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FOREWORD

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

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

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

March 1992

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GENERAL

INTERPRETATION OF DOCUMENTS

Application of the General Specification for Civil Engineering Works

1.01 (1) The provisions contained in the Particular Specification and the Drawings shall prevail over the provisions contained in this General Specification for Civil Engineering Works.

(2) The provisions contained in this General Specification for Civil Engineering Works shall prevail over the provisions contained in British Standards, British Standard Codes of Practice and similar standard documents stated in the Contract.

Abbreviations

1.02 (1) Abbreviations used in this General Specification for Civil Engineering Works shall have the following meanings:

AASHTO	:	American Association of State Highway and Transportation Officials
AMD	:	Amendment
AWWA	:	American Water Works Association
ASTM	:	American Society for Testing and Materials
BQ	:	Bills of Quantities
BS	:	British Standard
BS EN	:	European Standard adopted as British Standard
CCTV	:	closed circuit television
CD	:	Chart Datum
CI	:	cast iron
CP	:	British Standard Code of Practice
CS	:	Construction Standard
DI	:	ductile iron
DN	:	nominal size
dn	:	nominal size of tees and tapers
FGL	:	finished ground level, or finished level of the permanent works
GCC	:	General Conditions of Contract
GEO	:	Geotechnical Engineering Office, Civil Engineering Department
GI	:	galvanised iron
GS	:	General Specification for Civil Engineering Works
HDPE	:	high density polyethylene
HOKLAS	:	Hong Kong Laboratory Accreditation Scheme
HSFG	:	high strength friction grip
ISO	:	International Organisation for Standardization
OPC	:	ordinary Portland cement
PD	:	Principal Datum
PFA	:	pulverised-fuel ash
PPFAC	:	Portland pulverised-fuel ash cement
ppm	:	parts per million
PS	:	Particular Specification
PTFE	:	polytetrafluoroethylene
PVC	:	polyvinyl chloride
RHPC	:	rapid hardening Portland cement
SCC	:	Special Conditions of Contract

SIS	:	Swedish Standard
SMM	:	Standard Method of Measurement for Civil Engineering Works
SRPC	:	sulphate resisting Portland cement
UPVC	:	unplasticised polyvinyl chloride

(2) Abbreviations of units of measurement used in the GS shall have the following meanings:

°C	:	degrees Celsius
g	:	gram
g/mL	:	gram per millilitre
g/m^2	:	gram per square metre
ha	:	hectare
hr	:	hour
Hz	:	hertz
J	:	joule
kg	:	kilogram
kHz	:	kilohertz
kJ	:	kilojoule
km	:	kilometre
km/hr	:	kilometre per hour
kN	:	kilonewton
kPa	:	kilopascal
kV	:	kilovolt
kW	:	kilowatt
L	:	litre
L/min	:	litre per minute
L/s	:	litre per second
m	:	metre
m^2	:	square metre
m^3	:	cubic metre
m/s	:	metre per second
Mg	:	megagram
Mg/m^3	:	megagram per cubic metre
min	:	minute
mL	:	millilitre
mm	:	millimetre
mm^2	:	square millimetre
mm^3	:	cubic millimetre
mm/s	:	millimetre per second
MPa	:	megapascal
N	:	newton
N/mm	:	newton per millimetre
N/m^2	:	newton per square metre
No.	:	number
Pa.s	:	pascal second
r/min	:	revolution per minute
r/s	:	revolution per second
s	:	second
t	:	tonne
μm	:	micrometre
%	:	percentage

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

(2) Utilities are electricity, lighting, traffic control, telephone and other communication cables and gas, water, sewage and drainage pipes and ducts, including all associated protection, supports, ancillary structures, fittings and equipment.

Trials and approval 1.04 (1) Reference in the GS to the approval of the Engineer shall mean approval given by the Engineer in writing. Materials, methods of construction and any other matters which have been approved by the Engineer shall not be changed without the approval of the Engineer to the proposed changes.

(2) Trials shall be carried out as stated in the Contract to demonstrate that proposed materials and methods of construction will produce work which complies with the specified requirements.

(3) Trials shall be carried out before the relevant permanent work starts so as to allow the Engineer a sufficient period to determine if the trial complies with the specified requirements. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before the trial starts.

(4) Trials shall be carried out using materials and methods of construction of the types submitted to the Engineer, and at locations agreed by the Engineer.

(5) If in the opinion of the Engineer work which complies with the specified requirements has not been produced in the trial, particulars of proposed changes to the materials or methods of construction shall be submitted to the Engineer; further trials shall be carried out until work which complies with the specified requirements has been produced in the trial unless otherwise agreed by the Engineer. Works for which trials are required shall not commence until in the opinion of the Engineer work which complies with the specified requirements has been produced in the trial.

(6) Unless permitted by the Engineer, the materials and methods of construction used to produce work which complies with the specified requirements in a trial shall not be changed unless further trials have been carried out to demonstrate that the proposed changes are satisfactory.

British Standards, Codes of Practice and other standards 1.05 (1) Unless otherwise stated in the Contract, reference in the GS to British Standards, British Standard Codes of Practice and similar standards shall be to that edition of the document stated in Appendix 1.1 of the GS, including all amendments issued by the relevant authority up to 31 December 1991, unless otherwise stated.

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

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

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

Dimensions from Drawings 1.07 Dimensions shall not be obtained by scaling from the Drawings. Dimensions which are not shown on the Drawings or calculable from dimensions shown on the Drawings shall be obtained from the Engineer.

PROGRAMME

Programme 1.08 (1) In addition to the programme to be submitted to the Engineer in accordance with GCC Clause 16, the Contractor shall submit within a further 14 days a programme showing a detailed breakdown of the work to be carried out in the first 3 months, and an outline for the remainder of the work. A programme showing the work completed to date, a detailed breakdown of the work to be carried out in the next 3 months and an updated outline for the remainder of the work shall be submitted to the Engineer not later than 4 weeks before the commencement of each subsequent 3-monthly period.

(2) Programmes submitted in accordance with Clause 1.08(1) shall be in the form of a bar chart showing the earliest and latest start and finish dates for each activity, and the critical path.

(3) The breakdown of the work to be shown for each Section of the Works on the programme submitted in accordance with Clauses 1.08(1) shall be comprehensive. It shall include the key activities, key dates and milestones from the programme submitted under GCC Clause 16, the information required under GCC Clause 6 and the effects of the matters listed in GCC Clause 63, together with the following:

(a) work to be carried out, including testing and commissioning,

(b) fabrication, delivery and installation of materials to be fabricated off the Site,

(c) delivery of critical materials originating from outside Hong Kong,

(d) activities for which the Employer or Engineer is responsible, including the issue of critical drawings and other information, provision of materials by the Employer, nomination and approval of Nominated Sub-contractors and consideration and approval of drawings and proposals, and

(e) work to be carried out by Government departments, utility undertakings and other contractors.

(4) The Contractor shall be responsible for arranging, co-ordinating and agreeing with the utility undertakings a programme for their works. The Contractor shall make full allowance for time and provision of facilities for the utility undertakings in the preparation of his programmes.

CONTRACTOR'S SUPERINTENDENCE

Surveyor 1.09 (1) The Contractor shall employ on the Site in connection with the execution of the Works a surveyor for setting out the Works.

(2) The surveyor shall possess a diploma or equivalent qualification appropriate to the nature of the survey work required for the Contract, or be under the supervision of a suitably qualified surveyor.

Foreman for concrete work 1.10 If structural concrete work is included in the Contract, the Contractor shall employ on the Site in connection with the execution of the Works a foreman who is suitably experienced in concrete work. The foreman shall be on the Site at all times when concreting is in progress.

Particulars of agent and employees 1.11 (1) The following particulars of the proposed agent, surveyor and foreman for concrete work 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.

(2) The particulars of the agent shall be submitted for approval, and the particulars of the surveyor and foreman for concrete work shall be submitted for information.

(3) The particulars of the agent shall be submitted within 7 days after the date of commencement of the Works. The particulars of the surveyor and foreman for concrete work shall be submitted within 7 days of their appointment.

SAFETY

Safety 1.12 (1) A current copy of the following shall be kept on the Site:

(a) Construction Sites (Safety) Regulations,

(b) Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations,

(c) A Guide to the Construction Sites (Safety) Regulations, and

(d) A Guide to the Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations.

(2) Safety precautions for working in sewers, drains and other enclosed spaces shall comply with the requirements contained in the current edition of the document `Safety Guide to Working in Confined Spaces' issued by the Hong Kong Government.

(3) Divers shall undergo regular medical checks and obtain certificates of fitness. Safety precautions for diving shall be in accordance with the current edition of the `Code of Practice for Diving' issued by the Hong Kong Government.

(4) Adequate provision of safety equipment including as appropriate safety helmets, goggles, ear protectors, safety belts, safety equipment for working in sewers, drains and enclosed spaces, equipment for rescue from drowning, fire extinguishers, first aid equipment and other necessary safety equipment shall be made available on the Site at all times.

(5) Safety equipment, scaffolds, working platforms, ladders and other means of access, and lighting, signing and guarding equipment shall be inspected and maintained regularly. Lights and signs shall be kept clean and easy to read. Equipment which is damaged, dirty, incorrectly positioned or not in working order shall be repaired or replaced immediately.

(6) Posters in both English and Chinese drawing attention to safety shall be obtained from the Labour Department and displayed prominently on the Site.

WORK IN ROADS

Approval for temporary traffic arrangements and control

1.13 (1) In addition to any other requirements stated in the Contract, temporary traffic arrangements shall be in accordance with conditions and restrictions imposed by the Commissioner for Transport and the Commissioner of Police, and temporary lighting, signing, guarding and traffic control arrangements shall be in accordance with conditions and restrictions imposed by the Director of Highways. Traffic signs which are not prescribed by the Road Traffic Ordinance or its subsidiary legislation shall be in accordance with conditions and restrictions imposed by the Commissioner for Transport.

(2) The Contractor shall make all arrangements with and obtain the necessary approvals from the Commissioner for Transport, the Commissioner of Police, the Director of Highways and any other relevant authority for temporary traffic arrangements and control.

Temporary traffic arrangements and control

1.14 (1) Temporary traffic diversions and pedestrian routes shall be provided where work in roads or footways obstructs existing vehicular or pedestrian access. The relevant work shall not commence until the approved temporary traffic arrangements and control have been implemented.

(2) Temporary traffic arrangements and control for work in roads and footways shall comply with the requirements contained in the current edition of the document `Code of Practice for Lighting, Signing and Guarding of Road Works' issued by the Hong Kong Government; a copy of the document shall be kept on the Site.

(3) Temporary traffic light signals shall be a type approved by the Commissioner for Transport and shall comply with the requirements contained in the current editions of the documents `Type Approval Procedure for Portable Traffic Light Signals' and `Specification for Vehicle Actuated/Fixed Time Portable Traffic Signal Equipment' issued by the Hong Kong Government.

(4) Temporary traffic signs, including posts, backing plates and faces, shall comply with the requirements for traffic signs contained in Section 12 except as stated in Clauses 1.14(5) and (6).

(5) The thickness of backing plates for temporary traffic signs which will be erected for less than 6 months may be reduced to 1.5 mm; the posts for the signs may be constructed of timber or other material provided that in the opinion of the Engineer the traffic signs will be stable and safe.

(6) The arrangement of information contained on sign faces for temporary traffic directional signs shall be designed by the Contractor. The details of the background, borders and legends, including letters, numerals, characters and symbols, shall comply with the requirements of the Commissioner for Transport.

(7) Temporary traffic arrangements and control shall be inspected and maintained regularly, both by day and night. Traffic lights, lights and signs shall be kept clean and easy to read. Equipment which is damaged, dirty, incorrectly positioned or not in working order shall be repaired or replaced immediately.

Particulars of temporary traffic arrangements and control

1.15 The following particulars of the proposed temporary traffic arrangements and control shall be submitted to the Engineer for approval at least 7 days before the traffic arrangements and control are implemented:

(a) details of traffic diversions and pedestrian routes,

(b) details of lighting, signing, guarding and traffic control arrangements and equipment, and

(c) any conditions or restrictions imposed by the Commissioner for Transport, the Commissioner of Police, the Director of Highways or any other relevant authority, including copies of applications, correspondence and approvals.

Use of roads and footways

1.16 (1) Roads and footways on the Site in which work is not being carried out shall be maintained in a clean and passable condition and shall not be used to store materials or park Constructional Plant or other vehicles.

(2) Measures shall be taken to prevent excavated material, silt or debris from entering drainage systems in roads and footways; entry of water to the gullies shall not be obstructed.

(3) Surfaced roads on the Site and leading to the Site shall not be used by tracked vehicles unless protection against damage is provided.

(4) Constructional Plant and other vehicles leaving the Site shall be loaded in such a manner that excavated material, mud or debris will not be deposited on roads; loads shall be covered or protected to prevent dust being emitted. The wheels of Constructional Plant and other vehicles shall be washed before leaving the Site to avoid the deposition of mud and debris on roads.

Work in roads and footways 1.17 (1) Work in roads on the Site shall be carried out in sections such that the length of road occupied at any time does not exceed that stated in the Contract and the width of road occupied at any time does not exceed the width of one traffic lane unless permitted by the Engineer. Work in each section shall be completed and the road shall be reinstated and opened to traffic before work commences in the next section. Work in any section, including loading and unloading, shall be carried out in such a manner that traffic and utilities in the adjacent road and pedestrian access in the adjacent footway will be adequately maintained.

(2) Before excavations are carried out in roads or footways, except in areas covered with paving blocks or tiles, the limits of the area to be reinstated shall be bounded by a continuous saw-cut groove. The groove shall be at least 6 mm wide and at least 50 mm deep. Cutting the groove and breaking out the road or footway shall be carried out in such a manner that the adjacent road or footway, including edges, are not damaged.

(3) Excavated material shall not be stored adjacent to excavations in roads or footways unless permitted by the Engineer.

(4) Vehicular access across excavations in roads shall be provided by steel covers. The covers shall be designed to BS 449: Part 2 and shall be capable of withstanding the full traffic load permitted to use the road. The covers shall be secured in position and shall have anti-skid coating so that the skid resistance values on the covers measured in accordance with BS 3262 shall be not less than 45. Sufficient steel covers shall be kept on the Site adjacent to excavations in roads to permit vehicular access across the excavations in case of emergency.

Reinstatement of roads and footways 1.18 Temporary diversions, pedestrian access and lighting, signing, guarding and traffic control equipment shall be removed immediately they are no longer required. Roads, footways and other items affected by temporary traffic arrangements and control shall be reinstated to the same condition as was existing before the work started or to such other condition as may be agreed or instructed by the Engineer.

CARE OF THE WORKS

Protection from water 1.19 (1) Unless otherwise permitted by the Engineer, all work shall be carried out, as near as may be practicable in the circumstances, in dry conditions, except where the work is required to be carried out in or with water or other fluids.

(2) The Works, including materials for use in the Works, shall, where necessary and as near as may be practicable, be kept free of water and protected from damage due to water. Water on the Site and water entering the Site shall be disposed of by temporary drainage or pumping systems or by other methods capable of keeping the Works free of water and protected from damage due to water. Silt and debris shall be intercepted by traps before water is discharged from the Site.

(3) The discharge points of the temporary drainage and pumping systems shall be as approved by the Engineer. The Contractor shall make all arrangements with and obtain the necessary approvals and inspections from the relevant authorities for discharging water to drains, watercourses or the sea. The relevant work shall not start until the approved arrangements for disposal of the water have been implemented.

(4) Measures shall be taken to prevent flotation of new and existing structures.

Protection from weather

1.20 (1) Work shall not be carried out in weather conditions which may adversely affect the work unless protection by methods agreed by the Engineer is provided.

(2) Permanent work, including materials for permanent work, shall be protected by methods agreed by the Engineer from exposure to weather conditions which may adversely affect the work or materials.

Protection of work

1.21 Finished work shall be protected by methods agreed by the Engineer from damage which could arise from the execution of adjacent work. Work shall be carried out in such a manner that work carried out by others, including Government departments, utility undertakings and other contractors, is not damaged.

DAMAGE AND INTERFERENCE

Damage and interference

1.22 (1) Work shall be carried out in such a manner that, as far as is reasonable and practicable, there is no damage to or interference with the following, other than such damage as is required to enable the execution of the Works:

(a) watercourses or drainage systems,

(b) utilities,

(c) structures, roads including street furniture, or other property,

(d) public or private vehicular or pedestrian accesses, and

(e) trees, graves or burial urns.

The Contractor shall inform the Engineer as soon as practicable of any item, utility or thing which is not stated in the Contract as requiring diversion, removal or relocation but which the Contractor considers as requiring diversion, removal or relocation to enable the Works to be executed. The Contractor shall not divert, remove or relocate any such item, utility or thing without the prior approval of the Engineer.

(2) Items which are damaged or interfered with as a result of the work being carried out and items which are diverted, removed or relocated to enable the work to be carried out, shall be reinstated to the same condition as was existing before the work started or to such other condition as may be agreed or instructed by the Engineer.

Watercourses and drainage systems

1.23 (1) Existing watercourses and drainage systems shall be temporarily diverted as required to enable the work to be carried out. Particulars of the proposed diversions shall be submitted to the Engineer for approval at least 14 days before the relevant work starts. The diversions shall be maintained while the work is being carried out and shall be reinstated, including the removal of any obstructions to flow, as soon as practicable after the work is complete.

(2) Measures shall be taken to prevent excavated material, silt or debris from being deposited in existing drainage systems, watercourses or the sea.

Utilities

1.24 (1) The details of existing utilities are given for information only and the accuracy of the details is not guaranteed. The Contractor shall make his own enquiries and shall carefully excavate inspection pits to locate accurately the utilities indicated to him by the utility undertakings.

(2) Temporary supports and protection to utilities shall be provided by methods agreed by the Engineer; permanent supports and protection shall be provided if instructed by the Engineer.

(3) The Contractor shall inform the Engineer and the utility undertakings without delay of the following:

(a) damage to utilities,

(b) leakage of utilities,

(c) discovery of utilities not shown on the Drawings, and

(d) diversion, removal, repositioning or re-erection of utilities which is required to enable the execution of the Works.

(4) The Contractor shall take all steps necessary to enable the utility undertakings to proceed in accordance with the programme agreed between the Contractor and the utility undertakings under Clause 1.08(4). The Contractor shall maintain close liaison with the utility undertakings and shall inform the Engineer of any delays in works by the utility undertakings.

(5) Records of existing utilities encountered shall be kept by the Contractor on the Site and a copy provided for the Engineer. The records shall be agreed by the Engineer and shall contain the following details:

(a) location of utility,

(b) date on which utility was encountered,

(c) nature and size of utility,

(d) condition of utility, and

(e) temporary or permanent supports provided.

(6) Further to Clause 1.24(1), the Contractor shall submit for the Engineer's agreement, at least 14 days before any excavation by mechanical plant, a proposal for investigations to ascertain the nature, location and size of existing utilities by hand-dug inspection pits. Such investigations with inspection pits shall not relieve the Contractor of any of the duties, responsibilities, obligations or liabilities imposed upon him by any of the provisions of the Contract.

(7) Unless otherwise agreed by the Engineer in writing, the Contractor shall carry out investigations to locate utilities in accordance with the proposal referred to in Clause 1.24(6). The Contractor shall make his own enquiries with the utility undertakings as and when required and should any utility installations including cover tiles be exposed, the respective utility undertakings shall be contacted to determine if all their utilities have been located. All utility installations including cover tiles shall only be removed by the utility undertakings concerned.

(8) Any excavation with mechanical plant shall not commence until the nature, location and size of utilities which may be affected by the excavation have been ascertained and the setting out details have been checked by the Engineer. The nature includes the type of utilities, protective UPVC/GI ducts or conduits, concrete surround, haunching and the like. The location includes the top/bottom levels, the coordinates of the centrelines of the utilities and the like.

(9) The Contractor shall provide adequate and experienced site personnel to control the operation of heavy mechanical plant in the proximity of utilities.

(10) The Contractor shall make arrangements to avoid any heavy mechanical plant or vehicles standing or passing over buried pipeworks in particular those at shallow depths with less than 1 metre overburden cover, especially when the road surface is removed. Unless agreed by the Engineer, the Contractor shall not stockpile any material immediately over or in the vicinity of any pipeworks.

