71

The line and level of pipelines for water supply pipeworks shall be within 25 mm of the specified line and level.

SWABBING

Swabbing of pipelines 22.72

(1) Swabbing of small diameter mains with size below DN 600 shall be carried out to remove dirt and materials inadvertently left in the pipeline. Swabbing shall not normally be required for new pipes exceeding DN 600 that can be inspected internally to ensure cleanliness.

(2) For water mains of size less than 75 mm diameter, the Contractor can propose alternative cleaning method such as adequate flushing in lieu of swabbing for the consideration of the Engineer. Upon receiving the approval from the Engineer, the Contractor can adopt the alternative cleaning method.

(3) Swabs shall be of a proprietary brand obtained from an approved manufacturer and used in accordance with the manufacturer's instructions. They shall be of a compressible hard grade polyurethane foam in cylindrical shape and shall have the following diameters:

DN of Pipe	**Diameter of Swab**

Up to 300 mm	Pipe DN + 25%
Above 300 mm and below 600mm	Pipe DN + 75 mm

Swabs shall be suitable for clearing out new pipelines and removing dirt and materials inadvertently left in the pipeline during construction. Swabs shall be packed in polyethylene bags or other packaging accepted by the Engineer and stored in sheltered areas unless being used. Swabs shall be marked with a serial number. Amd 3/2026

(4) The Contractor shall be responsible for the conveyance of water to the place where swabbing work is required and if necessary, pressurize the water to a level sufficient for the swabbing work.

(5) Unless otherwise approved by the Engineer, the swab shall be inserted into a short plain-ended pipe at ground level adjacent to the trench. Prior to insertion, the Contractor shall demonstrate the pipe and the swab are clean. The pipe shall then be fitted, by means of flange adaptors, into position in the pipeline between two gate valves which shall then be opened to allow the swab to pass through the pipeline. Prior placement of reserve swabs in the pipeline and at tee branches for future swabbing operations shall not be allowed. Amd 3/2026

(6) The swab must be fully immersed in water during the entire operation using water as the driving medium. Foam swabs must not be air driven and the water must not drain away from the swab on downhill sections. The velocity of the swab, which shall be controlled by the rate of flow of water downstream of the swab, shall be kept within a range of 300 mm/sec to 1200 mm/sec.

(7) All air valves and valves on tees/branches from the pipeline shall be closed before swabbing work commences.

(8) At least 14 days before the swabbing operation is to be carried out, the Contractor shall submit the following information for the approval of the Engineer:

(a) Name and address of supplier of swab,

(b) Place and name of manufacturer,

(c) Type and grade of swab,

(d) Manufacturer's recommended instructions for use,

(e) Details of previous applications of the proposed type of swab,

(f) Programme and details of swabbing operation, and

(g) Means of recovering swab from pipeline at the end of the swabbing run.

(9) The Contractor shall record and submit the following information immediately after the swabbing operation:

(a) Start and end time of the swabbing,

(b) Start and end locations of the swabbed main,

(c) Travelling time and distance of the swabbing run,

(d) Serial number of the swab,

(e) Dimensional measurements of the swab before and after swabbing,

(10) After swabbing, the pipeline shall be flushed and capped to prevent contamination and intrusion of foreign materials. Amd 3/2026

CLEANING AND STERILISATION OF PIPELINES

Cleaning and sterilisation of pipelines 22.73

(1) Fresh water and potable water pipelines for water supply pipeworks shall be cleaned and flushed through with potable water. Cleaning and flushing shall be carried out after:

(a) The complete pipeline, or parts of the pipelines permitted by the Engineer, has been tested,

(b) Temporary Works required for testing have been removed, and

(c) Parts of the pipeline removed for testing have been reconnected.

(2) The pipeline shall be completely filled with water that has been dosed with a homogeneous solution of sterilising chemicals such that the final concentration of free chlorine in the water is at least 30 ppm. The water shall be left in the pipeline for at least 24 hours.

(3) After the 24-hour period, the pipeline shall be drained down and the sterilising water shall be flushed out using potable water until the concentration of the remaining chlorine is less than 1 ppm.

(4) Unless otherwise permitted by the Engineer, pipelines shall be cleaned and sterilised not more than 7 days before the pipeline is handed over.

CONNECTION TO EXISTING WATERMAINS

Connection to existing watermains 22.74

(1) Where connections to existing watermains are specified in the Contract, whether to be done by others or by the Contractor, the Contractor shall excavate inspection pits to determine the locations and levels of the existing watermains as directed by the Engineer. The Engineer may adjust the lines and levels of the proposed watermains to suit the lines and levels of the existing watermains.

(2) Where connections to existing watermains are specified in the Contract to be done by others, the Contractor shall lay and terminate the proposed watermains approximately 2 m from the existing watermains or as directed on Site by the Engineer.

IDENTIFICATION TAPES FOR WATERMAINS

Identification tapes for watermains 22.75 (1) Identification tapes for watermains shall be as shown on Drawing No. WSD 1.31 of the standard drawing of Water Supplies Department.

(2) A sample of the proposed identification tape of a minimum length of 1 metre shall be submitted to the Engineer for approval at least 14 days before the relevant work starts.

(3) During the backfilling of pipe trenches, the fill material shall be properly levelled and compacted to prepare for the laying of the identification tapes on a flat surface.

(4) Identification tapes shall be laid continuously along all watermains with the printed pattern facing upward. Wherever lapping is required, a minimum overlapping length of 300 mm shall be provided at each lap position. Identification tapes shall be temporarily secured in position before further backfilling.

(5) Identification tapes shall terminate at the external faces of chambers and pits.

DETECTABLE WARNING TAPE FOR NON-METALLIC WATERMAINS

Detectable warning tape for non-metallic watermains 22.76 (1) Detectable warning tape for buried non-metallic water mains shall be a polyethylene tape with a continuous aluminium foil inside as shown on Drawing No. WSD 1.37.

(2) At the commencement of the Contract, the Contractor shall submit a 1 m (minimum) long sample of proposed detectable warning tape to the Engineer for approval.

(3) Detectable warning tapes shall be laid continuously along all new buried non-metallic water mains and be used in conjunction with the identification tapes. Detectable warning tapes shall be placed directly on top of the non-metallic water mains with the printed pattern facing upward and fixed onto the pipe bodies using adhesive tapes at regular intervals of 5 m (approx.). Identification tapes shall then be placed at 300 mm above the crown of the water mains during backfilling.

(4) Wherever lapping is required, a minimum overlapping length of 300 mm shall be provided. At the lap, detectable warning tapes shall be jointed together by either 2 no. stainless steel crimps or a stainless steel clamp as shown on Drawing No. WSD 1.37. The stainless steel crimps/clamp shall pierce through the plastic covering of the tapes to make direct contact with the aluminium foils.

(5) Any change in direction of the detectable warning tape to suit the alignment of the water main shall be achieved by folding the tape and stapling the laps with stainless steel crimp(s) as shown on Drawing No. WSD 1.37. For tee connection of the water main, the tee joint of the detectable warning tape shall be formed by joining two tapes together perpendicularly using a stainless steel clamp as shown on Drawing No. WSD 1.37.

(6) Terminal connection points shall be provided at the internal face of valve pits at regular spacing not exceeding 200 m or at locations as indicated on the drawing. The detectable warning tape shall be brought to the surface within such valve pit and mounted to the pit wall to form a terminal connection point as shown on Drawing No. WSD 1.37 by means of a stainless steel clamp and rawl bolts. Further, the tape shall be folded to by-pass the valve in order to avoid interfering the normal open-close operation of the valve.

(7) The deposition and compaction of fill material to pipe trenches shall be carried out in such a manner as to enable the detectable warning tapes and identification tapes to be laid properly. During the backfilling of pipe trenches, the fill material shall be properly deposited, leveled and compacted to prepare for the laying of these tapes.

WORK ON ASBESTOS CEMENT PIPES AND DISPOSAL OF ASBESTOS WASTES

Work on asbestos cement pipes and disposal of asbestos wastes

22.77 (1) Two copies of the following publications shall be maintained on Site at all times for reference, one copy of which shall be for the sole use of the Engineer:

(a) "Guide to the Factories and Industrial Undertakings (Asbestos) Special Regulations 1986" issued by the Labour Department, Hong Kong.

(b) "Control of Asbestos at Work - Code of Practice" issued by the Labour Department, Hong Kong.

(c) "Code of Practice on the Handling, Transport and Disposal of Asbestos Waste" issued by the Secretary for Health & Welfare, Hong Kong.

(2) Not less than 7 days before disposing of any unwanted Asbestos Cement pipes or fittings, the Contractor shall confirm to the Engineer that the Permit required by Waste Disposal Authority has been obtained.

TESTING: JOINTS IN STEEL PIPES

Testing: joints in steel pipes

22.78 (1) Spigot and socket joints in steel pipes exceeding DN 700 for water supply pipeworks shall be tested after welding by the nitrogen gas test.

(2) A tapped hole of approximately 6 mm diameter shall be made in the socket end of each pipe to be tested and a non-return valve shall be fixed in the hole. The nitrogen gas test shall be carried out by pumping nitrogen to a pressure of 400 kPa into the annular space between the spigot and socket. The

pump shall be disconnected and the pressure shall be recorded for 30 minutes.

Compliance criteria: joints in steel pipes 22.79 There shall be no drop in pressure in the joint during the 30 minute period of the nitrogen gas test.

Non-compliance: joints in steel pipes 22.80 If the result of any nitrogen gas test does not comply with the specified requirement for the test, the weld at the joint shall be cut out and the joint shall be rewelded and tested.

TESTING: PRESSURE PIPELINES FOR WATER SUPPLY PIPEWORKS

Testing: pressure pipelines for water supply pipeworks 22.81 (1) Pressure pipelines for water supply pipeworks shall be tested as stated in Clause 22.81(2) to (6).

(2) The pipeline shall be tested in sections as stated in the Contract unless otherwise permitted by the Engineer. If testing in sections other than those stated in the Contract is permitted, the section to be tested shall be as long as practicable provided that the specified test pressure will not be exceeded. Final tests on complete pipelines that have been tested in sections shall not be carried out unless stated in the Contract.

(3) The test pressure shall be as stated in the Contract. If the test pressure is not stated in the Contract, the test pressure shall be:

(a) 1.5 times the maximum working pressure if the maximum working pressure does not exceed 1.5 MPa, or

(b) 1.3 times the maximum working pressure if the maximum working pressure exceeds 1.5 MPa.

(4) Unless otherwise permitted by the Engineer, pressure tests shall not be carried out until the fill material has been deposited and compacted over the complete length of the pipeline to be tested. If permitted, sufficient fill material shall be deposited to restrain the pipeline in position during the test.

(5) Tests shall not be carried out simultaneously on pipelines in the same trench.

(6) The method of testing shall be in accordance with Appendix 22.1.

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

Compliance criteria: pressure pipelines for water supply pipeworks 22.82 The results of tests on pressure pipelines for water supply pipeworks shall comply with the following requirements:

(a) The leakage of water from the pipeline determined by the pressure test shall not exceed the permitted leakage calculated in accordance with Clause 22.1.4 in Appendix 22.1.

(b) There shall be no discernable leakage of water from the pipeline or from any joint during the pressure test.

(c) All valves shall be operative and functional over the entire operation range at maximum working pressure of the pipeline. Amd 3/2026

Non-compliance: pressure pipelines for water supply pipeworks

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

TESTING: WATER STERILISATION

Testing: water sterilisation

22.84 (1) After the pressure test on fresh water and potable water pipelines for water supply pipelines has been completed, samples of the water in the pipeline will be taken by the Engineer. The number of samples and locations of sampling shall be as instructed by the Engineer. Testing shall be carried out as stated in Clauses 23.36 and 23.37 for water sterilisation of water retaining structures.

(2) The colour, odour, appearance, turbidity, conductivity and pH value of the water samples shall be of a quality comparable with that drawn from the supply point and acceptable for potable water.

APPENDIX 22.1

PRESSURE TESTS ON PIPELINES

Scope

22.1.1 This method covers the determination of the leakage of water from pipelines for water supply pipeworks by means of a pressure test.

Equipment

22.1.2 The following equipment is required:

(a) Blank flanges or caps.

(b) Struts and wedges.

(c) Temporary concrete blocks or other anchors.

(d) Force pump and pump feed tank.

(e) Pressure gauge, readable and accurate to 0.01 m head.

(f) Continuous pressure recorder and purpose made charts.

(g) Flowmeter accurate to 0.1 litre, if PE pipelines are tested.

(h) Continuous temperature logger accurate to 1°C for water inside pipeline, if PE pipelines are tested. Amd 3/2026

Procedure

22.1.3 The procedure shall be as follows:

(a) Pipes and valves shall be checked for cleanliness and the operation of valves shall be checked.

(b) Blank flanges or caps shall be fixed to the ends of the pipeline, or section of the pipeline, to be tested. Tests shall not be made against valve gates.

(c) The blank flanges and caps shall be secured with struts and wedges against temporary concrete blocks or other anchors. The blocks and anchors shall be completed and shall have hardened sufficiently before testing starts.

(d) Thrust and anchor blocks, pipe straps and other devices required to prevent movement of pipes and fittings shall be completed before testing starts.

(e) The pipeline shall be filled with water and all air shall be removed.

(f) Unless otherwise permitted by the Engineer, the pipeline shall remain filled for 3 days before pressure is applied Amd 3/2026 to allow absorption to take place and to achieve conditions that are as stable as practicable.

(g) Filling shall be made from locally lowest points to facilitate venting air from valves. Amd 3/2026

(h) The pressure in the pipeline shall be increased slowly to the specified test pressure by pumping water into the pipeline using a

force pump.

(i) The pressure in the pipeline shall be maintained within +0% and -5% of the specified test pressure for a test period of at least 2 hours.

(j) At the beginning and end of the test period and at 30 minute intervals during the test period, readings shall be taken from the pressure gauge and the pressures (p) shall be recorded. The pressure shall be adjusted to the specified test pressure each time a reading is taken.

(k) The pressure shall be adjusted to within the specified tolerances for the test pressure at any time during the test period when the pressure falls outside the specified tolerances.

(l) The pressure shall be monitored during the test by means of a continuous pressure recorder with purpose made charts.

(m) The leakage of water from the pipeline shall be measured as the amount of water required to maintain the specified test pressure in the pipeline. The amount of water shall be determined from the fall in level of water in the pump feed tank.

(n) At the completion of the test period, the pressure in the pipeline shall be depressurised to the maximum working pressure slowly. All valves shall be operated to test if they are functional over the entire operation range. Amd 3/2026

Filling of polyethylene pipelines 22.1.4

(1) The procedure for polyethylene pipelines shall be the same as other pipelines, except that

$$\text{Rate of filling} \leq 12.5\pi D^2 \text{ litre per second}$$

where D is the nominal diameter of the pipe (mm)

(2) Where filling of water could not be made at locally lowest points of the pipeline, or where air valves are not present in all locally highest points for venting, swabbing shall be performed to remove air pockets. Amd 3/2026

Calculation 22.1.5

(1) The average test pressure (P) shall be calculated as the average of the pressures (p) recorded during the test.

(2) The permitted leakage of water from the pipeline during the pressure test shall be calculated from the equation:

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

where:

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

Amd 3/2026

Modifications to Procedure for Polyethylene Pipelines

22.1.6 (1) Polyethylene pipelines shall not be tested together with other pipelines.

(2) Duration for keeping the pipeline filled for allowing absorption to take place and achieving conditions as stable as possible prior to applying pressure shall be shortened to 24 hours.

(3) When pressurising the tested pipeline to the specified test pressure, the volume of water added shall be recorded. The initial air content shall be determined by the following formula:

$$\text{Initial air content (\%)} = (V - E) / A$$

where:

- V is volume of water added during pressurising
- E is increase in internal volume of pipeline
- A is reduction in volume of trapped air due to pressurising

When introducing an additional 100m head from atmospheric pressure to 100m of high density polyethylene pipeline with Standard Dimension Ratio (SDR) of 11, E and A shall follow the values below:

Nominal size of pipeline (mm)	E (L)	A (L)
63	2	2
75	3	3
90	5	4
110	7	6
125	9	7
140	11	9
160	15	12
180	19	15
200	23	19
225	29	24
250	36	30
280	45	37
315	57	47
355	73	60
400	92	76
450	116	97
500	144	119
560	181	150
630	229	190

Assumptions:

- Polyethylene is assumed to have a Young's Modulus of 986 MPa.
- Pipeline is idealised as thin-wall cylinder to determine hoop stress.
- Water is assumed to be incompressible.

If initial air content is 4% or above, the pipeline shall be depressurised and swabbing of pipeline shall be performed to remove trapped air. The pipeline shall then be pressurised to the specified test pressure to determine the initial air content, and swabbing shall be repeated until initial air content is below 4%.

(4) The pipeline shall be left at specified test pressure for at least 12 hours

before the test period begins.

(5) During the test period, pressure of the pipeline shall be monitored by means of a continuous pressure recorder, and maintained within -5% to 0% of the specified test pressure for 5 hours. Temperature shall be recorded at five minute intervals over the test period.

(6) Readings shall be taken, and the pressure shall be restored to the specified test pressure at the beginning and the end of the test period, and every 30 minutes therein.

(7) The volume of water added from the second till the third hour ($\Delta V(3h\text{-}2h)$), both inclusive, shall be recorded. Likewise, the volume of water added from the fourth hour and fifth hour ($\Delta V(5h\text{-}4h)$) shall be recorded. In addition to other compliance criteria, the following criteria shall be satisfied:

$$\Delta V(5h\text{-}4h) \leq 0.55\,\Delta V(3h\text{-}2h) + 0.00014\,D\,L\,P$$

where:

- D is the nominal diameter of the pipe (mm)
- L is the length of pipeline tested (km)
- P is the average test pressure (m)

Amd 3/2026

Reporting of results 22.1.7 The following shall be reported:

(a) The internal diameter of the pipe to the nearest 1 mm.

(b) The length of pipeline tested to the nearest 1 m.

(c) The test period to the nearest 0.01 hr.

(d) The pressures recorded during the test to the nearest 0.01 m.

(e) The average test pressure to the nearest 0.01 m.

(f) The leakage and permitted leakage of water to the nearest 0.1 litre.

(g) Details of any discernable leakage of water from the pipeline during the test.

(h) Charts obtained from the continuous pressure recorder.

(i) That the test method used was in accordance with this Specification.

For polyethylene pipes, the following additional items shall be reported:

(j) The rate of filling polyethylene pipelines to the nearest 0.1 litre per second.

(k) The temperature of the water inside pipeline to the nearest 1°C.

(l) The amount of water added to the pipeline over the test period to nearest 0.1 litre.

Pressures recorded shall be presented in charts in reports and the data shall be separately submitted electronically. Amd 3/2026

APPENDIX 22.2

PROTECTION TO STEEL PIPES, FITTINGS AND SPECIALS USING EPOXY SYSTEM – OTHER REQUIREMENTS

GENERAL

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) The Contractor shall provide full documentation from the pipe manufacturer and/or protection supplier detailing the guaranteed service life of the proposed materials.

(3) The Contractor shall provide certification pursuant to AWWA C210 where epoxy system is applied.

(4) 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 by the Engineer.

(5) 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 the Table 22.2) and shall not require bituminous paint.

(6) Expansion joints shall be protected in accordance with sub-clauses (1) and (2) of this Clause, except stainless steel slides surfaces that require no coating.

(7) All bolts and nuts shall be hot dip galvanized or be coated with an epoxy- or plastic-based corrosion-protection coating.

(8) 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.

(9) 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.

(10) On-site completion or repair of protection lining shall be carried out in strict accordance with the manufacturer's recommendation. Except for epoxy or plastic based protection coatings, materials for completing and repairing the external and internal protections on site shall be approved by the Engineer. The manufacturer shall submit one set of the maintenance guideline/manual on repair of epoxy coatings to the Engineer.

GENERAL PROTECTION COATING REQUIREMENTS

General 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.

Planning and documentation 22.2.3 (1) All painting activities shall be fully incorporated into and regarded as an integral part of the fabrication plan.

(2) Procedures pertaining to overall management, painting facilities, painting equipment, painting application, quality assurance, quality checks, repair and maintenance etc. shall be established and documented in detail and submitted for the approval of the Engineer before commencement of the actual painting work.

Ambient conditions 22.2.4 (1) No final blast cleaning or coating application shall be done if the relative humidity is more than 85%, and if the steel temperature is less than 3 °C above dew point in the ambient. No coating shall be applied or cured at ambient temperatures below 10 °C.

(2) The coating specification and/or product data sheets shall specify the maximum and minimum application and curing temperatures and other relevant requisites regarding application and curing conditions for each product in any coating system.

Coating materials 22.2.5 The coating materials shall be suitable for the intended use and shall meet the following requirements:

(i) In compliance with health, safety and environment protection requirements

(ii) Suitable for raw water, salt water, fresh water and treated effluent

(iii) 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.

Pre-qualification of coating, personnel and procedures 22.2.7 Pre-qualification requirements as described in Clauses 22.2.16 to 22.2.19 of this Appendix shall be fulfilled and documented. In the case of equivalent product or alternative to the coating system specified in Clause 22.2.20 is to be proposed, prior written consent from the Engineer shall be obtained before commencement of any work in accordance with this specification.

HEALTH, SAFETY AND ENVIRONMENTAL CONCERNS

Requirements

22.2.8 The following information/documentation shall be properly filed and made available for inspection upon demand.

(a) Product Data Sheet of the coating material

(b) Material Safety Data Sheet of the coating material.

(c) Volatile Organic Compound content (g/l) of the coating material.

(d) Special handling precautions, personal protection, disposal instructions.

SURFACE PREPARATION OF THE SUBSTRATE

Pre-blasting preparation

22.2.9 (1) Sharp edges, blurs, welding seams shall be rounded or smoothened by mechanical grinding before blast cleaning.

(2) Hard surface lavers resulting from flame cutting shall be removed by mechanical grinding before blast cleaning.

(3) Welding slag shall be removed by mechanical chipping and/or grinding. Blow-holes and welding imperfections shall be repaired by spot welding or removed by mechanical grinding. All welds shall be inspected and if necessary repaired before final blast cleaning of the area.

(4) Any major surface defects, particularly surface laminations or scabs detrimental to the protective coating system shall be removed by suitable dressing. Where such defects have been revealed during blast cleaning, and dressing has been performed, the dressed area shall be re-blasted to the specified standard.

(5) The surface of the substrate shall be free from any foreign matter such as weld flux, residue, dirt, oil, grease, salt, etc. before blast cleaning.

(6) Any oil and grease contamination shall be cleaned by use of a new rag soaked with a suitable solvent.

Blast cleaning

22.2.10 (1) Blasting abrasives shall be dry, clean and free from contaminants that will be detrimental to the performance of the coating. It shall be in compliance with requirements as specified in BS EN ISO 11124.

(2) Size and shape of abrasive particles for blast cleaning shall be such that the prepared surface profile (anchor pattern profile) is in accordance with the requirements for the applicable coating system. The surface profile will be graded in accordance with BS EN ISO 8503.

(3) The cleanliness of the blast-cleaned surface shall be as referred to for each coating system i.e. Sa 2.5 or Sa 3 in accordance with BS EN ISO 8501-1:2001.

Final surface condition 22.2.11 (1) The substrate surface, after abrasive blast cleaning and before coating, shall be clean, dry, free from oil/grease and have the specified roughness and cleanliness ready for the first coat to be applied.

(2) Dust, residual blast abrasives etc. shall be removed from the surface after blasting such that the surface cleanliness complies with Rating 2 of BS EN ISO 8502-3:2000.

(3) The maximum content of soluble impurities on the blasted surface as sampled in accordance with BS EN ISO 8502-6:2000 shall not exceed a conductivity corresponding to a NaCl content of 100 mg/M^2. Equivalent methods may be used.

PAINT APPLICATION

General 22.2.12 (1) Product data sheet for each and every product used in a coating system shall be filed and made available for reference.

(2) The following information for each product used in the coating system shall be clearly specified.

(i) Surface treatment requirements

(ii) Wet film thickness/dry firm thickness (max, min. and specified).

(iii) Maximum and minimum recoating intervals at 10ºC gradient from 40ºC down to -5ºC.

(iv) Information on type of thinner to be used, thinning ratios.

(v) Mixing, handling and application requirements / recommendations.

Application equipment 22.2.13 (1) Roller shall not be used for paint application.