(11) Pursuant to Clause 1.24(1), the Contractor shall carry out the Works in such a manner so as not to cause any damage or interference with any concrete blocks or structures attached to the utilities. The Contractor shall ensure that all cable draw pits, valve pits and the like are not covered up or removed as a result of his work and are accessible by utility undertakings at any time during the course of the Works for emergency repair.

(12) Further to Clause 1.24(2), where utility installations are exposed, the Contractor shall liaise with the utility undertakers about the necessary protection for the exposed utilities and provide temporary protective measures and warning signs to prevent damaging the utility installations.

Structures, roads and other property

1.25 The Contractor shall immediately inform the Engineer of any damage to structures, roads or other property which is not required for the execution of the Works.

Access 1.26 Alternative access shall be provided if interference with existing public or private vehicular or pedestrian access is necessary to enable the execution of the Works. The arrangements for the alternative access shall be as agreed by the Engineer. The permanent access shall be reinstated as soon as practicable after the work is complete and the alternative access shall be removed as soon as practicable after it is no longer required.

Trees 1.27 Trees which are to be retained or which are not required to be removed in order to carry out the Works, shall be protected from damage at all times by methods agreed by the Engineer. Materials, including excavated materials, shall not be banked around such trees and they shall not be trimmed or cut without the approval of the Engineer.

RECORDS

Records of wage rates 1.28 The average, high and low wage rates for workers of each trade employed on the Site shall be entered on monthly wage return forms provided by the Engineer, and the completed forms returned to the Engineer within 4 days of the start of the succeeding month. For the purpose of completing the returns, actual trades shall be entered as the equivalent trades stated in Table 1.1.

Records of correspondence 1.29 Copies of correspondence relevant to the execution of the Works and not of a confidential nature received from or despatched to Government departments, utility undertakings and other contractors employed by the Employer shall be submitted to the Engineer for information as soon as possible but in any case not later than 7 days after receipt or despatch.

Records and reports 1.30 Reports and records which are to be submitted to the Engineer shall be in a format agreed by the Engineer. Reports and records shall be signed by the Contractor's agent or by another representative authorised by the Contractor.

Table 1.1: Equivalent trades

Actual trade	Equivalent trade
Office attendant	Labourer (unskilled), male or female
Watchman	Labourer (unskilled)
Working ganger	Ordinary worker in the trade in which he is employed or, if the trade is not listed, lorry driver
Survey labourer	Concretor's labourer (male)
Turf-layer	Concretor's labourer (male)
Bituminous material layer	Concretor's labourer (male)
Shot-firer	Plasterer

Table 1.1: Equivalent trades (continued)

Actual trade	Equivalent trade
Lorry checker	Labourer (unskilled), male
Motor driver (car/van)	Truck driver
Survey leveller	Plumber
Welder	Painter
Coxswain, barge engineer	Truck driver
Dredger crew, barge crew	Diver's linesman

LIAISON WITH OTHERS

Liaison with others 1.31 (1) The Contractor shall make all necessary arrangements with and obtain the necessary approvals from Government departments, utility undertakings and other duly constituted authorities for carrying out the Works.

(2) The Contractor shall maintain close liaison with other contractors employed by the Employer, utility undertakings or other authorities who are carrying out work on or adjacent to the Site. The Contractor shall ensure as far as possible that the progress of the Works is not adversely affected by the activities of such other contractors.

SITE CLEANLINESS

Site cleanliness 1.32 The Site shall be maintained in a clean and tidy condition. Materials, including materials required for Temporary Works, shall be stored in an orderly manner. Rubbish and debris shall be disposed of at least once a week.

Prevention of mosquito breeding 1.33 (1) Measures shall be taken to prevent mosquito breeding on the Site. The measures to be taken shall include the following:

(a) Empty cans, oil drums, packings and other receptacles which may retain water shall be deposited at a central collection point and those not required for future use shall be removed from the Site regularly.

(b) Standing water shall be treated at least once every week with an oil which will prevent mosquito breeding.

(c) Constructional Plant and other items on the Site which may retain water shall be stored, covered or treated in such a manner that water will not be retained.

(2) Posters in both English and Chinese drawing attention to the dangers of permitting mosquito breeding shall be obtained from the Hong Kong Government and displayed prominently on the Site.

Prevention of dust 1.34 Work shall be carried out in such a manner that avoidable dust is not generated.

MATERIALS AND EQUIPMENT

Materials and equipment provided by the Employe 1.35 (1) Materials and equipment which are to be provided by the Employer will be as stated in the Contract.

(2) Materials and equipment provided by the Employer shall be collected by the Contractor from the locations stated in Contract and delivered by the Contractor to the Site. The Contractor shall inspect the materials and equipment before taking receipt and shall immediately inform the Engineer of any shortage or damage.

(3) Materials or equipment provided by the Employer which are damaged after collection shall be repaired by the Contractor and submitted to the Engineer for approval. Materials or equipment which are lost or which in the opinion of the Engineer are not capable of being or have not been repaired satisfactorily shall be replaced by the Contractor.

(4) Crates and containers for materials or equipment provided by the Employer shall be disposed of by the Contractor.

(5) Equipment and materials provided by the Employer which are surplus to the requirements of the Works shall be returned to the locations stated in the Contract.

(6) The Contractor shall protect and maintain equipment provided by the Employer while it is on the Site and shall provide operatives, fuel and other consumables required to operate the equipment.

Materials 1.36 (1) Materials for inclusion in the permanent work shall be new or other material as stated in the Contract or approved by the Engineer.

(2) Certificates of tests by manufacturers which are submitted to the Engineer shall relate to the material delivered to the Site. Certified true copies of certificates may be submitted if the original certificates cannot be obtained from the manufacturer. A letter from the supplier stating that the certificates relate to the material delivered to the Site shall be submitted with the certificates.

(3) Materials which are specified by means of trade or proprietary names may be substituted by materials from a different manufacturer approved by the Engineer provided that the materials are of the same or better quality and comply with the specified requirements.

(4) Samples of materials submitted to the Engineer for information or approval shall be kept on the Site and shall not be returned to the Contractor or used in the permanent work unless permitted by the Engineer.

TESTING

Quality assurance schemes

1.37 Tests stated in the Contract may be omitted or reduced in number as agreed by the Engineer if materials or articles delivered to the Site:

(a) bear the stamp of the registered certification trade mark of the BS Institution, known as the BS Kitemark, or

(b) are covered by a manufacturer's quality assurance scheme stated in the Contract or approved by the Engineer.

Batches, samples and specimens

1.38 (1) A batch of material is a specified quantity of the material which satisfies specified conditions such that it may be assumed that all of the material in the batch is of consistent type and quality. If one of the specified conditions is that the material is delivered to the Site at the same time, material delivered to the Site over a period not exceeding 7 days may be considered as part of the same batch if in the opinion of the Engineer there is sufficient evidence that the other specified conditions applying to the batch apply to all of the material delivered over the period.

(2) A sample is a specified amount, or a specified number of pieces or units, taken from a batch for testing, such that the result of tests on the sample can be taken as representing the quality of the batch as a whole.

(3) A specimen is a portion of a sample which is to be tested.

Samples for testing

1.39 (1) For the purpose of this Clause and Clauses 1.40, 1.42 and 1.49, "the Employer's laboratories" shall mean:

(a) the laboratories of the Employer such as Public Works Laboratories (PWL), and

(b) the laboratories currently appointed by the Employer.

(2) Samples for laboratory tests or test locations for insitu tests shall be randomly selected by the Engineer. In addition, the Engineer shall be free to select samples he suspects to be defective. The test locations for insitu tests so selected and, if applicable, the area/extent of Works covered by the tests, shall be traceable by means of either a referenced co-ordinates system or a location plan with defined test positions and levels.

(3) Samples shall be representative and of sufficient size to enable all specified tests to be made.

(4) Samples shall be taken on Site under close supervision of the Engineer or by the Employer's laboratories having no direct commercial relationship with the Contractor or material supplier, and shall be clearly, indelibly and individually marked for identification.

(5) Once selected and taken, samples stored on Site prior to delivery to the place of testing shall remain in the charge of the Engineer or the Employer's laboratories, who/which shall be given adequate facilities (including sample store room) to keep samples securely under lock and key inaccessible to unauthorised persons at all times.

(a) Samples shall be protected, handled and stored in such a manner that they are not damaged nor contaminated such that the properties of the sample do not change. The method of storage shall comply with the requirements of the relevant test methods.

(b) Where insitu concreting works are to be carried out, the Contractor shall, at the discretion of the Engineer, provide sufficient number of steel container rooms (or the like) and curing tanks for storage and curing test cubes to the satisfaction of the Engineer. The steel container room and curing tank being provided shall be in accordance with Clause 1.49(4).

(6) Samples shall be collected and delivered by the Contractor under close supervision of the Engineer or by the Employer's laboratories to the specified place of testing. During transportation from Site to the specified place of testing, all samples shall be securely locked in containers or suitably modified vehicle compartments unless otherwise approved by the Engineer, with keys kept by the Engineer or the Employer's laboratories.

(7) The transfer of samples from one place/person to another shall be clearly documented and checked. The person receiving the samples shall acknowledge the receipt and confirm the identification of the samples. A record, showing :

(a) when, where and by whom the samples are taken, and

(b) persons who have handled the samples prior to and during delivery to the place of testing,

shall be prepared and maintained by the Engineer (with assistance of the Employer's laboratories when necessary) so that the samples delivered from Site to the specified place of testing are traceable.

(8) For those tests where supervisory attendance is essential in providing guidance on Site or in obtaining test data, details of such supervisory site staff present shall be recorded in relevant data sheets and/or sample submission forms to enhance data integrity.

(9) For the purpose of stock control to preclude the swapping of materials under test and where applicable the unauthorised use of materials prior to receipt of test results, the Contractor shall:

(a) clearly identify all batches of materials arrived on Site (the identification marks so designed shall contain information which can reveal the identity of the batch for each type of materials such as the Contract number, type of materials, batch number and other information as required by the Engineer);

(b) keep stockpiles and stock items from which samples have been taken pending test results separated from other materials by means of labels denoting "Stock under Test" or similarly agreed by the Engineer;

(c) establish and maintain a record system showing identification marks, testing status on all materials (under test or approved for use or rejected or re-test or omitted for testing, etc.), key dates (e.g. date of testing) and locations of storage; and

(d) in connection with the above, submit a proposal of stock management system on Site peculiar to the Contract to prevent unauthorised or uncontrolled use of materials for approval by the Engineer at the commencement of the Contract and subsequent supervision by the Engineer.

(10) Samples on which non-destructive tests have been carried out shall be collected from the place of testing after testing and delivered to the Site or other location instructed by the Engineer.

(11) Samples which have been tested may be incorporated in the permanent work provided that:

(a) the sample complies with the specified requirements,

(b) the sample is not damaged, and

(c) the sample is not required as stated in Clause 1.36(4).

(12) Additional samples shall be provided for testing if in the opinion of the Engineer:

(a) material previously tested no longer complies with the specified requirements, or

(b) material has been handled or stored in such a manner that it is no longer represented by previously tested samples.

Testing 1.40 (1) Unless otherwise stated in the Contract, insitu tests and laboratory tests shall be carried out by the Employer's laboratories if the aforesaid tests can be undertaken by the Employer's laboratories; testing shall not be carried out in other laboratories unless permitted by the Engineer. If testing is permitted to be carried out by the Contractor :

(a) independent laboratories with no affiliation as a legal entity to the Contractor and its sub-contractors shall be used,

(b) 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,

(c) particulars of the laboratory proposed by the Contractor shall be submitted to the Engineer for approval, and

(d) tests shall be adequately supervised by the Engineer.

(2) The Contractor shall be entitled to attend testing associated with the Works that is carried out in the Employer's laboratories, and to inspect relevant records.

(3) Unless otherwise stated in the Contract, equipment, apparatus and materials for insitu tests and laboratory tests carried out by the Contractor shall be provided by the Contractor. The equipment and apparatus shall be maintained by the Contractor and shall be calibrated before testing starts and at regular intervals agreed by the Engineer. Calibration requirements and source of calibration applicable to all laboratory equipment shall follow those recommended in the HOKLAS Supplementary Criteria No. 2 "All Test Categories - Equipment Calibration". The equipment, apparatus and materials for insitu tests shall be removed by the Contractor as soon as practicable after testing is complete.

Compliance of a batch 1.41 (1) Unless otherwise stated in the Contract, the results of tests on samples or specimens shall be considered as representing the whole of the batch from which the sample was taken.

(2) A batch shall be considered as complying with the specified requirements for the material if the results of specified tests for specified properties comply with the specified requirements for the properties.

(3) If additional tests are permitted and separate compliance criteria for the additional tests are not stated in the Contract, the Engineer shall determine if the batch complies with the specified requirements for the material on the basis of the results of all tests, including the additional tests, for every property.

Raw records of tests and test reports 1.42 (1) Raw records of insitu tests and laboratory compliance tests carried out by the Contractor (excluding the laboratories engaged by the Contractor) shall be submitted to the Engineer immediately, or such other time stated in the Contract, after the tests with a copy of the whole set of records kept by the Contractor on the Site.

(2) For all insitu tests and laboratory compliance tests, a test report shall be submitted to the Engineer in sealed envelope within 7 days, or such other time stated in the Contract, after completion of each test. The report shall contain the following details:

(a) material or part of the work tested,

(b) location and area/extent of the batch from which the samples were taken or location and area/extent of the part of the work,

(c) place of testing,

(d) date and time of tests,

(e) weather conditions in the case of insitu tests,

(f) technical personnel supervising or carrying out the tests,

(g) size and description of samples and specimens,

(h) method of sampling,

(i) properties tested,

(j) method of testing,

(k) readings and measurements taken during the tests,

(l) test results, including any calculations and graphs, and

(m) other details stated in the Contract.

(3) All test reports compiled by the laboratories (which refer to the Employer's laboratories and those engaged by the Contractor) shall be delivered directly to the Engineer in sealed envelope without routing through the Contractor.

(4) Copies of test records carried out through the Employer's laboratories will be given to the Contractor on request.

WORKMANSHIP AND TOLERANCES

Workmanship 1.43 Workmanship shall comply with best trade practice and with relevant British Standard.

Tolerances 1.44 (1) Tolerances stated in the Contract shall be measured perpendicular to the specified lines unless otherwise stated in the Contract.

(2) If adjacent parts of the Works are subject to different dimensional tolerances then the most critical tolerance shall apply to all such works which are related to each other in respect of dimension, line and level.

SITE ESTABLISHMENT

Use of the Site 1.45 (1) The Site shall not be used by the Contractor for any purpose other than for executing the Works or carrying out other work which is associated with the Works and approved by the Engineer.

(2) Concrete batching and mixing plant erected on the Site shall not be used to provide concrete for work outside the Site.

(3) Bituminous materials batching and mixing plant erected on the Site shall not be used to provide bituminous materials for work outside the Site.

(4) Rock crushing plant shall not be erected on the Site unless stated in the Contract.

(5) The location and size of stockpiles of materials, including excavated material, within the Site shall be as agreed by the Engineer. Stockpiles shall be maintained in a stable condition.

(6) Entry to and exit from the Site shall be obtained only at the locations stated in the Contract or agreed by the Engineer.

Submission of particulars 1.46 (1) The following particulars shall be submitted to the Engineer for approval not more than 14 days after the commencement of the Works:

(a) drawings showing the layout within the Site of the Engineer's and Contractor's accommodation, project signboards, access roads and major facilities required early in the Contract,

(b) drawings showing the layout and the construction details of the Engineer's accommodation, and

(c) drawings showing the details to be included on project signboards.

(2) Drawings showing the location of stores, storage areas, concrete and bituminous materials batching and mixing plants, rock crushing plants and other major facilities not required early in the Contract shall be submitted to the Engineer for approval as early as possible, but in any case not later than 28 days before such facilities are constructed on the Site.

Survey of the Site 1.47 A survey of the Site to establish the precise boundaries of the Site and the levels within the Site will be carried out by the Engineer after site clearance, and before other work starts in each area to be surveyed. The Contractor shall carry out the survey jointly with the Engineer and agree the result as soon as practicable after completion of site clearance, prior to commencing other works in the area surveyed.

Fences and signs on the Site 1.48 (1) Hoardings, fences, gates and signs on the Site shall be maintained in a clean, stable and secure condition.

(2) Project signboards stated in the Contract shall be erected not more than 4 weeks, or such other period agreed by the Engineer, after the date for commencement of the Works. Other advertising signs shall not be erected on the Site unless permitted by the Engineer.

(3) The permission of the Engineer shall be obtained before hoardings, fences, gates or signs are removed. Hoardings, fences, gates and signs which are to be left in position after completion of the Works shall be repaired and repainted as instructed by the Engineer.

The Engineer's Site accommodation 1.49 (1) The accommodation to be provided on the Site for the Engineer shall be ready for occupation, including connection of all utilities, not more than 8 weeks after the date of approval by the Engineer of the proposed location, layout and construction details.

(2) The accommodation shall be maintained in a clean, stable and secure condition and shall be cleaned at least daily. The services of a full-time attendant shall be provided for the Engineer.

(3) Equipment provided for the use of the Engineer/persons authorised by the Engineer shall be maintained in a clean and serviceable condition and all consumables shall be replenished when required. Measuring and testing equipment shall be calibrated before it is used and at regular intervals agreed by the Engineer. Calibration requirements as well as source of calibration applicable to all laboratory equipment shall follow those recommended in the HOKLAS Supplementary Criteria No. 2 “All Test Categories - Equipment Calibration”. Survey equipment shall be maintained by the service agent and shall be calibrated by an approved laboratory at regular intervals agreed by the Engineer. Equivalent replacements shall be provided for equipment which is out of service.

(4) Where insitu concreting works are to be carried out, steel container rooms and curing tanks shall be provided on the Site, at the discretion of the Engineer, according to the requirements stated in Appendix 1.2 and Appendix 1.3 respectively. In this connection, concreting works shall not commence until curing tanks and container rooms (or the like) are completed and accepted by the Engineer or unless otherwise approved by the Engineer. Where directed by the Engineer, Employer's laboratories shall be given sole access and use of the steel container rooms and curing tanks together with all the equipment provided under the Contract.

(5) The permission of the Engineer shall be obtained before accommodation or equipment is removed. Portable accommodation shall be moved at the times instructed by the Engineer. Accommodation or equipment which is to be left in position or become the property of the Employer after completion of the Works shall be repaired, repainted and serviced as instructed by the Engineer.

The Contractor's Site accommodation 1.50 The Contractor's offices, sheds, stores, mess rooms, latrines and other accommodation on the Site shall be maintained in a clean, stable and secure condition. Living accommodation shall not be provided on the Site unless stated in the Contract or approved by the Engineer.

Site utilities and access 1.51 (1) Temporary water, electricity, telephone, sewerage and drainage facilities shall be provided for the Engineer's accommodation and for the Contractor's use in carrying out the Works. The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for the facilities.

(2) Access roads and parking areas shall be provided within the Site as required and shall be maintained in a clean, passable and stable condition.

Transport for the Engineer 1.52 (1) Transport for the Engineer shall be provided from the date of commencement of the Works unless otherwise permitted or instructed by the Engineer.

(2) The transport shall be for the exclusive use of the Engineer and persons authorised by the Engineer and shall be available at all times during normal working hours and at other times when the Contractor is working or when instructed by the Engineer. The transport shall not be used by the Contractor or other persons.

(3) The transport shall be maintained in a clean and serviceable condition and shall be serviced regularly. Fuel, oil and other consumables, taxes, licenses, insurances, toll charges and parking and mooring fees shall be provided by the Contractor. Land transport shall be covered by fully comprehensive insurance, which includes passenger liability and which allows the vehicle to be driven by any driver.

(4) A competent English-speaking driver shall be appointed and shall be available to drive the land transport when required by the Engineer.

(5) Marine transport shall be equipped and manned in accordance with the statutory requirements of the Marine Department and licensed under the Merchant Shipping (Launches and Ferry Vessels) Regulations Chapter 281. A qualified English-speaking coxswain shall be appointed and shall be available when the marine transport is required by the Engineer.

(6) Records of journeys shall be kept in log books provided by the Engineer. Records shall include details of the times and purpose of journeys with appropriate odometer readings and distances travelled. The person using the transport or authorising the journey shall sign against the log book entries. Log books shall be presented for inspection when required by the Engineer and all completed log books shall be handed over to the Engineer.

(7) Equivalent transport shall be provided when transport is unavailable for any reason.

(8) The transport shall be provided until the end of the Maintenance Period or such earlier date instructed by the Engineer.

Clearance of the Site 1.53 Temporary Works which are not to remain on the Site after completion of the Works shall be removed on completion of the Works or at other times instructed by the Engineer. The Site shall be cleared and reinstated to the lines and levels and to the same condition as was existing before the Works started except as otherwise stated in the Contract.

MEETINGS

Meetings 1.54 The Contractor's agent shall attend, and shall arrange for the representatives of sub-contractors, Government departments, transport companies, utility undertakings and other Contractors to attend, meetings when required by the Engineer. The Contractor shall inform the Engineer 48 hours, or such shorter period agreed by the Engineer, before meetings with Government departments, transport companies, utility undertakings and other Contractors are to be held and shall give the Engineer the opportunity to attend such meetings.

PHOTOGRAPHS

Photographs 1.55 Colour photographs, including underwater photographs, showing the progress of the Works and the quality of the materials and workmanship shall be taken at the times and at locations instructed by the Engineer. Photographs shall be captioned with the time, date and location. Selected prints shall be authenticated by the Contractor and the Engineer by signing the back of the prints and the following shall be provided for the Engineer:

(a) a negative of each photograph,

(b) one 3R print of each photograph,

(c) albums to store the photographs, and

(d) framed 8R prints of photographs selected by the Engineer.

APPENDIX 1.1

STANDARDS

1.1.1 BRITISH STANDARDS

BS 4	Structural steel sections
BS 4: Part 1: 1980	Specification for hot-rolled sections
BS 12: 1989	Specification for Portland cements
BS 21: 1985	Specification for pipe threads for tubes and fittings where pressure - tight joints are made on the threads (metric dimensions)
BS 29: 1976(1987)	Specification for carbon steel forgings above 150 mm ruling section
BS 65: 1988	Specification for vitrified clay pipes, fittings, joints and ducts
BS 144: 1990	Wood preservation using coal tar creosotes
BS 373: 1957(1986)	Methods of testing small clear specimens of timber
BS 381C: 1988	Specification for colours for identification, coding and special purposes
BS 410: 1986	Specification for test sieves
BS 416: 1990	Discharge and ventilating pipes and fittings, sand-cast or spun in cast iron
BS 417: Part 2: 1987	Specification for galvanized low carbon steel cisterns, cistern lids, tanks and cylinders - metric units
BS 427: 1990	Method for Vickers hardness test and for verification of Vickers hardness testing machines
BS 434: 1984	Bitumen road emulsions (anionic and cationic)
BS 434: Part 1: 1984	Specification for bitumen road emulsions
BS 434: Part 2: 1984	Code of practice for use of bitumen road emulsions
BS 443: 1982(1990)	Specification for testing zinc coatings on steel wire and for quality requirements
BS 449: Part 2: 1969	Specification for the use of structural steel in building - metric units
BS 534: 1990	Specification for steel pipes, joints and specials for water and sewage

BS 544: 1969	Specification for linseed oil putty for use in wooden frames
BS 718: 1979(1985)	Specification for density hydrometers
BS 729: 1971(1986)	Specification for hot dip galvanized coatings on iron and steel articles
BS 743: 1970	Specification for materials for damp-proof courses
BS 747: 1977(1986)	Specification for roofing felts
BS 812	Testing aggregates
BS 812: Part 1: 1975	Methods for determination of particle size and shape
BS 812: Part 2: 1975	Methods for determination of physical properties
BS 812: Part 4: 1976	Chemical properties
BS 812: Part 101: 1984	Guide to sampling and testing aggregates
BS 812: Part 102: 1989	Methods for sampling
BS 812: Part 103	Methods for determination of particle size distribution
BS 812: Section 103.1: 1985	Sieve tests
BS 812: Section 103.2: 1989	Sedimentation test
BS 812: Part 105	Methods for determination of particle shape
BS 812: Section 105.1: 1989	Flakiness index
BS 812: Section 105.2: 1990	Elongation index of coarse aggregate
BS 812: Part 110: 1990	Methods for determination of aggregate crushing value (ACV)
BS 812: Part 111: 1990	Methods for determination of ten per cent fines value (TFV)
BS 812: Part 112: 1990	Method for determination of aggregate impact value (AIV)
BS 812: Part 113: 1990	Method for determination of aggregate abrasion value (AAV)
BS 864: Part 2: 1983	Specification for capillary and compression fittings for copper tubes
BS 873	Road traffic signs and internally illuminated bollards
BS 873: Part 1: 1983	Methods of test
BS 873: Part 5: 1983	Specification for internally illuminated signs and external lighting luminaires

BS 873: Part 6: 1983	Specification for retroreflective and non-retroreflective signs
BS 873: Part 7: 1984	Specification for posts and fittings
BS 882: 1992	Specification for aggregates from natural sources for concrete
BS 890: 1972	Specification for building limes
BS 903	Physical testing of rubber
BS 903: Part A1: 1980(1988)	Determination of density
BS 903: Part A2: 1989	Determination of tensile stress-strain properties
BS 903: Part A3: 1982	Determination of tear strength (trouser, angle and crescent test pieces)
BS 903: Part A4: 1990	Determination of compression stress-strain properties
BS 903: Part A5: 1974	Determination of tension set
BS 903: Part A6: 1969	Determination of compression set after constant strain
BS 903: Part A9: 1988	Determination of abrasion resistance
BS 903: Part A16: 1987	Determination of the effect of liquids
BS 903: Part A18: 1973(1985)	Determination of equilibrium water vapour absorption
BS 903: Part A19: 1986	Heat resistance and accelerated ageing tests
BS 903: Part A26: 1969	Determination of hardness
BS 903: Part A43: 1990	Method for determination of resistance to ozone cracking (static strain test)
BS 903: Part C2: 1982	Determination of volume resistivity
BS 952	Glass for glazing
BS 952: Part 1: 1978	Classification
BS 952: Part 2: 1980	Terminology for work on glass
BS 970: Part 1: 1983	General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels
BS 1004: 1972(1985)	Specification for zinc alloys for die casting and zinc alloy die casting
BS 1010: Part 2: 1973	Draw-off taps and above-ground stopvalves
BS 1014: 1975(1986)	Specification for pigments for Portland cement and Portland cement products

BS 1070: 1973(1979)	Specification for black paint (tar-based)
BS 1155: 1986	Specification for natural rubber compounds for extrusion
BS 1161: 1977(1984)	Specification for aluminium alloy sections for structural purposes
BS 1181: 1989	Specification for clay flue linings and flue terminals
BS 1191	Specification for gypsum building plasters
BS 1191: Part 1: 1973	Excluding premixed lightweight plasters
BS 1194: 1969	Specification for concrete porous pipes for under-drainage
BS 1199 and 1200: 1976	Specification for building sands from natural sources
BS 1203: 1979	Specification for synthetic resin adhesives (phenolic and aminoplastic) for plywood
BS 1204	Synthetic resin adhesives (phenolic and aminoplastic) for wood
BS 1204: Part 1: 1979(1991)	Specification for gap-filling adhesives
BS 1212	Float operated valves
BS 1212: Part 1: 1990	Specification for piston type float operated valves (copper alloy body) (excluding floats)
BS 1212: Part 2: 1990	Specification for diaphragm type float operated valves (copper alloy body) (excluding floats)
BS 1212: Part 3: 1990	Specification for diaphragm type float operated valves (plastic bodied) for cold water services only (excluding floats)
BS 1247: 1990	Manhole steps
BS 1336: 1971(1988)	Specification for knotting
BS 1369	Steel lathing for internal plastering and external rendering
BS 1369: Part 1: 1987	Specification for expanded metal and ribbed lathing
BS 1377: 1990 (as modified in accordance with GEO Report No. 36, entitled “Methods of Test for Soils in Hong Kong for Civil Engineering Purposes (Phase 1 Tests)”, except for Clauses 7.39(1) & 9.43(5) where the year of edition remains to be 1975)	Methods of test for soils for civil engineering purposes

BS 1387: 1985(1990)	Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads
BS 1400: 1985	Specification for copper alloy ingots and copper alloy and high conductivity copper castings
BS 1449: Part 1: 1983	Specification for carbon and carbon-manganese plate, sheet and strip
BS 1449: Part 2: 1983	Specification for stainless and heat-resisting steel plate, sheet and strip
BS 1452: 1990	Specification for flake graphite cast iron
BS 1470: 1987	Specification for wrought aluminium and aluminium alloys for general engineering purposes: plate, sheet and strip
BS 1471: 1972	Specification for wrought aluminium and aluminium alloys for general engineering purposes - drawn tube
BS 1473: 1972	Specification for wrought aluminium and aluminium alloys for general engineering purposes - rivet, bolt and screw stock
BS 1474: 1987	Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections
BS 1494: Part 2: 1967	Sundry fixings
BS 1610	Materials testing machines and force verification equipment
BS 1610: Part 1: 1992	Specification for the grading of the forces applied by materials testing machines when used in the compression mode
BS 1615: 1987	Method for specifying anodic oxidation coatings on aluminium and its alloys
BS 1722: Part 1: 1986	Specification for chain link fences
BS 1740: Part 1: 1971(1990)	Specification for wrought steel pipe fittings (screwed BS 21 R-series thread)
BS 1924: 1990	Stabilized materials for civil engineering purposes
BS 2000	Methods of test for petroleum and its products
BS 2015: 1965(1985)	Glossary of paint terms
BS 2451: 1963(1988)	Specification for chilled iron shot and grit
BS 2456: 1990	Specification for floats (plastics) for float operated valves for cold water services

BS 2494: 1990	Specification for elastomeric seals for joints in pipework and pipelines
BS 2499	Hot-applied joint sealant systems for concrete pavements
BS 2499: Part 1: 1993	Specification for joint sealants
BS 2499: Part 2: 1992	Code of practice for the application and use of joint sealants
BS 2499: Part 3: 1993	Methods of test
BS 2523: 1966(1983)	Specification for lead-based priming paints
BS 2569: Part 1: 1964(1988)	Protection of iron and steel by aluminium and zinc against atmospheric corrosion
BS 2600	Radiographic examination of fusion welded butt joints in steel
BS 2600: Part 1: 1983	Methods for steel 2 mm up to and including 50 mm thick
BS 2600: Part 2: 1973	Methods for steel over 50 mm up to and including 200 mm thick
BS 2633: 1987	Specification for Class I arc welding of ferritic steel pipework for carrying fluids
BS 2648: 1955	Performance requirements for electrically-heated laboratory drying ovens
BS 2760: 1973	Specification for pitch-impregnated fibre pipes and fittings for below and above ground drainage
BS 2782	Methods of testing plastics
BS 2782: Part 3: Methods 320A to 320F: 1976	Tensile strength, elongation and elastic modulus
BS 2782: Part 3: Method 365A: 1976(1989)	Determination of softness number of flexible plastics materials
BS 2782: Part 3: Method 365D: 1978(1983)	Determination of hardness of plastics and ebonite by the ball indentation method
BS 2782: Part 4: Methods 430A to 430D: 1983	Determination of water absorption at 23°C. Determination of water absorption at 23°C with allowance for water-soluble matter. Determination of boiling water absorption. Determination of boiling water absorption with allowance for water-soluble matter.
ISO 1183: 1999	Plastics – Methods for determining the density of non-cellular plastics

BS 2789: 1985	Specification for spheroidal graphite or nodular graphite cast iron
BS 2846: Part 3: 1975(1985)	Determination of a statistical tolerance interval
BS 2846: Part 4: 1976(1985)	Techniques of estimation and tests relating to means and variances
BS 2869: Part 2: 1988	Specification for fuel oil for agricultural and industrial engines and burners (classes A2, C1, C2, D, E, F, G and H)
BS 2871: Part 1: 1971	Copper tubes for water, gas and sanitation
BS 2874: 1986	Specification for copper and copper alloy rods and sections (other than forging stock)
BS 2910: 1986	Methods for radiographic examination of fusion welded circumferential butt joints in steel pipes
BS 2989: 1982	Specification for continuously hot-dip zinc coated and iron-zinc alloy coated steel: wide strip, sheet/plate and slit wide strip
BS 3019: Part 1: 1984	Specification for TIG welding of aluminum, magnesium and their alloys
BS 3049: 1976	Specification. Pedestrian guard rails (metal)
BS 3100: 1976(1984)	Specification for steel castings for general engineering purposes
BS 3148: 1980	Methods of test for water for making concrete (including notes on the suitability of the water)
BS 3262: Part 1: 1989	Specification for constituent materials and mixtures
BS 3262: Part 3: 1989	Specification for application of material to road surfaces
BS 3382: Part 1 & 2: 1961	Cadmium on steel components. Zinc on steel components
BS 3410: 1961	Specification for metal washers for general engineering purposes
BS 3416: 1991 with AMD 7288	Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water
BS 3468: 1986	Specification for austenitic cast iron
BS 3505: 1986	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water
BS 3506: 1969	Specification for unplasticized PVC pipe for industrial uses

BS 3571: Part 1: 1985	Specification for MIG welding of aluminium and aluminium alloys
BS 3600: 1976(1988)	Specification for dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes
BS 3601: 1987	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes
BS 3690: Part 1: 1989	Specification for bitumens for roads and other paved areas
BS 3690: Part 2: 1989	Specification for bitumens for industrial purposes
BS 3692: 1967	Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units
BS 3698: 1964(1979)	Specification for calcium plumbate priming paints
BS 3892: Part 1: 1982	Specification for pulverized-fuel ash for use as a cementitious component in structural concrete
BS 3900	Methods of test for paints
BS 3900: Part C5: 1992	Determination of film thickness
BS 3900: Part E10: 1979(1989)	Mechanical tests on paint films - Pull-off test for adhesion
BS 3923: Part 1: 1986	Methods for manual examination of fusion welds in ferritic steels
BS 3923: Part 2: 1972	Automatic examination of fusion welded butt joints in ferritic steels
BS 3981: 1976(1985)	Specification. Iron oxide pigments for paints
BS 3987: 1974	Specification for anodic oxide coatings on wrought aluminium for external architectural applications
BS 3998: 1989	Recommendations for tree work
BS 4027: 1980	Specification for sulphate-resisting Portland cement
BS 4072: 1987	Wood preservation by means of copper/chromium/arsenic compositions
BS 4102: 1990	Specification for steel wire and wire products for fences
BS 4147: 1980(1987)	Specification for bitumen-based hot-applied coating materials for protecting iron and steel, including suitable primers where required
BS 4168: Part 1: 1981	Specification for hexagon socket head cap screws

BS 4190: 1967	Specification for ISO metric black hexagon bolts, screws and nuts
BS 4211: 1987	Specification for ladders for permanent access to chimneys, other high structures, silos and bins
BS 4232: 1967	Specification for surface finish of blast-cleaned steel for painting
BS 4254: 1983	Specification for two-part polysulphide-based sealants
BS 4320: 1968	Specification for metal washers for general engineering purposes. Metric series
BS 4345: 1968(1986)	Specification for slotted angles
BS 4346	Joints and fittings for use with unplasticized PVC pressure pipes
BS 4346: Part 1: 1969	Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply
BS 4346: Part 2: 1970	Mechanical joints and fittings, principally of unplasticized PVC
BS 4346: Part 3: 1982	Specification for solvent cement
BS 4360: 1986	Specification for weldable structural steels
BS 4393: 1969(1985)	Specification for tin or tin-lead coated copper wire
BS 4395	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering
BS 4395: Part 1: 1969	General grade
BS 4395: Part 2: 1969	Higher grade bolts and nuts and general grade washers
BS 4395: Part 3: 1973	Higher grade bolts (waisted shank), nuts and general grade washers
BS 4447: 1973(1990)	Specification for the performance of prestressing anchorage for post-tensioned construction
BS 4466: 1989	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
BS 4482: 1985	Specification for cold reduced steel wire for the reinforcement of concrete
BS 4483: 1985	Specification for steel fabric for the reinforcement of concrete

BS 4486: 1980	Specification for hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete
BS 4504: Section 3.1: 1989	Circular flanges for pipes, valves and fittings (PN designated) - Specification for steel flanges
BS 4514: 1983	Specification for unplasticized PVC soil and ventilating pipes, fittings and accessories
BS 4515: 1984	Specification for welding of steel pipelines on land and offshore
BS 4550: Part 1: 1978	Methods of testing cement – Sampling
BS 4550: Part 2: 1970	Methods of testing cement - Chemical tests
BS 4550: Part 3: 1978	Methods of testing cement - Physical tests
BS 4551: 1980	Methods of testing mortars, screeds and plasters
BS 4568	Specification for steel conduit and fittings with metric threads of ISO form electrical installations
BS 4568: Part 1: 1970	Steel conduit, bends and couplers
BS 4568: Part 2: 1970(1988)	Fittings and components
BS 4570: 1985	Specification for fusion welding of steel castings
BS 4576: Part 1: 1989	Unplasticized polyvinyl chloride (PVC-U) rainwater goods and assessories - Half-round gutters and pipes of circular cross-section
BS 4604	Specification for the use of high strength friction grip bolts in structural steelwork.
BS 4604: Part 1: 1970	General grade
BS 4604: Part 2: 1970	Higher grade (parallel shank)
BS 4620: 1970(1988)	Specification for rivets for general engineering purposes
BS 4622: 1970(1983)	Specification for grey iron pipes and fittings
BS 4652: 1971(1979)	Specification for metallic zinc-rich priming paint (organic media)
BS 4660: 1989	Specification for unplasticized polyvinyl chloride (PVC-U) pipes and plastics fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage
BS 4662: 1970(1989)	Specification for boxes for the enclosure of electrical accessories

BS 4677: 1984	Specification for arc welding of austenitic stainless steel pipework for carrying fluids
BS 4756: 1971(1983)	Specification for ready mixed aluminium priming paints for woodwork
BS 4772: 1988	Specification for ductile iron pipes and fittings
BS 4848	Specification for hot-rolled structural steel sections
BS 4848: Part 2: 1975	Hollow sections
BS 4848: Part 4: 1972(1986)	Equal and unequal angles
BS 4848: Part 5: 1980	Bulb flats
BS 4865: Part 1: 1989	Specification for non-metallic flat gaskets (including gaskets for flanges to BS 4772)
BS 4870: Part 1: 1981	Specification for approval testing of welding procedures - Fusion welding of steel
BS EN 287 : Part 1 : 1992	Approval testing of welders for fusion welding - Steels
BS 4872: Part 1: 1982	Specification for approval testing of welders when welding procedure approval is not required - Fusion welding of steel
BS 4873: 1986	Specification for aluminium alloy windows
BS 4921: 1988	Specification for sheradized coatings on iron or steel
BS 4933: 1973	Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts
BS 4942: 1981	Short link chain for lifting purposes
BS 5075: Part 1: 1982	Specification for accelerating admixtures, retarding admixtures and water reducing admixtures
BS 5075: Part 3: 1985	Specification for superplasticizing admixtures
BS 5135: 1984	Specification for arc welding or carbon and carbon manganese steels
BS 5150: 1990	Specification for cast iron gate valves
BS 5154: 1989	Specification for copper alloy globe, globe stop and check, check and gate valves
BS 5163: 1986	Specification for predominantly key-operated cast iron gate valves for waterworks purposes
BS 5212: 1990	Cold applied joint sealant systems for concrete pavements

BS 5215: 1986	Specification for one-part gun grade polysulphide-based sealants
BS 5252F: 1976(1986)	Colour matching fan
BS 5255: 1989	Specification for thermoplastics waste pipe and fittings
BS 5268: Part 2: 1988	Structural use of timber - Code of practice for permissible stress design, materials and workmanship
BS 5284: 1976	Methods. Sampling and testing mastic asphalt and pitchmastic used in building
BS 5289: 1976(1983)	Code of practice. Visual inspection of fusion welded joints
BS 5395: Part 1: 1977(1984)	Code of practice for the design of straight stairs
BS 5400	Steel, concrete and composite bridges
BS 5400: Part 2: 1978	Specification for loads
BS 5400: Part 4: 1990	Code of practice for design of concrete bridges
BS 5400: Part 6: 1980	Specification for materials and workmanship, steel
BS 5400: Part 9: 1983	Bridge bearings
BS 5400: Section 9.2: 1983	Specification for materials, manufacture and installation of bridge bearings
BS 5481: 1977(1989)	Specification for unplasticized PVC pipe and fittings for gravity sewers
BS 5493: 1977	Code of practice for protective coating of iron and steel structures against corrosion
BS 5573: 1978	Code of practice for safety precautions in the construction of large diameter boreholes for piling and other purposes
BS 5589: 1989	Code of practice for preservation of timber
BS 5756: 1980(1985)	Specification for tropical hardwoods graded for structural use
BS 5896: 1980	Specification for high tensile steel wire and strand for the prestressing of concrete
BS 5911	Precast concrete pipes, fittings and ancillary products
BS 5911: Part 2: 1982	Specification for inspection chambers and street gullies
BS 5911: Part 3: 1982	Specification for pipes and fittings with ogee joints