(2) When paints are applied by brush, the brush used shall be of a style and quality acceptable to the coating manufacturer. Brush application shall be done so that a smooth coat in accordance with specified thickness is obtained.

(3) Airless spray equipment is recommended to achieve uniform coating with good penetration. Coating supplier 's recommendation for pressure settings, nozzle sizes and fan angles shall be followed.

Application 22.2.14 (1) Before application of each coat, a stripe coat shall be applied by brush to all welds, corners, behind angles, sharp edges of beams and areas not fully reachable by spray, etc. in order to obtain the specified film thickness in these areas.

(2) Edges of existing coating shall be feathered before over-coating and overlapping.

(3) Each coat shall be applied uniformly over the entire surface. Skips, runs. sags and drips shall be avoided. Each coat shall be free from pinholes, blisters and holidays.

(4) Contamination of painted surface between coats shall be avoided. Any

contamination shall be removed as per ANSI/AWWA C210 requirements.

Repair

22.2.15 All repairs of coating shall be conducted in accordance with the original surface preparation requirements for the substrate and coating application requirements. The Contractor shall submit a method statement for to repair any damage caused to the epoxy coating for the approval of the Engineer.

QUALIFICATION OF PERSONNEL, SUPPLIER AND PRODUCT

Operators

22.2.16 (1) Operators for blast cleaning, paint application etc. shall be properly trained and approved by the Engineer with knowledge in areas concerning operational technique, equipment use, product handling, industrial safety, personal health and use of protection equipment, etc.

(2) The personnel involved in carrying out quality inspection or verification such as QC/QA staff shall be qualified in accordance with industrial standard. A relevant qualification in this regard is acceptable if the person has attained the status of Certified Painting Inspector by FROSIO or NACE Painting Inspector - Level 3 or equivalent.

Supplier

22.2.17 (1) The Supplier of coating material shall be evaluated and approved by the Engineer.

(2) The Supplier shall demonstrate that it has the resources technically, financially to fulfill its commitments with supply to the Contract. In this regard, Manufacturer's research and development ability to support product advancement, production capacity, quality assurance system, supply logistics, and on-site technical after-sale support shall be evaluated.

Coating material

22.2.18 (1) The coating material used for internal lining shall be tested and pass the requirements of BS 6920. A certification issued by Water Research Centre of the UK approving such coating for contact with potable water suitable for human consumption or its equivalent shall be provided.

(2) Coatings used for both internal and external lining shall be demonstrated suitable mechanical properties and anti-corrosion properties for the long-term protection of the substrate. In this regard, the following properties may be used as selection criteria:

(i) Minimum adhesion strength in accordance with ASTM D4541 shall be equal to 19 MPa or in accordance with BS EN ISO 4624:2003 shall be equal to 12 MPa.

(ii) Minimum impact test in accordance with ASTM D2794 shall be 0.136 kg-m.

(iii) Minimum abrasion resistance in accordance with ASTM D4060 (Taber Abraser Wheel CS-17) shall be 200mg/1000 rotations, load 1000 grams.

Paint working specification (PWS)

22.2.19 The Supplier of coating material shall provide a working specification sheet giving a summary of the work procedures. This working specification shall be properly filed and made available for reference from time to time to ensure correct procedures are followed.

COATING SYSTEM

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**

INSPECTION AND TESTING

Testing and inspection 22.2.21 (1) Testing and inspection shall be carried out in accordance with Table 22.2.21 throughout the application process to ensure overall specification is met.

(2) All epoxy and plastic bond coating shall be tested in accordance with BS 6920 and WIS 4-52-01.

Table 22.2.21: Testing and inspection

Test Type	**Method**	**Frequency**	**Acceptance criteria**	**Action to take in case of failure**
Environmental Conditions	Ambient and steel temperature. Relative humidity Dew point	Before start of each shift + twice per shift evenly timed	(a) Relative Humidity below 85% (b) Steel surface temp. 3°C above dew point	No blasting or coating
Visual examination	Visual for sharp edges. Welding spatter slivers rust grades etc.	100% of all surface	No defect. Ref. Specified requirement	Defects to be repaired
Cleanliness	BS EN ISO 8501-1:2001	100% visual of all surface	Min Sa2.5	Re-blasting
De-dust condition	BS EN ISO 8502-3:2000	Spot check	Dust condition Max. quantity and size rating 2	Re-cleaning and retesting until acceptable
Water soluble salts on steel surface	BS EN ISO 8502-6:2000	Spot check	Max. conductivity Corresponding to 100 mg/ m^2 NaCl	Re-cleaning and retesting until acceptable
Surface profile of the blast cleaned surface	BS EN ISO 8503	Spot check	Profile grade “Medium”	Re-blasting
Visual Examination of Coating defects	Visual to determine: 1. Contamination 2. Solvent retention 3. Pinholes 4. Sagging 5. Surface defects	100% of surface for each coat	1. No contamination 2. No solvent trap 3. No pinholes 4. No sagging 5. Smooth and good cosmetic appearance	Repair of defect
Film thickness	SSPC-PA 2 Calibration on smooth surface	SSPC-PA2	SSPC-PA2 Apply DS/R 454-80:20 rule	Repair additional coats or re-coating as appropriate
Adhesion	ASTM D 3359	Spot check	Above level 3	Coating to be rejected
NOTES: All readings should refer to coating system specification.				

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 23

WATER RETAINING STRUCTURES

SECTION 23

WATER RETAINING STRUCTURES

GENERAL

General requirements 23.01 The works and materials specified in Clauses 23.02 to 23.07 shall comply with the sections stated, unless otherwise stated in this Section.

Earthworks 23.02 Earthworks shall comply with Section 6.

Formwork 23.03 Formwork and finishes to concrete shall comply with Section 14.

Reinforcement 23.04 Steel reinforcement shall comply with Section 15.

Concrete 23.05 Concrete shall comply with Section 16.

Joints in concrete 23.06 Joints in concrete shall comply with Section 16.

Drainage systems 23.07 Drainage systems shall comply with Section 5.

GLOSSARY OF TERMS

Water retaining structure 23.08 Water retaining structure is a structure, or part of a structure, including walls, floors, roofs, columns and footings, which is stated in the Contract to be constructed for storing, conveying or excluding water, sewage or other aqueous liquids.

MATERIALS

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.

MATERIALS PROVIDED AND EQUIPMENT LOANED BY THE EMPLOYER

Materials provided by the Employer 23.10 (1) Water and sterilising chemicals for cleaning, sterilising and testing water retaining structures as stated in Clauses 23.24 and 23.32 will be provided by the Employer for one set of tests. The water and sterilising chemicals shall be obtained from the locations stated in the Contract or from other locations agreed by the Engineer and shall be mixed by the Contractor.

(2) Further to sub-clause (1) of this Clause, the Contractor shall be responsible for providing the water and sterilizing chemicals for re-testing when the water retaining structures tests do not comply with the test requirements and compliance criteria specified in the Contract.

Equipment loaned by the Employer 23.11 The equipment for recording water levels in tests on water retaining structures as stated in Clause 23.32(4) that is to be included in Contracts entered into with the Water Supplies Department will be loaned by the Employer.

SUBMISSIONS

Particulars of sliding layers 23.12 Particulars of the source and type of proposed sliding layers for water retaining structures shall be submitted to the Engineer for approval at least 14 days before the first delivery of the sliding layer to the Site.

Particulars of materials and methods of construction for water retaining structures 23.13 (1) The following particulars of the proposed materials and methods of construction for water retaining structures shall be submitted to the Engineer:

(a) Sequence and method of concreting bays in floor slabs, walls and roof slabs and in columns and footings,

(b) Details of alternative locations of construction joints if required,

(c) Details of type and size of waterstops at construction joints and box-outs,

(d) Sequence and method of testing roofs for watertightness, and

(e) Details of method of testing water retaining structures for watertightness including:

- Arrangement of pumps and equipment
- Source of water
- Equipment for measuring fall in water level
- Device for dampening the oscillatory motion of the water surface
- Filling rate
- Method of correction for evaporation and rainfall.

(2) The particulars shall be submitted to the Engineer at least 28 days before the relevant work starts.

Samples of sliding layers 23.14 Samples of the proposed sliding layers for water retaining structures shall be submitted to the Engineer at the same time as particulars of the sliding layer are submitted.

STORAGE OF MATERIALS

Storage of sliding layers 23.15 Sliding layers for water retaining structures shall be stored in accordance with the manufacturer's recommendations in a dry weatherproof store.

DRAINAGE SYSTEMS

Drainage systems 23.16 Measures shall be taken to prevent concrete and deleterious material from being deposited in drainage systems under floors and on roofs of water retaining structures. After construction and before testing, the drainage system shall be thoroughly cleaned by rodding and flushing to remove any deleterious material that may impede the flow of water into or through the drainage system. The lines and levels of drainage systems shall be within 20 mm of the specified horizontal alignment and within 10 mm of the specified vertical alignment.

CONSTRUCTION OF WATER RETAINING STRUCTURES

Laying sliding layers 23.17 Polyethylene sheeting in sliding layers below floor slabs of water retaining structures shall be laid flat without creases. Laps shall be at least 225 mm and there shall be no gaps at the edges of bays.

Floor slabs of water retaining structures 23.18 If reinforcement is continuous across the joint between bays in the floor slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.

Walls of water retaining structures 23.19 (1) If reinforcement is continuous across the joint between bays in the wall of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 72 hours between the completion of concreting the lift in one bay and commencement of concreting the adjacent lift in the adjacent bay.

(2) Unless otherwise permitted by the Engineer the first lift in each bay in the walls of water retaining structures shall be concreted not more than 7 days after completion of concreting the adjacent base of the wall. Individual lifts shall be concreted in one continuous operation without cold joints, whether or not the full height of the wall is concreted in one lift. If the full height of the wall is not placed in one lift, succeeding lifts shall be concreted within 7 days of concreting of the adjacent lift unless otherwise permitted by the Engineer.

Roof slabs of water retaining structures 23.20 If reinforcement is continuous across the joint between bays in the roof slab of water retaining structures, the bays shall be concreted contiguously, in sequence, with a minimum period of 48 hours between completion of concreting one bay and commencement of concreting the adjacent bay.

Built-in pipes in water retaining structures 23.21 Puddle flanges on built-in pipes in water retaining structures shall be located centrally within the formwork. Waterstops shall be fixed around the perimeter of box-outs to the built-in pipes.

PROTECTION OF WATER RETAINING STRUCTURES

Protection of water retaining structures 23.22 (1) Immediately after the roof slab of water retaining structures has been tested, the slab shall be protected with damp sacks or by other methods agreed by the Engineer from exposure to conditions that may affect the slab. The

protection shall be continued until the roof drainage system has been constructed or the fill material has been deposited and compacted.

(2) Materials shall not be stockpiled on roof slabs of water retaining structures. Construction plant or other vehicles shall not stand or run on floor slabs or roof slabs of water retaining structures unless permitted by the Engineer.

DEPOSITION OF FILL MATERIAL

Deposition of fill material 23.23 (1) Fill material shall not be deposited behind sections of walls of water retaining structures until at least 7 days after completion of concreting to the section of wall.

(2) Fill material shall be spread out evenly and shall not be stockpiled on roofs to water retaining structures. Weed killer or other chemicals shall not be applied to fill material on the roofs of water retaining structures for potable or fresh water.

(3) Deposition of fill material on or adjacent to water retaining structures shall be carried out after the watertightness test on the structure has been completed, unless otherwise permitted by the Engineer.

CLEANING AND STERILISATION OF WATER RETAINING STRUCTURES

Cleaning and sterilisation of water retaining structures 23.24 (1) Immediately before water retaining structures are tested for watertightness, all dust, debris, unused materials and equipment shall be removed from the structure and the interior of the structure shall be washed and brushed down with water.

(2) Water for washing water retaining structures for potable or fresh water shall be fresh, potable water incorporating a mixture of sterilising chemicals added before the structure is washed at a concentration instructed by the Engineer. The structure shall be maintained in a clean condition after cleaning.

Treatment and disposal of effluent 23.25 (1) Whereas the cleansing effluent is not fit for discharging into the natural stream course or the storm water drainage system, it should be discharged to the washout chamber or into the sewerage system subject to the approval of the Engineer and the agreement of the Drainage Services Department.

(2) If the cleansing effluent requires de-chlorination, the outlet pipe of the washout chamber should be blocked and the cleansing effluent shall be pumped from the washout chamber to the de-chlorination plant for de-chlorination before discharging to waste. The discharge of cleansing effluent from the washout shall be stopped under the following situation whichever first occurs as directed by the Engineer:-

- The bottom deposits are visually discovered in the cleansing effluent discharged into the washout chamber; or
- Any part of the compartment floor is not submerged; or

- At level as instructed by the Engineer.

(3) The outlet pipe of the washout chamber shall then be kept blocked. The remaining sludge inside the compartment shall then be discharged to the washout. The sludge shall be pumped from the washout chamber to a mobile "centrifuge and microfiltration plant" or equivalent mobile treatment plant approved by the Engineer for treatment. Treatment of sludge with the mobile "centrifuge and microfiltration plant" shall be as detailed in Appendix 23.1**.** If equivalent mobile treatment plant is used, the Contractor shall submit details of the plant, including but limited to, method statement, detailed description of the types and capacity of different components of the plant, the particulars and dosage of chemicals used in the treatment process, layout, previous job records, etc. to the Engineer for approval. The Contractor shall also carry out trials to demonstrate to the Engineer that the proposed mobile treatment plant shall meet the specification in Appendix 23.2.

(4) Sludge cake samples shall be taken in hourly intervals and the samples shall be sent to the HOKLAS (Hong Kong Laboratory Accreditation Scheme) accredited laboratory for testing their dry solid content. The results shall be recorded in the form as shown in Appendix 23.3. The sampling record shall be submitted to the Engineer within two weeks after cleaning works.

(5) Subject to the approval of the Environmental Protection Department, the sludge cake produced shall be disposed of at landfill site.

(6) Samples of filtrate from the microfiltration plant or in case if equivalent mobile treatment plant approved by the Engineer is used, samples of the final effluent from the mobile treatment plant, shall be taken at hourly intervals and the samples shall be tested for turbidity on site and sent to the HOKLAS accredited laboratory for testing their suspended solids content. If the turbidity of the filtrate or in case of equivalent mobile treatment plant approved by the Engineer is used, the final effluent from the mobile treatment plant, is higher than the limit specified by the Engineer, the Contractor is required to stop the discharge and rectify the situation before restart of operation. The testing results shall be recorded in the log record as shown in Appendix 23.4. The sampling record shall be submitted to the Engineer within two weeks after cleaning works.

TESTING: DRAINAGE SYSTEMS FOR WATER RETAINING STRUCTURES

Testing: drainage systems for water retaining structures

23.26 Drainage systems under floors and on roofs of water retaining structures shall be tested in accordance with the following requirements:

(a) Water shall be poured at different locations agreed by the Engineer along the drainage system and the flow of water observed at junction pits, outfalls and other discharge points.

(b) A mandrel shall be pulled through each completed section of pipeline of 300 mm diameter or less. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.

Compliance criteria: drainage systems for

23.27 The results of tests on drainage systems for water retaining structures shall comply with the following requirements:

water retaining structures

(a) The water shall in the opinion of the Engineer be freely discharged by the drainage system.

(b) The bore, linearity and jointing of pipes shall comply with the specified requirements.

Non-compliance: drainage systems for water retaining structures

23.28 If the result of any test on the drainage system for water retaining structures does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the drainage system shall be retested.

TESTING: WATERTIGHTNESS OF ROOFS

Testing: watertightness of roofs

23.29 (1) The roofs of water retaining structures shall be tested for watertightness over the complete area of the roof, including perimeter joints. Roofs shall not be tested in sections unless permitted by the Engineer.

(2) Water shall be allowed to be ponding on the roof for a period of 3 days and topped up to maintain a depth of at least 75 mm. The test shall be carried out before fill material is deposited or drainage systems are constructed on the roof.

Compliance criteria: watertightness of roofs

23.30 There shall be no leaks or damp patches visible on the soffits of roofs of water retaining structures during or at the end of the test for watertightness.

Non-compliance: watertightness of roofs

23.31 If the result of any test for watertightness of the roof of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the roof shall be retested.

TESTING: WATERTIGHTNESS OF STRUCTURES

Testing: watertightness of structures

23.32 (1) Water retaining structures shall be tested for watertightness as stated in Clause 23.32(2) to (7). Each compartment of structures, which incorporate division walls, shall be tested separately with adjoining compartments empty. The complete structure shall also be tested.

(2) The structure shall be filled with water at an approximately uniform rate not exceeding 2 m depth in 24 hours to the levels stated in Table 23.1. The water used for testing water retaining structures for potable or fresh water shall be fresh potable water. The permission of the Engineer shall be obtained before filling starts. The structure or each compartment of the structure being tested shall be kept full for 7 days before testing allow for absorption.

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

(4) The equipment for recording water levels shall be installed in a temporary enclosure of minimum dimensions 2 m x 2 m x 2.5 m high with a lockable door. The enclosure shall be located over stilling wells, manhole openings or other points of recording water levels. The temporary enclosure

shall be removed on completion of the test. The equipment shall be calibrated before testing starts and at regular intervals agreed by the Engineer and shall be readable and accurate to 0.5 mm.

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

(6) Except as stated in Clause 23.32(7), structures shall be emptied after completion of testing and maintained in a clean and dry condition. The water shall be removed at an approximately uniform rate not exceeding 2 m depth in 24 hours. The permission of the Engineer shall be obtained before emptying starts.

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

Compliance criteria: watertightness of structures

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

(a) The total fall in water level at the end of the test period, after adjustment for evaporation and rainfall, shall not exceed 1/500 times the maximum specified depth of water in the test or 10 mm, whichever is less.

(b) There shall be no leaks or damp patches visible on the surface of the structure, including any division walls, during or at the end of the test.

Non-compliance: watertightness of structures

23.34 If the result of any test for watertightness of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the structure shall be retested.

Table 23.1: Tests on water retaining structures

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

	Structure with division wall - complete structure	
	Structure without division wall	

TESTING: WATER STERILITY

Samples: water sterilisation 23.35 After the test for watertightness of a water retaining structure for potable or fresh water has been completed, samples of the water in the structure shall be taken by the Engineer. The number of samples and location of sampling shall be as instructed by the Engineer.

Testing: water sterilisation 23.36 Each sample of water shall be tested to determine the bacteriological content. The colour, odour, appearance, turbidity, conductivity and pH value of the water samples shall be of quality acceptable for potable water.

Compliance criteria: water sterilisation 23.37 The results of tests for bacteriological content of the water and the parameters stated in Clause 23.36 shall demonstrate that in the opinion of the Engineer the structure has been adequately sterilised for potable or fresh water.

APPENDIX 23.1

TREATMENT OF SLUDGE WITH MOBILE "CENTRIFUGE AND MICROFILTRATION PLANT"

Plant

23.1.1 The mobile "centrifuge and microfiltration plant" shall be capable of producing a final effluent with suspended solid of not more than 5 mg/litre and turbidity of not more than 2 Nephelometric Turbidity Units (NTU).

Procedures

23.1.2 (1) The sludge shall first be pumped to a mobile centrifuge for dewatering. The specifications of the mobile centrifuge shall be: -

- Nominal capacity shall be not less than 8 cubic metres per hour.
- Dry solid content of the sludge cake produced shall be more than 30% by weight.
- The mobile centrifuge shall not be washed or cleaned on site.
- A water meter or other measuring device should be installed at the inlet pipe of the centrifuge to measure the amount of sludge treated, in cubic metres.

(2) The centrate shall be treated by a mobile microfiltration plant with the following specifications: -

- Nominal capacity shall not be less than 8 cubic metres per hour.
- The filter shall be capable of treating the centrate generated by the mobile centrifuge.
- The filter media shall be backwashable using the filtrate (the volume of water for backwash shall not be greater than 20% of water filtrated).
- All chemicals used for cleaning the filter shall be disposed of at the Chemical Waste Treatment Facility as approved by the Engineer.
- The suspended solid content and turbidity of the filtrate shall meet either Criteria A or Criteria B of the table below, as directed by the Engineer.

	Criteria A	**Criteria B**
Suspended Solid Content	Not more than 10 mg/litre	Not more than 5 mg/litre
Turbidity	Not more than 4 NTU	Not more than 2 NTU

- A water-meter or other measuring device should be installed at the outlet pipe for the wash water to measure the amount of wash- water produced, in cubic metres.
- A water-meter or other measuring device should be installed at the outpipe for the filtrate to measure the amount of filtrate produced, in cubic metres.

(3) The wash-water discharged from the mobile microfiltration plant shall be returned to and treated by the centrifuge.

APPENDIX 23.2

SPECIFICATION OF THE MOBILE TREATMENT PLANT

Plant

23.2.1 The mobile treatment plant shall be capable of producing a final effluent with suspended solid of not more than 5 mg/litre and turbidity of not more than 2 NTU. Dry solid content of the sludge cake produced shall be more than 30% by weight. In addition, the mobile treatment plant should meet the following requirements:

- Nominal capacity shall not be less than 8 cubic metres per hour.
- The plant shall not be washed or cleaned on site.
- The plant shall be easily dismantled into small units for easy transportation.
- The design of the plant shall be compact, such that the area occupied by the plant will be approximately the plan area of two standard containers.
- The suspended solid content and turbidity of the final effluent shall meet either Criteria A or Criteria B of the table below, as directed by the Engineer.

	Criteria A	**Criteria B**
Suspended Solid Content	Not more than 10 mg/litre	Not more than 5 mg/litre
Turbidity	Not more than 4 NTU	Not more than 2 NTU

(NTU: Nephelometric turbidity units)

- A water-meter or other measuring device shall be installed at the inlet and outlet of the mobile treatment plant to measure the amount of influent and final effluent, in cubic metres.
- If filtration is adopted, the filter media shall be backwashable using the filtrate (the volume of water for backwash shall not be greater than 20% of water filtrated). All chemicals used for cleaning the filter shall be disposed of at the Chemical Waste Treatment Facility as approved by the Engineer. The wash water shall be returned to the inlet of the mobile treatment plant for treatment.

APPENDIX 23.3

SAMPLE RECORD FOR SLUDEGE CAKE PRODUCED

Contract No.:
Name of installation:
Date:
Recorded by:

Time	Sludge Cake	
	Sample No.	Dry Solid Content (%)

APPENDIX 23.4

SAMPLING RECORD FOR FILTRATE PRODUCED BY THE MICROFILTRATION PLANT OR FINAL EFFLUENT PRODUCED BY THE MOBILE TREATMENT PLANT

Contract No.:
Name of installation:
Date:
Recorded by:

Time	Filtrate/Final Effluent*		
	Sample No.	Turbidity (NTU)	Suspended Solids Content (%)

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 24

BUILDING WORKS

SECTION 24

BUILDING WORKS

PART 1: ASPHALT ROOFING

MATERIALS

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.

SUBMISSIONS

Particulars of asphalt roofing 24.09 (1) The following particulars of the proposed materials and methods of construction for asphalt roofing shall be submitted to the Engineer:

(a) Name of specialist sub-contractor,

(b) A certificate for each material for asphalt roofing showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests on mastic asphalt for

- Hardness number, and
- Binder content and grading of mineral aggregate.

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

Samples of materials 24.10 Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the material are provided:

(a) Mastic asphalt,

(b) Sand, and

(c) Stone chippings.

STORAGE OF MATERIALS

Storage of isolating membrane, bitumen dressing compound, bituminous paint, sand, stone chippings, reflective paint and metal lathing 24.11 Isolating membrane, bitumen dressing compound, bituminous paint, sand, stone chippings, reflective paint and metal lathing shall be stored in a dry weatherproof store.

ASPHALT ROOFING WORK

Heating asphalt 24.12 (1) Mastic asphalt for asphalt roofing shall be gradually heated in a purpose made mixer to a temperature until it flows but not exceeding 230°C. The asphalt shall be continuously agitated such that local overheating is prevented during heating and until it has been discharged for use.

(2) The molten asphalt shall be transported in buckets that have been coated with cement. Ashes or oil shall not be used for coating buckets and other equipment.

Laying mastic asphalt 24.13 (1) Asphalt work for asphalt roofing shall be carried out in accordance with BS 8217.

(2) Mastic asphalt shall be laid on a clean dry surface using wood or metal gauges to ensure the correct thickness of each coat. Two coats of equal thickness to a total thickness of at least 20 mm shall be laid on horizontal roof surfaces and on slopes not exceeding 30°. Two coats of equal thickness to a total thickness of at least 13 mm shall be laid to skirtings, upstands and drips and on slopes exceeding 30°.

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

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

Laying isolating membrane 24.14 Black sheathing felt for asphalt roofing shall be laid on a dry surface and shall not be sealed to the structure on slopes less than 30° to the horizontal. Laps of at least 75 mm shall be formed at joints.

Forming angles 24.15 (1) Internal angles between horizontal and vertical surfaces on asphalt roofing shall be formed with stout asphalt fillets. The fillets shall be at least 50 mm on face and shall be continuous with the surfaces.

(2) The specified total thickness of asphalt shall be maintained at external angles between horizontal and vertical surfaces or between sloping surfaces.

Forming skirtings 24.16 Skirtings shall be formed in asphalt roofing and shall be at least 150 mm high above roof finishes. The top edge shall be splayed and tucked into a groove at least 25 mm deep and 25 mm wide.

Dressing to rainwater outlets 24.17 Asphalt roofing shall be neatly dressed into rainwater outlets and sealed. Metal surfaces in contact with the asphalt roofing shall be cleaned and primed with one coat of bituminous paint before the asphalt is laid. Flashings to rainwater outlets shall be embedded in the first coat of the asphalt and then the second coat shall be applied.

Dressing to pipes through roofs 24.18 Asphalt roofing and isolating membrane shall be neatly dressed around sleeves to pipes passing through roofs. The dressing shall be at least 150 mm high and shall have a stout asphalt angle fillet at the bottom. Metal surfaces in contact with the asphalt roofing shall be cleaned and primed with one coat of bituminous paint before the asphalt is laid.

Finishing roof surfaces 24.19 Immediately after asphalt laying to asphalt roofing is complete, the roof surfaces shall be well rubbed with a clean wood float and fine clean sand.

Solar protection 24.20 (1) Roof surfaces to which stone chippings are to be applied shall be dressed with bitumen dressing compound applied at a rate of 3 kg/m^2. The surfaces shall be dressed immediately with stone chippings lightly rolled in at a rate of 15 kg/m^2. Loose chippings shall be removed.

(2) Reflective paint to asphalt roofing shall be applied in two coats at the rate recommended by the manufacturer.

TESTING: ASPHALT ROOFING

Batch: mastic asphalt 24.21 A batch of mastic asphalt is any quantity of mastic asphalt of the same type, manufactured at the same time in the same place and delivered to the Site at any one time and which, for the purpose of testing laid mastic asphalt, is laid on the same day.

Samples: mastic asphalt 24.22 (1) Samples of mastic asphalt shall be provided from each batch of mastic asphalt delivered to the Site. The samples shall be provided at least 14 days before asphalt roofing work starts.

(2) Samples of mastic asphalt shall be provided from each batch of laid mastic asphalt. Holes formed by taking samples of laid mastic asphalt shall be reinstated using mastic asphalt.

(3) The number and size of samples and the method of sampling shall be in accordance with BS 5284.

Testing: mastic asphalt 24.23 (1) Each sample of mastic asphalt shall be tested to determine the hardness number, binder content and grading of mineral aggregate.

(2) The method of testing shall be in accordance with BS 5284.

Compliance criteria: 24.24 The results of tests on mastic asphalt shall comply with BS 6925.

mastic asphalt

PART 2: CARPENTRY AND JOINERY

MATERIALS

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.

SUBMISSIONS

Particulars of timber 24.29 (1) The following particulars of the proposed timber for carpentry and joinery shall be submitted to the Engineer:

(a) The species and country of origin;

(b) The name of the concessions or plantations from which these timbers originate;

(c) Copies of the forest policies implemented by these concessions or plantations which confirm that the management of the timber resource is sustainable;

(d) Shipping documents that confirm that the suppliers in Hong Kong

has obtained the timber from the stated concessions or plantations.

(e) A certificate from the Forest Stewardship Council (FSC) or other approved authority

(f) A certificate for each type of timber showing the source of the timber and showing that the timber complies with the requirements stated in the Contract and including results of tests for
- Density, and
- Moisture content.

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

Samples of materials 24.30 Samples of the following proposed materials shall be submitted to the Engineer at the same time as particulars of the timber are submitted:

(a) Hardwood, softwood and plywood, and

(b) Nails, screws and plugs.

STORAGE OF MATERIALS

Storage of timber 24.31 Timber shall be stored in a dry, weatherproof and well ventilated store with a raised floor.

CARPENTRY AND JOINERY WORK

Treatment to timber 24.32 (1) Unexposed surfaces of timber doors and windows, including backing, fillets, backs of door and window frames, shall be treated with two coats of wood preservative before fixing or bedding in. Door and window frames shall be knotted and shall receive at least one coat of primer before being fixed in position.

(2) Hidden faces of built-in timber shall be treated with two coats of wood preservative before being assembled and fixed in position.

Finish to timber 24.33 Planed timber shall be used for all surfaces of carpentry and joinery. Exposed surfaces shall have a fine glasspapered finish and arrises shall be rounded to a radius of 1 mm.

Framed timber 24.34 (1) Faces of framed joints of timber shall be square and shall be driven together to give a close accurate fit.

(2) Timber shall be prepared and framed up with dry joints and stored until required for fixing in position. Before fixing, all joints shall be opened up, put back together with white lead and wedged up. Sections that have warped or developed shakes or other defects shall be replaced.

Running bonded joints 24.35 Running bonded joints in timber shall be cross-tongued using teak tongues. Double tongues shall be used for work exceeding 40 mm thick.

Building-in timber 24.36 Timber sections shall be screwed or nailed to the backing that shall be plugged. The location of concealed services shall be checked before fixing timber sections to walls and other surfaces.

Nailing 24.37 Timber sections that are split when nailing shall be replaced. Nail heads shall be punched below timber surfaces.

Fixing screws 24.38 (1) Timber sections shall be screwed in drilled pilot holes.

(2) Screws shall be inserted to their full depth with a screwdriver, and hammers shall not be used.

(3) Screw heads shall be countersunk at least 5 mm below timber surfaces. Colour and grain matched pellets cut from similar timber shall be fixed in with adhesive and finished off flush with the surrounding surface.

TESTING: TIMBER

Batch: timber 24.39 A batch of timber is any quantity of timber of the same type and grade, from the same source, covered by the same certificates and delivered to the Site at any one time.

Samples: timber 24.40 (1) 1 sample of timber shall be provided from each batch of timber.

(2) The size of each sample shall be 1000 mm x 50 mm x 50 mm.

Testing: timber 24.41 (1) Each sample of timber shall be tested to determine the moisture content at the time of fabrication.

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

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

where

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

(3) The dry mass shall be determined by drying the sample in an oven at a temperature of 103°C ± 2°C until the mass is constant and weighing the sample.

PART 3: GLAZING

MATERIALS

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.

SUBMISSIONS

Samples of materials 24.45 Samples of each proposed type of glass shall be submitted to the Engineer at least 14 days before glazing starts.

STORAGE OF MATERIALS

Storage of glass and putty 24.46 (1) Glass shall be stored vertically in a dry weatherproof store with a raised floor. Glass shall be kept clean and dry and shall be protected from exposure to condensation and moisture.

(2) Putty shall be stored in sealed containers which shall be marked to identify the contents and protected from exposure to conditions which may adversely affect the putty all in accordance with the manufacturer's recommendations. The putty shall not be used after the recommended shelf life has been exceeded.

GLAZING WORK

Glazing work 24.47 (1) Glazing work shall be carried out in accordance with BS 8000-7 and BS 8000-0 and also conform to the glazing manual published by the Glass Association of North America (GANA). External glazing shall be weather-tight on completion.

(2) Frames and beading shall be cleaned and primed before glazing as stated in Part 6 of this section.

(3) Directionally patterned or wired glass shall be set with the pattern or wires parallel to the surround and aligned with adjacent panes. Cut edges of wired glass shall be painted with one coat of bituminous paint.

(4) Edge clearances shall be at least 3 mm and shall be equally spaced around each pane.

(5) Putty edge covers shall be as stated in Table 24.1.

(6) Setting blocks are to be used for all glass panes and are to be located at quarter points of the bottom edge of the glass. To minimize bending of the transom under dead load, the setting blocks may be moved to eighth points but must not be closer than recommended by GANA.

(7) Back putty shall be finished flush with the frame on top edges and sides, and at 45° on bottom edges. There shall be no metal-glass or wood-glass contact, and no voids or spaces in the putty.

(8) Glass shall be secured to wood surrounds by glazing sprigs at a maximum spacing of 450 mm and shall be secured to metal surrounds by spring clips. Glazing sprigs and spring clips shall be provided by the manufacturer of the surround.

(9) Back putty shall be of regular thickness and at least 2 mm thick. Front putty shall be formed to a triangular fillet stopping 2 mm short of sight lines. Opening lights shall be kept closed until the putty has hardened.

(10) Putty shall be primed and painted as soon as it has hardened.

(11) Timber beading shall be bedded in putty and secured with countersunk brass screws and cups. Screws and cups shall be at a maximum spacing of 200 mm and shall not be more than 75 mm from each corner.

(12) Metal beading shall be supplied with the frames and shall be fixed in accordance with the manufacturer's recommendations.

(13) Gaps between glass and beading shall be sealed with putty.

Table 24.1: Edge covers for glazing

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

PART 4: PLUMBING

GENERAL

Licensed plumber 24.48 Plumbing shall be carried out by a licensed plumber.

Taps, valves and fittings 24.49 Taps, valves and fittings shall be of a proprietary type approved by Water Supplies Department. Red lead jointing materials shall not be used.

Plumbing 24.49A All plumbing systems shall comply with the requirements stated in the General Specification for Building Services Amd 2/2025 Installation Amd 2/2025 in Government Buildings of Amd 2/2025 the Hong Kong Special Administrative Region 2022 Edition Amd 2/2025 published by the Architectural Services Department and its latest amendments ("GSBS Amd 2/2025"), except that the following amendments shall apply:

(1) The word "Supervising Officer" shall be replaced by "Engineer" whenever it appears in the GSBS Amd. 2/2025;

(2) The word Amd 2/2025 "Building Contractor" shall be replaced by "Contractor" whenever they appear in the GSBS Amd 2/2025;

(3) Reference to the BS 6920 series shall refer to the version of BS 6920 required by the Water Authority as promulgated from time to time; Amd 2/2025

(4) The terms and definitions for "Supervising Officer" and Amd 2/2025 "Building Contractor" Amd 2/2025 in Clause 1.1.1.3 Amd 2/2025 shall be deleted and the term "Conditions" in Clause 1.1.1.3 Amd 2/2025 shall be defined as "The General Conditions of Contract for Civil Engineering Works and the Special Conditions of Contract";

(5) Clauses 1.1.3.2, 1.1.3.3, 1.1.3.4, 1.1.3.5, 1.1.3.6, 1.1.5.1 Amd 2/2025 shall be deleted;

(6) The words "This General Specification, Particular Specification, Tender Equipment Schedule and Drawings detail the performance requirements of the Installations" in clause 1.1.1.2 Amd 2/2025 shall be deleted;

(7) The words "Such materials and equipment shall not be removed from Site without the prior approval of the Supervising Officer in writing. Where the Building Contractor is in overall control of the Site, the Building Contractor may also be required to record details of all incoming/outgoing materials and equipment. Amd 2/2025" in clause 1.1.3.9 Amd 2/2025 shall be deleted;

(8) The paragraphs

"A detailed installation drawing submission schedule and programme shall be submitted to the Supervising Officer. Reasonable time shall be allowed in the programme for vetting of the installation drawings by the Supervising Officer and for drawing resubmissions as necessary. Amd 2/2025

Amd 2/2025

A comprehensive "Submission Schedule" of installation drawings and builder's work drawings shall be submitted to the Supervising Officer within

2 weeks after the acceptance of Tender, taking into account of the overall programme of the Installations including any Specialist Works and works by the utility undertakings. No equipment shall be delivered to the Site and no work shall be executed until the installation drawings have been approved by the Supervising Officer. The installation drawings and builder's work drawings shall be progressively submitted in accordance with the approved "Submission Schedule"

At least 6 hard copies and one electronic copy shall be provided unless otherwise specified in the Contract."

in clause 1.1.5.2.1 shall be deleted;

Amd 2/2025

(9) The words "At least 6 hard copies and one electronic copy, unless otherwise specified in the Contract or the Sub-contract as appropriate, of the approved installation drawings shall be submitted" shall be added after "These drawings shall be fully dimensioned and shall be based on the basic intentions of the 'Drawings'" in clause 1.1.5.2.1; Amd 2/2025

(10) The words "Submission Schedule Amd 2/2025" in clause 1.1.5.2.4 Amd 2/2025 shall be replaced by "programme";

(11) The words "Clause 24.31 of General Specification for Building" in clause 13.1.1.10.4 Amd 2/2025 shall be replaced by "GS Section 5";

Amd 2/2025

Drainage 24.49B All above ground surface water and foul water drainage system installations shall comply with the requirements stated in the General Specification for Building Services Amd 2/2025 Installation in Government Buildings of the Hong Kong Special Administrative Region 2022 Edition Amd 2/2025 published by the Architectural Services Department and its latest amendments ("GSBS Amd 2/2025"), except that the Amd 2/2025 amendments in Sections 24.49A (1) to (11) Amd 2/2025 shall apply.

Amd 2/2025

Building works with due consideration for installation of plumbing system and above ground surface water and foul water drainage systems 24.49C The Contractor shall give due consideration in the building works for the installation of the plumbing system and above ground surface water and foul water drainage systems, including provision of openings or holes through building structure or partition walls; trenching, cutting and making good; and construction of all plinths, concrete bases, supports, ducts, etc. The Contractor shall ensure that such works are essential for the execution of the installation of the plumbing system and above ground surface water drainage and foul water drainage systems. The Contractor shall carry out any rectification work at his own cost in the event that any of such works is proved to be non-essential, unnecessary and/or abortive, including but not limited to any unnecessary or incorrect cutting-away and making-good.

MATERIALS

Not used 24.50 Not used.

Not used 24.51 Not used.

Draw-off taps and stop valve 24.52 (1) Draw-off taps for those of a single tap type shall comply with BS EN 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.

Not used 24.53 Not used.

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.

Not used 24.55 Not used.

SUBMISSIONS

Particulars of plumbing work 24.56 (1) The following particulars of the proposed plumber and materials for plumbing work shall be submitted to the Engineer:

(a) Name and registration number of plumber, and

(b) Manufacturer's literature for pipework, cisterns, tanks and cylinders, draw-off taps and valves, float operated valves, sanitary appliances and pipe brackets.

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

Programme 24.56A Further to GS Clause 1.08(3), all plumbing system and above ground surface water and foul water drainage system installation works shall be shown on the programme submitted in accordance with GS Clause 1.08(1).

Not used 24.57 Not used.

STORAGE OF MATERIALS

Not used 24.58 Not used.

Storage of sanitary appliances 24.59 Sanitary appliances shall be stored in a dry weatherproof store. Metal sinks and similar appliances shall be stored on a level surface and in a manner that will not result in contamination by cement or lime.

NOT USED

Not used 24.60 Not used.

TESTING: PLUMBING AND DRAINAGE SYSTEM

Inspection, testing and commissioning of plumbing and drainage system 24.61 Further to Part D of the GSP and the GSD, the inspection, testing and commissioning of all plumbing system and above ground surface water and foul water drainage system installations shall be carried out in accordance with the Testing and Commissioning Procedure for Plumbing Installation in Government Buildings of the Hong Kong Special Administrative Region (2017 Edition) and the Testing and Commissioning Procedure for Drainage

Installation in Government Buildings of the Hong Kong Special Administrative Region (2017 Edition) published by the Architectural Services Department and their latest amendments ("T&C Procedure"), except that the following amendments shall apply:

(1) The word "Supervising Officer" shall be replaced by "Engineer" whenever it appears in the T&C Procedure;

(2) The words "contractor for the Plumbing Installation" "Plumbing Contractor", "contractor for the Drainage Installation" and "Drainage Contractor" shall be replaced by "Contractor" whenever they appear in the T&C Procedure; and

(3) The words "Project Building Services Engineer", "PBSE" and "PBSI" shall be replaced by "Engineer" whenever they appear in the T&C Procedure.

Not used 24.62 Not used.

NOT USED

Not used 24.63 Not used.

Not used 24.64 Not used.

PART 5: PLASTERWORK AND OTHER FINISHES

MATERIALS

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 μm	40 – 80
300 μm	5 – 40
150 μm	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 μm	55 - 100
300 μm	5 - 50
150 μm	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
i. 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.

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.

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/A118/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/A118/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.

SUBMISSIONS

Particulars of plasterwork and other finishes 24.86 (1) The following particulars of the proposed materials for plasterwork and other finishes shall be submitted to the Engineer:

(a) A certificate for cement, gypsum plaster and lime showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract,

(b) A certificate for sand, stone chippings and each type of aggregate

showing the source of the material and showing that the material complies with the requirements stated in the Contract, and including results of tests as appropriate, for
- Grading
- Silt content,

(c) Manufacturer's literature and a certificate for each type of tile and fittings showing the manufacturer's name, the date and place of manufacture and showing that the tiles comply with the requirements stated in the Contract.

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

Particulars of tile adhesive and tile grout

24.87 (1) The following particulars of the proposed material for tile adhesive and tile grout shall be submitted to the Engineer:

(a) Catalogue, brand name/model name and job reference;

(b) Name, address and contact person of the local supplier;

(c) Name, address and contact person of the manufacturer;

(d) Where applicable, either the document from the manufacturer showing his authorization for the supplier as the agent/distributor in Hong Kong or document from the supplier showing the appointment of the manufacturer and manufacturer's agreement for the production of the proposed product;

(e) Detailed Method Statement for the installation of the tiling systems, showing all work procedures from the preparation of background through to the cleaning of the completed assembly;

(f) Original or certified true copy (issued or certified by the accredited laboratory) of the test reports showing full compliance with the requirements of sub-clauses 24.84(3), 24.84(4) & Clause 24.94. The date of the test shall be generally within two years before the date of commencement of the Contract.

(g) Original or certified true copy (certified by the certification body) of the ISO 9000 series certification for the manufacturing plant for the Engineer's inspection. The certification body shall be either accredited by the Hong Kong Accreditation Service (HKAS) or considered as having equivalent standard by the Environment, Transport and Works Bureau.

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

Samples of materials

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

(a) Sand, stone chippings and aggregates,

(b) Tiles and fittings, and

(c) Tile adhesives and tile grout.

DELIVERY AND STORAGE OF MATERIALS

Delivery and storage of cement, gypsum plaster and lime 24.89 Cement, gypsum plaster and lime shall be delivered in sealed bags or containers bearing the manufacturer's name. The bags and containers shall be stored in a dry weatherproof store with a raised floor.

Storage of tile adhesive 24.90 Tile adhesive shall be stored in sealed containers marked to identify the contents and protected from exposure to conditions which may adversely affect the adhesive. The adhesive shall be stored in accordance with the manufacturer's recommendations and shall not be used after the recommended shelf life has been exceeded.

Storage of premixed plaster 24.91 Bagged premixed plaster shall be stored separately by types, off the ground in dry, well-ventilated and covered space. Use in order of delivery and within manufacturer recommended time limit.

ON SITE DELIVERY CHECK

General 24.92 (1) When instructed by the Engineer, all necessary and calibrated equipment shall be provided and the following tests shall be carried out for non-slip homogenous floor tiles, glazed ceramic wall tiles, unglazed vitreous mosaic wall tiles, glass mosaic tiles, homogenous coved tile skirting, homogenous wall tiles and external facing tiles upon delivery on Site in the presence of Engineer's Representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the Engineer's Approved sample

In case of doubtful results, laboratory tests shall be carried out for confirmation;

(2) Sampling frequency for the above tests for non-slip homogenous floor tiles, glazed ceramic wall tiles, unglazed vitreous mosaic wall tiles, glass mosaic tiles, homogenous coved tile skirting, homogenous wall tiles and external facing tiles upon delivery on Site shall be as follows:

Test Items	Sample Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(3) In the event of samples failing to meet the requirements for test upon delivery on Site, remove the representative consignment off Site.

(4) When instructed by the Engineer, the following checks shall be carried out for tile adhesives and tile grout upon delivery on Site in the presence of Engineer's Representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of Origin & Delivery Note	Document Check	From an Approved origin with information of product identification numbers
2. Product Identification Number	Document Check	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(5) In the event of the checking results failing to meet the checking requirements upon delivery on Site, the failed consignment shall be removed off Site.

TRIAL PANELS

Trial panels 24.93 (1) A trial panel shall be constructed for each type of plastering and rendering, each textured finish to screeds, terrazzo, granolithic concrete and each type of tile to demonstrate that the proposed materials will produce a finish which complies with the specified requirements.

(2) Trial panels shall be constructed at least 7 days before the relevant work starts.

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

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

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

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

Trial panels for tile adhesive

24.94 (1) Tile adhesive compatibility with panel wall shall be demonstrated via the following test method:

(a) The tile adhesive shall be tested against the panel wall partition selected for the Contract complete with moisture sealer. Acceptance standard shall be minimum 0.3 N/mm^2;

(b) Four specimens of 200x200mm ceramic glazed wall tile shall be selected and fixed vertically without additional support according to the manufacturer's specification;

(c) The interval between applying tile adhesive and placing tiles shall not be more than 5 minutes. The extent to which slip occurs per the first minute after placing tile specimen shall be recorded. The tile specimens shall be fixed by adhesive tape to prevent further slip;

(d) The sample shall be subjected to tests of Tensile Adhesion Strength with an adhesive not exceeding 3mm in final bed thickness;

(e) Tiles shall be pulled off on a minimum of 28 days after fixing;

(f) An aluminium/steel dolly shall be attached onto the surface of the specimen by a suitable adhesive resin;

(g) Strong adhesive tape shall be used to fix the position of dolly until strength of the resin is developed as advised by the resin manufacturer;

(h) The dolly shall be connected to the Pull-off Test device. The pull-off equipment shall be capable of increasing the load steadily without jerking at a rate of 5 mm/min to 6 mm/min, and must be provided with a measurement device which shall retain the maximum force exerted, the so called failure load to the nearest 0.01kN. The measurement inaccuracy of the equipment must be less than 2%, in accordance with class 2 of testing machine range of BS EN ISO 7500-1;

(i) A tensile force shall be applied gradually by the device;

(j) The failure force, location of failure and any other observations or abnormalities shall be recorded;

(k) The force shall be recorded from the readout unit;

(l) Steps as described in sub-clauses (f) to (k) of this Clause shall be repeated until Pull-off Tests to all four tiles are completed;

(m) Photographs shall be taken.

(2) Tile adhesive compatibility with off-form concrete shall be demonstrated via the following test method:

(a) The tile adhesive shall be tested against a mass concrete wall Grade 35/20 of 200mm thick. Dimensions of the wall shall be determined by the laboratory carrying out the test;

(b) Method as described in sub-clauses (1)(b) to (1)(h) of this Clause shall be followed.

Non-compliance: trial panels 24.95 If in the opinion of the Engineer the specified finish or tile adhesive has not been produced in the trial panel, particulars of proposed changes to the materials and methods of construction shall be submitted to the Engineer; further trial panels shall be constructed until the specified finish or tile adhesive is produced in the trial panel.

Commencement of plasterwork and other finishes 24.96 Plasterwork and other finishes shall not commence until in the opinion of the Engineer the specified finish has been produced in the trial panel.

Changes in materials 24.97 Unless permitted by the Engineer, the materials used to produce the specified finish in trial panels and the trial panels for adhesive shall not be changed.

PLASTERING AND RENDERING

Applying spatterdash to new concrete 24.98 (1) Concrete surfaces which are to be plastered or rendered shall be spatterdashed immediately after the formwork has been removed or shall be treated with a proprietary type of bonding agent approved by the Engineer. Existing concrete surfaces shall be hacked uniformly over the complete area to expose the aggregate over at least 50% of the area. The joints in brickwork surfaces shall be raked out to a depth of at least 10 mm.

(2) Spatterdash shall consist of cement and coarse sand or granite fines in the proportions 1:2 by volume mixed with the minimum amount of water necessary to achieve the consistency of a thick slurry. Spatterdash shall be thrown with a hand trowel onto the surface to a thickness not exceeding 6 mm and shall cover at least 60% of the area that is to be plastered or rendered. Spatterdash shall be wetted one hour after application and shall be allowed to cure and harden before undercoats are applied. The surface shall be maintained moist for 24 hours.