BS 5911: Part 100: 1988	Specification for unreinforced and reinforced pipes and fittings with flexible joints
BS 5911: Part 200: 1989	Specification for unreinforced and reinforced manholes and soakaways of circular cross section
BS 5930: 1981	Code of practice for site investigations
BS 5931: 1980	Code of practice for machine laid in situ edge details for paved areas
BS 5950: Part 2: 1985	Specification for materials, fabrication and erection: hot rolled sections
BS 5996: 1980	Methods for ultrasonic testing and specifying quality grades of ferritic steel plate
BS 6044: 1987	Specification for pavement marking paints
BS 6072: 1981(1986)	Method for magnetic particle flaw detection
BS 6088: 1981(1985)	Specification for solid glass beads for use with road marking compounds and for other industrial uses
BS 6089: 1981	Guide to assessment of concrete strength in existing structures
BS 6105: 1981	Specification for corrosion-resistant stainless steel fasteners
BS 6150: 1982	Code of practice for painting of buildings
BS 6262: 1982	Code of practice for glazing for buildings
BS 6323: 1982(1990)	Specification for seamless and welded steel tubes for automobile, mechanical and general engineering purposes
BS 6323: Part 1: 1982(1990)	General requirements
BS 6323: Part 3: 1982(1990)	Specific requirements for hot finished seamless steel tubes
BS 6323: Part 8: 1982(1990)	Specific requirements for longitudinally welded stainless steel tubes
BS 6349: Part 1: 1984	Code of practice for maritime structures - General criteria
BS 6362: 1990	Specification for stainless steel tubes suitable for screwing in accordance with BS 21 `Pipe threads for tubes and fittings where pressure-tight joints are made on the threads'
BS 6405: 1984	Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: class 1 and 2

BS 6431	Ceramic floor and wall tiles
BS 6431: Part 1: 1983	Specification for classification and marking, including definitions and characteristics
BS 6431: Part 2: 1984	Specification for extruded ceramic tiles with a low water absorption ($E \leq 3\%$). Group A1
BS 6431: Part 3	Extruded ceramic tiles with a water absorption of $3\% < E \leq 6\%$. Group A11a
BS 6431: Part 3: Section 3.1: 1986	Specification for general products
BS 6431: Part 3: Section 3.2: 1986	Specification for products (terre cuite, cotto, baldosin catalan)
BS 6431: Part 4	Extruded ceramic tiles with a water absorption of $6\% < E \leq 10\%$. Group A11b
BS 6431: Part 4: Section 4.1: 1986	Specification for general products
BS 6431: Part 4: Section 4.2: 1986	Specification for specific products (terre cuite, cotto, baldosin catalan)
BS 6443: 1984	Method for penetrant flaw detection
BS 6463	Quicklime, hydrated lime and natural calcium carbonate
BS 6463: Part 1: 1984	Methods of sampling
BS 6463: Part 2: 1984	Methods of chemical analysis
BS 6463: Part 4: 1987	Methods of test for physical properties of hydrated lime and lime putty
BS 6510: 1984	Specification for steel windows, sills, window boards and doors
BS 6558: 1985	Optical fibres and cables
BS 6566	Plywood
BS 6577: 1985	Specification for mastic asphalt for building (natural rock asphalt aggregate)
BS 6588: 1985	Specification for Portland pulverized-fuel ash cement
BS 6657: 1986	Guide for prevention of inadvertent initiation of electro-explosive devices by radio-frequency radiation
BS 6681: 1986	Specification for malleable cast iron
BS 6700: 1987	Specification for design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages

BS 6920	Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water
BS 6920: Part 1: 1990	Specification
BS 6920: Part 2	Methods of test
BS 6920: Section 2.1: 1990	Samples for testing
BS 6920: Section 2.2	Taste of water
BS 6920: Subsection 2.2.1: 1990	General method of test
BS 6920: Subsection 2.2.2: 1990	Method of testing tastes imparted to water by hoses
BS 6920: Subsection 2.2.3: 1990	Method of testing tastes imparted to water by hoses for conveying water for food and drink preparation
BS 6920: Section 2.3: 1990	Appearance of water
BS 6920: Section 2.4: 1988(1994)	Growth of aquatic microorganisms
BS 6920: Section 2.5: 1990	The extraction of substances that may be of concern to public health
BS 6920: Section 2.6: 1990	The extraction of metals
BS 6920: Part 3: 1990	High temperature tests
BS 6925: 1988	Specification for mastic asphalt for building and civil engineering (limestone aggregate)
BS 6949: 1988	Specification for bitumen-based coatings for cold application, excluding use in contact with potable water
BS 7263: 1990	Precast concrete flags, kerbs, channels, edgings and quadrants
BS 7263: Part 1:1990	Specification
BS 7295	Fusion bonded epoxy coated carbon steel bars for the reinforcement of concrete
BS 7295: Part 1: 1990	Specification for coated bars with AMD 6955
BS 7295: Part 2: 1990	Specification for coatings with AMD 6956
BS 8004: 1986	Code of practice for foundations
BS 8005: Part 1: 1987	Guide to new sewerage construction
CP 144	Roof coverings
CP 144: Part 4: 1970	Mastic asphalt. Metric units

1.1.2 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS

ASTM C 117-95	Test method for materials finer than 75-μm sieve in mineral aggregates by washing
ASTM C 127-88	Test method for specific gravity and absorption of coarse aggregate
ASTM C 128-88	Test method for specific gravity and absorption of fine aggregate
ASTM C 131-81(1987)	Test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles Machine
ASTM C 136-96a	Method for sieve analysis of fine and coarse aggregates
ASTM C 188-84	Test method for density of hydraulic cement
ASTM C 939-87	Test method of flow of grout for preplaced-aggregate concrete
ASTM D 5-86	Test method for penetration of bituminous materials
ASTM D 113-86	Test method for ductility of bituminous materials
ASTM D 140-88	Method for sampling bituminous materials
ASTM D 242-85	Specification for mineral filler for bituminous paving mixtures
ASTM D 546-88	Method for sieve analysis of mineral filler for road and paving materials
ASTM D 854-83	Test method for specific gravity of soils
ASTM D 946-82	Specification for penetration-graded asphalt cement for use in pavement construction
ASTM D 979-87	Methods for sampling bituminous paving mixtures
ASTM D 1559-82	Test method for resistance to plastic flow of bituminous mixtures using Marshall apparatus
ASTM D 1754-87	Test method for effect of heat and air on asphaltic materials (thin-film over test)
ASTM D 2000-86	Classification system for rubber products in automobile applications
ASTM D 2027-76(1986)	Specification for cutback asphalt (medium-curing type)
ASTM D 2041-95	Test method for theoretical maximum specific gravity of bituminous paving mixtures

ASTM D 2042-81(1985)	Test method for solubility of asphalt materials in trichloroethylene
ASTM D 2171-88	Test method for viscosity of asphalts by vacuum capillary
ASTM D 2172-95	Test method for quantitative extraction of bitumen from bituminous paving mixtures
ASTM D 2726-96a	Test method for bulk specific gravity of compacted bituminous mixtures using saturated surface-dry specimens
ASTM D 3203-94	Test method for percent air voids in compacted dense and open bituminous paving mixtures
ASTM D 3289-85	Test method for specific gravity or density of semi-solid and solid bituminous materials by nickel crucible

1.1.3 AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) STANDARD

AASHTO Designation M252-81	Standard specification for corrugated polyethylene drainage tubing

1.1.4 AMERICAN WATER WORKS ASSOCIATION (AWWA) STANDARD

AWWA C 203-86	Coal tar enamel protective coatings for steel water pipes

1.1.5 CONSTRUCTION STANDARD

CS1: 1990 with AMD 1101, AMD 1201, AMD 1202 and AMD 1203	Testing Concrete
CS2: 1995	Carbon Steel Bars for the Reinforcement of Concrete

1.1.6 SWEDISH STANDARD

SIS 05 59 00	Surface preparation standard for painting steel surfaces

APPENDIX 1.2

REQUIREMENTS FOR STEEL CONTAINER ROOM

General 1.2.1 As a reference, a standard steel container room of nominal size 6000 mm x 2500 mm x 2350 mm may accommodate up to a maximum of five standard curing tanks (see Appendix 1.3 – Clause 1.3.1(2)).

Equipment 1.2.2 Each steel container room shall be equipped with the following:

(a) A security door-lock.

(b) Windows with security metal grilles.

(c) Fluorescent lighting.

(d) Air-conditioner with heating and cooling facilities that is capable to keep the room temperature at 25°C ± 5°C.

(e) Adequate number of power plugs for operating the curing tanks.

(f) Water supply.

(g) Drainage outlets connecting to the drainage valves and overflow system of the curing tanks.

APPENDIX 1.3

REQUIREMENTS FOR CURING TANK

General 1.3.1 (1) The requirements for a curing tank shall be as stated in Appendix A of CS1.

(2) As a reference, a standard curing tank of nominal size 1650 mm x 860 mm x 510 mm has a capacity to accommodate about sixty-four number of 150 mm concrete cubes.

(3) For curing tanks of different non-standard sizes, the number of curing tanks required may be estimated on the basis of the capacity for a standard curing tank of equivalent volume at the discretion of the Engineer, who may require appropriate adjustments in the pump and heater capacities.

(4) Each curing tank shall be accessible for operation and maintenance.

(5) At least one stand-by curing tank shall be provided at all times.

Equipment 1.3.2 Each curing tank shall be constructed of corrosion-resistant material of adequate strength such as galvanized sheet steel to BS 729 for hot-dip galvanized coating or BS 2569 for flame sprayed metal coating, fully welded on all seams and equipped with the following accessories:

(a) A lockable insulated lid (or cover) properly numbered.

(b) A recirculating water pump and a stand-by pump, both of a waterproof type and with capacity not less than 1000 litres per hour, earthed and fitted internally at one end of the tank drawing water through a pipe from the bottom to the diagonally opposite top of the tank at least 25 mm above the water level to stimulate efficient mixing of the water by free falling.

(c) A thermostatically controlled electric immersion heater and a stand-by heater, both with power of not less than 3 kW and connected with a temperature sensor for continual controlling of the water temperature at 27°C ± 3°C.

(d) A set of three removable lower racks.

(e) A drainage valve and an overflow system.

(f) A steel stand supporting the water tank.

(g) Minimum/maximum thermometers for measuring water temperature.

(h) A switch panel.

Maintenance 1.3.3 Each curing tank shall be cleaned at regular intervals and the water in each tank be changed at least once a month in accordance with CS1 or as directed by the Engineer. In order to ensure adequate circulation of water and to facilitate the removal of test cubes from the curing tank, a gap of at least 15 mm shall be provided between the test cubes and the sides of the tank.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 2

SITE CLEARANCE

SECTION 2

SITE CLEARANCE

GENERAL

General requirements 2.01 The works and materials specified in Clauses 2.02 and 2.03 shall comply with the sections stated, unless otherwise stated in this Section.

Pipes and manholes to be abandoned 2.02 The abandonment of pipes and manholes shall comply with Section 5.

Earthworks 2.03 Earthworks, including blasting, shall comply with Section 6.

SITE CLEARANCE

Demolition 2.04 (1) Areas adjacent to demolition work shall be protected from damage resulting from the demolition.

(2) Structures which are to be demolished shall be surveyed by the Contractor, and the result given to the Engineer for information, before demolition starts.

(3) Particulars of the proposed methods of carrying out demolition work shall be submitted to the Engineer for information at least 14 days before the demolition starts.

Pipes and cables 2.05 The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for disconnecting utilities inside and outside the Site. The ends of disconnected utilities shall be made good and sealed; the positions of the ends shall be marked with marker posts or by other methods agreed by the Engineer.

Trees 2.06 The roots of trees and shrubs which have been cut down shall be grubbed up. Branches shall not be removed from trees which are to be retained unless permitted by the Engineer; if permitted, the branches shall be removed in accordance with BS 3998 and the cut surfaces shall be treated with a wound sealant approved by the Engineer.

Reinstatement 2.07 (1) Unless otherwise permitted by the Engineer, areas affected by site clearance shall be reinstated as stated in Clause 2.07(2) to (5).

(2) Fine fill material shall be deposited and compacted in voids which are left in the ground.

(3) Holes which are left in structures and pavements shall be made good using material similar to that in the adjoining area.

(4) The ends of fences, walls, structures, utilities and other items shall be made good in such a manner that the affected parts will not corrode or deteriorate, and will remain stable.

(5) Straining posts shall be fixed at the end of strained fences which have been cut and the fences shall be restrained.

Materials and equipment for re-use and storage

2.08 (1) Items which are to be re-used or taken to store shall be dismantled and removed by a suitable method so as to avoid damage or minimise the damage if this is unavoidable. The items shall be cleaned before re-use or taking to store.

(2) Items which are to be re-used in the Works shall be kept in stores provided by the Contractor.

(3) Items which are to be taken to the Employer's store shall be delivered by the Contractor.

(4) Materials or equipment which are to be re-used or taken to store and which are damaged due to the Contractor's negligence shall be repaired by the Contractor by a method agreed by the Engineer. Materials or equipment which are lost or which in the opinion of the Engineer are not capable of being repaired satisfactorily shall be replaced by the Contractor. Except for items which are to be re-used or taken to store, demolished items, trees, shrubs, vegetation, boulders, debris, rubbish and other items arising from site clearance shall be disposed of by the Contractor and shall become the property of the Contractor when they are removed from the Site.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 3

LANDSCAPE SOFTWORKS AND ESTABLISHMENT WORKS

SECTION 3

LANDSCAPE SOFTWORKS AND ESTABLISHMENT WORKS

GENERAL

General requirements	3.01	The works and materials specified in Clauses 3.02 to 3.05 shall comply with the sections stated, unless otherwise stated in this Section.
Site clearance	3.02	Site clearance shall comply with Section 2.
Earthworks	3.03	Earthworks shall comply with Section 6.
Landscape hardworks	3.04	Landscape hardworks shall comply with Section 11.
Geotechnical works	3.05	Geotechnical works shall comply with Section 7.
Weather and ground conditions	3.06	Soiling, cultivation, planting and other similar landscape softworks and establishment works operations shall not be carried out at times when weather or ground conditions may in the opinion of the Engineer adversely affect the permanent works.
Use of chemicals	3.07	Chemicals shall not be used for landscape softworks and establishment works unless approved by the Engineer. Chemicals shall be used, stored, mixed and applied in accordance with the manufacturer's recommendations. Containers for chemicals shall be disposed of off Site by methods agreed by the Engineer.

GLOSSARY OF TERMS

Landscape softworks	3.08	Landscape softworks are all works of a horticultural nature, and shall include the placing, cultivation and preparation of topsoil and subsoil layers, and the supply and planting of trees, shrubs and other plant material, and any work essentially associated with these.
Landscape hardworks	3.09	Landscape hardworks are the paving, tree grilles, tree guards and tree rings and any other items stated as such in the Contract.
Establishment works	3.10	Establishment works are the regular inspections, cultivation, watering, fertilizing and other operations specified to be performed during the period stated in the Contract for such inspections and operations.

MATERIALS

Seedling trees

3.11 Seedling trees shall have the following characteristics:

(a) less than 2 years old,

(b) single slender stem,

(c) well developed vigorous root system,

(d) height above soil level of between 150 mm and 900 mm, and

(e) grown in a container at least 50 mm diameter and 150 mm deep.

Whip trees

3.12 Whip trees shall have the following characteristics:

(a) less than 3 years old,

(b) single central stem well furnished with side branches according to species,

(c) well developed vigorous root system,

(d) height above soil level of between 900 mm and 2000 mm, and

(e) grown in a container at least 75 mm diameter and 150 mm deep.

Light standard trees

3.13 Light standard trees shall have the following characteristics:

(a) sturdy straight stem at least 1500 mm high from soil level to the lowest branch,

(b) stem diameter of between 20 mm and 25 mm measured at a height of 1 m from soil level,

(c) according to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry,

(d) total height above soil level of between 2000 mm and 3000 mm, and

(e) rootball at least 300 mm diameter and 250 mm deep.

Standard trees 3.14 Standard trees shall have the following characteristics:

(a) sturdy straight stem at least 1800 mm high from soil level to the lowest branch,

(b) stem diameter of between 25 mm and 50 mm measured at a height of 1 m from soil level,

(c) according to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry,

(d) total height above soil level of between 2750 mm and 3500 mm, and

(e) rootball at least 350 mm diameter and 300 mm deep.

Heavy standard tree 3.15 Heavy standard trees shall have the following characteristics:

(a) sturdy, straight stem at least 2100 mm high between the soil level and the lowest branch,

(b) stem diameter of between 50 mm and 100 mm measured at a height of 1 m from soil level,

(c) according to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry,

(d) total height above soil level exceeding 3500 mm, and

(e) rootball at least 400 mm diameter and 350 mm deep.

Small shrubs 3.16 Small shrubs shall have the following characteristics:

(a) at least two one-year old vigorous stems arising at or near base,

(b) well developed, vigorous root system,

(c) according to species, height above soil level not less than the height stated in the Contract, and

(d) grown and supplied in a container at least 75 mm diameter and 125 mm deep.

Large shrubs

3.17 Large shrubs shall have the following characteristics:

(a) bush with at least three one-year old vigorous stems arising at or near the base, with an overall diameter equal to 2/3 of the height,

(b) well developed vigorous root system,

(c) according to species height above soil level not less than the height stated in the Contract, and

(d) grown and supplied in a container at least 100 mm diameter and 125 mm deep.

Conifers

3.18 Conifers shall have the following characteristics:

(a) well developed stem well furnished with leaf or needle bearing side shoots,

(b) well developed vigorous root system,

(c) size not less than that stated in the Contract, and

(d) grown and supplied in a container with dimensions not less than the dimensions stated in the Contract.

Palms

3.19 Palms shall have the following characteristics:

(a) well developed upright habit with a well balanced, symmetrical head,

(b) well developed vigorous root system,

(c) for single stem species, height above soil level to the growth point not less than the height stated in the Contract,

(d) for multi-stemmed species, height above soil level not less than the overall height stated in the Contract, and

(e) rootball or grown and supplied in a container at least 300 mm diameter and 300 mm deep.

Bamboo

3.20 Bamboo shall have the following characteristics:

(a) well developed vigorous root system,

(b) for single stem species, a single shoot or trunk with height above soil level not less than the height stated in the Contract,

(c) for multi-stemmed species, a clump of at least three stems with height above soil level not less than the height stated in the Contract, and

(d) rootball of at least 200 mm diameter and 200 mm deep.

Herbaceous plants 3.21 Herbaceous plants shall have the following characteristics:

(a) well developed vigorous shoots,

(b) a well developed vigorous root system,

(c) height above soil level or diameter of plant for clumps not less than the height or diameter stated in the Contract, and

(d) healthy well developed bulbs, corms, rhizomes or tubers.

Containerised plants 3.22 Containerised plants shall be grown in open ground and then lifted and placed in a rigid or semi-rigid container; plants shall be left to grow in the containers for at least 3 months before being delivered to the Site. The dimensions of containers shall not be less than the relevant rootball or container dimensions stated in Clauses 3.11 to 3.20.

Grass seed 3.23 (1) Grass seed shall be supplied true to species and variety and shall not contain impurities except as stated in Clause 3.23(2). The origin of all seed and the name of the supplier shall be stated on the containers.

(2) The quality of grass seed shall be gauged by purity, germination percentage and freedom from weeds. The total weed seed content shall not exceed 0.5% by mass and the total content of other crop seeds shall not exceed 1% by mass.

Turf 3.24 (1) First quality turf shall consist of 75%-85% axonopus compressus and 15%-25% cynodon dactylon and other stoloniferous species unless otherwise stated in the Contract.

(2) The grass shall be of even density, forming a turf which is sufficiently fibrous to hold together when handled. The grass shall be free from pest or disease. Turf shall consist of sods with soil and roots.