Joint inspection to spatterdash 24.99 (1) Joint inspection to minimum 10% of spatterdash shall be carried out with the Engineer's Representative.

(2) After hardening and curing, the adhesion of the spatterdash coat shall be checked by brushing with a stiff wire brush.

(3) Where spatterdash is easily removed, loosened spatterdash shall be completely removed. Spatterdash shall be re-applied and re-inspected after 7 days.

(4) Subsequent works on any affected area shall not start until re-inspection is to the satisfaction of the Engineer.

Background preparation for plastering and rendering

24.100 (1) Background for plastering and rendering generally shall be in accordance with PD CEN/TR 15123, BS EN 13914-2 & BS 8481 and BS EN 13914-1 respectively.

(2) High pressure water jet shall be used to remove efflorescence, laitance, oil, formwork release agent, grease, dirt and loose materials from the concrete surfaces before application of subsequent finishes.

(3) Minimum 4 weeks continuous drying out shall be allowed for new concrete wall after curing before cement sand plastering/rendering commence.

(4) After application of cement sand plastering/rendering to concrete wall, additional 2 weeks drying out shall be allowed before tiling. Drying time in damp weather conditions should be extended and programme should be adjusted accordingly to ensure satisfactory installation.

(5) The prepared concrete surfaces shall be protected from the weather and contamination from concreting run-offs.

Preparation of hardened concrete to receive cementitious renders

24.101 Concrete surface shall be prepared by:

Either:

1. (a) Shortly before applying the finish, thoroughly hacking the concrete surface to remove any laitance or, where approved, with an electric spade;

   (b) Thoroughly cleaning and wetting the surface as required, to adjust its suction, before applying finish and remove surplus water;

   (c) Brushing neat cement slurry into the damp surface immediately before applying the finish;

Or

2. Applying bonding agent in accordance with the manufacturer's recommendations.

Preparation of hardened concrete to receive gypsum renders

24.102 Concrete surface shall be prepared by applying bonding agent in accordance with the manufacturer's recommendations.

Dubbing out

24.103 When it is necessary to correct inaccuracies in the background, dubbing out shall be as follows:

(a) In layers of a maximum thickness of 10 mm;

(b) In the same mix as the first coat;

(c) Allowing each coat to dry out before applying the next;

(d) Cross scratching each coat to provide a key for the next; and

(e) To a total thickness not exceeding 25 mm.

Fixing steel lathing

24.104 (1) Exposed external arrises of plastering or rendering shall be formed at right angles made with galvanized steel corner beads, which shall comply with BS EN ISO 1461 or otherwise approved by the Engineer.

(2) Junctions between dissimilar solid backgrounds in the same plane that are to be plastered or rendered shall be jointed with a strip of metal lathing. The largest dimension of the mesh shall be perpendicular to the direction of the supports. The lathing shall extend at least 150 mm along each side of the junction and shall be fixed at 100 mm centres with galvanized steel staples, nails or tying wire as appropriate to the nature of the background. The galvanized steel staples and nails shall comply with BS EN ISO 1461 while the tying wire shall be in accordance with BS EN 10244-2 or otherwise approved by the Engineer. Laps shall be at least 50 mm where end laps occur between supports and shall be at least 25 mm at other locations. Laps shall be secured with tying wire at 75 mm centres. Cut ends of lathing shall be painted with one coat of bituminous paint complying with Clause 24.134**.**

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

Mixing plaster and render

24.105 (1) Mixing plaster and render shall be in accordance with BS 8000:Part 0. Too strong or too wet render mix that will increase the render drying shrinkage should be avoided. Plaster and render shall be mixed using the minimum amount of water necessary to achieve the required consistency making due allowance for the moisture content of sand and shall be used within one hour after mixing. The mixed materials shall not be reconstituted and shall not be used after the initial set has taken place. Unless otherwise permitted by the Engineer, the materials shall be mixed by mechanical methods.

(2) Renders containing plasticizers shall not be over-mixed and the constituents shall be dried before mixing with lime putty or water.

(3) Admixtures should not be used for mixing gypsum plasters.

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.

Lime plaster 24.109 (1) Lime plaster for internal use shall be applied in two coats on solid backgrounds. The first coat shall consist of cement, lime and sand in the proportions 1:4:16 by volume and shall not exceed 10 mm thick on walls and 5 mm thick on soffits. The second coat shall consist of cement, lime and sand in the proportions 1:12:30 by volume and shall be 5 mm thick. The total thickness shall not exceed 15 mm on walls and 10 mm on soffits.

(2) Lime plaster for internal use shall be applied in three coats on metal lathing. The first coat and the second coat shall consist of cement, lime and sand in the proportions 1:2:6 by volume. The finishing coat shall consist of cement, lime and sand in the proportions 1:12:30 by volume and shall be 5 mm thick. The total thickness shall not exceed 13 mm measured from the outer face of the metal lathing.

Shanghai plaster 24.110 (1) Shanghai plaster shall be applied in two coats, each 10 mm thick. The

base coat shall consist of cement and sand in the proportions 1:3 by volume. The finishing coat shall consist of cement and stone chippings or marble chippings in the proportions 1:1 by volume. The chippings shall be mixed in one of the proportions stated in Table 24.6.

(2) After the finishing coat has set, the surface shall be scrubbed to expose the aggregate.

Table 24.6: Proportions of chippings in Shanghai plaster

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

SCREEDS, TERRAZZO AND GRANOLITHIC CONCRETE

Preparation for screeds, terrazzo and granolithic concrete

24.111 (1) Concrete surfaces which are to receive screeds, terrazzo or granolithic concrete shall be hacked uniformly over the complete area to expose the coarse aggregate. Laitance shall be removed from fresh concrete by using stiff brushes or other methods agreed by the Engineer.

(2) The surfaces shall be cleaned to remove dirt, dust, oil and other deleterious material. The surfaces shall be dampened for 12 hours before applying the finish in such a manner that surplus water will not be left. Neat cement slurry shall be brushed onto the existing surface immediately before applying the finish. A proprietary type of bonding agent approved by the Engineer may be used instead of cement slurry.

Mixing screeds, terrazzo and granolithic concrete

24.112 Screeds, terrazzo and granolithic concrete shall be mixed as stated in Clause 24.105 for plaster and render.

Screeds

24.113 (1) Floor screeds exceeding 40 mm thick shall consist of cement, sand or granite fines and coarse aggregate in the proportions 1:1½:3 by volume. The coarse aggregate shall be graded such that 100% passes a 10 mm BS test sieve and 75% is retained on a 5 mm BS test sieve.

(2) Lightweight screeds shall consist of cement and lightweight aggregate

in the proportions 1:8 by volume for roofs and 1:6 by volume for floors unless otherwise approved by the Engineer. The screed shall be finished with cement and sand or granite fines in the proportions 1:4 by volume.

(3) Other screeds shall consist of cement and sand or granite fines in the proportion 1:3 by volume.

(4) Wall screeds shall be at least 10 mm thick. The surface shall be lightly scratched to form a key.

(5) Floor screeds that are to be laid monolithically with the base shall be at least 15 mm thick and shall be applied within 3 hours after laying the base. Floor screeds that are to be bonded to a hardened concrete base shall be at least 20 mm thick.

(6) Lightweight screeds shall be at least 50 mm thick excluding the topping. The topping shall be at least 15 mm thick and shall be laid monolithically with the screed.

(7) Vapour barriers for lightweight roof screeds shall be laid flat without creases. Laps shall be at least 150 mm.

(8) Screeds shall be laid between timber battens and in bays not exceeding 15 m^2. The length of each bay shall not exceed 1½ times the width of the bay and the top surface of the batten shall be set to the required level. Screeds shall be compacted to a uniform density throughout.

(9) Screeds shall be completed with one of the following surface finishes as stated in the Contract:

(a) A smooth untextured finish using a steel trowel or power float,

(b) An even textured finish using a wood float, or

(c) A slightly roughened textured finish using a stiff brush.

Terrazzo

24.114 (1) Terrazzo shall be applied in two coats. The minimum thickness of each coat shall be as stated in Table 24.7. The first coat shall consist of cement and sand or granite fines in the proportions 1:3 by volume. The finishing coat shall consist of white or coloured cement and marble aggregate in the proportions 1:2½ by volume. The finishing coat shall be applied before the first coat has set.

(2) Terrazzo shall be laid in bays not exceeding 1 m^2. The length of each bay shall not exceed 1½ times the width of the bay. Bays shall be laid in a chequer board pattern and 24 hours shall be allowed between laying adjacent bays. Bays shall be separated from other bays and from adjacent finishes to the complete depth of both coats by 3 mm thick brass strips. Terrazzo shall be compacted to a uniform density throughout.

(3) After curing has been completed as stated in Clause 24.119**,** the surface of terrazzo shall be ground to a smooth finish and to expose the aggregate. Voids in the surface shall be filled with matching cement.

(4) One coat of wax polish shall be applied to the surface of wall finishes. Floor finishes shall not be highly polished or wax polished.

Table 24.7: Thickness of finish of Terrazzo

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

Granolithic concrete 24.115 (1) The proportions and surface finish of the different types of granolithic concrete shall be as stated Table 24.8.

(2) Granolithic concrete that is to be laid monolithically with the base shall be at least 20 mm thick and shall be applied within 3 hours after laying the base. Granolithic concrete that is to be bonded to a hardened concrete base shall be at least 40 mm thick.

(3) Granolithic concrete shall be laid and compacted as stated in Clause 24.113(8) for screeds and 24 hours shall be allowed between laying adjacent bays.

(4) Trowelled surface finishes to granolithic concrete shall be formed by trowelling the surface with a steel trowel at least 3 times over a period of 6 hours to 10 hours after compaction to give a smooth finish. Cement shall not be used to absorb surplus water. Laitance produced by trowelling shall be removed and shall not be worked into the surface.

(5) Rubbed surface finishes to granolithic concrete shall be formed by rubbing down a trowelled surface finish after it has set with fine carborundum stone to form a smooth finish and to expose the aggregate.

(6) Washed surface finishes to granolithic concrete shall be formed by brushing off a trowelled surface finish before it has set to expose the aggregate.

Table 24.8: Proportions and surface finish of granolithic concrete

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

TILING

Floor tiles 24.116 (1) Floor tiles on concrete bases shall be laid by the semi-dry method as stated in Clause 24.116(2) to (4).

(2) The tiles shall be laid on a bed of cement and sand in the proportions 1:4 by volume. The bed shall be mixed semi-dry and shall be at least 20 mm thick. The concrete base that is to receive the tiles and bed shall be prepared and cleaned as stated in Clause 24.111.

(3) The tiles shall be immersed in water for 30 minutes and shall be allowed to drain immediately before laying. The cement and sand bed shall be compacted and finished to the required level. A slurry of cement and sand in the proportions 1:1 by volume shall be mixed with the minimum amount of water necessary to achieve a creamy consistency and shall be spread and trowelled over the bed to a nominal thickness of 3 mm. The tiles shall be firmly bedded into the slurry to leave straight and even joints. Tiles with minor variation in colour shall be placed at random locations.

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

(5) Floor tiles on floor screeds shall be laid by the thick bed method as stated in Clauses 24.116(6) to (8).

(6) The tiles shall be laid on a bed of cement and sand or granite fines in the proportions 1:3 by volume. The bed shall be approximately 15 mm thick and shall not be thicker than the tiles. The screed shall be dampened with clean water to prevent water being absorbed from the bed.

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

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

(9) After lying floor tiles, no traffic shall be allowed on the floor for the first 4 days and after that only light traffic as approved by the Engineer is allowed for the next 10 days.

Wall tiles

24.117 (1) Wall tiles shall be fixed to wall screeds as stated in Clauses 24.116(5) to (8) except as stated in Clauses 24.117(2) to (9).

(2) Glazed wall tiles shall be laid on a bed of cement and sand or granite fines in the proportions 1:3 by volume. The bed shall be at least 5 mm, and shall not exceed 15 mm, thick. Mosaic tiles shall be laid on a bed of cement and granite fines in the proportions 1:3 by volume. The bed shall be 10 mm thick. Plain or coloured cement and water shall be mixed to a creamy consistency and white cement shall not be used except otherwise stated. Tiles with minor variations in colour shall be placed at random locations.

(3) Glazed wall tiles shall be soaked in clean water for at least 30 minutes and stacked to drain and fix as soon as the surface water has drained from them. Mosaic tiles shall not be soaked but the wall render shall be dampened with clean water sufficiently to prevent the mosaic tiles absorbing water from the bedding mortar.

(4) The backs of glazed wall tiles shall be coated with a mortar of cement and sand or granite fines in the proportions 1:3 by volume. The glazed wall tiles shall be tamped firmly into position so that the bed is uniformly spread throughout to a minimum thickness of 3 mm and not more than 6 mm at localised areas for rectification of slight variations in the trueness of the render background. The tiles and joints shall be cleaned before the bedding hardens.

(5) The backs of sheets of mosaic tiles shall be coated with a slurry of cement of the same colour as the final grout. The backing paper of mosaic tiles shall be removed and final straightening of the tiles shall be carried out as the sheets are fixed firmly into position. The surface shall be rubbed with grout and coloured, as required, to fill the joints and clean any surplus from the face of the tiles as the work proceeds.

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

(7) When cement-based adhesive bedding method is used to fix wall tiles, the tiling work shall be carried out in accordance with BS 5385-1 and the followings:

(i) Site demonstration is to be carried out by the adhesive supplier on the whole application procedures before commencing the tiling works.

(ii) Tiles shall be cleaned free of dust and loose powder and left thoroughly dry before immediate application.

(iii) Tiles shall not be wetted when fixing with tile adhesive unless stated in the manufacturer's recommendations.

(iv) Tile adhesive shall be prepared and mixed in strict accordance with the manufacturer's recommendations.

(v) The adhesive shall be applied by notched trowelling and buttering method.

(vi) For fixing mosaic tiles with adhesive, in addition to (i) to (v) of this sub-clause, BS 5385:Part 1 with particular attention to 8.4.1 for internal wall and BS 5385:Part 2 with particular attention to 12 for external wall are required. The joints shall be grouted with a proprietary grout applied in accordance with the grout manufacturer's recommendations.

Roof tiles 24.118 (1) Roof tiles shall be laid on a bed of cement and sand in the proportions 1:4 by volume.

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

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

PROTECTION OF PLASTERWORK AND OTHER FINISHES

Protection of plasterwork and other finishes 24.119 Completed and partially completed surfaces of plasterwork and other finishes shall be protected from rapid or localised drying out for at least 7 days by covering with polythene sheeting, damp hessian, or a layer of damp sand at least 50 mm thick, or by other methods agreed by the Engineer.

TOLERANCES

Tolerances: plasterwork and other finishes 24.120 There shall be no abrupt irregularities in the surface of plasterwork and other finishes and there shall be no gradual irregularities exceeding 5 mm in a 2 m length.

TESTING

Non-slip homogenous floor tiles 24.121 The quality tests for non-slip homogenous floor tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			**200 x 200**	**300 x 300**	**400 x 400**
BS EN 14411 Classification			**BIb**	**BIb**	**BIb**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	± 0.75	± 0.6	± 0.6
	Deviation from Average Size (%)		± 0.5	± 0.5	± 0.5
2. Thickness			± 5	± 5	± 5
3. Straightness of sides (%)			± 0.5	± 0.5	± 0.5
4. Rectangularity (%)			± 0.6	± 0.6	± 0.6
5. Surface flatness	Centre curvature (%)		± 0.5	± 0.5	± 0.5
	Edge curvature (%)		± 0.5	± 0.5	± 0.5
	Warpage (%)		± 0.5	± 0.5	± 0.5
6. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			= > 95	= > 95	= > 95

b) Physical properties:

Test Items		Test Method	200 x 200	300 x 300	400 x 400
Nominal Size (mm)					
BS EN 14411 Classification			**BIb**	**BIb**	**BIb**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	< = 3	< = 3	< = 3
	Individual		< = 3.3	< = 3.3	< = 3.3
2. *Modulus of rupture (N/mm^2)	Average	BS EN ISO 10545-4	> = 30	> = 30	> = 30
	Individual		> = 27	> = 27	> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the Engineer	> = 6	> = 6	> = 6
4. *Abrasion resistance	Deep abrasion (mm^3)	BS EN ISO 10545-6	< = 175	< = 175	< = 175
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0	< = 9.0	< = 9.0

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are

acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size			**200 x 200**	**300 x 300**	**400 x 400**
BS EN 14411 Classification			**BIb**	**BIb**	**BIb**
1. *Resistance to acids and alkali	Sulphuric acid	BS EN ISO 10545-13	Required	Required	Required
	Lactic acid		Required	Required	Required
	Potassium hydroxide		Required	Required	Required
2.*Resistance to household chemicals	Ammonium chloride		Required	Required	Required
	Standard cleaning agent		Required	Required	Required
3.*Resistance to swimming pool salts	Sodium hypochlorite		Required	Required	Required
	Copper sulphate		Required	Required	Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction;

d) Slip resistance:

Test Items	Test Method	Acceptance Standards		
Nominal Size (mm)		**200 x 200**	**300 x 300**	**400 x 400**
BS EN 14411 Classification		**BIb**	**BIb**	**BIb**
1. Anti-slip property	DIN 51130	R11 (or R10 V4) or above		

Glazed ceramic wall tiles

24.122 The quality tests for glazed ceramic wall tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			**108 x 108**	**152 x 152**	**200 x 200**
BS EN 14411 Classification			**BIII**	**BIII**	**BIII**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	0.75 / (-0.3, +0.6)	± 0.5 / (-0.3, +0.6)	± 0.5 / (-0.3, +0.6)
	Deviation from Average Size (%)		± 0.5 / (± 0.25)	± 0.3 / (± 0.25)	± 0.3 / (± 0.25)
2. Thickness		To be decided by the Engineer	± 0.5	± 0.5	± 0.6
3. Minimum thickness (mm)			4	5.5	-
4. Straightness of sides (%)		BS EN ISO 10545-2	± 0.3	± 0.3	± 0.3
5. Rectangularity (%)			± 0.5 / (± 0.3)	± 0.5 / (± 0.3)	± 0.5 / (± 0.3)
6. Surface flatness	Centre curvature (%)		- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)
	Edge curvature (%)		- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)
	Warpage (%)		± 0.5 / (± 0.5 mm)	± 0.5 / (± 0.5 mm)	± 0.5 / (± 0.75 mm)
7. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95	> = 95	> = 95
8. Tile with spacer lugs	Width of tile grout at tiled surface (mm) (G)	To be decided by the Engineer	-	-	G = 3 mm ± 20%

Note: Values in brackets are for tiles with spacer lugs only.

b) Physical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			**108 x 108**	**152 x 152**	**200 x 200**
BS EN 14411 Classification			**BIII**	**BIII**	**BIII**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	= > 10 & < = 20	= > 10 & < = 20	= > 10 & < = 20
2. *Modulus of rupture (N/mm^2)	Thickness < 7.5mm	BS EN ISO 10545-4	> = 15	> = 15	> = 15
	Thickness > = 7.5mm		> = 12	> = 12	> = 12
3. *Scratch hardness of surface (Moh's Scale)		To be decided by the Engineer	> = 3	> = 3	> = 3
4. *Abrasion resistance	Surface abrasion (Class I-IV)	(PEI Method) BS EN ISO 10545-7	Minimum Class II	Minimum Class II	Minimum Class II
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0	< = 9.0	< = 9.0
6. *Crazing resistance		BS EN ISO 10545-11	Required	Required	Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size			**108 x 108**	**152 x 152**	**200 x 200**
BS EN 14411 Classification			**BIII**	**BIII**	**BIII**
1. *Resistance to acids and alkali	Hydrochloric acid	BS EN ISO 10545-13	Minimum Class B	Minimum Class B	Minimum Class B
	Citric acid		Minimum Class B	Minimum Class B	Minimum Class B
	Potassium hydroxide		Minimum Class B	Minimum Class B	Minimum Class B
2.*Resistance to household chemicals	Ammonium chloride		Minimum Class B	Minimum Class B	Minimum Class B
	Standard cleaning agent (See Note 2)		Minimum Class B	Minimum Class B	Minimum Class B
3. *Resistance to swimming pool salts	Sodium hypochlorite		Minimum Class B	Minimum Class B	Minimum Class B
	Copper sulphate		Minimum Class B	Minimum Class B	Minimum Class B
4. *Resistance to staining	Methylene blue	BS EN ISO 10545-14	Minimum Class B	Minimum Class B	Minimum Class B
	Potassium permanganate		Minimum Class B	Minimum Class B	Minimum Class B

Note: 1. For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction;

2. The cleaning agent used is "Bathroom Magiclean" available in supermarkets.

Unglazed vitreous mosaic wall tiles

24.123 The quality tests for unglazed vitreous mosaic wall tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**20 x 20, 50 x 50**
BS EN 14411 Classification			**BIb**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-42	± 1.2
	Deviation from Average Size (%)		± 0.75
2. Thickness (%)			± 10
3. Minimum thickness (mm)		To be decided by the Engineer	4 (20 x 20)
			5 (50 x 50)
4. Straightness of sides (%)		BS EN ISO 10545-2	± 0.75
5. Rectangularity (%)			± 1.0
6. Surface flatness	Centre curvature (%)		± 1.0
	Edge curvature (%)		± 1.0
	Warpage (%)		± 1.0
7. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**20 x 20, 50 x 50**
BS EN 14411 Classification			**BIb**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	0.5 > & < = 3
	Individual		< = 3.3
2. *Modulus of rupture (N/mm^2)	Average	BS EN ISO 10545-4	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the Engineer	> = 6
4. *Abrasion resistance	Deep abrasion (mm)	BS EN ISO 10545-6	< = 175
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size			**20 x 20, 50 x 50**
BS EN 14411 Classification			**BIb**
1. *Resistance to acids and alkali	Sulphuric acid	BS EN ISO 10545-13	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

Glass mosaic wall tiles 24.124 The quality tests for glass mosaic wall tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**20 x 20**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	± 1.2
2. Thickness (%)			± 10
3. Minimum thickness (mm)		To be decided by the Engineer	4
4. Surface flatness	Centre curvature (%)	BS EN ISO 10545-2	± 1.0
	Edge curvature (%)		± 1.0
5. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**20 x 20**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	0.5 < & < = 3
	Individual		< = 3.3
2. *Modulus of rupture (N/mm^2)	Average	BS EN ISO 10545-4	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		To be decided by the Engineer	> = 6
4. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size			**20 x 20**
1.*Resistance to acids and alkali	Sulphuric acid	BS EN ISO 10545-13	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

Homogenous coved tile skirting

24.125 The quality tests for homogenous coved tile skirting shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**200 x 75 x 7**
BS EN 14411 classification			**BIb**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	± 1.0
	Deviation from Average Size (%)		± 0.5
2. Thickness (%)			± 10 (or to be decided by the Engineer)
3. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**200 x 75 x 7**
BS EN 14411 classification			**Bib**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	0.5 = < & < = 3
	Individual		< = 3.3
2. *Scratch hardness of surface (Moh's Scale)		To be decided by the Engineer	> = 6
3. *Abrasion resistance	Deep abrasion (mm^3)	BS EN ISO 10545-6	< = 175
4. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size			**200 x 75 x 7**
BS EN 14411 classification			**Bib**
1. *Resistance to acids and alkali	Sulphuric acid	BS EN ISO 10545-13	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

Homogenous wall tiles 24.126 The quality tests for homogenous wall tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**100 x 100**
BS EN 14411 classification			**Bib**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	± 1.0
	Deviation from Average Size (%)		± 0.5
2. Thickness (%)			± 10
3. Straightness of sides (%)			± 0.5
4. Rectanularity (%)			± 0.6
5. Surface flatness	Centre curvature (%)		± 0.5
	Edge curvature (%)		± 0.5
	Warpage (%)		± 0.5
3. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			**100 x 100**
BS EN 14411 classification			**Bib**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	0.5 < = & < = 3
	Individual		< = 3.3
2. *Modules of rupture (N/mm^2)	Average	BS EN ISO 10545-4	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the Engineer	> = 6
4. *Abrasion resistance	Deep abrasion (mm^3)	BS EN ISO 10545-6	< = 175
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size			**100 x 100**
BS EN 14411 classification			**BI**
1. *Resistance to acids and alkali	Sulphuric acid	BS EN ISO 10545-13	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

External facing tiles 24.127 The quality tests for external facing tiles shall be as follow:

(a) Dimensions and surface quality

Test Items		**Test Method**	**Acceptance Standards**
Nominal Size (mm)			**45 x 45 x 7 & 45 x 95 x 7**
BS EN 14411 classification			**Bib**
1. Length and Width	Deviation from Work Size (%)	BS EN ISO 10545-2	± 1.2
	Deviation from Average Size (%)		± 0.75
2. Thickness (%)			± 10
3. Straightness of sides (%)			± 0.75
4. Rectangularity (%)			± 1.0
5. Surface flatness	Centre curvature (%)		± 1.0
	Edge curvature (%)		± 1.0
	Warpage (%)		± 1.0
3. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

b) Physical properties:

Test Items		**Test Method**	**Acceptance Standards**
Nominal Size (mm)			**45 x 45 x 7 & 45 x 95 x 7**
BS EN 14411 classification			**Bib**
1. *Water absorption (%)	Average	BS EN ISO 10545-3	0.5 < = & < = 3
	Individual		< = 3.3
2. *Modules of rupture (N/mm^2)	Average	BS EN ISO 10545-4	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		To be decided by the Engineer	> = 5
4. *Abrasion resistance	Surface abrasion (Class I – IV)	(PEI Method) BS EN ISO 10545-7	Minimum Class III
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		BS EN ISO 10545-8	< = 9.0
6. *Crazing resistance		BS EN ISO 10545-11	Required

Note: For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size			**45 x 45 x 7 & 45 x 95 x 7**
BS EN 14411 classification			**Bib**
1. *Resistance to acids and alkali	Hydrochloric acid	BS EN ISO 10545-13	Minimum Class B
	Citric acid		Minimum Class B
	Potassium hydroxide		Minimum Class B
2. *Resistance to household chemicals	Ammonium chloride		Minimum Class B
	Standard cleaning agent (See Note 2)		Minimum Class B
3. *Resistance to swimming pool salts	Sodium hypochlorite		Minimum Class B
	Copper sulphate		Minimum Class B
4. *Resistance to Staining	Methylene blue		Minimum Class 2
	Potassium permanganate (See Note 2)		Minimum Class 2

Note: 1. For the tests marked with *, valid test certificates (original or certified true copies issued by the testing laboratories) for tests carried out within the past 12 months are acceptable as evidence of compliance to the Engineer's satisfaction.

2. The cleaning agent used is "Bathroom Magiclean" available in supermarkets.

PART 6: PAINTING

MATERIALS

Paint and associated materials

24.128 (1) Unless otherwise approved by the Engineer, paint and associated materials in a coat ing 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.

Selection of colours for paintwork 24.147 (1) The colours of paintwork shall be provisionally selected by the Engineer from a catalogue showing the range of colours offered by the manufacturers. The catalogue shall be submitted to the Engineer at least 14 days before painting starts.

(2) Trial panels shall be painted in each of the colours provisionally selected by the Engineer. Each trial panel shall be 1 m x 1 m and shall be painted with the complete paintwork system.

(3) The Engineer shall select the final colour of paintwork from the trial panel.

(4) Trial panels shall be used as a means of comparison for the colour of the finished paintwork. Trial panels shall be protected from damage and shall be left in position until the Engineer instructs their removal.

STORAGE OF MATERIALS

Storage of paint and associated materials 24.148 (1) Paint and associated materials shall be stored in a dry weatherproof store. The store shall be maintained in a cool, well-ventilated condition.

(2) Tins of paint shall be labelled as being for external use, internal use, undercoating and finishing, as appropriate, and shall be protected from exposure to conditions that may adversely affect the material. Paint and associated materials shall be stored in accordance with the manufacturers' recommendations and shall not be used after the recommended shelf life has been exceeded.

ON-SITE DELIVERY CHECK

Emulsion paint, synthetic paint and multi-layer acrylic paint

24.149 (1) The checking requirement are in the following table:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of origin & Delivery Note	Document check	From Approved origin with information of product identification number
2. Colour Code/Label/Serial Number	Check information printed on the packing	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(2) In the event that the checking results fail to meet the checking requirements upon delivery on Site, the failed consignment shall be removed off Site.

PAINTWORK

Preparation of surfaces for painting

24.150 (1) Surfaces that are to be painted shall be dry and clean, and deleterious and loose material shall be removed.

(2) Absorbent surfaces which are to be painted with cement paint shall be thoroughly dampened to provide even suction.

(3) Knotting shall be applied to knots in timber.

(4) Screws and nails in timber and building board surfaces shall be recessed or punched below the finished surface and the whole surface shall be stopped.

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

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

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

Type and number of coats for painting system

24.151 The type and number of coats applied to different surfaces for each painting system shall be as stated in Table 24.9.

Application of paint and associated materials

24.152 (1) Paint and associated materials shall be applied in accordance with BS 6150+A1, BS 8000-0 and BS 8000-12 and shall be mixed and applied in accordance with the manufacturers' recommendations.

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

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

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

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

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

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

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

Health and safety

24.153 (1) Lead based primers and calcium plumbate primers shall not be applied by spaying.

(2) Respirators, which supply clean air during blasting cleaning, paint spraying or in a situation where toxic fumes are generated, shall be worn.

(3) Precautions shall be taken to avoid skin and eye contact with paints and their solvents. All precautionary measures as recommended by the paint manufacturers shall be followed.

Table 24.9: Type and number of coats for painting systems

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

TESTING

Emulsion paint 24.154 The quality tests for emulsion paint shall be as follows:

Test Items		Test Method	Acceptance Standards
Preliminary Examination of paint	Surface skin	BS EN ISO 1513	- No surface skin
	Consistency		- No gelling
	Colour separation into layers		- No colour separation
	Visible impurities		-No visible impurities
	Sediment		- No hard settling
Drying times	Hard drying	BS EN ISO 9117-1	< = 1 hour
Fineness of grind (µm)		BS EN ISO 1524	< = 50µm
Hiding power (contrast ratio %)		BS EN ISO 2814; BS 3900 : D4	> = 75%
Specular gloss	85º	BS EN ISO 2813	< = 20
Viscosity (procedure B)		ASTM : D562 : 10	65 – 85 KU
Scrub resistance (cycle)		ASTM : D2486 - 17	> = 400 cycles

Synthetic paint 24.155 The quality tests for synthetic paint shall be as follows:

Test Items		Test Method	Acceptance Standards
Preliminary examination of paint	Surface skin	BS EN ISO 1513	- No surface skin
	Consistency		- No gelling
	Colour separation into layers		- No colour separation
	Settling		-No hard settling
	Extraneous matter		- extraneous matter
Viscosity (Flow Cup No. 6) (sec)		BS EN ISO 2431	45 to 60 sec
Drying times	Surface drying (hour)	BS EN ISO 9117-3	< = 4
	Hard drying	BS EN ISO 9117-1	< = 18
Fineness of grind (µm)		BS EN ISO 1524	< = 25µm
Hiding power (contrast ratio %)		BS EN ISO 2814; BS 3900 : D4	> = 85%
Specular gloss	60º	BS EN ISO 2813	> 80
Bend test		BS EN ISO 1519	No coating crack at 3 mm mandrel
Scratch test (g)		BS EN ISO 1518-1	> = 600

Multi-layer acrylic paint

24.156 The quality tests for multi-layer acrylie paint shall be as follows:

Test Items	Test Method	Acceptance Standards	Remarks
1. Low Temperature Stability	Table 2 JIS A 6909-2003	No lumps and free from separation and aggregation of the composing materials	Respective coatings of primer coating, main coating and top coating are regarded as samples.
2. Change in Consistency	Clause 5.6 JIS A 6910 – 1988 Table 2 JIS A 6909-2003	± 15%	Respective coatings of primer coating, main coating and top coating are regarded as samples.
3. Cracking Resistance due to Initial Stage Drying	Clause 5.7 JIS A 6910 – 1988 Table 2 JIS A 6909-2003	No cracking shall occur.	
4. Adhesion Strength	Table 2 JIS A 6909-2003	Standard condition > = 68.6 N/cm^2 Immersion in water > = 49.0 N/cm^2	
5. Repeated Warning and Cooling	Table 2 JIS A 6909-2003	No peering, cracking and blistering and remarkable discolouration and degradation in luster on the surface.	
6. Permeability	Table 2 JIS A 6909-2003	< = 0.5 ml	
7. Impact Resistance	Clause 5.11 JIS A 6910 – 1988 Table 2 JIS A 6909-2003	Cracking, remarkable deformation and peeling shall not occur.	

Test Items	Test Method	Acceptance Standards	Remarks
8. Weather Resistance	ASTM G154-06	Cracking and peeling shall not occur and the discolouration shall be No. 3 or over in grey scale according to JIS 6910-1988.	The test conditions: Fluorescent UV Lamp: UVA-340 Cycle: 24 hrs UV at 60°C Total exposure time: 250 hours
9. Determination of Resistance to humid atmospheres containing sulphur dioxide	BS EN ISO 3231; BS 3900: F8 : 1993	No blistering, loss of adhesion, rust staining, change of colour, embrittlement and other signs of deterioration.	The amount of sulphur dioxide to be used in testing is one litre. The test cycle to be 12 cycles
10. Resistance to Fungal Growth	BS 3900: G6 : 1989	Rating 0, no fungal growth	

Note: 1. The colour of paint to be tested shall be selected by the Engineer.
2. The base plate for testing to be 20 mm thick cement mortar board.

PART 7: BRICKWORK AND BLOCKWORK

MATERIALS

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.

SUBMISSIONS

Particulars of brickwork and blockwork

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

(a) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the materials comply with the requirements stated in the Contract and including results of tests for crushing strength of clay bricks, concrete bricks and blocks and concrete hollow blocks,

(b) Details of brickwork reinforcement, damp proof course and wall ties, and

(c) Details of materials for mortar.

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

Samples of materials

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

(a) Each type of brick and block, and

(b) Brickwork reinforcement, damp proof course and wall ties.

TRIAL PANELS

Trial panels

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

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

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

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

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

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

Non-compliance: brickwork and blockwork 24.167 If in the opinion of the Engineer the brickwork or blockwork in the trial panel does not comply with the specified requirements for brickwork or blockwork, particulars of proposed changes to the materials and methods of construction shall be submitted to the Engineer. Further trial panels shall be constructed until the trial panel complies with the specified requirements.

Commencement of brickwork and blockwork 24.168 Brickwork and blockwork shall not commence until in the opinion of the Engineer the trial panel complies with the specified requirements.

Changes in materials 24.169 Unless permitted by the Engineer, the materials used to produce a trial panel that complies with the specified requirements shall not be changed.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of bricks and blocks 24.170 (1) Bricks and blocks shall be unloaded and handled in a manner which will not result in soiling, chipping or other damage to the bricks and blocks.

(2) Bricks and blocks shall be stored on a dry, levelled and maintained hard-standing ground base on level supports and in a manner which will not result in damage or deformation to the bricks or blocks or in contamination of the bricks or blocks.

(3) Bricks and blocks shall be stored horizontally.

(4) Bricks and blocks shall be protected from damage and damaged bricks and blocks shall not be used in the permanent work unless permitted by the Engineer.

LAYING BRICKS AND BLOCKS

Type of mortar 24.171 (1) Cement mortar shall be used for brickwork and blockwork:

(a) Below the damp proof course, including basement walls,

(b) For brickwork and blockwork not exceeding 150 mm thick,

(c) In load-bearing walls, and

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

(2) Cement lime mortar shall be used for brickwork and blockwork other than those stated in Clause 24.171(1).

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

Bond and gauge of brickwork and blockwork 24.172 (1) Stretcher bond shall be used for half brick walls and English bond shall be used for brick walls exceeding half brick thick. Stretcher bond shall be used for blockwork.

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

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

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

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

(6) Bricks and blocks shall be wetted before laying during dry weather using the minimum amount of water necessary to prevent premature drying out of the mortar. During wet weather, freshly laid brickwork and blockwork shall be protected at the completion of each day's work or in heavy rain.

Laying damp proof courses 24.173 (1) Brickwork shall be flushed up with cement mortar to form a level and even bed to receive the horizontal damp proof course.

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

Fixing wall ties 24.174 (1) At junctions of walls and concrete, wall ties shall be fixed at 300 mm centres vertically and shall project 250 mm into the wall.

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

Finishing of joints in brickwork and blockwork 24.175 Joints that will not be visible in the finished brickwork and blockwork shall be struck off as the work proceeds. Joints that will be exposed shall be struck flush and weather pointed as the work proceeds. Joints in brickwork to which plaster or other wet applied finishes will be applied shall be raked out to a depth of 10 mm.

TOLERANCES

Tolerances: brickwork 24.176 Brickwork and blockwork shall comply with the following requirements:

and blockwork

(a) The position on plan shall be within 15 mm of the specified position.

(b) The length shall be within 15 mm of the specified length.

(c) The height shall be within 10 mm of the specified height.

(d) The level of bed joints shall be within 10 mm of the specified level in any 5 m length.

(e) The brickwork and blockwork shall be straight to within 15 mm in any 5 m length.

(f) The brickwork and blockwork shall be vertical to within 15 mm in any 3 m height.

TESTING: BRICKS AND BLOCK

Batch: bricks and blocks

24.177 A batch of bricks or blocks is any quantity of bricks or blocks of the same type, manufactured or produced at the same time in the same place, covered by the same certificates and delivered to the Site at any one time.

Samples: bricks and blocks

24.178 (1) Unless otherwise permitted by the Engineer, one sample of each type of bricks or blocks shall be provided at the same time as particulars of the material are submitted to the Engineer and one sample of each type of bricks or blocks shall be provided from each batch of the material delivered to the Site.

(2) The number of bricks or blocks in the sample shall be 10 for each batch of 15,000 bricks or blocks or part thereof.

(3) The method of sampling shall be in accordance with BS 3921.

Testing: bricks and blocks

24.179 (1) Each brick or block in the sample shall be tested to determine the crushing strength of the brick or block.

(2) The method of testing shall be in accordance with BS 3921.

(3) The average of the 10 crushing strengths of the bricks or blocks shall be calculated and referred to as the compressive strength.

Compliance criteria: bricks and blocks

24.180 The compressive strength of bricks and blocks shall be as stated in Clauses 24.157(4), 24.158(1) and 24.159, or as stated elsewhere in the Contract.

PART 8: METAL WINDOWS AND DOORS

MATERIALS

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.

DESIGN AND FABRICATION OF METAL WINDOWS AND DOORS

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.

Fittings and furniture to steel windows and doors

24.183 (1) Fittings and furniture to steel windows and doors shall be of a proprietary type approved by the Engineer and shall comply with the requirements stated in Clause 24.183(2) to (13).

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

(3) Fittings, including friction grip pivots, casement fasteners, spring catches, brackets, slide arms, shoes, slip bolts, cabin hooks and eyes, and handles shall be manganese brass with bronze finish and shall be capable of retaining the opening parts rigidly in both the open and closed positions.

(4) Handle plates and round headed stay brackets shall be welded to the fixed frames and shall have interchangeable handles and stays.

(5) Windows and doors which are to be hung to open shall be fitted with the fittings and furniture stated in Clause 24.183(6) to (11).

(6) Side-hung casements and vertically centre-hung ventilators shall be fitted with a two-point nose fastener or a two throw casement fastener with mild steel adjustable connecting rod and a 250 mm peg stay or bronze sliding stay as stated in the Contract.

(7) Projecting casements shall be fitted with bronze sliding shoes, pivots and friction side arms and one spring catch with a ring for hand or pole operation and two square-shank barrel bolts.

(8) Top-hung ventilators shall be fitted with a 200 mm peg stay with a round-headed stay bracket welded to the fixed frame and with a second peg to secure the stay firmly and horizontally against the first peg when the ventilator is closed.

(9) Bottom-hung ventilators shall be fitted with a spring catch and fanlight roller stay to limit opening and to permit the ventilator to swing free for cleaning.

(10) Horizontally centre-hung ventilators shall be fitted with a spring catch with ring and eye for cord or pole operation.

(11) Doors shall be fitted with sliding bolts of suitable length, striking plates at top and bottom, magnetic catch, panic bolt, three-lever mortice lock with two keys, lever or knob handles and escutcheon plates as stated in the Contract.

(12) Flyscreens shall be extruded aluminium with plastic covered fibre-glass mosquito gauze with 7 x 7 mesh per 10 mm square. Side-hung casements for use with flyscreens shall have a locking handle and an opening and closing mechanism consisting of a bronze cam handle and bronze roto operator. Top-hung casements for use with flyscreens shall have bronze through-the-frame type stays.

(13) Window poles shall be 25 mm diameter teak with a strong brass hook at one end suitable for opening and closing high windows.

Aluminium windows and doors

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.

Roller shutters and doors 24.186 The design of roller shutters and doors, including boxes, hoods, guides and all other parts shall be carried out by the Contractor in accordance with the requirements stated in the Contract.

SUBMISSIONS

Particulars of metal windows and doors 24.187 (1) The following particulars of the proposed materials and methods of construction for metal windows and doors shall be submitted to the Engineer:

(a) Name and address of manufacturer,

(b) Manufacturer's literature, and

(c) Three sets of working drawings.

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

Samples of materials 24.188 Samples of materials for metal windows and doors, including fittings and furniture, shall be submitted to the Engineer at the same time as particulars of the windows or doors are submitted. Details of the samples to be provided shall be as agreed by the Engineer.

Instruction manuals 24.189 Two copies of instruction manuals shall be provided for motorised roller shutters and doors. The manuals shall include detailed operating and maintenance instructions, including wiring and schematic drawings, a schedule of component parts and a priced list of recommended spares. The manuals shall be provided at the same time as the particulars of the roller shutters and doors are submitted.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of metal windows and doors 24.190 (1) Metal windows and doors shall be handled and stored in a manner which will not result in damage or distortion. Opening lights shall be kept closed.

(2) Temporary steel clamps in steel windows and doors shall be left in

position until installation is complete. Wrapping to aluminium windows and doors shall not be removed until installation starts.

FIXING METAL WINDOWS AND DOORS

Fixing metal windows and doors 24.191 (1) Metal windows and doors which consist of composite units shall be assembled using all necessary bolts, screws and other fixings. Joints shall be sealed using polysulphide-based sealant.

(2) Windows and doors shall be positioned plumb, level and square.

(3) Pockets shall be formed in heads, jambs, cills and other parts of structures to receive fixing lugs. The pockets shall be made good after building in the lugs and screws to frames. Frames shall be screwed using packing pieces where necessary.

(4) Steel frames shall be bedded in mortar to form a waterproof seal.

(5) Aluminium frames shall be bedded in a proprietary type of butyl mastic bedding compound approved by the Engineer to form a waterproof seal.

(6) Joints around external edges of steel frames shall be raked out and pointed with a proprietary type of oil based mastic sealant approved by the Engineer to form a smooth, flat joint.

(7) Joints around external edge of aluminium frames shall be raked out and pointed with polysulphide-based sealant to form a smooth, flat joint.

(8) Adjoining surfaces to joints shall be temporarily masked to prevent contamination during pointing.

PART 9: MASONRY

MATERIALS

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.

SUBMISSIONS

Samples of materials 24.196 Samples of the following proposed materials for masonry shall be submitted to the Engineer for approval of the source and type of each material at least 14 days before the masonry work starts:

(a) Each type of stone,

(b) Wall ties, and

(c) Damp proof course.

TRIAL PANELS

Trial panels 24.197 A trial panel shall be constructed for each type of masonry as stated in Clauses 24.166 to 24.169 for brickwork and blockwork.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of stone 24.198 Stone for ashlar stone walling shall be transported with the minimum amount of handling and shall be stacked in the vehicle using packing pieces to prevent damage. The stone shall be stored in stacks on battens and protected from exposure to rain.

RUBBLE STONE WALLING

Preparation of stone for rubble stone walling 24.199 (1) Stones for random rubble walling shall be irregular in shape and roughly cut to between 75 mm and 300 mm high, at least 75 mm deep and between 75 mm and 600 mm long on bed. The length or depth on bed of each stone shall be greater than the height.

(2) Stones for squared rubble walling shall be trimmed roughly square to between 75 mm and 300 mm high, varying in 75 mm stages. Each stone shall be between 100 mm and 150 mm deep and between 100 mm and 600 mm long on bed. The length or depth on bed of each stone shall be greater than the height.

(3) Stones for square coursed rubble walling shall be trimmed roughly square as stated in Clause 24.199(2) to suit courses of regular height varying from 150 mm to 250 mm.

Laying and jointing rubble stone walling

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

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

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

(4) Roughly squared stones in square coursed walling shall be laid as stated in Clause 24.200(2) but brought up to courses at centres not exceeding 750 mm to line up with quoin and jamb stones.

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

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

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

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

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

(b) Bonding stones shall be provided as stated in Clause 24.200(5) but shall be carried through the full thickness of the wall or 450 mm into the core.

Pointing rubble stone walling

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

ASHLAR STONE WALLING

Preparation of stone for ashlar stone walling 24.202 The exposed faces and joint faces of each stone for ashlar stone walling shall be dressed square and true, free from hollows or rough areas. Exposed faces shall be finished to a finely squared dressed surface. Stones shall be at least 300 mm high. Each stone shall be clearly marked to indicate its position in the finished work.

Laying and jointing ashlar stone walling 24.203 Stones in ashlar stone walling shall be laid on a full, even bed of mortar consisting of cement and fine crushed stone in the proportions 1:3 by volume. All joints shall be filled and shall be 5 mm wide. Stones shall be laid to bond together throughout the wall, and to the backing, using projecting bonding stones.

Pointing ashlar stone walling 24.204 Joints in ashlar stone walling shall be raked to a depth of 15 mm as the work proceeds and shall be pointed with a flush joint on completion using bedding mortar.

PROTECTION OF MASONRY

Protection of masonry 24.205 Newly erected masonry shall be protected from exposure to conditions which may adversely affect the masonry. Arrises, projections and similar features shall be covered with protective sheeting lapped and securely held in position. Facework shall be kept clean at all times.

WALL TIES FOR MASONRY

Wall ties for masonry 24.206 (1) Wall ties in masonry which is to face an existing or newly constructed wall shall be fixed at a rate of 5 per m^2. Ties shall be fixed 100 mm into the wall and 75 mm into the masonry.

(2) Wall ties shall be fixed between the ends of walls and concrete or brickwork at centres of at least 450 mm vertically and shall project 250 mm into the masonry.

TOLERANCES

Tolerances: masonry 24.207 (1) Rubble stone walling shall comply with the following requirements:

(a) The position on plan shall be within 25 mm of the specified position.

(b) The length shall be within 25 mm of the specified length.

(c) The height shall be within 25 mm of the specified height.

(d) The level of bed joints shall be within 25 mm of the specified level in any 5 m length.

(e) The walling shall be straight to within 25 mm in any 5 m length.

(f) The walling shall be vertical to within 20 mm in any 3 m height.

(2) Ashlar stone walling shall comply with the following requirements:

(a) The position on plan shall be within 15 mm of the specified position.

(b) The length shall be within 15 mm of the specified length.

(c) The height shall be within 10 mm of the specified height.

(d) The level of bed joints shall be within 10 mm of the specified level in any 5 m length.

(e) The walling shall be straight to within 15 mm in any 5 m length.

(f) The walling shall be vertical to within 15 mm in any 3 m height.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 25

ENVIRONMENTAL PROTECTION

SECTION 25

ENVIRONMENTAL PROTECTION

GENERAL

General requirements 25.01 (1) The Contractor shall undertake environmental protection measures to reduce the environmental impacts arising from execution of the Works. In particular, he shall arrange his method of working to minimize the effects on the air, noise, water quality as well as nuisance of waste within and outside the Site, on transport routes and at the stockpiling, loading, dredging and dumping areas.

(2) The Contractor shall observe and comply with all the current enactments, relevant environmental protection and pollution control ordinances and regulations, and any additions or amendments thereto coming into effect before completion of the Works. The Contractor shall provide his staff and the Engineer on site at all times with on-line access through the Internet to such ordinances and regulations. If on-line access is not possible and when required by the Engineer, the Contractor shall maintain on site legal copies of the relevant ordinances and their regulations, and provide one legal copy for the Engineer.

(3) The Contractor shall design, construct, operate and maintain pollution control measures to ensure compliance with the contract provisions as well as the relevant ordinances and their regulations.

(4) The Contractor shall cooperate with and assist the Environmental Team in conducting compliance monitoring and audit on the environmental aspects of the construction activities.