Sprigs 3.25 Sprigs shall consist of axonopus compressus, cynodon dactylon, paspalum distichum and other stoloniferous grasses. Axonopus compressus shall not be used on slopes exceeding 15° to the horizontal. Sprigs shall be at least 100 mm long.

Soil-mix 3.26 Soil-mix shall consist of friable, completely decomposed granite and soil conditioner in the proportions 3:1 by volume. Soil-mix shall be free from grass or weed growth, sticky clays, salt, stones exceeding 50 mm diameter, the materials stated in Clause 6.07(2) and other deleterious material.

Soil conditioner 3.27 (1) Soil conditioner shall be organic material and shall be free from impurities and substances injurious to plants. Soil conditioner shall have the following properties:

(a) The pH value shall be between 5.0 and 7.5.

(b) The moisture content measured in accordance with Clause 6.65(2) shall be between 30% and 50%.

(c) The consistency shall be fine and freely flowing.

(d) The carbon/nitrogen ratio shall be between 25 and 70.

(2) Soil conditioner shall be peat moss or properly composted organic material. Composted organic material shall be stable and shall not be liable to decompose further generating heat.

Mulch 3.28 Mulch shall be a composted organic material either as stated in Clause 3.27 for soil conditioner or granulated tree bark or wood shavings. The properties of mulch shall be as stated in Clause 3.27 for soil conditioner except that the consistency shall be coarser to avoid being blown away by wind.

Mulch for hydroseeding 3.29 Mulch for hydroseeding shall be a proprietary type approved by the Engineer and shall be a hydroseeding mulch manufactured from cellulose or paper based materials.

Fertilizer 3.30 (1) Pre-planting fertilizer shall be 15:9:15:2 (nitrogen/phosphorus/ potassium/magnesium) slow release granular fertilizer or an equivalent approved by the Engineer.

(2) Post-planting fertilizer shall be 12:12:17 (nitrogen/phosphorus/ potassium) granular fertilizer or an equivalent approved by the Engineer.

(3) Hydroseeding fertilizer shall be 15:15:15 (nitrogen/phosphorus/ potassium) or an equivalent approved by the Engineer.

(4) Phosphate fertilizer shall be triple superphosphate powder or an equivalent approved by the Engineer.

(5) Fertilizer shall be supplied in sealed waterproof bags.

Soil binder 3.31 Soil binder shall be a proprietary type approved by the Engineer and shall consist of a binding medium applied in aqueous suspension by spraying onto the surface of the soil to stabilise and condition the soil. The binding agent shall not be injurious to plant growth.

Stakes, ties and guy 3.32 (1) Steel stakes for heavy standard trees shall be 25 mm x 25 mm x 4 mm or 40 mm x 40 mm x 4 mm angle iron and shall have the appropriate lengths stated in Clauses 3.60(2), 3.61(2) and 3.62(2); steel stakes shall have all sharp edges removed to avoid damage to the tree.

(2) Ties shall be rot-proof rope or straps fitted with plastic, bamboo or other spacers and a protective sleeve to fit around the plant; ties shall be capable of adjustment after fixing.

(3) Guys shall be a multi-strand twisted galvanized steel wire of between 4 mm and 6 mm diameter. Each guy shall be fitted with a flexible rubber or plastic sleeve to prevent chafing, rubbing or abrasion of the plant, and a turnbuckle for adjustment.

Protective fabric material 3.33 Protective fabric material for hydroseeding shall be a proprietary type of degradable fabric approved by the Engineer. The fabric shall not degrade within 100 days after application or until the specified grass cover has been established.

SUBMISSIONS

Particulars of seed mixture, turf, sprigs, soil conditioner and water

3.34 (1) The following particulars of the proposed materials for landscape softworks and establishment works shall be submitted to the Engineer:

(a) origin of trees, shrubs, turves, sprigs and other plant material,

(b) details of nurseries,

(c) a certificate or a numbered seed analysis report for each seed mixture issued within 6 months before the date of use of the seed showing the species and variety of the seed, the date of testing and including results of tests for:

- percentage germination of pure seed in a fixed time under standard laboratory conditions,

- percentage composition by weight, including details of impurities,

(d) a certificate of analysis for soil conditioner including details of the composition and results of tests for:

- pH value,

- moisture content,

- carbon/nitrogen ratio, and

(e) source of water for watering.

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

Particulars of hydroseeding

3.35 (1) The following particulars of the proposed materials and methods for hydroseeding shall be submitted to the Engineer:

(a) species and rate of application of grass seed,

(b) type and rate of application of fertilizer, mulch and soil binder,

(c) type and colour of dye,

(d) type of protective fabric material, and

(e) details of the company employed to carry out the hydroseeding and the equipment to be used.

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

Samples of materials 3.36 (1) 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 seed mixture,

(b) turf,

(c) sprigs, and

(d) soil-mix.

(2) Samples of materials for landscape works and establishment works may be inspected by the Engineer at nurseries and other sources before the materials are delivered to the Site.

HANDLING, STORAGE AND TRANSPORT

Handling and storage of rootballed stock 3.37 Plants grown in open ground shall be well watered before lifting and shall be lifted in such a manner that the specified rootball is obtained with minimum disturbance to the roots. The rootball shall be securely wrapped immediately after lifting to prevent loss of soil and moisture using hessian, straw or other material agreed by the Engineer. The wrapping material shall not be removed until the plant is required for planting.

Handling and storage of container grown and containerised stock 3.38 Container grown and containerised stock shall be well watered before despatch from the nursery and shall remain in the containers until required for planting.

Transport of plants 3.39 Plants shall be wrapped and protected to prevent mechanical damage during lifting and transportation. The trunk from soil level to the lower branches of trees in the light standard, standard and heavy standard categories shall be securely wrapped to prevent moisture loss using hessian, straw or other material agreed by the Engineer. All plant material which is to be removed while in leaf shall be covered with tarpaulin during transport to reduce excessive transpiration.

Storage of plants 3.40 (1) Plants shall be protected from exposure to conditions which may affect the plant adversely.

(2) Plants shall be protected from damage and damaged plants shall not be used in the permanent work unless permitted by the Engineer. If the Engineer permits damaged plants to be used, damaged material shall be pruned and wounds shall be dressed as stated in Clause 3.82.

Storage of trees and shrubs 3.41 Trees and shrubs which are not immediately planted in their permanent positions shall be supported upright on level ground, regularly watered and maintained in good condition.

Handling and storage of turf and sprigs 3.42 Turf and sprigs shall not be lifted when waterlogged or very dry and shall be packed to avoid drying out. Turf and sprigs shall be stored by spreading out and shall not be stacked. Turf and sprigs shall be kept moist and in good condition and shall be delivered and laid within 72 hours after lifting.

Storage of grass seed 3.43 Grass seed shall be stored in bags off the ground in a clean, dry, well ventilated location free from vermin. Prolonged storage shall be carried out under controlled conditions of temperature and humidity.

Storage of fertilizer 3.44 Fertilizer shall be stored off the ground in sealed waterproof bags and shall be protected from exposure to conditions which may adversely affect the fertilizer.

PRE-PLANTING WORKS

Preparatory works 3.45 Before soiling or planting for landscape softworks and establishment works starts, preparatory works shall be carried out by one or more of the treatments stated in Clauses 3.46 to 3.53, as appropriate or as stated elsewhere in the Contract.

Cleaning ground 3.46 Weeds, rubbish, litter, stones exceeding 50 mm diameter and all deleterious material shall be removed from the surface of the ground. Vegetation shall be cleared without using herbicide unless permitted by the Engineer. If permitted, the herbicide shall be a proprietary type approved by the Engineer and shall be applied in accordance with the manufacturer's recommendations.

Ripping 3.47 The ground shall be ripped by drawing a tine through the soil to a depth of 300 mm at 500 mm centres. All obstructions to cultivation or deleterious material brought to the surface shall be removed and voids left by the ripping operation shall be filled with soil of the same type as existing. Ground at a slope exceeding 15° to the horizontal shall not be ripped.

Contaminated ground 3.48 Ground which is contaminated by oil, chemicals or other substances which in the opinion of the Engineer may affect plant growth adversely shall be excavated to 300 mm below the contaminated depth and beyond the extent of the contamination. Voids left by excavation shall be filled with uncontaminated soil of the same type as existing.

Soiling 3.49 Soil-mix shall be spread and levelled to the depth stated in the Contract. The depth of uncompacted soil-mix shall be sufficient to allow the level of the area to comply with finished levels after natural settlement has taken place. The finished level of soil-mix over areas to be grassed shall be 25 mm above adjacent kerbs, paving, covers, frames and other hardware.

Cultivation 3.50 (1) Cultivation of areas stated in the Contract or instructed by the Engineer shall be carried out to a minimum depth of 150 mm or as stated in the Contract. Pre-planting fertilizer and soil conditioner shall be spread to a thickness of 50 mm over the surface before cultivation.

(2) Stones exceeding 50 mm diameter shall be removed from the surface of the soil after cultivation.

Scarifying 3.51 Scarifying shall be carried out by loosening the soil to a depth of between 10 mm and 20 mm using a pronged implement such as a rake but without turning the soil.

Protection of prepared ground 3.52 (1) Prepared ground shall be protected from compaction, erosion and siltation and shall not be used by Constructional Plant, other vehicles or pedestrian traffic.

(2) Prepared ground which becomes compacted, eroded, silted up or damaged shall be replaced or dealt with by methods agreed by the Engineer.

Removal of material 3.53 Weeds, rubbish, litter, stones exceeding 50 mm diameter and deleterious material removed during ground preparation shall be disposed of by the Contractor by methods agreed by the Engineer.

PLANTING

General 3.54 (1) Planting for landscape softworks and establishment works shall be carried out as stated in Clauses 3.54(2) and 3.55 to 3.64.

(2) Unless otherwise permitted by the Engineer, planting shall be carried out between 1st March and 30th September except as stated in Clause 3.06.

Use of excavated material 3.55 Material excavated from planting pits which complies with the specified requirements for decomposed granite may be used for soil-mix. Material excavated from planting pits which does not comply with the specified requirements for decomposed granite shall be disposed of by the Contractor and shall be replaced by material which complies with the specified requirements for decomposed granite.

Planting 3.56 (1) Plants shall be well watered several hours before planting; the soil in the container or rootball shall be moist and cohesive. Containers or rootball wrapping shall not be removed until the time of planting and the rootball shall not be disturbed by loosening or breaking.

(2) Each plant shall be placed upright in the pit and set at the same level as planted in the nursery or container.

(3) Soil-mix shall be deposited and compacted in layers around the rootball until level with the surrounding ground in such a manner that the rootball is not disturbed. Plants shall be well watered to soak the rootball and soil-mix immediately after planting.

Staking, tying and guying 3.57 (1) Stakes shall be driven into the ground after the pit has been excavated and before planting in such a manner that the rootball and aerial parts of the plant are not damaged. The stake shall be secure after driving and shall not be higher than 30% of the overall height of the plant.

(2) Guys and sleeves shall be fixed in such a manner that chafing, rubbing and abrasion of the plant is prevented and shall be secured to a well driven steel stake or other anchor. Each plant shall be fitted with three guys secured at a point not higher than 60% of the overall height of the plant. Turnbuckles shall be adjusted as necessary after planting.

(3) Bamboo stakes shall be used in locations stated in the Contract and where in the opinion of the Engineer it is impracticable to use steel stakes or guys. Bamboo stakes shall be securely tied with "scaffold tie" to form a tripod not exceeding 60% of the overall height of the plant. The plant shall be secured to the tripod as stated in Clause 3.57(1) and (2).

Mulching 3.58 After planting and watering, mulch shall be spread to a consolidated thickness of at least 50 mm on areas of bare ground as stated in the Contract.

Notch planting of seedlings 3.59 Notch planting of seedlings shall be carried out by forming a notch making two cuts at approximately 90° using a hand held pick or spade with the apex pointing up any slope; the notch shall be sufficiently deep to accommodate the root system of the seedling. The notch shall be opened on the second cut to receive the plant and shall then be pushed firmly back into place.

Pit planting of seedlings, shrubs, whips and herbaceous plants 3.60 (1) The size of pits for seedlings, shrubs, whips and herbaceous plants shall be 100 mm greater than the rootball or container diameter and 50 mm deeper than the rootball or container. 50 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Whips which in the opinion of the Engineer require to be staked shall be secured using one 2 m long stake and one tie.

Pit planting of light standard and standard trees 3.61 (1) The size of pits for light standard trees and standard trees shall be 200 mm greater than the rootball or container diameter and 100 mm deeper than the rootball or container. The bottom of the pit shall be broken up to a depth of 150 mm. 150 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Each tree shall be secured using two 2.5 m long steel stakes and two ties.

Pit planting of heavy standard trees 3.62 (1) The size of pits for heavy standard trees shall be 300 mm greater than the rootball or container diameter and 150 mm deeper than the rootball or container. The bottom of the pit shall be broken up to a depth of 150 mm. 250 g of pre-planting fertilizer shall be mixed into the soil-mix.

(2) Each tree shall be secured using two 3 m long steel stakes and two ties. Trees exceeding 4 m overall height shall be guyed.

Pit planting of bamboos and palms 3.63 Bamboos and palms shall be planted in accordance with the following:

(a) height not exceeding 2000 mm	: Clause 3.60
(b) height exceeding 2000 mm and not exceeding 2500 mm	: Clause 3.61
(c) height exceeding 2500 mm	: Clause 3.62

Pit planting on slopes 3.64 Pits excavated for planting on or adjacent to slopes shall not be left open during wet weather.

GRASSING

Hydroseeding 3.65 (1) Hydroseeding for landscape softworks and establishment works shall be carried out as stated in Clauses 3.65(2) and 3.66 to 3.71.

(2) Unless otherwise permitted by the Engineer, hydroseeding shall be carried out between 1st March and 30th September except as stated in Clause 3.06. If hydroseeding is permitted at other times, particulars of changes to the materials and methods for hydroseeding shall be submitted to the Engineer for approval.

Hydroseeding cover 3.66 Hydroseeding shall achieve a cover by grass species of at least 90% of the surface area of each 10 m^2 of the area to be hydroseeded within 100 days after the area has been hydroseeded. The grass cover shall be healthy, vigorous and free from perennial and other weeds. The method of determining the cover shall be as stated in Clauses 3.90 to 3.92.

Surface conditions for hydroseeding 3.67 The surface to be hydroseeded shall be finished to a coarse open textured surface and shall not be smooth or glazed. Finishing work on slopes by machines shall be carried out across the slope. Vehicle track marks and bucket teeth marks shall not be left parallel to the line of maximum gradient of the slope.

Application of hydroseeding 3.68 (1) Hydroseeding shall be carried out using a proprietary type of hydroseeding equipment unless otherwise approved by the Engineer.

(2) Materials for hydroseeding shall be well mixed on the Site in the hydroseeding equipment immediately before spraying, ensuring that seed is not damaged.

(3) Soil binders shall be applied at the rate recommended by the manufacturer, modified as necessary to suit conditions in Hong Kong. Dye shall be used to demonstrate that adequate cover has been achieved, unless in the opinion of the Engineer runoff or water courses will be coloured to an unacceptable level.

(4) The hydroseeding mixture shall be constantly agitated during spraying to keep it homogeneous and avoid blockage to pipes. Measures shall be taken during application to ensure that material is not lost due to runoff.

(5) Walking on areas that have been hydroseeded shall be restricted to access for fixing protective material and for patching up.

Protective material 3.69 Areas which have been hydroseeded shall be covered with protective material within 2 days after hydroseeding. The material shall be spiked or stapled to the soil surface with a minimum of 150 mm overlap.

Patching up 3.70 (1) Immediately after germination and a general greening of the hydroseeded area is apparent, areas where in the opinion of the Engineer germination has been unsuccessful shall be resprayed. Areas affected by repairs to washout and gullies and other erosion on slopes shall be resprayed.

(2) Areas which in the opinion of the Engineer are not accessible or are too small for the use of a hydroseeder may be patched up by broadcasting seed. The area shall be lightly scarified with a rake or similar implement and the seed and fertilizer shall be broadcast over the area at a rate of not less than 75 g/m2. The seed shall be covered by lightly working into the surface or by spreading sufficient soil to just cover the seed. Broadcast seeding shall be carried out using Bermuda grass (cynodon dactylon) perennial ryegrass (lolium perenne) or carpet grass (axonopus compressus).

Post-planting fertilizer 3.71 Post-planting fertilizer shall be applied between 2 months and 9 months after application of hydroseed and, unless otherwise permitted by the Engineer, shall be applied between 1st March and 30th September.

Turfing 3.72 (1) Turf shall not be laid on slopes exceeding 15° to the horizontal.

(2) The area to be turfed shall be cultivated by applying pre-planting fertilizer at a uniform rate of 40 g/m2 and shall then be raked and consolidated to the required level. The finished level after turfing shall be 25 mm above adjacent kerbs, paving, covers, frames and other hardware.

(3) The turves shall be laid on the prepared soil and shall be firmed into position using wooden beaters; the beaters shall be frequently scraped clean of accumulated soil or mud. A top dressing of soil-mix shall be applied and well worked into joints and spaces. Irregularities in finished levels due to variation in turf thickness or uneven consolidation of the soil shall be adjusted.

(4) Turfed areas shall be watered immediately after turf has been laid and as often as is necessary to ensure establishment. If shrinkage occurs and the joints open, soil-mix shall be worked in and well watered.

Sprigging 3.73 (1) Sprigging shall not be used on slopes exceeding 45° to the horizontal.

(2) The area to be sprigged shall be scarified before sprigging and sprigs shall be evenly spread over the area at approximately 50 mm centres. The area shall be topdressed with soil-mix to just cover the sprigs and pre-planting fertilizer shall be applied at a uniform rate of 40 g/m2.

Completion of turfing and sprigging 3.74 (1) Turfing and sprigging shall be considered to be complete when the first flush of growth achieves 90% cover. The method of determining the cover shall be as stated in Clauses 3.90 to 3.92.

(2) Bare patches or areas which in the opinion of the Engineer fail to become established shall be returfed or resprigged to maintain 90% cover throughout the establishment period. Areas affected by repairs to washouts and gullies and other erosion shall be returfed or resprigged.

ESTABLISHMENT WORKS

Establishment works 3.75 (1) Establishment works shall be carried out for the period stated in the Contract.

(2) Establishment works shall be carried out as stated in Clauses 3.75(3) and 3.76 to 3.89.

(3) All necessary measures shall be taken to ensure that grass, trees and other plants become established and to keep the landscape softworks neat and tidy and free from litter and rubbish.

Inspection of establishment works 3.76 An inspection of landscape softworks and establishment works shall be carried out jointly by the Contractor and the Engineer at monthly intervals to determine the establishment works which are required. The Engineer shall instruct the Contractor to carry out establishment works which in the opinion of the Engineer are necessary; the work instructed shall be completed within 14 days after the date of the Engineer's instruction.

Replacement of plants and grass 3.77 (1) Plants which in the opinion of the Engineer are dead, dying or otherwise unsatisfactory shall be replaced. Replacement planting shall be carried out in season as stated in Clause 3.54(2) using plant material of a similar size to that already established. Measures shall be taken to ensure satisfactory establishment of the replacement plants before the end of the period for establishment works.

(2) 90% cover of the grass area shall be maintained throughout the period for establishment works and the grass shall provide effective cover of 90% of the area at the end of the period for establishment works. The grass shall be healthy, vigorous and free from perennial and other weeds. Areas which in the opinion of the Engineer are unsatisfactory shall be reseeded by hydroseeding or broadcast seeding as stated in Clause 3.70(2) or returfed as stated in Clause 3.72 or sprigged as stated in Clause 3.73. Measures shall be taken to ensure satisfactory establishment of the replacement grass or turf before the end of the period for establishment works.

Security of stakes and ties 3.78 The Contractor shall be responsible for the security of stakes and ties throughout the establishment period. An inspection of stakes and ties shall be carried out each month by the Contractor; broken, damaged and other unsatisfactory stakes and ties shall be replaced and ties which are causing chafing or abrasion of the plant shall be adjusted.

Firming up plants 3.79 Plants which become loose as a result of wind rock or other causes shall be firmed up.

Watering 3.80 (1) Fresh water shall be used for watering landscape softworks. Water shall be applied using a rose or sprinkler of a type agreed by the Engineer and in such a manner that compaction, washout of soil or loosening of plants will not be caused; any damage caused shall be made good immediately.