(5) The Contractor shall follow "Environmental Monitoring and Audit (EM&A) Guidelines for Development Projects in Hong Kong" for the EM&A practice. The guidelines are given by Environment Protection Department (EPD) on the website:-

http://www.epd.gov.hk/eia/hb/materials/guidelines.htm

The above website is subject to change and hence the homepage of EPD should be referred to when warranted.

(6) Where the activities on Site are found not in compliance with the requirements as specified or cause unacceptable environmental impacts, the Contractor shall immediately carry out appropriate environmental mitigation measures to rectify the situation to the Engineer's satisfaction.

(7) The Contractor shall make due allowance in his resources and programme for carrying out of the Works in compliance with the environmental protection control requirements under the Contract.

(8) The Contractor shall provide suitable training to the workers on environmental nuisance abatement and waste management.

WATER POLLUTION CONTROL

Water pollution control - general requirements 25.02

(1) The Contractor shall observe and comply with the Water Pollution Control Ordinance, its subsidiary regulations and the Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters and any additions or amendments thereto coming into effect before completion of the Works.

(2) The Contractor shall carry out the Works in such a manner as to minimise adverse impacts on the water quality during execution of the Works. In particular he shall arrange his method of working to minimise the adverse effects on the water quality within and outside the Site, on the transport routes and at the stockpiling, loading, dredging and dumping areas.

(3) The Contractor shall follow the practices and be responsible for the design, construction, operation and maintenance of all the necessary mitigation measures, as specified in the Professional Persons Environmental Consultative Committee Practice Note (ProPECC PN) 1/94 "Construction Site Drainage" issued by the Director of Environmental Protection, or any update or reissue of this document posted on the website of Environmental Protection Department (http://www.epd.gov.hk) under Resources and Publications\Publications\Guidelines and Reference Materials. The Contractor shall submit the design of the mitigation measures to the Engineer for approval. The mitigation measures shall be continuously reviewed and modified as necessary to cope with the changing site conditions as the Works progress.

Marine plant and equipment 25.03

(1) Two weeks before commencement of any marine works, the Contractor shall submit to the Engineer for approval the proposed methods of working and the marine plant and equipment to be used.

(2) The marine plant and equipment to be used on the Works shall meet the requirement in sub-clauses (1) and (3) of Clause 25.04 and shall be operated accordingly to achieve the water quality requirements. The Contractor shall provide all necessary facilities to the Engineer for inspecting or checking such plant and equipment and shall not use such plant and equipment for execution of the Works without the agreement of the Engineer. The Engineer may require the Contractor to carry out trials of any plant and equipment to prove their suitability.

(3) After commencement of the Works, if the plant and equipment or working methods are, in the opinion of the Engineer, not in compliance with the requirements of the Technical Memorandum on Effluent Standards issued under the Water Pollution Control Ordinance, the Engineer may notify the Contractor in writing, and the Contractor shall immediately initiate remedial measures to halt deterioration. Where such remedial measures include the use of additional or alternative plant and equipment, such plant and equipment shall not be used on the Works until agreed by the Engineer. Where remedial measures include maintenance or modification of previously approved plant and equipment, such plant and equipment shall not be used on the Works until the necessary maintenance or modification is completed and the adequacy of the maintenance or modification is demonstrated to the satisfaction of the Engineer.

(4) The Contractor shall comply with the conditions of dumping permits obtained from the Director of Environmental Protection. The permits shall

be prominently displayed in both Chinese and English languages on site and also on the dredgers and barges.

Avoidance of pollution during dredging, transporting and dumping of marine mud

25.04 (1) Pollution-avoidance measures shall include but not be limited to the following:

(a) All equipment shall be designed and maintained to minimise the risk of silt and other contaminants being released into the water column or deposited in locations other than designated location;

(b) Mechanical grabs shall be designed and maintained to avoid spillage and shall be sealed tightly while being lifted;

(c) Where trailing suction hopper dredgers for dredging of marine mud are in use, overflow from the dredger and the operation of lean mixture overboard systems shall not be permitted unless expressly approved by the Engineer in consultation with the Director of Environmental Protection;

(d) Cutter heads of suction dredgers shall be suitable for the material being excavated and be designed to minimize overbreak and sedimentation around the cutter;

(e) All vessels shall be sized so that adequate clearance is maintained between vessels and the sea bed at all states of the tide to ensure that undue turbidity is not generated by turbulence from vessel movement or propeller wash;

(f) All leaking pipes shall be repaired promptly and plant shall not be operated with leaking pipes;

(g) Before moving vessels that are used for transporting dredged material, the excess material shall be cleaned from the decks and exposed fittings of vessels. The excess material shall not be dumped into the sea except at the approved locations;

(h) Adequate freeboard shall be maintained on barges to ensure that decks are not washed by wave action;

(i) The Contractor shall monitor all vessels transporting material to ensure that no dumping outside the approved location takes place. The Contractor shall keep and produce logs and other records to demonstrate compliance and that journey times are consistent with designated locations and copies of such records shall be submitted to the Engineer;

(j) All bottom-dumping vessels shall be fitted with tight fitting seals to their bottom openings to prevent leakage of material;

(k) Loading of barges and hoppers shall be controlled to prevent splashing of dredged material to the surrounding water, and vessels shall not be filled with material to a such level that will cause overflowing of material or polluted water during loading or transportation; and

(l) The Engineer may monitor any or all vessels transporting material to check that no dumping outside the approved location or loss of

material during transportation takes place. The Contractor shall provide all reasonable assistance to the Engineer for this purpose.

(2) The Contractor shall be responsible for obtaining all necessary dumping permits. All fees in respect of applications for disposal permits shall be borne by the Contractor. The dredged marine mud shall only be disposed of at the disposal site or sites designated in the dumping permit.

(3) When dredging, transporting and disposing of contaminated marine mud, the Contractor shall implement adequate measures for avoidance of pollution, which shall include but not be limited to the following: -

(a) Dredging of contaminated marine mud shall be undertaken with a suitable grab dredger using closed watertight grab;

(b) Contaminated marine mud shall be transported by split barge of not less than 750 m^3 capacity, well maintained and capable of rapid opening and discharging at the disposal site;

(c) The material shall be placed into the disposal pit by means of bottom dumping;

(d) Discharge from split barges shall take place within a radius of 100 metres of centre of the area allocated for the disposal of contaminated marine mud;

(e) Discharge shall be undertaken rapidly and the hoppers shall then be closed immediately. Ensure that material adhering to the sides of the hopper is not washed out of the hopper and the hopper remains closed until the barge returns next to the disposal site; and

(f) The dumping vessel shall be anchored throughout the dumping operation.

(4) The Contractor shall ensure that all marine mud is disposed of at the approved locations. He shall be required to ensure accurate positioning of vessels before the discharge, and submit proposals for accurate position control at the disposal sites to the Engineer for approval before commencing dredging and dumping.

(5) The Contractor shall ensure that all material unsuitable for reuse as fill material is disposed of at the approved landfill or other designated locations.

(6) The Contractor shall only employ vessels equipped with automatic self-monitoring devices specified by the Director of Environmental Protection for disposal operation. He shall co-operate with and facilitate the Director of Environmental Protection in inspection of the device and retrieval of the record stored in the device on a regular basis.

(7) The Contractor shall provide experienced full-time personnel on board all dumping vessels to ensure that appropriate methods to minimize pollution are implemented.

Protection of water quality at water intakes and storage

25.05 When dredging mud or placing fill in the vicinity of a water intake, the Contractor shall protect the water intake by surrounding it with a suitable silt curtain to prevent excessive suspended solids from entering the intake. The silt curtain shall be designed to ensure that the concentration of suspended

solids entering the intake meets the intake user requirements.

Discharge into sewers, drains and water bodies 25.06 (1) In accordance with the Water Pollution Control Ordinance (WPCO) requirements, the Contractor shall apply for the WPCO licence before discharging any effluent, including but not limited to any trade effluent or foul or contaminated water or cooling or hot water, from the Site into any public sewer, stormwater drain, channel, stream-course or sea. The Contractor shall provide a copy of the application and licence to the Engineer. The content of effluent to be discharged into the waters from the Site shall strictly comply with the limits set in the WPCO and the discharge licence.

(2) The discharge licence may include conditions to require the Contractor to provide, operate and maintain at the Contractor's own expense to the satisfaction of the Engineer suitable works for the treatment and disposal of such trade effluent or foul or contaminated or cooling or hot water. The design of such treatment works, if required, shall be submitted to the Engineer for approval not less than one month before commencement of the relevant works.

(3) If any toilet or shower facilities are erected, foul water effluent from these facilities shall be discharged to a foul sewer either directly or indirectly by means of pumping or other means approved by the Engineer. Wastewater collected from a kitchen or canteen, including that from basins, sinks and floor drains, shall be discharged into four sewers via grease traps of adequate retention capacities as appropriate. If no sewer connection is available, the Contractor shall arrange for a licensed sub-contractor to collect the sewage generated from the Site or implement an on-site packaged sewage treatment system approved by the Engineer.

Wastewater from construction activities 25.07 (1) The following mitigation measures shall be carried out to mitigate environmental impacts from wastewater due to construction activities:

(a) Water used for water testing, boring, piling, drilling works, concrete batching, washing of concrete trucks, and precast concrete casting and the like shall be re-circulated and re-used for such beneficial uses as dust suppression, wheel washing and general cleaning. The discharge of wastewater shall be kept to a minimum.

(b) Online standby sump pumps of adequate capacity and with automatic alternating devices shall be provided to prevent overflow of wastewater from any water recycling system.

(c) Wastewater from concrete batching, bored piling and precast concrete casting activities shall be treated for pH adjustment and silt removal before discharge.

(d) Sand, silt or other materials present in the wash-water resulting from wheel washing facilities shall be removed before discharge of the wastewater. That section of access road between any site exit and the public road shall be paved with concrete or bituminous surfacing and provided with a suitable backfall to prevent the site run-off from entering the public road.

(e) Drainage of groundwater, including water pumped out of trenches and excavations, shall only be discharged after removal of silt.

(f) All fuel tanks and fuel storage areas shall be provided with locks and sited on bunded sealed areas of a capacity equal to at least 110% of the storage capacity of the largest tank.

(g) Site compounds and plant/vehicle service areas shall be, unless it is practically impossible, located within roofed areas. The drainage in these areas shall be discharged to a proper wastewater system (e.g. foul sewer, septic tank or storage tank) via a properly maintained oil interceptor to prevent release of oil into the surface water drainage system after accidental spillages. The interceptor shall have a bypass to prevent flushing during periods of heavy rain. Waste-oil shall be collected and stored for recycling or disposal in accordance with the Waste Disposal Ordinance.

(2) The drainage system for stormwater run-off shall be designed as segregated from the system for wastewater discharge arising from construction activities, unless it is practically impossible to reduce the risk of cross contamination.

Surface runoff

25.08 (1) Surface run-off from the Site shall be discharged into stormwater drains or natural streams via adequately designed silt-removal facilities such as sand traps, silt traps, silt retention pond, sediment basins and mechanical water treatment plant. Channels or earth bunds or sand bag barriers shall be provided on the Site to properly direct stormwater to such silt-removal facilities. Perimeter channels at the Site boundaries shall be provided where necessary to intercept storm run-off from outside the Site so that it will not wash across the Site. Catchpits and perimeter channels shall be constructed in advance of site formation works and earthworks. Manholes shall be adequately covered or temporarily sealed.

(2) Silt-removal facilities shall be designed with adequate capacity and constructed within the surface-water drainage systems at appropriate locations.

(3) The Contractor shall be responsible for adequately maintaining any existing Site drainage system at all times including removal of solids from sand traps, manholes and stream beds. The Contractor shall carry out dredging of water-courses after informing the Engineer and all work in natural streams/rivers shall follow the requirements in Clause 25.09.

(4) Silt-removal facilities, channels and manholes shall be maintained and the deposited silt and grit shall be removed regularly, and after each rainstorm, to ensure that these facilities are functioning properly at all times. Disposal of material shall be carried out properly subject to the knowledge and approval of the Engineer. These facilities shall be regularly inspected as required by the Engineer.

(5) Temporary access roads shall be protected with crushed stone or gravel, particularly during the rainy seasons. Intercepting channels shall be provided to prevent storm runoff from washing across exposed soil surfaces.

(6) The Contractor shall pay particular attention to prevention of erosion during earthwork operations, including but not limited to the following works:

(a) Construction works shall be programmed to minimize soil excavation in the rainy seasons as far as possible.

(b) Earthwork surfaces, whether temporary or final, shall be adequately compacted and subsequent permanent works shall be performed immediately, whenever possible, to prevent erosion and silty runoff. Temporary protection of such surfaces with hydroseeding or hard cover (e.g. shotcrete) shall be carried out as required by the Engineer if they have to remain exposed for more than 10 calendar days.

(c) Arrangements shall always be in place to ensure that adequate surface protection measures be safely carried out well before the arrival of a rainstorm.

(7) Exposed stockpiles of construction materials on the Site such as aggregates, sand or fill material shall be protected from erosion during rainstorms (e.g. by means of covering them with tarpaulin or similar fabric) to prevent the stockpiled materials from being washed away into any drainage system. In addition, the Engineer may require a separate run-off collection and treatment system for large stockpiles.

Protection of natural streams/rivers

25.09 (1) For the purpose of the Contract, a natural stream/river shall refer to a natural channel including the natural banks and riparian zones, with natural water fed from upper terrains with water flowing throughout the year or intermittent water-flow only during wet seasons, and any other water-carrying channels, ponds or the like and the extents are as defined on the Drawings. The Contractor shall keep on the Site records of photographs of the existing natural streams and rivers within the Site, and provide the Engineer with a copy of the same records before any works commence in or near natural streams/rivers.

(2) Natural streams/rivers on the Site where work is not being carried out shall be maintained in clean and tidy conditions and shall be free of any floating debris. Natural streams/rivers shall not be used to store materials or to park construction plant or other vehicles.

(3) The natural bottom and existing flow in the river shall be maintained as far as possible to avoid disturbance to the river habitats. Tracked vehicles shall not use the river-bed/stream-bed unless protection against damage is provided to the satisfaction of the Engineer. Temporary river crossings should be supported on stilts or pontoons or the like above the riverbed. Temporary river crossings and temporary access to the works site shall be carefully planned and located to minimize disturbance to the substrates of streams/rivers and riparian vegetations caused by the construction plant. Temporary river crossings and temporary access shall not be constructed without the prior consent in writing from the Engineer.

(4) Where specified in the Contract, the Contractor shall use smaller construction plant of a type approved by the Engineer for works in or near natural streams and rivers to reduce disturbance to the stream-bed/river-bed where aquatic inhabitants are located.

(5) Excavated or backfilling materials shall not be stored adjacent to natural streams/rivers unless permitted by the Engineer.

(6) No excavated material, silt, debris, rubbish, cement slurry or such construction waste shall be deposited into natural streams/rivers. The Contractor shall submit preventive measures to prevent soil/ mud from slipping into the streams/rivers to the Engineer for agreement before any

works commence in or near natural streams/rivers. Should such deposits be found, the Contractor shall remove them, and restore the affected natural streams/rivers to their original state to the satisfaction of the Engineer. If the works site is inside or in the proximity of natural rivers/streams, the Contractor shall temporarily isolate the construction works with proper methods, such as by placing of sandbags or silt curtains with lead edge at bottom and properly supported props, to prevent adverse impacts on the water quality.

(7) Without the prior consent of the Engineer, the Contractor shall not excavate boulders, gravel or sand or other substrata materials from the natural streams/rivers, whether these materials are for the purpose of temporary, long-term or off-site use as construction material, or for any other purposes.

NOISE CONTROL

Noise control - general requirements 25.10

(1) The Contractor shall observe and comply with the Summary Offences Ordinance and the Noise Control Ordinance including their subsidiary regulations and technical memoranda and any additions or amendments thereto coming into effect before completion of the Works.

(2) The Environmental Protection Department (EPD) (http://www.epd.gov.hk/epd/) has published a category of Quality Powered Mechanical Equipment (QPME) on the website:

http://www.epd.gov.hk/cgi-bin/npg/qpme/list.pl?lang_eng

The categories of the QPME include, but are not limited to, those in the website. A list of the plant models under the QPME is also given by the EPD on the website: -
http://www.epd.gov.hk/cgi-bin/npg/qpme/search_gen.pl?lang=eng&st=sim&smtype=1

The above websites of the QPME is subject to change and hence the homepage of EPD should be referred to when warranted.

(3) Where a QPME is used, the plant shall be registered with EPD, and the label issued by EPD from such registration shall be affixed on the plant at all times and kept legible. The Engineer shall deem a construction plant or equipment as non-compliant for the purpose of this sub-clause if it does not have its registration label so affixed.

(4) To facilitate monitoring and control, the Contractor shall establish a register to record all QPME referred to in sub-clause (2) used on the Site.

(5) The Contractor shall devise, arrange methods of working and carry out the Works in such a manner so as to minimize noise impacts on the surrounding environment, and shall provide experienced personnel with suitable training to ensure that these methods are implemented.

(6) The Contractor shall submit for the Engineer's prior approval, at least 2 weeks before commencement of any work, method statements, the plant and equipment to be used, and the sound-reducing measures to be adopted on the Site for the work. Noise reduction methods shall include but not be limited to scheduling of the work, locating of facilities, selection of plant and

equipment and use of purpose-built acoustic panels and enclosures, as specified in the Professional Persons Environmental Consultative Committee Practice Note (ProPECC PN) 2/93 "Noise from Construction Activities – Non-statutory Controls" issued by the Director of Environmental Protection, or any update or reissue of this document posted on the website of Environmental Protection Department (http://www.epd.gov.hk) under Resources and Publications\Publications\Guidelines and Reference Materials. The Contractor's submission shall also include a statement explaining why his proposed methods of working, plant and equipment are able to minimize the noise impacts arising from the work. The method statements shall be updated and resubmitted for agreement from time to time as required by the Engineer.

(7) In considering the submissions made under sub-clause (6) above, the Engineer may require the Contractor to demonstrate the proposed methods of working, plant equipment and sound-reducing measures to be used on the Site in trials or make them available for inspection, to ensure that they are suitable for execution of the Works.

Allowable noise limits 25.11 (1) For carrying out any construction work other than percussive piling during the time period from 0700 to 1900 hours on any day not being a general holiday (including Sundays), the Contractor shall comply with the following requirements

(a) The noise level at 1m from the most affected external facade of the nearby noise sensitive receivers from the construction works alone during any 30-minute period shall not exceed an equivalent sound level (Leq) of 75 dB(A). All domestic premises, hotels, hostel, temporary housing accommodation, hospital, medical clinic, educational institution, place of public worship, library, court of law, performing arts centre or office building shall be considered as noise sensitive receivers.

(b) In addition to the requirement in sub-clause (1)(a), the noise level at 1m from the most affected external facade of the nearby schools from the construction works alone during any 30-minute period shall not exceed an equivalent sound level (Leq) of 70 dB(A). The allowable equivalent sound level is reduced to 65 dB(A) during school examination periods. The Contractor shall liaise with the schools and/or the Examination Authority to ascertain the exact dates and times of all examination periods during the course of the Contract.

(c) If the limits stated in the above sub-clauses (1)(a) and (1)(b) are exceeded, the construction shall stop and shall not re-commence until appropriate measures acceptable to the Engineer that are necessary for compliance have been implemented.

(2) Notwithstanding the requirements and limitations set out in sub-clause (1) above and subject to the Contractor's compliance with sub-clauses (2) to (5) of Clause 25.10 above, the Engineer may, upon application in writing by the Contractor, allow the use of equipment and carrying out of any construction activities for any duration, provided that he is satisfied with the application and in his opinion, such application is considered to be of absolute necessity and adequate noise insulation has been provided to the noise sensitive receivers affected, or is of emergency nature, and is not in contravention with the Noise Control Ordinance in any respect.

Noise mitigation measures

25.12 (1) All hoods, cover panels and inspection hatches of powered mechanical plant such as generators, air compressors etc. shall be closed during operation.

(2) Diesel hammer shall not be used for piling works.

(3) Blasting shall not be carried out during the period specified in the blasting clauses under Section 6 to avoid noise impact at sensitive hours.

(4) The Contractor shall use non-percussive equipment such as hydraulic crusher, sawing, coring machines, etc. for demolition and concrete-breaking work. In circumstances permitted by the Engineer, the Contractor can use percussive equipment for demolition and concrete-breaking work. Where percussive breakers are used, the Contractor shall enclose/wrap the breaker tip of any percussion breaker used with sound absorbing material to reduce the noise. This requirement may be exempted for works under emergency, or with prior agreement from the Engineer that the provision of such is not necessary. Mufflers or silencers, and damping layer with steel collars shall be fitted to hand-held pneumatic breakers.

(5) The Contractor shall provide damping materials inside and outside refuse chutes.

(6) The Contractor shall use non-percussive methods such as hydraulic hammer, vibration or jacking method for installing or extracting sheet piles.

Construction Noise Permits

25.13 The Contractor shall, when necessary, apply for a Construction Noise Permit in accordance with the Noise Control (General) Regulations before commencing the relevant part(s) of the works, display the Permit as required and provide a copy to the Engineer. Construction activities and noise shall not deviate from or exceed the terms and conditions defined in the Construction Noise Permits.

AIR POLLUTION CONTROL

Air pollution control - general requirements

25.14 (1) The Contractor shall observe and comply with the Air Pollution Control Ordinance and its subsidiary regulations, particularly the Air Pollution Control (Open Burning) Regulation, Air Pollution Control (Construction Dust) Regulation, Air Pollution Control (Smoke) Regulations and Air Pollution Control (Non-road Mobile Machinery) (Emission) Regulation and any additions or amendments thereto coming into effect before completion of the Works.

(2) The Contractor shall submit for the Engineer's prior approval, at least 2 weeks before commencement of any work, method statements identifying operations and plant likely to cause air pollution or dust emissions from the Site, together with measures to be implemented to mitigate and control such pollution and emissions.

(3) In considering the submissions made under sub-clause (2) above, the Engineer may require the methods of working, plant, equipment and air pollution control system to be used on the site to be demonstrated or made available for inspection to ensure that they are suitable for the project.

(4) If during the course of construction, the equipment or work methods

submitted in sub-clause (2) above are in the opinion of the Engineer not effective in controlling air quality impacts to meet the Contract requirements, the Contractor shall update and resubmit the proposals for agreement promptly.

(5) The Contractor shall undertake at all times to prevent dust nuisance and smoke as a result of his activities.

Dust suppression 25.15 (1) The Contractor shall devise, arrange methods of working and carrying out the works in such a manner as to minimize dust impact on the surrounding environment, and shall provide experienced personnel with suitable training to ensure that these methods are implemented.

(2) Material storage and handling areas shall be located on a hard-core surface or the like to facilitate cleaning and minimise dust generation. Screens, dust-sheets, tarpaulins or other methods agreed by the Engineer shall be used to prevent generation of dust.

(3) In the process of material handling, any material that has the potential to create dust shall be treated with water or sprayed with a wetting agent unless this would have a detrimental affect on the material.

(4) All conveyors carrying materials that have the potential to create dust shall be totally enclosed and fitted with belt cleaners. Conveyor transfer points and hopper discharge areas shall be housed in three-sided roofed enclosures with a flexible curtain on the fourth side to minimize dust emission. Exhaust ventilation shall be provided for this enclosure and vented to a fabric filter system.

(5) Cement and other fine-graded materials delivered in bulk shall be stored in closed silos fitted with high-level alarm indicator. The high-level alarm indicators shall be interlocked with the filling line so that in the event of the hopper approaching an overfull condition, an audible alarm will operate, and the pneumatic line to the filling tanker will close automatically. All air vents on cement silos shall be fitted with suitable fabric filters provided with either shaking or pulse-air cleaning mechanisms. The filter must be thoroughly cleaned after cement is blown into the silo to ensure adequate dust collection capacity for subsequent loads.

(6) The Contractor shall restrict the speed of all vehicles moving within the Site to minimize fugitive dust emission. Haulage and delivery vehicles shall be confined to designated roadways inside the Site. Unpaved roads shall be regularly compacted and the road surface shall be kept clear of loose material. The Contractor shall ensure that areas within the Site where there is regular traffic of vehicles are paved with either concrete or bituminous material and kept clear of any loose surface material.

(7) The Contractor shall undertake regular cleaning and watering of the Site, including access roads, construction areas and material stockpiles, after starting work each day to minimize fugitive dust emission as follows:

(a) The frequencies, extent and amount of watering shall be adequate for the respective areas of the Site during the operational day to attain the invisible dust emission level.

(b) The Contractor shall ensure that there is adequate water supply/storage for dust suppression at all times.

(c) The Contractor shall, from commencement to completion of the Contract, ensure that the watering facilities are available on the Site in good working conditions at all times.

(d) The Contractor shall ensure that the watering facilities are properly maintained and operating efficiently at all times and replacement facilities are deployed in full operating conditions immediately in the event of down time owing to mechanical repairs or any other reasons.

(8) Earth, rock or debris including any deposits arising from the movement of plant or vehicles shall not be deposited on public roads or private rights of way as a result of the Contractor's activities. Wheel-washing and vehicle-cleaning facilities shall be provided as specified in Clause 25.26(4). Cement and concrete trucks in particular shall be thoroughly cleaned before leaving the site.

(9) All dump trucks (i.e. goods vehicle of gross vehicle weight equal to or more than 16 tonnes, fitted with a dump bed) leaving the Site carrying dusty materials shall be fitted with a mechanical cover to cover the dump bed. The mechanical cover shall be in good service condition and the Contractor shall be responsible for selecting a design of mechanical cover satisfying all the following requirements:

(a) The cover shall be constructed of durable materials and suitable components in good condition. The materials of the cover shall be effective in preventing dust emissions. The cover shall be power-operated with manual backup. Except in the manual backup mode, the cover shall only be operable inside the driving cabin, if applicable.

(b) The cover system shall incorporate controls to ensure safety in operation. The cover shall be inoperable unless the vehicle has come to a standstill, and after the hand brake is on. A warning system, consisting of flashing amber lights and audible alarm, shall be activated automatically when the cover is being operated inside the driving cabin. The warning system shall be visible and audible from both inside (by an indicator light or the like if necessary) and outside the driving cabin. A locking system shall be in place to prevent accidental opening of the cover, if applicable.

(c) The cover shall be able to withstand strong winds under normal circumstances. After the cover to the dump bed is closed, any gap left on the system of enclosure shall be less than 25mm wide measured in a direction across the gap as far as practicable. Any remaining gap shall be sealed up tightly with suitable materials of sufficient length to bridge across the gap as far as practicable. In addition, the cover shall not accumulate any significant amount of dust or debris which may obstruct its operation. The gross vehicle weight and maximum dimensions of the truck after fitted with the cover and associated accessories shall comply with the relevant legislation.

(10) The Engineer or his Representative shall have the power to refuse entry into the Site any dump truck that fails to meet this specification and to require

any loaded dump truck to unload its contents before leaving the Site if its dump bed and cover are found not to comply with the above requirements after loading. Provided always that approval for leaving the Site of a loaded dump truck by the Engineer or his site supervisory staff shall not relieve the Contractor of his obligation to comply with the relevant legislation, and the Employer shall not be liable for any loss or damage sustained by the Contractor or the truck drivers or truck owners arising from or in connection with any offence committed by the Contractor or the truck drivers or truck owners in relation to transportation of the Construction and Demolition (C&D) materials from the Site.

(11) Vehicles other than dump truck carrying dusty materials away from the Site may use means other than mechanical covers to cover their dusty materials, provided that the vehicle shall have properly fitted side-boards and tail-boards, with dusty materials loaded to a height not exceeding the height of the side-boards and tail-boards, and covered with a tarpaulin or suitable impervious covering material (as approved by the Engineer or his Representative) in good condition. The covering shall be properly secured and extended at least 300 mm over the edges of the side-boards and tail-boards before leaving the Site and maintained throughout the journey to the off-loading destination. For the purpose of this sub-clause, "dusty materials" include cement, earth, pulverized fuel ash, excavated and crushed rock, aggregates, silt, stone fines, sand, debris, saw dust and wooden chips, etc.

(12) Earth-moving operations shall be carefully controlled with enhanced dust-suppression measures when winds are strong and particularly blowing towards the adjacent sensitive receivers. Sheltered areas of the Site shall be used for dusty operations, especially during windy periods.

(13) The areas with earthwork activities, including the final compaction activities, shall be completed as quickly as possible and in compliance with good practices, to limit creation of wind-blown dust.

(14) The location of dust-producing plant or facilities, either fixed or temporary, shall be subject to the agreement of the Engineer.

(15) For activities that are likely to generate a substantial amount of dust and where there are no effective measures or it is not possible to adequately control the dust level, vacuum cleaners should be used where practicable to suppress such dust.

Smoke and exhaust control

25.16 (1) The Contractor shall not light bonfires on the Site for burning of debris or other materials.

(2) Use Ultra-low-sulphur diesel (ULSD) (defined as diesel fuel containing not more than 0.005% by weight of sulphur) for all diesel-operated plant and equipment on the Site. The Contractor shall demonstrate his compliance by maintaining a summary record of all the delivery notes of ULSD delivered to the Site, including those ordered by his sub-contractors, together with the details of replenishment of such fuel by the individual plant and equipment on the Site. The record shall be supported by the original receipts of delivery notes from the oil companies. A proforma of the summary record is attached at Appendix 25.1.

(3) B5 diesel shall be used as fuel for all non-road based construction machinery on the Site. The non-road based construction machinery includes all types of machines and plants which are powered by internal combustion

engines, such as air compressors, mobile generators, excavators, crawler cranes, bulldozers, rollers, etc.

(4) B5 diesel shall be Euro V diesel containing a fatty acid methyl ester content of 5%, as determined in accordance with the document published by the European Committee for Standardization commonly known as EN 14078. The Euro V diesel shall be light diesel oil complying with the specifications set out in Chapter 311L Schedule 1 – Air Pollution Control (Motor Vehicle Fuel) Regulation of the Laws of Hong Kong, all applicable legislation in Hong Kong and the requirements of all relevant regulatory authorities in Hong Kong which are effect on the date that the B5 diesel is supplied.

(5) The Contractor shall maintain a proper record of the use of B5 diesel on the Site for inspection by the Engineer whenever necessary.

(6) Notwithstanding Clause (3) above, the Contractor may propose for the Engineer's approval for the use of Euro V diesel instead of B5 diesel should there be a supply shortage or other difficulties in delivering of B5 diesel to the Site.

Prior consent for pollutant emitting equipment

25.17 The Contractor shall not, upon the Site or any part thereof, install or use any machinery, furnace boiler or other equipment, or use any fuel that may result in the discharge or emission of any pollutant or any noxious, harmful or corrosive matter, whether it be in the form of gas, smoke, liquid, solid or otherwise, without the prior written consent of the Engineer in consultation with the Director of Environmental Protection.

Odour Mitigation

25.18 (1) The Contractor shall take necessary measures, including but not limited to masking sprays and suitable covering, to minimize odour problems arising from the construction activities and the temporary stockpile of odorous material.

(2) Temporary stockpiling of odorous material and the mitigation measures shall be subject to the prior approval of the Engineer. Approved odorous stockpiles shall be placed as far away from air sensitive receivers as possible.

Hoardings adjoining public areas

25.19 (1) In addition to the fences for security and safety required in other parts of the Contract, the Contractor shall provide and remove upon completion of the Contract, hoarding of height not less than 2.4m from ground level along the entire length of the portion of the site boundary which adjoins a road, street, footway, cycle track, service lane or other area accessible to the public, except at site entrances and/or exits or for road opening or resurfacing work, before any works commence in the vicinity.

(2) Where the work is carried out adjacent to a public premise not screened off by the hoarding pursuant to sub-clause (1), the Contractor shall provide a screen, with dimensions and details agreed by the Engineer, to shield the public from the dust or exhaust fume generated by the plant or equipment, except for works under emergency, or with prior agreement of the Engineer that the provision of such is not necessary.

WASTE MANAGEMENT

Waste management - general requirements

25.20 (1) The Contractor shall observe and comply with the Waste Disposal Ordinance and its subsidiary regulations and any additions or amendments

thereto coming into effect before completion of the Works.

(2) The Contractor shall be responsible for the control of waste within the Site, removal of the waste material arising from the Site and implementation of any mitigation measures to minimize waste or reduce problems arising from the waste produced on the Site.

Measures to reduce/minimize generation of C&D materials

25.21 (1) The Contractor shall identify and list out the work processes or activities that will generate C&D materials during construction activities, and the proposed measures to reduce/minimize such generation in particular metallic waste, timber, paper/cardboard packaging and chemical waste. The Contractor shall submit the list of work processes/activities and the proposed measures to the Engineer for approval within 45 days of the date of the Employer's letter of acceptance of the Tender. The submission should also include the Contractor's proposed organizational structure and lines of responsibilities for implementation of the waste management measures on the Site.

(2) The proposed measures shall include proper planning of works, good site management, minimizing over-ordering, avoiding cross contamination to reusable and/or recyclable materials collected, optimizing the use of metal formwork or other work processes to reduce or minimize the use of timber in temporary works construction, maximizing the reuse of excavated inert C&D materials within the Site, etc.

Reduced use of timber in temporary works

25.22 (1) The Contractor shall not use tropical hardwood for formwork, falsework and shoring for trenches and pits. Alternative materials to tropical hardwood shall be used for such works.

(2) The Contractor shall avoid, reduce or minimize the use of any timber in temporary works construction as far as possible. Where the Contractor has to use timber for temporary works construction for one process/activity with an estimated quantity exceeding $5m^3$, he shall submit a method statement to the Engineer's Representative for agreement before commencement of the works. The method statement should include the justifications for and the measures taken to minimize the use of timber in the temporary works.

Works involving demolition

25.23 (1) For works involving demolition, the Contractor shall submit a method statement for the works to the Engineer for approval before commencing demolition on the Site. The Contractor shall include in the method statement the sequence of demolition and the works programme to facilitate effective recovery of reusable and/or recyclable portions of the demolition materials at the earliest stage, so as to minimize the need for subsequent sorting. The Contractor shall pay particular attention to materials that will cause contamination or ill-health to workers. Demolition materials shall be separated into the following categories:

(i) Broken concrete

(ii) Other inert materials (i.e. blockwork, brickwork, etc.)

(iii) Metals (e.g. reinforcement bars, metal from mechanical and electrical fittings, and other building services fittings)

(iv) General refuse

Sorting of C&D

25.24 (1) All C&D materials (which mean both the inert and non-inert materials

materials

generated from construction and demolition activities) arising from or in connection with the Works shall be sorted on site to recover the inert portion of these materials, and reusable and/or recyclable materials before disposal of the waste portion off site. The inert portion of the C&D materials includes soil, building debris, broken rock, concrete, etc. and the non-inert portion comprises timber, paper, plastics, general refuse, etc.

(2) The Contractor shall devise a system for on-site sorting of C&D materials. The system shall include the identification of the source of generation, estimated quantity, arrangement for on-site sorting and/or collection, temporary storage areas, frequency of collection by recycling contractors or frequency of removal off the Site, etc. The Contractor shall submit details of the proposed system for sorting of C&D materials to the Engineer for approval within 45 days of the date of the Employer's letter of acceptance of the Tender.

(3) The Contractor shall ensure that different types of C&D materials are sorted on site and stored in different containers, skips or stockpiles to facilitate reuse/recycling and disposal at different outlets as appropriate.

(4) The Contractor shall identify the inert portion of C&D materials that are suitable for recycling into aggregates, in particular hard rock and broken concrete generated from demolition or road improvement works, and recover the materials for delivery to recycling facilities or a location as notified by the Engineer. All inert C&D materials shall also be broken down according to the Dumping Licence conditions before disposal.

(5) For other C&D materials, the Contractor shall be required to check and ensure that the general refuse, as far as reasonably practicable, contains no observable inert or reusable/recyclable C&D materials (e.g. metal, and paper/cardboard packaging) before disposal to landfills. If it is found that the Contractor cannot meet this requirement, the Engineer shall request the Contractor to review the system for retrieval of reusable or recyclable materials that are observed. In addition, sorted inert C&D materials for disposal to public filling outlets shall contain no observable non-inert materials, such as general refuse, timber etc.

(6) Equipment and material packaging (i.e. paper and cardboard) shall be recovered, properly stockpiled in a dry and covered condition to prevent cross-contamination by other C&D materials before disposal by recycling sub-contractors. The Contractor shall pay particular attention to avoiding cross-contamination in the course of collecting paper for recycling.

(7) The Contractor shall identify and provide sufficient space for temporary storage of C&D materials to facilitate collection and/or sorting on the Site. The space provided shall be commensurate with the estimated quantity for each type of C&D materials generated from the Site.

(8) Except for those inert C&D materials to be reused on the Site, the Contractor shall remove all other C&D materials off the Site as soon as practicable in order to optimize the use of the on-site storage space.

(9) The Contractor shall make arrangements with the potential recycling contractors to facilitate the collection of recyclable materials sorted from the Site with reasonable care.

(10) The Contractor shall establish a system for proper handling and storage

of chemical wastes generated from the Site, and arrange collection and disposal of such chemical wastes by specialist contractors. The Contractor shall record the details about the nature of the chemical wastes, method of storage (e.g. type, size and materials of the container), the collection and disposal arrangements, etc.

(11) The Contractor shall record the quantities of C&D materials generated using the table in Appendix 25.2, and submit the table at quarterly intervals to the Engineer within two weeks of the end of each February, May, August and November, until completion of the Works.

Trip ticket system 25.25 (1) The Contractor shall implement a Trip Ticket System (TTS) for removal of C&D materials from the Site to the designated disposal ground.

(2) The inert portion of the C&D materials shall be disposed of at the designated public fill reception facilities and the non-inert portion of the C&D materials shall be disposed of at the designated landfills or outlying islands transfer facilities, as specified in the Contract.

Avoidance of nuisance 25.26 (1) All works are to be carried out in such a manner as to cause no damage and as little inconvenience as possible to all nearby residents, property, business and the public in general.

(2) The Contractor shall not permit any sewage, wastewater, effluent or surface runoff to flow from the Site onto any adjoining land or allow any waste matter or refuse which is not part of the final product from waste processing plant to be deposited anywhere within the Site or onto any adjoining land.

(3) In the event of any spoil or debris from the Site being deposited on adjacent land or any silt being washed down to any area, the Engineer shall be informed immediately. The Contractor shall arrange for removal of such matter in a proper manner to the satisfaction of the Engineer. If the spoil or debris is found contaminated, special precautions shall be taken during removal of the material to ensure that the environmental impacts are minimized. After removal of the spoil, debris or material and silt, the Contractor shall restore to the satisfaction of the Engineer the affected land or areas to their natural state.

(4) The Contractor shall ensure that no earth, rock or debris including any deposit arising from the movement of plant or vehicles is deposited on public roads or private rights of way as a result of the activities of the Contractor, his Sub-contractors, and other contractors working on the Site. The Contractor shall provide adequate wheel-washing and vehicle-cleaning facilities to wash mud and the like from the wheels and bodywork of all vehicles to the satisfaction of the Engineer before the vehicles leave the Site.

(5) If any earth, rock or debris generated from activities on the Site are deposited on public roads or private rights of way, the Contractor shall immediately remove all these materials and restore the affected roads and rights of way to their original state to the Engineer's satisfaction.

Handling and disposal of waste 25.27 (1) General refuse shall be stored in enclosed bins separate from inert C&D material and chemical wastes and shall be removed from the Site on a regular basis in order to minimize odour, pest and litter impacts. Burning of refuse on site is not permitted.

(2) The Contractor shall take the following general measures to minimize adverse impacts while handling waste:

(a) Handle and store waste in a manner which ensures that it is held securely without loss or leakage, thereby minimizing the potential for pollution;

(b) Remove waste in a timely manner;

(c) Maintain and clean waste storage areas regularly;

(d) Use reputable and authorized waste collectors to collect specific categories of waste for recycling or disposal;

(e) Minimize windblown litter and dust during transportation by either fitting trucks with mechanical covers or transporting waste in enclosed containers;

Chemical waste control 25.28 (1) The Contractor shall observe and comply with the Waste Disposal (Chemical Waste) (General) Regulation and any additions or amendments thereto coming into effect before completion of the Works.

(2) The Contractor shall apply for registration as chemical waste producer under the Waste Disposal (Chemical Waste) (General) Regulation when chemical waste is produced. All chemical waste shall be properly identified, stored and disposed in accordance with the Regulation and the Code of Practice on the Packaging, Handling and Storage of Chemical Waste published by the Environmental Protection Department.

(3) The Contractor shall ensure that the disposal of chemical waste is:

(a) Handled by a licensed waste collector; and

(b) At a recycling, treatment or disposal facility that is licensed under the Waste Disposal Ordinance to receive chemical waste

(c) Carried out with appropriate preventive measures to minimize adverse impacts and leakage of the waste.

(4) The Contractor must ensure that all the necessary waste disposal permits are obtained and the conditions specified in these permits are fully complied with.

APPENDIX 25.1

PROFORMA FOR MONTHLY RECORDING DELIVERY AND CONSUMPTION OF ULTRA LOW SULPHUR DIESEL ON SITE

Contract No.: _____

Contract Title: _____

Name of Person completing the Proforma: _____

Name of Person responsible for audit checking: _____

Date	**Intake**			**Consumption**			
	Name of Contractor/ Sub-contractor	**Details of Ordering Fuel**	**Quantity of Fuel Delivered** (in litre)	**Details of Plant belong to the Contractor/ Sub-contractor**	**Date of Arrival**	**Date of Departure**	**Quantity of Fuel Consumed** (in litre)
		- name of oil company - delivery note no. and reference		- plant name and serial no.			
		Total Delivered				Total Consumed	

[N.B. The total for the month is for checking the relative order of quantity of fuel delivered and consumed on the Site and need not necessarily be balance]

APPENDIX 25.2

SAMPLE OF WASTE FLOW TABLE

Name of Department: CEDD/DSD/HyD/WSD Contract No.: _____

Waste Flow Table

Quarter ending	Actual Quantities of Inert C&D Materials Generated Quarterly						Actual Quantities of C&D Wastes Generated Quarterly				
	Total Quantity Generated	Broken Concrete (see Note 3)	Reused in the Contract	Reused in other Projects	Disposed as Public Fill	Imported Fill	Metals	Paper/ cardboard packaging	Plastics (see Note 2)	Chemical Waste	Others, e.g. general refuse
	(in '000m^3)	(in '000m^3)	(in '000m^3)	(in '000m^3)	(in '000m^3)	(in '000m^3)	(in'000 kg)	(in'000 kg)	(in'000 kg)	(in'000 kg)	(in'000m^3)
Feb											
May											
Aug											
Nov											
Total											

Notes: (1) The waste flow table shall also include C&D materials that are specified in the Contract to be imported for use at the Site.
(2) Plastics refer to plastic bottles/containers, plastic sheets/foam from packaging material.
(3) Broken concrete for recycling into aggregates.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 26

PRESERVATION AND PROTECTION OF TREES

SECTION 26

PRESERVATION AND PROTECTION OF TREES

GENERAL

Definitions regarding trees

26.01 "Tree" means a plant with diameter at breast height measuring 95 mm or more. Plants growing on retaining structures shall also be measured and considered.

"Diameter at breast height" means the diameter of the trunk of the plant measured at a height of 1.3 m above ground level. For trunk with an obviously elliptical cross-section, the diameter at breast height shall be the average of any two-diameter measurements taken at right angle.

"Tree crown spread" means the diameter of the tree crown defined by the outermost branches of the tree. For tree crown with an obviously elliptical cross-section, the diameter of the tree crown shall be the average of any two-diameter measurements taken at right angle.

"Tree height" means the height from ground level to the top of the tree.

"Dripline" of a tree means the imaginary vertical plumb line that extends downward from the tips of the outermost tree branches and intersects the ground.

"Tree protection zone" means an area the perimeter of which is defined by the dripline of the tree.

"Preserved tree," means an existing tree not earmarked to be felled, which may be a tree to be retained at its existing location, a tree at its existing location before transplanting, or a tree transplanted within the Site.

"Arboricultural work" means any work related to the cultivation and care of trees for any purpose other than timber production, including but not limited to planting, replanting, transplanting, tree surgery work and control of pest and disease.

General requirements

26.02 (1) The Contractor shall submit a Tree Preservation and Protection Plan before commencing any works on site, which may affect any tree.

(2) The Contractor shall make all necessary allowance for the preservation and protection of existing trees in his programming of, and method of construction of the works, including the full extent of all temporary works and access arrangements.

(3) The Contractor shall assign a person to oversee the implementation of Tree Preservation and Protection Plan and delegate to that person the full authority to make all decisions related to such works. The person assigned shall be working full time on the Site but not necessarily working solely for matters related to preservation and protection to existing trees.

(4) The limits of site clearance shall be agreed by the Engineer on the Site before site clearance commences.

SURVEY AND IDENTIFICATION OF EXISTING TREES

Tree Survey 26.03 (1) Unless otherwise directed by the Engineer, the Contractor shall carry out a tree survey and submit the survey record to the Engineer within 28 days of the date for commencement of the Works.

(2) The tree survey record shall cover all existing trees present within the Site or within 2 m of the site boundary and any other trees likely to be affected by the Works. The Contractor shall carry out tree survey for each individual tree. Where it is found not practical to carry out a tree survey for each individual tree and that the tree group survey methodology is necessary, the Contractor shall obtain the Engineer's approval to the tree group survey methodology before commencing the tree survey on the Site. Each tree or tree group shall be assigned a unique identification number according to a numbering system agreed with the Engineer beforehand. The tree survey record shall be in the form of an A4-sized, bound report which shall bear a report cover indicating the Contract number, Contract title, and date of the report and shall include the following documents, the format of which shall be agreed by the Engineer before submission of the report:

(a) A tree survey plan showing the locations of all existing individual trees and tree groups and identifying:

(i) Trees which are earmarked under the Contract for retention at their existing locations,

(ii) Trees which are earmarked under the Contract for transplanting,

(iii) Trees which are earmarked under the Contract for felling and

(iv) Any other trees which have not been reported/identified under the Contract and their treatment has yet to be instructed by the Engineer,

(b) A tree schedule for all the trees under sub-clause (a)iv) of this Clause comprising the following information of each individual tree::

(i) Botanical name of the tree species and the identity code/number as shown on the tree survey plan and marked on the Site,

(ii) Diameter at breast height of the tree,

(iii) Tree crown spread,

(iv) Tree height,

(v) Condition of the tree including its form and health (highlighting any structural defects or unhealthy or decaying symptoms which may pose danger to the public if the tree falls), amenity value, survival rate after transplanting and special features, and

(vi) Existing ground level at the trunk base;
and the following information of each tree group:

(vii) The approximate number of trees in the group,

(viii) Botanical names of the tree species in the group and the percentage composition of each species,

(ix) The diameter range of the trees in the group,

(x) General description of the type of woodland to which the group belongs, and

(xi) General condition of the trees in the group.

(c) Photographic record for each individual tree and tree group under sub-clause (a)iv) of this Clause complying with the following:

(i) All photographs shall be date-stamped to indicate the dates that the photographs are taken and shall be well-annotated, and

(ii) The photograph of each tree or tree group shall show clearly the whole tree or entire tree group as far as possible, the identification number of the tree or tree group, and the status of the tree as identified by the labelling or marking system on the Site as required in Clause 26.04.

Labelling of Trees 26.04 (1) The Contractor shall mark on the Site with labelling or marking systems to identify trees of different status in accordance with the classification in sub-clauses (2)(a)(i) to (iv) of Clause 26.03. The Contractor shall comply with the following in providing the identification labelling or marking systems:

(a) The identification labelling or marking systems for different tree status shall be in different colours and be clearly distinguishable,

(b) The tree identification number of each tree or tree group shall be clearly shown on the label or mark.

(c) The identification labelling or marking system for the preserved trees shall be made of durable materials that are non-injurious to the trees, be placed at a position not easily accessible but clearly visible to the public, and be attached in such a manner that allows for the growth of the trees and does not injure the trees,

(d) The identification labelling or marking systems and the on-site status identification of trees shall be agreed by the Engineer and installed before commencing site clearance, demolition, construction of permanent or temporary works, and any other site operations which may affect the trees, and

(e) The Contractor shall reinstate or replace, where necessary, the identification labelling or marking systems for the preserved trees and shall remove these identification labelling or marking systems from the Site upon completion of the Works, or earlier if so directed by the Engineer.

(2) For those individual trees or tree groups identified under sub-clause (a)(iv) of Clause 26.03, the Contractor shall change the label or mark on them to reflect their updated status immediately once the Engineer has instructed the treatment to them.