(2) All planted areas shall be watered to ensure successful establishment of the plants. Plants reaching permanent wilting point shall be watered immediately.

(3) Grass shall not be watered in the period for establishment works unless stated in the Contract.

Weeding 3.81 (1) All grassed and planted areas shall be kept free from weeds throughout the period for establishment works.

(2) Weeding shall be carried out by hand or by mechanical methods agreed by the Engineer in such a manner that damage to the grass and planted areas will not be caused. All weeds, litter and other rubbish resulting from the weeding operation shall be disposed of by the Contractor.

(3) Planted areas in bare ground shall be weeded to remove all unwanted vegetative growth including aerial parts and roots, over the complete area. Planted areas other than in bare ground shall be weeded to remove all competing and overhanging vegetative growth by cutting the growth down to not more than 50 mm above soil level.

Pruning 3.82 Pruning and removal of branches shall be carried out using sharp, clean implements. Pruning shall be carried out with the cut just above and sloping away from an outward facing healthy bud. Removal of branches shall be carried out by cutting outside of a line drawn between the branch bark ridge and the branch collar in such a way that no part of the stem is damaged or torn, and leaving no snags or stumps.

Grass cutting 3.83 (1) Grassed areas shall be cut by manual or mechanical methods agreed by the Engineer and in a manner that does not cause pulling of roots or damage to planting in or near the grassed area. All cuttings shall be raked off and disposed of within 24 hours after cutting.

(2) Category 1 grass shall be as stated in the Contract and shall be reduced by cutting to a height of 50 mm when it reaches 100 mm high.

(3) Category 2 grass shall be as stated in the Contract and shall be reduced by cutting to a height of 100 mm when it reaches 300 mm high.

(4) Category 3 grass cutting shall be cutting of areas of hydroseeding which are stated in the Contract to be subsequently maintained as mown grass.

Litter collection 3.84 All litter exposed by grass cutting shall be gathered up and disposed of within 24 hours.

Post-planting fertilizer 3.85 Post-planting fertilizer shall be applied not less than 100 days, and not more than 300 days, after grassing or planting. The fertilizer shall be applied at a rate of:

(a) 100 g/m^2 for amenity grass and shrub planting,

(b) 100 g for each light standard, standard and heavy standard tree,

(c) 50 g for each seedling and whip tree, and

(d) 40 g/m^2 for grass on slopes and grass grown by hydroseeding.

Control of pests and disease 3.86 Pesticide or fungicide shall be applied in accordance with the manufacturer's recommendations to control pests and disease.

Forking over 3.87 Surfaces of bare ground which in the opinion of the Engineer are subject to surface panning or compaction of the soil shall be forked over in such a manner that roots are not disturbed and plants are not loosened; plants which are disturbed or loosened shall be firmed up and well watered immediately.

Mulching 3.88 All mulch which is disturbed by replacement planting, weeding or watering shall be made good. Additional mulching over areas of forking-over and over areas disturbed by others shall be carried out if instructed by the Engineer.

Completion of work 3.89 Immediately before the end of the period for establishment works:

(a) all tree and shrub planting shall be free from weeds,

(b) all planted and grassed areas shall be free from litter,

(c) all replacement planting and patching up of grass shall be completed,

(d) all stakes and ties shall be secure, and

(e) all grassed areas shall be cut and the edges trimmed.

TESTING: GRASS COVER

Testing: grass cover 3.90 (1) Tests shall be carried out to determine the grass cover. The tests shall be carried out 100 days after grassing and at the end of the period for establishment works. The grass shall be cut to a height of 300 mm if necessary over the parts of the area to be tested.

(2) The number of tests shall be as instructed by the Engineer.

(3) Testing to determine the grass cover will be carried out by the Engineer.

(4) Tests shall be carried out at locations which in the opinion of the Engineer are representative of the grassed area as a whole. At each test location an approximately square area of 10 m^2 shall be marked.

(5) The percentage of bare ground other than rock and other hard material in each 10 m^2 test area shall be measured.

Compliance criteria: grass cover 3.91 At least 90% of each test area shall be covered with grass.

Non-compliance: grass cover 3.92 If the result of any test for grass cover of landscape softworks and establishment works does not comply with the specified requirements for grass cover the area shall be rehydroseeded or reseeded in accordance with Clause 3.70(1) or (2) as instructed by the Engineer, depending upon the size of the defective area.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 4

FENCING

SECTION 4

FENCING

GENERAL

General requirements	4.01	The works and materials specified in Clauses 4.02 to 4.09 shall comply with the sections stated, unless otherwise stated in this Section.
Handrailing	4.02	Handrailing shall comply with Section 19.
Earthworks	4.03	Earthworks shall comply with Section 6.
Pedestrian guardrailing	4.04	Pedestrian guardrailing shall comply with Section 11.
Formwork and finishes to concrete	4.05	Formwork and finishes to concrete shall comply with Section 14.
Reinforcement	4.06	Reinforcement shall comply with Section 15.
Concrete	4.07	Concrete shall comply with Section 16.
Steelwork	4.08	Steelwork, including protective treatment, shall comply with Section 18.
Vehicular parapets	4.09	Vehicular parapets shall comply with Section 20.

MATERIALS

Wire 4.10

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

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

(3) Galvanized coatings to steel wire shall comply with BS 443.

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

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

Plywood 4.12 Plywood for hoardings shall comply with BS 6566 and shall have a Grade 2 veneer. The bonding adhesive between veneers shall be phenol formaldehyde resin adhesive classified as weather-proof and boil-proof in accordance with BS 1203.

Timber 4.13 (1) Timber for fencing 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 20%.

(2) Hardwood shall be `San Cheung' (Kapore) and shall have a density of at least 720 kg/m^3 at 15% moisture content.

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

(4) Timber which is not to be painted shall be preserved with coal tar creosote. The creosote shall comply with BS 144 and shall be applied by pressure impregnation in accordance with BS 144.

Steel 4.14 Steel for fencing shall comply with the following:

Hot rolled sections	: BS 4: Part 1
Hot rolled structural steel sections	
- equal and unequal angles	: BS 4848: Part 4
- hollow sections	: BS 4848: Part 2
Weldable structural steels	: BS 4360.

Bolts, nuts, washers and fittings 4.15 (1) Bolts, nuts and washers for fencing shall comply with the following:

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

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

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

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

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

FABRICATION OF FENCING

Fabrication of steelwork 4.16 Steelwork for fencing shall be fabricated in accordance with BS 5950: Part 2.

Galvanizing to steel 4.17 (1) Steel which is to be galvanized shall be hot-dip galvanized in accordance with BS 729 to a coating thickness of at least 500 g/m^2.

(2) Galvanizing to steel shall be applied as far as possible after welding, drilling and cutting are complete.

Welding steel 4.18 (1) Welds to steel for fencing shall be full depth fillet welds. Weld surfaces shall be clean and flush before application of the protective coating.

(2) Steel shall not be welded after galvanizing unless permitted by the Engineer; if permitted, the welded areas shall be free from scale and slag and shall be treated with an alternative galvanizing or zinc coating system approved by the Engineer.

POSTS AND GATES FOR FENCING

Concrete posts 4.19 (1) Concrete posts and struts for fencing shall be precast using Grade 30/10 concrete. The finish to formed surfaces shall be Class F4 and the finish to unformed surfaces shall be Class U5. The tops of posts and all arrises shall be rounded or chamfered.

(2) Reinforcement for concrete posts and struts shall be Grade 250 plain round steel bars.

Gates 4.20 (1) Steel gates shall be of welded construction. The frame shall be square with the corners mitred or saddled.

(2) Chain link infilling in gates shall be of the same type and size as in the adjoining fence and shall be attached to the framework by stretcher bars.

SUBMISSIONS

Particulars of fencing 4.21 (1) The following particulars of the proposed fencing shall be submitted to the Engineer:

(a) drawings showing the fabrication details of gates, and

(b) details of the source, type and properties of timber.

(2) The particulars of the proposed fencing shall be submitted to the Engineer at least 14 days before the fencing is erected.

Samples of materials 4.22 The following samples of the proposed materials shall be submitted to the Engineer at the same time as particulars of the proposed fencing are submitted:

(a) each type of wire and fitting,

(b) chain link,

(c) plywood, and

(d) precast concrete, steel and timber posts.

STORAGE OF MATERIALS

Storage of fencing 4.23 (1) Plywood and timber posts, rails and struts for fencing shall be stored on level supports in a dry weatherproof store.

(2) Gates and concrete and steel posts and struts for fencing shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the materials or in contamination of the materials.

(3) Fencing shall be protected from damage and damaged fencing shall not be used in the permanent work unless permitted by the Engineer.

ERECTING FENCING

Alignment of fencing 4.24 Fencing shall be erected to a smooth alignment with no abrupt irregularities. The ground shall be trimmed or filled in such a manner that the bottom of the fence will approximately follow the level of the ground. The distance between the bottom of chain link mesh and hoardings and the ground shall not exceed 100 mm.

Posts for fencing 4.25 (1) Straining posts for fencing shall be provided at all ends and corners, at changes in direction, at abrupt changes in level, at gate posts and at intervals not exceeding 30 m along straight lengths of fencing. Struts shall be fitted to straining posts in the direction of each wire secured to the post.

(2) Intermediate posts shall be provided at intervals not exceeding 3.5 m.

Erecting posts for fencing 4.26 (1) Posts and struts for fencing shall be set in excavations for foundations and the excavations shall be filled with Grade 30/20 concrete up to 50 mm below ground level.

(2) Struts shall be fitted into slots in timber posts and concrete posts; struts shall be bolted to steel posts.

(3) The ground surface around posts shall be made good with the same material as in the adjoining area.

Fixing wire for fencing 4.27 (1) Line wire, chain link mesh and barbed wire for fencing shall be strained tightly between straining posts. Winding brackets shall be used for straining between steel posts and winding brackets or eye bolt strainers shall be used for straining between concrete and timber posts. The tension in the wire on each side of straining posts shall be equal. Wire shall not be strained until at least 14 days after concrete has been placed in the foundation.

(2) Chain link mesh shall be secured at each straining post by a stretcher bar and shall be tied to the line wire by tying wire at 150 mm intervals.

(3) Each line wire and each line of barbed wire shall be secured to each intermediate post by one of the following methods as stated in Table 4.1.

(a) A hairpin staple shall be passed through a hole in the post and secured to the wire by three complete turns on each side of the post.

(b) A stirrup shall be passed through a hole in the post and the ends bent over twice.

(c) The wire shall be threaded through a hole in the post.

(d) The wire shall be stapled to the post.

(e) A hook bolt shall be passed through a hole in the post and secured with a nut and washer.

Table 4.1: Method of securing wire to intermediate posts

Type of fence	Type of wire	Type of post	Method of securing wire
Strained wire	Line wire	Concrete	(a), (b) or (c)
		Steel	(a), (b) or (c)
		Timber	(a), (c) or (d)
	Barbed wire	Concrete	(a) or (b)
		Steel	(a)
		Timber	(a) or (d)
Chain link	Line wire Mesh wire	Concrete	(a), (b) or (e)
		Steel	(a) or (c)
		Timber	(d)
	Barbed wire	Concrete	(a), (b) or (e)
		Steel	(a)
		Timber	(d)

Fixing gates 4.28 Gates shall be hung plumb and shall not be installed until the wire has been strained.

Fixing timber for fencing 4.29 The ends of timber rails for fencing shall be closely butted together and the rails shall be securely nailed to each post. The ends of plywood sheets in hoardings shall be closely butted together and the sheets shall be securely nailed to each post and to the horizontal rails.

TOLERANCES

Tolerances: fencing 4.30 Fencing shall comply with the following requirements:

(a) The position of posts shall be within 75 mm of the specified position.

(b) The level of the top of posts shall be within 25 mm of the specified level.

(c) Posts shall be vertical to within 5 mm in the height of the post.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 5

DRAINAGE WORKS

SECTION 5

DRAINAGE WORKS

GENERAL

General requirements	5.01	The works and materials specified in Clauses 5.02 to 5.08 shall comply with the sections stated, unless otherwise stated in this Section.
Metalwork	5.02	Metalwork for handrailing, ladders, stairs, metal flooring, toe plates and safety chains shall comply with Section 19.
Earthworks	5.03	Earthworks shall comply with Section 6.
Formwork	5.04	Formwork and finishes to concrete shall comply with Section 14.
Concrete	5.05	Concrete shall comply with Section 16.
Materials for grout	5.06	Materials for grout shall comply with Section 16.
Water supply pipeworks	5.07	Water supply pipeworks shall comply with Section 23.
Cable duct systems	5.08	Cable duct systems for electrical and mechanical installations shall comply with Section 13.

GLOSSARY OF TERMS

Pipes	5.09	Pipes for drainage works are pipes for conveying sewage and surface water.

MATERIALS

Precast concrete pipes and fittings	5.10	(1) Precast concrete pipes and fittings shall comply with BS 5911: Part 100. (2) Precast concrete pipes and fittings shall have flexible spigot and socket joints.
Vitrified clay pipes and fittings	5.11	(1) Vitrified clay pipes and fittings shall comply with BS 65; the pipes and fittings shall be glazed and shall be the normal chemical resistant type. (2) Vitrified clay pipes and fittings shall have flexible mechanical joints.
DI pipes and fittings	5.12	(1) DI pipes and fittings shall comply with BS 4772. Pipes and fittings shall be lined internally with cement mortar and shall be coated externally with bituminous coating.

(2) Flexible joints in DI pipes and fittings shall be the push-in type and shall be capable of withstanding a minimum angular deflection of 4°. Flexible joints shall also be capable of withstanding axial movements and shall allow a minimum withdrawal of 38 mm when there is no deflection of the joint.

(3) Flanged joints in DI pipes and fittings shall be PN 16 rating complying with BS 4504: Section 3.1.

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

Grey iron pipes and fittings 5.13 Grey iron pipes and fittings shall comply with BS 4622.

UPVC pipes and fittings 5.14 (1) UPVC pipes and fittings shall comply with the relevant British Standard stated in Table 5.1.

(2) UPVC pipes and fittings above ground shall have solvent welded spigot and socket joints. UPVC pipes and fittings below ground shall have either solvent welded spigot and socket joints or flexible spigot and socket joints with elastomeric joint rings as stated in the Contract.

(3) Joints and fittings for UPVC pressure pipes complying with BS 3506 shall comply with the following:

Injection moulded UPVC fittings for solvent welding for use with pressure pipes, including water supply	: BS 4346: Part 1
Mechanical joints and fittings principally of UPVC	: BS 4346: Part 2

(4) Solvent cement for UPVC pressure pipes shall comply with BS 4346: Part 3.

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

GI pipes and fittings 5.15 (1) GI pipes and fittings shall comply with the following:

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

(2) GI pipes and fittings shall be medium class thickness and shall be galvanized in accordance with BS 729.

Table 5.1: UPVC pipes and fittings

Use	Nominal diameter (mm)	British Standard
Gravity sewage pipes and fittings above ground	32 - 50	BS 5255
	82 - 160	BS 4514
Gravity surface water pipes and fittings above ground	63 - 75	BS 4576: Part 1
	82 - 160	BS 4514
Gravity sewage and storm water pipes and fittings below ground	110 - 160	BS 4660
	200 - 630	BS 5481
Pressure pipes and fittings above and below ground	10 - 600	BS 3506

Bolts, nuts and washers

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

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

Metal washers for general engineering purposes : BS 4320.

The bolts, nuts and washers shall be hot-dip galvanised in accordance with BS 729 or treated with other suitable coating approved by the Engineer.

(2) Stainless steel bolts and nuts shall comply with BS 6105, steel Grade A4 and property Class 80. Washers shall be Grade 316 S 31 in the softened condition complying with BS 1449: Part 2.

(3) Spheroidal graphite iron bolts shall be Grade 500/7 metal complying with BS 2789.

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

(5) Bolts and nuts shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

Elastomeric joint rings 5.17 (1) Elastomeric joint rings shall comply with BS 2494, Type D. The rings shall be compatible with the type of joint and, unless otherwise approved by the Engineer, shall be obtained from the same manufacturer as the joint.

(2) Elastomeric joint rings for flanged pipes shall be the inside diameter bolt circle type. The rings shall be natural rubber with a thickness of 3.2 mm and with other dimensions complying with BS 4865: Part 1.

Detachable couplings and flange adapters 5.18 (1) Detachable couplings and flange adapters shall be a proprietary type approved by the Engineer.

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

Table 5.2: Angular deflection and straight draw

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

Anticorrosion tape 5.19 (1) Anticorrosion tape shall be a proprietary type approved by the Engineer. The tape shall be a rubber/bitumen compound with fabric reinforcement and shall be backed with PVC film. The tape shall have a high resistance to cathodic disbonding, acids and alkalis and shall have the minimum properties stated in Table 5.3.

(2) Anticorrosion tape shall be applied to valves, flanged joints, slip-on couplings and flange adapters. Type 1 shall be used for pipes smaller than 700 mm diameter and Type 2 shall be used for pipes 700 mm diameter and above.

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

Table 5.3: Properties of anticorrosion tape
(except where stated the values shown are minimum values)

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

Bituminous coatings 5.20 (1) Bituminous coatings shall comply with the following:

Bitumen based hot applied coating material for protecting iron and steel including suitable primers where required	:	BS 4147, Type I, Grade C
Black bitumen coating solutions for cold application	:	BS 3416, Type II.

(2) Bituminous coatings used for repairing joints and coatings shall be compatible with the adjacent coating.

Aggregates for granular bed and granular fill

5.21 (1) Granular bed shall be Type A material and granular fill shall be Type B material.

(2) Type A or Type B material shall consist of hard, clean, crushed slag, gravel, crushed rock, crushed concrete or crushed inert demolition material having a grading within the limits of Table 5.4. The ten percent fines values shall be at least 50 kN. The material passing the 425 μm BS test sieve shall be non-plastic when tested in accordance with BS 1377.

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

(4) Aggregates for granular bed shall have the compacting fraction values stated in Clause 5.87.

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

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

Table 5.5: Joint filler for concrete bed, haunch and surround

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

Joint filler and compressible padding 5.22 (1) Joint filler for joints in concrete bed, haunch and surround shall be a firm, compressible, single thickness, non-rotting filler. The thickness of the filler shall be as stated in Table 5.5.

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

Polyethylene sheeting 5.23 Polyethylene sheeting shall be impermeable and shall have a nominal thickness of 0.125 mm.

Precast concrete manholes 5.24 Precast concrete manhole units shall comply with BS 5911: Part 200. Cover slabs and reducing slabs shall be reinforced as required to comply with the load test requirements stated in BS 5911: Part 200.

Chambers and gullies 5.25 (1) Precast concrete chambers and gullies shall comply with BS 5911: Part 2. Cover slabs shall be reinforced as required to comply with the load test requirements stated in BS 5911: Part 2. The types of cement for the manufacture of precast concrete chambers and gullies, and cover slabs shall be as stated in BS 5911: Part 2, or a combination of PFA and OPC complying with BS 12, or PPFAC. The PFA content shall not exceed 40% by mass of the cementitious content.

(2) Vitrified clay gullies shall comply with BS 65.

Step irons 5.26 Step irons shall comply with BS 1247. Step irons shall be malleable cast iron complying with BS 6681 and shall be hot-dip galvanised in accordance with BS 729.

Manhole covers, gully gratings and kerb overflow weirs 5.27 (1) Manhole covers, gully gratings and kerb overflow weirs shall be Grade 150 cast iron complying with BS 1452; bolts and nuts shall comply with BS 4190.

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

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

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

Table 5.6: Details of manhole covers and frames

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

Table 5.7: Details of gully gratings and frames

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

Table 5.8: Details of kerb overflow weirs

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

Penstocks 5.28 (1) Penstocks shall comply with the following requirements:

(a) Frames and gates shall be cast iron complying with BS 1452, Grade 220.

(b) Stems shall be stainless steel complying with BS 970: Part 1, Grade 316 S 31.

(c) Operating nuts shall be gunmetal complying with BS 1400, Grade LG2.

(d) Sealing faces shall be phosphor bronze complying with BS 2874, Grade PB 102.

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

(f) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.16(2).

(g) Adjustable wedges shall be phosphor bronze complying with BS 2874, Grade PB 102 or stainless steel complying with BS 970: Part 1, Grade 316 S 31.

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

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

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

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

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

Gate valves 5.29 (1) Gate valves shall comply with BS 5150 and with the following requirements:

(a) Bodies and wedges shall be cast iron complying with BS 1452, Grade 220 and shall have renewable gunmetal seat rings.

(b) Gunmetal for renewable seat rings shall be Grade LG2 complying with BS 1400.

(c) Stem nuts shall be gunmetal complying with BS 1400, Grade LG2.

(d) Stems shall be aluminium bronze complying with BS 2874, Grade CA 104.

(e) Assembly and fixing nuts and bolts shall be stainless steel complying with Clause 5.16(2).

(2) Gate valves shall be double flange-ended solid wedge type with nominal pressure designation PN 16. Flanges shall be PN 16 complying with BS 4504: Part 1.

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

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

(5) Chains for chain operated gate valves shall be mild steel complying with BS 970: Part 1 and hot-dip galvanized in accordance with BS 729; the chains shall be continuous.

Flap valves 5.30 (1) Flap valves shall comply with the following requirements:

(a) Frames and flaps shall be cast iron complying with BS 1452, Grade 220.

(b) Sealing faces and hinge pins shall be gunmetal complying with BS 1400, Grade LG2.

(2) The flap shall be hung with double hinges and secured with hinge pins.

(3) Flanges for flange mounting types of flap valves shall be PN 16 complying with BS 4504: Part 1.

Sludge valves 5.31 (1) Sludge valves shall comply with the following requirements:

(a) Bodies and valve sections shall be cast iron complying with BS 1452, Grade 220.

(b) Sealing faces and stem nuts shall be gunmetal complying with BS 1400, Grade LG2.

(c) Stems shall be aluminium bronze complying with BS 2874, Grade CA 104.

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

(3) Outlet flanges of sludge valves shall be PN 16 complying with BS 4504: Section 3.1.

Air valves 5.32 (1) Air valves shall be of the elongated body type and shall have a pressure rating of 3 bars unless otherwise stated in the Contract.

(2) Dual orifice air valves shall have:

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

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

(3) The bodies and covers of small and large orifice valves shall be cast iron complying with BS 1452, Grade 220; the trim and float shall be stainless steel complying with BS 970: Part 1, Grade 316 S 31.

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

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

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

Fittings for penstocks and valves 5.33 (1) Handwheels and tee keys for penstocks and valves shall turn in a clockwise direction for closing. Handwheels shall have smooth rims and the direction of opening and closing shall be clearly cast on the handwheel. The opening effort required at any point on the handwheel rim shall not exceed 250 N when operated against the full unbalanced pressure.

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

(3) Handwheels, tee keys, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings for penstocks and valves shall be cast iron complying with BS 1452.

(4) Bolts and nuts for fixing penstocks and valves to structures shall be stainless steel complying with Clause 5.16(2). Bolts shall be indented foundation bolts.

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

Filling abandoned pipes and manholes

5.34 (1) Foam concrete for filling abandoned pipes, culverts, manholes and voids shall be composed of OPC (or PPFAC), fine aggregate, water, admixtures for accelerating or retarding the setting time and foam to reduce the density and to produce a flowing self levelling material.

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

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

SUBMISSIONS

Particulars of pipes, joints and fittings

5.35 (1) The following particulars of the proposed pipes, joints and fittings for drainage works shall be submitted to the Engineer:

(a) manufacturers' 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, and

(b) a certificate for each material showing the manufacturer's name, the date and place of manufacture and showing that the material complies with the requirements stated in the Contract and including results of tests required in accordance with the 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 anticorrosion tape and joint filler

5.36 (1) The following particulars of the proposed anticorrosion tape and joint filler for drainage works shall be submitted to the Engineer:

(a) manufacturer's literature for anticorrosion tape, and

(b) certificates for anticorrosion tape and joint filler showing the manufacturers' 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.

(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 aggregates for granular bed

5.37 (1) A certificate for each type of aggregate showing the source of the aggregate and showing that the aggregate complies with the requirements stated in the Contract, and including the results of tests in accordance with the Contract, shall be submitted to the Engineer for the proposed aggregates for granular bed for drainage works.

(2) The particulars, including certificates, shall be submitted to the Engineer at least 14 days before the first delivery of the aggregate to the Site and thereafter each time the source is changed.

Particulars of manholes, chambers and gullies

5.38 (1) The following particulars of the proposed materials for manholes, chambers and gullies for drainage works shall be submitted to the Engineer:

(a) a certificate for each type of manhole and chamber unit and for each type of gully 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 required in accordance with the Contract,

(b) a certificate for step irons showing the manufacturer's name, the date and place of manufacture and showing that the step irons comply with the requirements stated in the Contract, and including results of tests required in accordance with the Contract, and

(c) a certificate for each type of manhole cover, gully grating and kerb overflow weir 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 in accordance with 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 penstocks and valves

5.39 (1) The following particulars of the proposed penstocks and valves for drainage works shall be submitted to the Engineer:

(a) manufacturer's literature, including details of:
- materials
- pressure ratings
- recommendations for handling, storage and installation,

(b) drawings showing details of the penstocks and valves, including lengths of stems and details of handwheels, tee keys, extension stems, headstocks, guide brackets for stems, supporting brackets, surface boxes and other fittings, and positions and sizes of rebates and box-outs.

(2) The particulars shall be submitted to the Engineer at least 28 days before the first delivery of the material to the Site.

Particulars of foam concrete and OPC/PFA grout

5.40 (1) The following particulars of the foam concrete and grouting procedure for filling abandoned pipes, culverts, manholes and voids shall be submitted to the Engineer:

(a) proportions of each constituent,

(b) source of supply,

(c) details of mixing,

(d) setting time,

(e) strength,

(f) shrinkage expected (for OPC/PFA grout),

(g) details of mixing and grouting equipment, and

(h) method of grouting, including details of trials.

(2) The particulars shall be submitted to the Engineer at least 7 days before grouting starts.

Particulars of tests

5.41 (1) The following particulars of the proposed procedures for tests on pipelines and penstocks for drainage works 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.

Particulars of CCTV inspections

5.42 (1) The following particulars of the proposed procedure for CCTV inspections shall be submitted to the Engineer:

(a) names and experience of persons carrying out or supervising the inspections,

(b) details of equipment,

(c) details of the format of report, and

(d) examples of video films and photographs obtained from inspections employing the same equipment.

(2) The particulars of the procedure shall be submitted to the Engineer at least 28 days before the inspection starts.

Particulars of diversions of flow

5.43 Unless otherwise permitted by the Engineer particulars of the proposed procedures for diversions of existing flows shall be submitted to the Engineer at least 14 days before the diversion starts.

TRANSPORT, HANDLING AND STORAGE OF MATERIALS

Transport, handling and storage of pipes, joints and fittings

5.44 (1) Pipes, joints and fittings for drainage works 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.

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

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

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

Handling of pipes and fittings

5.45 (1) Pipes and fittings shall be handled manually 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 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 5.46 (1) 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 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.

Storage of anticorrosion tape and joint filler 5.47 Anticorrosion tape and joint filler shall be stored in accordance with the manufacturer's recommendations in a dry, weatherproof store with a raised floor.

Handling and storage of aggregates for granular bed 5.48 Aggregates for granular bed shall not be handled or stored in a manner which will result in mixing of the different types and sizes or in contamination of the aggregates. Different types and sizes of aggregates shall be stored in separate stockpiles.

Handling and storage of units for manholes, chambers and gullies 5.49 (1) Units for manholes, chambers and gullies shall be lifted only at the lifting points recommended by the manufacturer and shall not be subjected to rough handling, shock loading or dropping.

(2) Units for manholes, chambers and gullies shall be stored off the ground on level supports and in a manner which will not result in damage to the units or in contamination or deformation 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.

Storage of covers, gratings, weirs penstocks and valves 5.50 Manhole covers, gully gratings, kerb overflow weirs, penstocks and valves, including fittings, shall be stored off the ground on level supports and in a manner which will not result in damage to the units or in contamination or deformation 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.

EXCAVATION

Excavation 5.51 (1) Excavation for any section of a trench for drainage works shall not commence until the nature, location and size of existing utilities which may be affected by the excavation have been ascertained and the setting out details have been approved by the Engineer.

(2) The effective trench width of trenches for drainage works shall not exceed the relevant effective trench widths stated in Table 5.9 for the different diameters of pipe. The effective trench width shall be measured as stated in the Contract.

Table 5.9: Effective trench widths

Nominal diameter of pipe (mm)	Effective trench width (mm)	Nominal diameter of pipe (mm)	Effective trench width (mm)
100	550	1125	2200
150	600	1200	2300
225	700	1350	2450
300	750	1500	2600
375	1050	1650	2800
450	1150	1800	2950
525	1200	1950	3150
600	1350	2100	3350
675	1450	2250	3400
750	1500	2400	3500
825	1600	2550	3650
900	1900	2700	3800
975	2000	2850	3950
1050	2050	3000	4150

LAYING AND BEDDING PIPES

Laying pipes 5.52 (1) The Contractor shall allow the Engineer to inspect trenches, bedding, pipes, joints, fittings and valves before pipelaying for drainage works 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.

(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, testing and backfilling shall follow as closely as practicable on excavation of the trench.

(7) Unless otherwise permitted by the Engineer, pipelines 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 or shallow gradients and such that the pipes will comply with the specified tolerances.

Bedding pipes 5.53 (1) Surfaces on which pipes for drainage works will be laid shall be cleaned and objects which 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 PIPES

Cutting pipes 5.54 (1) Pipes for drainage works shall be cut and the ends shall be prepared in accordance with the manufacturers' recommendations; purpose-made equipment recommended by the manufacturer or approved by the Engineer shall be used for cutting the pipes.

(2) Cut ends of pipes shall be square or cut to the correct angle and without damage to the pipe or coating. Cut ends 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) Reinforcement in precast concrete pipes which are cut shall be cut back flush with the concrete and protected with epoxy resin or by other methods agreed by the Engineer.

(5) Pipes which terminate at the inside face of structures shall be cut such that the end of the pipe is flush with the face.

JOINTING PIPES

Jointing pipes 5.55 (1) Pipes for drainage works shall be jointed in accordance with the manufacturers' recommendations and using jointing equipment and jointing materials recommended by the manufacturer or approved 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. Surfaces which are to be jointed and jointing materials shall be cleaned immediately before jointing. Pipes shall be cleaned out with clean water.

(3) All joints in pipelines shall be watertight.

(4) The widths of gaps at joints shall be in accordance with the manufacturers' 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.

Flanged joints 5.56 (1) Flanged joints in pipes for drainage works shall be made as stated in Clause 5.56(2) and (3).

(2) 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.

(3) 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 for this purpose.

Flexible collar joints 5.57 (1) Flexible collar joints in pipes for drainage works shall be made as stated in Clause 5.57(2) to (4).

(2) The elastomeric joint rings shall be placed in position inside the grooves of the sleeve. The ends of the pipes shall be well smeared with lubricant over a distance of at least 100 mm from the end of the pipe.

(3) The sleeve shall be placed on the end of the laid pipe and pushed home to the location mark on the pipe; the location mark shall be at a distance of half the length of the sleeve minus 3 mm from the end of the pipe unless otherwise recommended by the manufacturer.

(4) The pipe which is to be jointed to the laid pipe shall be placed in the sleeve and pushed home to the location mark on the pipe.

Push-in joints 5.58 Push-in joints in pipes for drainage works shall be made by smearing the elastomeric joint ring with lubricant and placing the ring in position on the spigot end of the pipe. The spigot shall be placed in the socket of the laid pipe and pushed home.

Detachable joints 5.59 (1) Detachable joints in pipes for drainage works shall be jointed as stated in Clause 5.59(2) and (3).

(2) Both CI flanges, the elastomeric joint rings and the central collar shall be placed over the ends of the pipes before the pipes are placed to the required line and level; a gap of between 5 mm and 6 mm shall be left between the ends of the pipes.

(3) The flanges, elastomeric joint rings and central collar shall be moved into position at the ends of the pipes; the central collar shall be positioned centrally over the gap between the ends of the pipe before the bolts are tightened.

Flange adapters 5.60 Joints with flange adapters in pipes for drainage works shall be made by placing the flange adaptor on the plain end before the bolts are tightened.

Solvent welded joints 5.61 Solvent welded joints in pipes for drainage works shall be made by applying solvent cement to the pipes to be jointed and pushing the pipes home. Excess solvent shall not be applied and surplus solvent shall be removed after jointing. Solvent welded pipes jointed outside the trench shall not be placed in the trench until the solvent setting period recommended by the manufacturer has elapsed. In addition, any material or thing contaminated by the solvent shall not be left in the pipe or trench.

Screw joints 5.62 Screw joints in pipes for drainage works shall be made using a threaded coupler. The threaded surfaces of the pipes and coupler shall be cleaned and the threads shall be painted with two coats of bituminous paint. The pipe thread shall be wrapped with three turns of spun yarn or other material approved by the Engineer and the joint tightened using purpose made tools. Coal tar compounds or white lead paint shall not be used. Locking nuts to branch connections shall be tightened. Branch connections shall not protrude inside the pipe.

PROTECTION OF JOINTS

Protection of joints 5.63

(1) Flanged joints, detachable couplings and flange adapters on buried pipes for drainage works shall be protected as stated in Clause 5.63(2) to (4).

(2) The joint, including bolts and nuts, shall be cleaned to remove all moisture, dust, oil, grease and deleterious material. Bolts and nuts shall be painted with two coats of bituminous point 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 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.

REPAIRS TO COATINGS AND LININGS

Repairs to coatings and linings 5.64

Damage to coatings and linings of pipes for drainage works shall not be repaired unless permitted by the Engineer. If permitted, repairs shall be carried out using materials recommended by the manufacturer and approved by the Engineer.

THRUST AND ANCHOR BLOCKS

Thrust and anchor blocks 5.65

(1) Thrust or anchor blocks shall be used to resist forces at bends, branches and stopends in pressure pipelines for drainage works except where self anchoring joints are used. Concrete for thrust and anchor blocks shall be Grade 20.

(2) The bearing face, and other faces stated in the Contract, of concrete anchor and thrust blocks shall be cast directly against undisturbed ground; the faces of excavations shall be trimmed to remove loose material before concreting. Excavation required for the block beyond the trench width shall be carried out after the pipe or fitting has been jointed. Excess excavation beyond the face at the block shall be filled with concrete of the same Grade as the block.

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

BED, HAUNCH AND SURROUND

Granular bed 5.66 (1) Granular bed to pipelines for drainage works shall be constructed as stated in Clause 5.66(2) to (4).

(2) Aggregates for granular bed shall be deposited in the trench in layers not exceeding 150 mm thick and for the complete width of the trench. Each layer shall be compacted using a plate vibrator or by other methods agreed by the Engineer.

(3) Holes shall be dug in the granular bed to prevent pipes resting on the sockets and to allow the pipes to be jointed. The pipes shall be laid directly on the granular bed; temporary supports shall not be used.

(4) After the pipes have been jointed, aggregate shall be deposited in layers not exceeding 150 mm thick equally on both sides of the pipe to the specified level for the complete width of the trench. Each layer shall be compacted using a plate vibrator or by other methods agreed by the Engineer.

Concrete bed, haunch and surround 5.67 (1) Concrete bed, haunch and surround to pipelines for drainage works shall be constructed as stated in Clause 5.67(2) to (7).

(2) Concrete for concrete bed, haunch and surround shall be Grade 20.

(3) Polyethylene sheeting or a blinding layer shall be placed on the trench bottom before concreting.

(4) 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.

(5) 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.

(6) 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.

(7) Pipes for drainage works which are 1 m or less below the surface of a carriageway shall be protected with Grade 20 concrete surround.

(8) The aggregate for Grade 20 concrete stated in Clause 5.67(1) to (7) shall be natural stone, crushed rock or crushed concrete. Such Grade 20 concrete shall have the following minimum cementitious content:

Exposure condition*	Minimum cementitious content (kg/m^3)
Moderate	280
Severe	330

[* Exposure condition shall be as stated in the Contract]

Fill material surround 5.68 Fill material surround to pipelines for drainage works shall be deposited and compacted as stated in Clauses 6.43 and 6.48.

TOLERANCES

Tolerances: pipelines for drainage works 5.69 (1) Except as stated in Clause 5.69(2), pipelines for drainage works shall comply with the following requirements:

(a) The line of gravity pipelines shall be within 20 mm of the specified line.

(b) The invert level of gravity pipelines shall be within 6 mm of the specified invert level and shall be such that there is no backfall at any point.

(c) The line of pressure pipelines shall be within 50 mm of the specified line.

(d) The invert level of pressure pipelines shall be within 20 mm of the specified invert level.

(2) Termination pipes in pipelines for drainage works which are designed to connect to pipes or fittings laid by others shall comply with the following requirements:

(a) The position of the centre of the termination face of the pipe in the longitudinal direction shall be within 10 mm of the specified position.

(b) The position of the centre of the termination face of the pipe in the lateral direction shall be within 3 mm of the specified position.

(c) The gradient of the termination pipe shall be within 0.5° of the specified gradient.

(d) The invert level at the termination face of the pipe shall be within 3 mm of the specified invert level.

CONNECTIONS

Connections to structures 5.70 (1) The joints between pipes for drainage works and structures into which the pipes are built shall be watertight; protective coatings shall be removed over the length to be built in before the pipe is built in. Pipe collars and sockets shall not be built in to structures.

(2) Two flexible joints shall be provided in pipelines adjacent to the outside faces of structures into which pipes will be built. The distances from the outside face of the structure to the first joint and from the first joint to the second joint shall be as stated in Table 5.10.

(3) The ends of pipes which are built in to structures shall be temporarily sealed with a blank flange, brickwork or timber boarding as instructed by the Engineer. The temporary seals shall be left in position until the Engineer instructs their removal.

Table 5.10: Flexible joints at structures

Diameter of pipe	Position of first flexible joint from structure		Distance of second flexible joint from first flexible joint
	Minimum	Maximum	
not exceeding 450 mm	150 mm	500 mm or diameter of pipe, whichever is less	450 mm - 800 mm
exceeding 450 mm but not exceeding 1050 mm			900 mm - 1200 mm
exceeding 1050 mm			1500 mm - 1800 mm

Connections to pipes 5.71 (1) Pipe saddles shall be connected to concrete or vitrified clay pipes by bedding the saddle on a cement mortar bed and forming a cement mortar fillet to provide at least 50 mm cover to the base of the saddle. Cement mortar shall consist of cement and sand in the proportions 1:3 by mass.

(2) UPVC pipe saddles shall be fixed to UPVC pipes using a purpose-made mechanical clip or solvent cement of a type recommended by the manufacturer and approved by the Engineer.

(3) Unless otherwise agreed by the Engineer, branch pipelines shall be connected to main pipelines using Y-junctions of the same type and strength as the stronger of the pipes being jointed; the angle of the Y-junction shall be between 30° and 45°.

(4) Pipes which are to be connected to concrete or clay pipes without a Y-junction or purpose made pipe saddle shall be cut on a splay to form a junction such that the incoming pipe is at an angle of between 30° and 60° to the main pipe upstream of the joint. The hole which is cut in the main pipe to which a connection is to be made shall be of a suitable elliptical shape to suit the cut end of the branch pipe. The length of the branch pipe shall be such that:

(a) the cut end of the pipe rests on the outside barrel of the main pipe, and

(b) the cut pipe does not project inside the main pipe.

The joint between the cut pipe and the main pipe shall be sealed externally and, unless otherwise permitted by the Engineer, sealed internally flush with the main pipe with cement mortar. Cement mortar shall consist of cement and sand in the proportions 1:3 by mass.

(5) The positions of the pipe junctions relative to the manhole or structure immediately downstream shall be measured and recorded before backfilling.

(6) The ends of connecting pipes which are not required for immediate use shall be sealed with a blank flange, brickwork or other methods instructed by the Engineer and the position measured and recorded before backfilling.

MANHOLES, CHAMBERS, GULLIES AND CHANNELS

Manholes, chambers and gullies 5.72

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

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

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

(4) The frames for manhole covers and gully gratings shall be set to the same levels as the surrounding surface, allowing for falls and cambers, using brickwork and/or concrete as specified in the Contract. The number of courses of brickwork used below frames shall not exceed three and the minimum grade for concrete shall be Grade 20.