REMOVAL OF EXISTING TREES

Felling of existing trees 26.05 (1) Site clearance should be carried out in stages to suit the actual clearance requirement as works progress. The limits of site clearance for any part of the Site shall be agreed by the Engineer before site clearance at the respective part commences. No clearance shall be carried out until such requirement is met.

(2) The Contractor shall comply with the following requirements in respect of tree felling:

(a) Fell only those trees earmarked for such purposes under the Contract and labelled for such purposes on the Site pursuant to Clause 26.04 or those as directed or approved by the Engineer,

(b) Take all necessary precautions to protect the people engaged in the tree felling work as well as the people and property in the vicinity,

(c) Adopt working methods that avoid any damage to adjacent plants to be retained, including damage to their root systems,

(d) Completely remove the tree to be felled including the stumps and rootballs,

(e) If, in the opinion of the Engineer or as required in the Contract, removal of stumps and rootballs is not necessary, fell the trees by cutting them near the ground, with their stumps ground rather than pulled,

(f) Remove all debris, cut wood, and roots pursuant to sub-clauses (2)(d) and 2(e) of this Clause, from the trees felled from the Site as soon as possible, and

(g) Reinstate where appropriate the ground around the adjacent plants to be retained to ensure their continued healthy growth and stability.

Transplanting of existing trees 26.06 The Contractor shall comply with the following requirements in respect of tree transplanting, either within or off the Site:

(a) Transplant only those trees earmarked for such purposes under the Contract and labelled for such purposes on the Site pursuant to Clause 26.04 or those as directed or approved by the Engineer, and

(b) Commence any work related to tree transplanting on the Site only after the Engineer is satisfied that the Contractor has complied with the requirements stipulated for completion before tree transplanting work commences.

Unplanned tree removal 26.07 Where it is found necessary for the completion of the Works to remove, either by felling or by transplanting, any trees other than those earmarked for such

purposes under the Contract and labelled purposes on the Site pursuant to Clause 26.04 or those directed or approved purposes during the progress of the Works by the Engineer, the Contractor shall comply with the following requirements:

(a) Report to the Engineer the necessity on such tree removal,

(b) Provide all reasonable assistance as required by the Engineer in the tree survey and the justification for the proposed tree removal with substantiation and the necessary details including method statement, site formation plan and engineering drawings, for the Engineer's preparation of the tree felling or transplanting application for the tree removal, and

(c) Fell or transplant the trees only after the Engineer's approval of the tree removal has been given. Such approval shalll normally be given after the tree felling or transplanting application has been approved by the government approving authority.

PRESERVATION AND PROTECTION OF EXISTING TREES

General Precautionary Measures to Preserved Trees

26.08 The Contractor shall exercise the greatest care to avoid any damage to the preserved trees and shall comply with the following in respect of all the preserved trees:

(a) Take all necessary precautions to ensure that:

(i) No nails or other fixings shall be driven into the trees, including the exposed tree roots,

(ii) No fencing, services, or signs other than the identification labels or markings required under Clause 26.04 shall be attached to any part of the trees,

(iii) No trees shall be used as anchorages for ropes or chains used in guying or pulling, or for any other purposes,

(iv) No soil, materials, equipment or machinery shall be stockpiled or stored within the tree protection zones,

(v) No site offices, workshops, canteens, containers or similar structures shall be installed within the tree protection zones,

(vi) Petrol, oil, bitumen, creosote, cement and other materials likely to be injurious to the trees shall be kept away from the tree protection zones, and any accidental spills of these materials shall be cleaned up immediately,

(vii) Excessive water shall be drained away from the tree protection zones to prevent damage to tree roots by asphyxiation,

(viii) The surface on slopes shall be shaped so that water will not drain to the tree trunks but bypass them,

(ix) No passage or parking of vehicles and no operation of equipment or machinery shall take place within the tree protection zones unless otherwise agreed by the Engineer,

(x) No stripping of surface vegetation or top layer of soil, and no paving or earth filling shall be carried out within the tree protection zones unless otherwise agreed by the Engineer,

(xi) No fires shall be lit within the tree protection zones or in a position where the flames will likely extend to within 5 m of foliage, branches or trunks of the trees, bearing in mind the size of the fire and the wind direction,

(xii) No concrete mixing, gas tank filling, paintbrush and tool cleaning, or equipment maintenance shall be carried out within the tree protection zones,

(xiii) Any necessary scarification or cultivation within the tree protection zones shall be carried out carefully by hand so as not to cause damage to the trees, in particular the bark and the roots,

(xiv) Any equipment, in particular delivery vehicles, overhead cranes, mechanical excavations, drilling rigs and piling rigs, shall be carefully operated so as not to cause striking of the trunks, branches, foliage or root collars of the trees,

(xv) The trees to be felled, which are adjacent to, or which lie within a continuous canopy of the preserved trees, shall be carefully removed, and if necessary in sections but not using bulldozers in any circumstances, so as not to cause damage to the preserved trees such as scraping bark off trunks or breaking branches of trees,

(xvi) Where it is necessary to use herbicides to kill any vegetation, herbicides that can leach through the soil, such as the products containing sodium chlorate, and any other herbicides that are injurious to the trees shall not be used,

(xvii) Allowance shall be made for the slope of the ground so that damaging materials such as concrete washings, mortar or diesel oil cannot run towards the trees,

(xviii) Alkaline clay or limestone shall not be used for filling or paving, concrete shall be mixed on a thick plastic tarpaulin, and mixing trucks shall not be rinsed out on the Site, so as not to change, in particular no to increase the soil pH, and

(xix) All building debris and chemical wastes shall be hauled away for proper disposal, and in any circumstances shall not be burned or buried on the Site or be disposed of by pouring them on the soil within the Site,

(b) Repair any damage to the trees in accordance with the requirements stipulated in Clause 26.16,

(c) Where the passage or parking of vehicles or the operation of

equipment or machinery within the tree protection zones as referred to in sub-clause (a)(ix) of this Clause is considered necessary and is agreed by the Engineer, carry out the following measures to reduce soil compaction:

(i) Minimize the traffic of the vehicles, equipment or machinery, and

(ii) Confine the passage or parking of vehicles or operation of equipment or machinery to the areas laid with temporary protective mulching as stipulated in sub-clause (5)(b) of Clause 26.09 and with double, overlapping, thick metal sheet coverings, or other materials of equivalent strength as agreed by the Engineer placed on top,

(d) Where it is necessary to clear the existing undergrowth within the tree protection zones to allow access and visibility for, and operation of any construction work,

(i) Shrubs shall be pruned and grass or other herbaceous plants shall be cut to a height of not less than 50 mm above the ground level but not pulled out by equipment in any circumstances, and

(ii) The agreement of the Engineer shall be obtained before vegetation clearance commences,

(e) Protect the preserved trees, where necessary, from increased exposure to sun and wind due to removal of adjacent trees,

(f) Align all routes of the overhead services within the Site and all access routes to the Site or within the Site away from the preserved trees as far as possible and seek the Engineer approval to the alignment,

(g) Report to the Engineer any preserved tree that has structural defects or unhealthy or has decaying symptoms,

(h) Submit a report comprising the updated photographic records of all the preserved trees to the Engineer every two months or at intervals agreed by the Engineer, complying with the following:

(i) Each of the reports shall be in the form of an A4-sized, bound document which shall bear a report cover indicating the Contract number, Contract title, and date of the report,

(ii) The format of the reports shall be agreed by the Engineer before submission of the first report,

(iii) All photographs shall be date-stamped to indicate the dates that the photographs are taken and shall be well-annotated,

(iv) The photograph of each tree shall show clearly the whole tree as far as possible, the identification number of the tree, and the status of the tree as identified by the labelling or marking system on the Site as required in Clause 26.04, and

(v) Each of the reports shall include details of any damage caused to the trees and any signs of health deterioration of the trees in the reporting period, accompanied with photographic record of the damage and the tree deterioration.

Protection of preserved trees from physical damage and soil compaction

26.09 (1) The Contractor shall erect, secure and maintain in good condition temporary protective fencing with a minimum height of 1.5 m to protect the preserved trees. The Contractor shall submit method statements including proposed design details of the temporary protective fencing to the Engineer for approval and obtain such approval before commencing the erection of the fencing.

(2) The temporary protective fencing shall be erected along or beyond the perimeter of the tree protection zone of each individual tree. Where the tree protection zones of two or more trees overlap with each other, the temporary protective fencing shall be erected along or beyond the perimeter of the aggregate tree protection zone of the trees or as directed by the Engineer.

(3) The Contractor shall complete erection of the temporary protective fencing before commencing of site clearance, demolition, construction of permanent or other temporary works, and any other site operations that may affect the trees.

(4) The Contractor shall remove the temporary protective fencing from the Site upon completion of the Works or earlier if so directed by the Engineer. The Contractor shall not remove or relocate the temporary protective fencing or enter the area enclosed by the temporary protective fencing without the prior agreement of the Engineer.

(5) If, in the opinion of the Engineer, erection of temporary of protective fencing of the preserved trees is not practical, then the following precautions shall be taken by the Contractor:

(a) The Contractor shall provide temporary protective hessian armouring around tree trunks to protect the preserved trees. When instructed by the Engineer, the Contractor shall provide temporary protective hessian and plank armouring as an alternative to the same trees for enhanced protection. The minimum height of the hessian armouring or hessian and plank armouring from the ground shall be 1.5 m. The Contractor shall submit details of the temporary protective hessian armouring and hessian and plank armouring to the Engineer for approval and obtain such approval before commencing installing such protection measures.

(b) Unless otherwise agreed by the Engineer, the ground of the tree protection zones of the trees referred to in the sub-clause (5)(a) of this Clause shall be protected from damage by construction activities through the use of temporary protective mulching to cover the entire tree protection zone. When instructed by the Engineer, double, overlapping, thick metal sheet coverings, or other materials of equivalent strength as agreed by the Engineer, shall be laid on top of the temporary protective mulching to provide additional protection from soil compaction due to passage or parking of vehicles or operation of equipment or machinery. The Contractor shall submit details of the temporary protective mulching to the Engineer for approval and obtain such approval

before commencing installing such protection measures.

(c) The Contractor shall complete erection of the temporary protective armouring and application of the temporary protective mulching before commencing site clearance, demolition, construction of permanent or other temporary works, and any other site operations that may affect the trees.

(d) The Contractor shall remove the temporary protective armouring and the temporary protective mulching from the Site upon completion of the Works, or earlier if so directed by the Engineer. The Contractor shall not remove or relocate the temporary protective armouring or the temporary protective mulching without the prior agreement of the Engineer.

Protection of preserved trees from changes in ground levels

26.10 (1) Without the Engineer's prior approval, the Contractor shall not change the existing ground levels within the tree protection zones of the preserved trees unless the Contract explicitly requires such changes.

(2) Where it is necessary for completion of the Works and the Engineer's approval has been obtained for temporarily or permanently reducing the existing ground level around a preserved tree, but this will result in lowering the existing ground level within the tree protection zone, the Contractor shall comply with the following requirements:

(a) Implement measures agreed by the Engineer to accommodate reduction in the existing ground level and to ensure the stability of the tree,

(b) Before commencing implementation of the measures to accommodate reduction in the ground level pursuant to sub-clause 2(a) of this Clause, submit method statements for the measures, including the necessary engineering design, construction details, and associated precautionary works such as those noted in sub-clause (e) of this Clause, for the Engineer's approval,

(c) Commence implementation of the measures only after the Engineer's approval of the method statements has been given,

(d) Follow the requirements stipulated in Clause 26.11 regarding excavation and cutting of tree roots, and

(e) Maintain balanced moisture content in the tree and in the soil after implementation of the measures, by carrying out necessary precautionary measures such as crown thinning, watering and mulching.

(3) Where it is necessary for completion of the Works and the Engineer's approval has been obtained for temporarily or permanently raising the existing ground level around a preserved tree, but this will result in a rise in the existing ground level within the tree protection zone, the Contractor shall comply with the following requirements:

(a) Implement the measures agreed by the Engineer to accommodate raising the existing ground level,

(b) Before commencing implementation of the measures to

accommodate raising the ground level pursuant to sub-clause (3)(a) of this Clause, the Contractor shall submit method statements, including the necessary engineering design, construction details, and associated precautionary works for the measures for the Engineer's approval, and

(c) Commence implementation of the measures only after the Engineer's approval to the method statements has been given.

Protection of preserved trees from excavation including trenching

26.11 (1) Without the Engineer's prior approval, the Contractor shall not carry out any excavation within the tree protection zones of the preserved trees unless the Contract explicitly requires such excavation work to be carried out. For the approved excavation work within the tree protection zones, the Contractor shall comply with the following requirements:

(a) Obtain agreement from the Engineer about the detailed locations and extent of the excavations before commencing any excavation work,

(b) Carry out the following work before commencing any cutting work to the aerial roots or underground roots of the preserved trees:

(i) Determine the locations of the major roots and the bulk of their absorbing roots so as to keep the cutting of tree roots to a minimum and to preserve the tap roots, sinker roots and support roots of the trees in any circumstances,

(ii) Obtain agreement from the Engineer about the extent of root cutting on the Site, and

(iii) Where the stability of the trees is likely to be jeopardised, comply with the requirements stipulated in Clause 26.13.

(c) Submit to the Engineer photographic records showing the condition of the affected trees and the agreed extent of excavations and root cuttings as marked on the Site before commencing the excavation work and root-cutting work and thereafter submit photographic records showing the condition of the affected trees and the progress of the excavation work and root-cutting work at weekly intervals until backfilling of the excavation is complete,

(d) Pile the excavated materials outside the tree protection zones to reduce soil compaction,

(e) Carry out the excavation work carefully so as not to damage the bark and root collars of the preserved trees,

(f) Maintain balanced moisture content in the trees and in the soil after backfilling of the excavation, by carrying out necessary precautionary measures such as crown thinning, watering and mulching, and

(g) Move the temporary protection fencing stipulated in Clause 26.09 to the edge of the intended excavation area, between the excavation area and the rest of the tree protection zone, during the duration of excavation work, and move back the same to its original location after backfilling.

(2) The Contractor shall take the following precautions when carrying out excavation that involves cutting of the roots of the preserved trees:

(a) Excavation shall be carried out using only hand-held tools such as hoe and spade, but not mechanical diggers or bulldozers,

(b) Whenever roots are encountered and before root cutting is carried out, soil shall be carefully forked away from the roots using hand-held tools up to the edge along which root cutting is required,

(c) Root cutting shall be carried out carefully using sterilised hand-held pruning tools, and roots greater than 25 mm in diameter shall be pruned carefully so as not to result in shattered and frayed roots,

(d) Any roots damaged during excavation shall be cut back cleanly with sharp tools to undamaged tissue and treated with an approved fungicidal dressing before backfilling,

(e) All cut and exposed roots shall be prevented from drying out during excavation by adopting the following measures until backfilling, unless otherwise agreed by the Engineer:

(i) Wrap the tap roots, sinker roots, support roots, and roots with diameter exceeding 50 mm with hessian, straw or other porous, absorbent fabric once they are exposed,

(ii) Hang thick hessian or other porous, absorbent fabric from top of the cut surface over the exposed roots and soil immediately after root cutting, and

(iii) Mist the hessian or fabric in a frequency that keeps the roots and the soil at the cut surface moist all the time,

(f) The hessian, straw or other porous, absorbent fabric stipulated in sub-clause (2)(e)i) of this Clause and the hessian or fabric stipulated in sub-clause (2)(e)ii) of this Clause shall be removed immediately before backfilling, and

(g) Excavations shall be backfilled with soil mix incorporated with slow release fertiliser at a rate of 500 g/m^3 or at a rate as directed by the Engineer to a level equivalent to the original soil level at the root collar after settlement.

Protection of preserved trees from drilling

26.12 (1) Without the Engineer's prior approval, the Contractor shall not carry out drilling, such as soil nailing and drilling for bore holes, rock bolts or dowels, within the tree protection zones of the preserved trees unless the Contract explicitly requires such drilling work within the tree protection zones. For the approved drilling work within the tree protection zones, the Contractor shall comply with the following requirements:

(a) Obtain agreement from the Engineer about the detailed locations and extent of the drill holes before commencing any drilling work. The Contractor should bear in mind that the drill holes shall be located in such a way that the structures to be placed into the drill holes, including the surface elements of the structures such as soil nail heads, are at a minimum distance of 500 mm from the trunks of the preserved trees unless otherwise agreed by the Engineer, and

(b) Carry out the following before commencing any cutting work to the aerial roots or underground roots of the preserved trees:

(i) Determine the locations of their major roots and the bulk of their absorbing roots so as to keep the cutting of tree roots to a minimum and to preserve the tap roots, sinker roots and support roots of the trees in any circumstances,

(ii) Obtain agreement from the Engineer about the extent of root cutting on the Site,

(iii) Where the stability of the trees is likely to be jeopardised, comply with the requirements stipulated in Clause 26.13,

(c) Carry out the drilling work carefully so as not to damage the branches, foliage, trunk, bark and root collars of the preserved trees when gaining access for, supporting, mobilising, positioning and operating the drilling rig, and

(d) Maintain balanced moisture content in the trees and in the soil after the drilling work, by carrying out necessary precautionary measures such as crown thinning, watering and mulching.

(2) The Contractor shall take the following precautions when carrying out drilling work that involves cutting of the roots of the preserved trees:

(a) Drilling work and root cutting work shall be carried out carefully,

(b) Roots greater than 25 mm in diameter shall be pruned carefully in order to prevent shattered and frayed roots, and

(c) Any roots damaged during drilling shall be cut back cleanly with sharp tools to undamaged tissue and treated with an approved fungicidal dressing.

Protection of preserved trees from instability

26.13 (1) Where the Works involve cutting of any major roots or other major parts of the preserved trees or any other works that may jeopardise the stability of the preserved trees, the Contractor shall install all necessary physical support measures that will ensure the stability of the preserved trees. The Contractor shall pay particular attention to the preserved trees growing on retaining structures in order to prevent the trees from being dislodged from its position as a result of inadequate support.

(2) The physical support measures for the preserved trees shall be installed securely before commencing root cutting, tree pruning or any other works that may affect the stability of the trees. Before commencing installation of these measures, the Contractor shall submit the method statements of these measures to the Engineer for approval. The Contractor shall commence installation of the support measures only after the Engineer's approval to the method statements has been given.

(3) The physical support for the preserved trees shall be securely founded in footings independent of existing walls or building structures or in other supporting systems as appropriate, without interfering with other works, other existing features, and the preserved trees. Where the affected tree is growing on a retaining structure, the Contractor shall make a detailed assessment to estimate the weight of the tree and identify the best position of supporting the tree in relation to its overall spread and centre of gravity. The method statements of the support measures designed by the Contractor in respect of the trees growing on retaining structures shall include the following information:

(a) Details of the form of construction for the support measures to demonstrate the bearing capacity of each element,

(b) Details of the foundation of the support measures to demonstrate that the support measures shall not interfere with other works, other existing features, and the preserved trees and shall not affect the stability of the retaining structure,

(c) Means of securing the tree to the supporting measures, including how cups and ties are adjusted to the form of the tree, and

(d) Method of fabrication and erection on the Site.

(4) The Contractor shall remove the physical support for the preserved trees from the Site upon completion of the Works, or earlier if so directed by the Engineer. The Contractor shall not remove or relocate the physical support for the trees without the Engineer's prior agreement.

Pruning of preserved trees

26.14 (1) The Contractor shall not carry out pruning to the preserved trees unless the pruning work is required under the Contract or is directed by the Engineer. The Contractor shall notify the Engineer of any preserved trees whose branches interfere with the Works and thus require pruning. Pruning shall only commence after the Engineer's approval has been obtained. The Contractor shall carry out the approved pruning work during the site clearance stage unless otherwise instructed or agreed by the Engineer.

(2) The Contractor shall comply with the requirements in Clause 3.86 when carrying out the pruning work.

Control of pest and disease for preserved trees

26.15 (1) The Contractor shall take all necessary precautionary measures to protect the preserved trees from pest and disease attack and all necessary control measures to eradicate pest and disease from the infected trees in the execution of the Works. The Contractor shall regularly check for any pest and disease attack particularly during known periods of activity and shall report to the Engineer on any such occurrence.

(2) Before commencing application of the pest and disease control

measures, the Contractor shall submit the method statements of the control measures to the Engineer for approval. The Contractor shall commence application of the control measures only after obtaining the Engineer's approval for the method statements.

(3) The method statements for the pest and disease control measures shall cover, amongst other aspects as required by the Engineer, the pesticide, insecticide or fungicide to be used and any other necessary associated arboricultural work to the infected areas.

(4) The Contractor shall comply with the requirements in Clause 3.90 in applying the pest and disease control measures.

REPAIR OF DAMAGE

Repair of damage to preserved trees and other affected plants

26.16 (1) The Contractor shall carry out all necessary work of repair of any damage to the preserved trees and any other plants affected. All necessary work of repair of damage shall be carried out at the Contractor's own costs if the necessity for such work is, in the opinion of the Engineer, due to negligence or failure on the part of the Contractor to comply with any obligation expressed or implied on the Contractor's part under the Contract.

(2) The work of repair of damage as referred to in sub-clause (1) of this Clause shall include the following:

(a) All necessary arboricultural work to the preserved trees and any other plants damaged, which may include:

(i) Tree surgery work to remove dead, damaged, diseased or hazardous parts, to repair wounds, or to provide cables or braces for additional support,

(ii) Watering and/or mulching in case of water deficiency,

(iii) Applying appropriate fertilizers in case of nutrient deficiency, and

(iv) Applying appropriate pest and disease control measures in case of pest and disease attack;

(b) The replacement planting pursuant to sub-clause (7) of this Clause for the trees and any other plants damaged to an extent as described in sub-clause (6) of this Clause and the subsequent Establishment Works for the new plants for 1 year, when instructed by the Engineer, and

(c) Any other reinstatement work necessary to bring the damaged plants to their original condition before occurrence of the damage, as directed by the Engineer.

(3) The Contractor shall notify the Engineer of any damage to the preserved trees and other affected plants within the same day of the occurrence of damage and shall submit to the Engineer within 3 days of the occurrence of damage, a report comprising the following information in a format agreed by Engineer:

(a) The timing of the damage,

(b) The nature and extent of the damage,

(c) Photographic records of the damage,

(d) The proposed work of repair of the damage, and

(e) The proposed protection measures to avoid recurrence of similar incident.

(4) When directed by the Engineer, the Contractor shall firm up and secure all dislodged trees and any other dislodged plants and shall treat all wounds of the damaged trees/plants within 3 days of the occurrence of the damage.

(5) Save as stated in sub-clause (4) of this Clause, the Contractor shall not carry out any work of repair of the damage before the Engineer's acceptance of the report as required in sub-clause (3) of this Clause.

(6) The Contractor shall provide replacement planting of the damaged trees and any other affected plants under the following circumstances:

(a) In the opinion of the Engineer the damaged trees or other affected plants are dead,

(b) In the opinion of the Engineer, the trees/plants have been substantially damaged, resulting in one or more of the following conditions:

(i) That imminent death of the trees or other affected plants within the coming growing season is predicted,

(ii) That the structural integrity of the damaged trees or other affected plants is permanently compromised and consequently the trees or other affected plants become an irreparable public hazard,

(iii) That any major parts of the damaged trees or other affected plants have been lost and consequently their form, habit and balance have been grossly altered so that their function cannot be reasonably recovered or the trees or other affected plants are causing harm to other preserved trees.

(7) When instructed by the Engineer, the Contractor shall carry out the following work:

(a) Removal of the damaged trees or other affected plants for which replacement planting as sub-clause (6) of this Clause is required, in accordance with the following requirements:

(i) For the removal of the damaged trees, the Contractor shall prepare a tree felling application document to the Engineer's satisfaction and provide any other assistance or information as required by the Engineer, for the Engineer's application for approval to the felling of the damaged trees from the government approving authority,

(ii) The Contractor shall fell the damaged trees only after the Engineer's approval to the tree felling, which shall normally be given only after the tree felling application has been approved by the government approving authority, and

(iii) The Contractor shall remove the damaged plants from the Site, and

(b) Unless otherwise agreed by the Engineer, replacement planting of new plants in accordance with the following requirements:

(i) The Contractor shall complete the replacement planting within 28 days of the Engineer's instruction or other time duration as agreed by the Engineer, and

(ii) For replacement planting, the Contractor shall plant new plants of the same species and of similar size and form as the damaged plants before the damage or provide other alternative replacement planting as agreed by the Engineer.