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

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

Concrete open channels 5.73

The top surfaces of side walls of concrete open channels shall be constructed to the same levels as the adjoining permanent works. Excess excavation beyond the channel walls shall be filled with Grade 10 concrete.

MARKER BLOCKS

Marker blocks 5.74

(1) The ends of pipes which do not terminate at a manhole, chamber, gully or structure shall be marked with marker blocks. The blocks shall be 150 mm x 150 mm x 150 mm and shall be constructed using Grade 20 concrete.

(2) A wire shall be connected from a hook on the underside of the block to the plug on the end of pipes.

(3) Marker blocks shall be set flush with level of the adjacent permanent works and shall have the letters `CD' marked on the upper surface.

INSTALLATION OF PENSTOCKS AND VALVES

Installation of penstocks and valves 5.75

(1) Penstocks and valves shall be installed in accordance with the manufacturer's recommendations and in the closed position.

(2) Frames for penstocks shall be fixed in position leaving a 20 mm gap between the frame and the concrete surface. Contact between the penstock door and frame shall be checked using a feeler gauge 0.1 mm thick or other size recommended by the manufacturer.

(3) Box-outs and rebates for penstock and valve frames and gaps between frames and concrete surfaces shall be filled with cement mortar.

(4) After installation, penstocks and valves shall be cleaned and moving parts shall be lightly greased and checked for ease of operation. Penstocks and valves shall be left in a closed position.

PIPES AND MANHOLES TO BE ABANDONED

Pipes and manholes to be abandoned 5.76

(1) If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, which is to be abandoned is 1 m or less below the finished ground level, the pipe, manhole, chamber or gully shall be removed and disposed of unless otherwise permitted by the Engineer. The void shall be filled with foam concrete, granular fill material or special fill material as directed by the Engineer.

(2) If the top of a pipe or culvert, or the bottom of a manhole, chamber or gully, is more than 1 m below the finished ground level, the pipe, culvert, manhole, chamber or gully shall be filled with foam concrete or grout as stated in Clause 5.34.

(3) Manholes, chambers and gullies which are to be abandoned shall be demolished to 1 m below finished ground level unless otherwise stated in the Contract. Abandoned pipes, culverts, manholes, chambers and gullies shall be filled with foam concrete or grout, by pumping or by gravity. The lowest point of abandoned pipelines shall be sealed with concrete, bricks or by other methods approved by the Engineer. Filling shall start from the lowest point and shall continue until all voids are completely filled.

CLEANING OF PIPELINES

Cleaning of pipelines 5.77

(1) Pipelines for drainage works shall be cleaned by pigging, by high pressure water jetting or by other methods agreed by the Engineer; manholes and chambers shall be cleaned and washed. Cleaning shall be carried out after:

(a) the pipeline 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) Unless otherwise permitted by the Engineer, pipelines shall be cleaned not more than 7 days before the pipeline is handed over.

INSPECTION OF PIPELINES

Inspection of pipelines 5.78

Unless otherwise permitted by the Engineer, the cleanliness, bore, linearity and joints of pipelines of 450 mm diameter or less shall be checked by pulling a mandrel through the completed pipeline, or parts of the pipeline if permitted by the Engineer, after cleaning. The mandrel shall be 750 mm long and 12 mm less in diameter than the nominal diameter of the pipe.

Inspection of pipelines by CCTV 5.79

The procedure for internal inspection of pipelines by CCTV shall be as stated in Appendix 5.1.

TESTING: PIPES FOR DRAINAGE WORKS

Batch: pipes for drainage works 5.80

A batch of pipes or fittings for drainage works is any quantity of pipes or fittings of the same type and nominal diameter, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: pipes for drainage works 5.81

Unless otherwise required by the Engineer, one sample of pipe for drainage works and each type of fitting shall be provided from each 50 pipes or fittings or part thereof in a batch.

Testing: pipes for drainage works 5.82

(1) Unless otherwise permitted by the Engineer, each sample of pipes and fittings for drainage works shall be tested in accordance with the relevant British Standard.

(2) The method of testing shall be in accordance with the following:

Concrete pipes and fittings	: BS 5911: Part 100
Vitrified clay pipes, fittings and joints	: BS 65
Ductile iron pipes and fittings	: BS 4772
Grey iron pipes and fittings	: BS 4622
UPVC pipes for industrial purposes	: BS 3506
UPVC soil and ventilating pipes, fittings and accessories	: BS 4514
UPVC rainwater goods	: BS 4576: Part 1
UPVC underground drain pipes and fittings	: BS 4660
Plastic waste pipes and fittings	: BS 5255
UPVC pipes and fittings for gravity sewers	: BS 5481.

Non-compliance: pipes for drainage works

5.83 (1) If the result of any test required in accordance with the relevant British Standard for pipes and fittings for drainage works does not comply with the specified requirements for the test, one additional sample 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: AGGREGATES FOR GRANULAR BED

Batch: aggregates for granular bed

5.84 A batch of aggregates for granular bed is any quantity of aggregates for granular bed of the same type, produced at the same time in the same place, covered by the same certificates and delivered to the Site at any one time.

Samples: aggregates for granular bed

5.85 (1) Unless otherwise permitted by the Engineer, one sample of aggregates for granular bed shall be provided from each batch of aggregates for granular bed delivered to the Site.

(2) The size of each sample shall be 40 kg.

(3) The method of sampling shall be in accordance with BS 812: Part 102.

(4) The moisture content of the sample shall be representative of the moisture content of the material in the batch.

Testing: aggregates for granular bed

5.86 Each sample of aggregates for granular bed shall be tested to determine the particle size distribution and the ten percent fines value in accordance with BS 812:Part 103 and BS 812:Part 111, and the compaction fraction value in accordance with Appendix 5.2.

Compliance criteria: compaction fraction value

5.87 The results of tests for compaction fraction value of aggregates for granular bed shall comply with the following requirements:

(a) The compaction fraction value for bed for pipes not exceeding 300 mm nominal diameter shall not exceed 0.3.

(b) The compaction fraction value for bed for pipes exceeding 300 mm nominal diameter shall not exceed 0.15.

TESTING: PRECAST CONCRETE UNITS FOR MANHOLES, CHAMBERS AND GULLIES

Batch: manholes, chambers and gullies

5.88 A batch of precast concrete units for manholes, chambers or gullies is any quantity of precast concrete units for manholes, chambers or gullies of the same type and size, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: manholes, chambers and gullies

5.89 Unless otherwise permitted by the Engineer, one sample of precast units for manholes, chambers or gullies shall be provided from each 50 precast concrete units for manholes, chambers or gullies or part thereof in a batch.

Testing: manholes, chambers and gullies

5.90 (1) Unless otherwise permitted by the Engineer, each sample of precast concrete units for manholes, chambers or gullies shall be tested in accordance with the relevant British Standard.

(2) The method of testing shall be in accordance with the following:

Precast concrete units for manholes	: BS 5911: Part 200
Inspection chambers and gullies	: BS 5911: Part 2.

Non-compliance: manholes, chambers and gullies

5.91 (1) If the result of any test required in accordance with the relevant British Standard for precast concrete units for manholes, chambers or gullies does not comply with the specified requirements for the test, one additional sample 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: MANHOLE COVERS, GULLY GRATINGS AND KERB OVERFLOW WEIRS

Batch: covers, gratings and weirs

5.92 A batch of manhole covers, gully gratings or kerb overflow weirs is any quantity of covers, gratings or weirs of the same type, manufactured by the same manufacturer, covered by the same certificates and delivered to the Site at any one time.

Samples: covers, gratings and weirs

5.93 One sample of manhole covers, gully gratings or kerb overflow weirs shall be provided from each 20 covers, gratings or weirs or part thereof in a batch.

Testing: covers, gratings and weirs

5.94 (1) Each sample of manhole covers, gully gratings or kerb overflow weirs shall be weighed and subjected to a load test.

(2) The method of testing shall be as stated in Appendix 5.3. The test loads shall be as stated in Table 5.6 and Table 5.7.

Compliance criterion: resistance to fracture of covers and gratings

5.95 Manhole covers and gully gratings shall withstand the test load without fracture or cracking.

Non-compliance: mass of covers, gratings and weirs

5.96 (1) If any manhole cover, gully grating or kerb overflow weir does not comply with the specified requirements for mass, every cover, grating and frame in the batch shall be weighed to determine its mass.

(2) If any cover, grating or weir does not comply with the specified requirements for mass, it shall not be used in the permanent work.

Non-compliance: resistance to fracture of covers and gratings

5.97 (1) If any manhole cover or gully grating does not comply with the specified requirements for resistance to fracture, two additional samples shall be provided from the same batch and tested to determine their resistance to fracture.

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

TESTING: WATERTIGHTNESS OF PENSTOCKS

Testing: watertightness of penstocks

5.98 (1) Penstocks which are to be tested shall be tested for watertightness after installation by applying pressure using a head of water applied to one face of the penstock and no head of water on the other face. The test pressure and the face on which the pressure is to be applied shall be as stated in the Contract.

(2) The method of testing shall be as agreed by the Engineer.

(3) The test pressure shall be maintained for 24 hours.

Compliance criteria: watertightness of penstocks

5.99 The results of tests for watertightness of penstocks shall comply with the following requirements:

(a) There shall be no leaks through the penstock during the test.

(b) There shall be no leaks or damp patches visible at the joint between the penstock and the structure during the test.

Non-compliance: watertightness of penstocks

5.100 If the result of any test for watertightness of penstocks does not comply with the specified requirements, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the penstock shall be re-tested.

TESTING: GRAVITY PIPELINES FOR DRAINAGE WORKS

Testing: gravity pipelines for drainage works

5.101 (1) Gravity pipelines for drainage works shall be tested as stated in Clause 5.101(2) to (6).

(2) Gravity pipelines for sewage shall be tested by the methods stated in Table 5.11 at the following times:

(a) after the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, and

(b) after haunch and surround has been placed and fill material has been deposited and compacted, and

(c) not more than 7 days before the pipeline is handed over.

(3) Gravity pipelines for surface water shall be tested by the methods stated in Table 5.11 at the following times:

(a) after the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, or

(b) after haunch and surround has been placed and fill material has been deposited and compacted.

(4) Water tests and air tests on pipelines shall be carried out on the complete pipeline between manholes, chambers and structures; pipelines shall not be tested in parts unless permitted by the Engineer or unless the specified test pressure would otherwise be exceeded. Short branch pipelines shall be tested with the main pipeline and long branch pipelines shall be tested separately.

(5) Infiltration tests shall be carried out on the complete pipeline between manholes, chambers and structures, including manholes, chambers and branches within the pipeline system.

(6) The method of testing shall be in accordance with Appendix 5.4.

Table 5.11: Testing gravity pipelines

Type of pipeline	Diameter of pipeline	Time of test	Method of testing
Sewage	not exceeding 900 mm	as Clause 5.101(2)(a)	Water test or air test
		as Clause 5.101(2)(b)	Water test or air test
		as Clause 5.101(2)(c)	Infiltration test
Sewage	exceeding 900 mm	as Clause 5.101(2)(a)	Visual inspection
		as Clause 5.101(2)(b)	Water test or air test
		as Clause 5.101(2)(c)	Infiltration test
Surface water	not exceeding 900 mm	as Clause 5.101(3)(a) or as Clause 5.101(3)(b)	Water test or air test
Surface water	exceeding 900 mm	as Clause 5.101(3)(a)	Visual inspection
		as Clause 5.101(3)(b)	Water test or air test

Compliance criteria: gravity pipelines for drainage works

5.102 The results of tests on gravity pipelines for drainage works shall comply with the following requirements:

(a) The leakage of water from the pipeline determined by the water test shall not exceed the permitted leakage calculated in accordance with Clause 5.4.8 of Appendix 5.4.

(b) There shall be no discernable leakage from the pipe or from any joint during the water test.

(c) The air pressure shall remain above 75 mm head of water at the end of the air test.

(d) There shall be no infiltration or damage to pipes or joints as determined by the visual inspection.

Non-compliance: gravity pipelines for drainage works

5.103 If the result of any test on gravity pipelines 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 re-tested.

TESTING: PRESSURE PIPELINES FOR DRAINAGE WORKS

Testing pressure pipelines for drainage works

5.104 (1) Pressure pipelines for drainage works shall be tested as stated in Clause 5.104(2) to (7).

(2) The pipeline shall be tested at the following times:

(a) after the pipes have been jointed and the bedding has been placed and immediately before haunch or surround is placed or fill material is deposited, and

(b) after haunch and surround has been placed and fill material has been deposited and compacted.

(3) The test stated in Clause 5.104(2)(a) shall not be carried out on parts of a pipeline unless permitted by the Engineer or unless the specified test pressure would otherwise be exceeded. The test stated in Clause 5.104(2)(b) shall be carried out on the complete pipeline.

(4) 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 1.5 times the maximum working pressure in the part of the pipeline tested.

(5) Tests shall not be carried out simultaneously on more than one pipeline in the same trench.

(6) The method of testing shall be in accordance with Appendix 5.5.

(7) Testing of pressure pipelines by means of tests on individual joints shall not be carried out instead of tests stated in Clause 5.104(2) to (6) unless permitted by the Engineer; if permitted, the method of testing and the compliance criteria shall be as approved by the Engineer.

Compliance criteria: pressure pipelines for drainage works

5.105 The results of tests on pressure pipelines for drainage works 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 5.5.4 of Appendix 5.5.

(b) There shall be no discernable leakage of water from the pipeline or from any joint during the pressure test.

Non-compliance: pressure pipelines for drainage works

5.106 If the result of any test on pressure pipelines for drainage works 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 re-tested.

APPENDIX 5.1

CCTV INSPECTION OF PIPELINES

Scope 5.1.1 This methods covers the internal inspection of pipelines by means of closed circuit television.

Equipment 5.1.2 The following equipment is required:

(a) A CCTV colour camera with integral lighting unit. The camera shall be a type designed and constructed for the specified purpose and shall be capable of operating in 100% relative humidity. The camera shall be fitted with a rotating mirror for complete circumferential viewing. The system shall be capable of producing a clear and high quality picture of the entire periphery of the pipe on the monitor screen and recording tape. The camera and lighting unit shall be mounted on a self-propelled crawler or on skids linked to a manual or power operated winch.

(b) A monitor screen which displays the camera view during the inspection. The monitor screen shall be housed in covered accommodation with facilities for inspection by the Engineer and others.

(c) A screen writer which displays on the monitor screen details of the inspection including date, location, pipe material, diameter of pipe, direction of view and comments on the condition of the pipe.

(d) A measuring device which displays the camera location automatically on the monitor screen. The device shall be capable of measuring the location to within an accuracy of 0.1% of the length of the pipeline or ±0.3 m whichever is the greater.

(e) A control unit which controls camera movement, lighting intensity, focusing and recording.

(f) A VHS video recording system to record the inspection and information displayed on the monitor screen.

(g) A 35 mm single lens reflex (SLR) camera capable of producing photographs with the date.

Procedure 5.1.3 The procedure shall be as follows:

(a) The camera shall be moved through the pipeline in the direction instructed by the Engineer at a speed not exceeding 0.15 m/s. If the camera cannot pass through the complete pipeline in one operation, the inspection may be carried out from both ends of the pipeline.

(b) The camera shall be stopped whenever instructed by the Engineer to allow inspection by the Engineer.

(c) The video system shall be operated during the complete inspection to provide a continuous record of the inspection and information on the monitor screen.

(d) Photographs of the monitor screen shall be taken whenever instructed by the Engineer.

Recording of results 5.1.4 (1) Records of the inspections shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 14 days of completion of the inspection. The report shall contain the following details:

(a) key map showing pipelines inspected and associated manholes, chambers and structures,

(b) tables listing details of inspection, including date, location, pipe material, diameter of pipe, chainage, manholes, junctions and other features and the condition of pipes and joints; the condition of pipes and joints shall be illustrated by a coding systems in accordance with the `Manual of Sewer Condition Classification' (1980) published by the U.K. National Water Council, and

(c) a summary showing the number and type of defects in each pipeline inspected.

(2) The following items shall be submitted at the same time as the report:

(a) video film providing a continuous record of the inspection and information on the monitor screen, and

(b) photographs of the monitor screen including date and chainage; the photographs shall be 3R size and shall be mounted in photograph albums.

APPENDIX 5.2

DETERMINATION OF THE COMPACTION FRACTION VALUE OF AGGREGATES FOR GRANULAR BED

Scope 5.2.1 This method covers the determination of the compaction fraction value of aggregates for granular bed.

Apparatus 5.2.2 The following apparatus is required:

(a) A steel open-ended cylinder, 150 mm internal diameter by 250 mm high, with a wall thickness of not less than 3.5mm.

(b) A steel rammer of 40 mm diameter weighing approximately 1 kg.

(c) A steel rule calibrated to 1 mm.

Procedure 5.2.3 The procedure shall be as follows:

(a) The sample shall be placed on a clean surface and shall be divided by quartering or by using a riffle box to obtain a specimen weighing approximately 10 kg.

(b) The cylinder shall be placed on a firm level surface and shall be filled without tamping with material taken from the sample. Surplus material shall be struck off level with the top of the cylinder, and cleared from the area around the cylinder.

(c) The cylinder shall be lifted clear of the contents and placed alongside the material.

(d) Approximately one quarter of the material shall be placed in the cylinder and compacted using the rammer until no further compaction can be achieved. The procedure shall be repeated for each of the remaining three quarters of the material. The top surface shall be compacted as level as practicable.

(e) The distance (d) from the top of the cylinder to the top surface of the material shall be measured to the nearest 1 mm.

Calculation 5.2.4 The compaction fraction value of the material shall be calculated from the equation:

Compaction fraction value = d/h

where:

- d is the distance from the top of the cylinder to the top surface of the material (mm),

- h is the height of the cylinder (mm).

Reporting of results 5.2.5 The following shall be reported:

(a) Identification of sample.

(b) The compaction fraction value to the nearest 0.01.

(c) Source and type of material.

(d) Date of test.

(e) That the test method used was in accordance with this Specification.

APPENDIX 5.3

DETERMINATION OF THE RESISTANCE TO FRACTURE OF MANHOLE COVERS AND GULLY GRATINGS

Scope 5.3.1 This method covers the determination of the resistance to fracture of manhole covers and gully gratings by means of a load test.

Equipment 5.3.2 The following equipment is required:

(a) The manufacturer's recommended frame for the manhole cover or gully grating or a fabricated test frame of a type agreed by the Engineer which will simulate the normal conditions of use of the cover or grating.

(b) A circular hardwood bearing block faced with hard rubber or other resilient material. The diameter of the block shall be as stated in Table 5.6 or Table 5.7 for the relevant cover or grating. The block shall be sufficiently rigid to ensure that the load is equally distributed over the whole area of the block.

(c) Test loads.

(d) Equipment for measuring the loads applied, readable and accurate to 0.05 t or 2% of the specified test load, whichever is greater.

Procedure 5.3.3 The procedure shall be as follows:

(a) The full bearing area of the frame shall be rigidly supported.

(b) The cover or grating shall be placed in the frame. The bearing block shall be placed centrally on the cover or grating.

(c) The specified test load as stated in Table 5.6 and 5.7 shall be applied without shock.

(d) The specified test load shall be maintained for at least 30 seconds and removed.

Reporting of results 5.3.4 The following shall be reported:

(a) Identification of sample.

(b) The load applied, to the nearest 0.05 t or 2% of the specified test load, whichever is greater.

(c) Details of any fracture or cracks.

(d) That the test method used was in accordance with this Specification.

APPENDIX 5.4

TESTS ON GRAVITY PIPELINES FOR DRAINAGE WORKS

Scope

5.4.1 This method covers water tests, air tests, visual inspections and infiltration tests on gravity pipelines for drainage works.

Equipment

5.4.2 The following equipment is required:

(a) Expanding disc stoppers, air bags or other methods of sealing pipes agreed by the Engineer.

(b) Struts and wedges.

(c) Force pump for water test.

(d) Standpipe for water test.

(e) Measuring vessel for water test, readable and accurate to 0.01 litre.

(f) U-tube for air test.

(g) Trolleys to obtain access inside pipelines for visual inspections. Mechanical fans shall be provided to ensure that an adequate air supply is available; engine driven fans shall be fitted with a flexible exhaust or other methods of keeping exhaust fumes clear of the fresh air intake.

Procedure: before tests and inspections

5.4.3 The procedure before tests and inspections shall be as follows:

(a) Debris and water shall be removed from the pipeline.

(b) Openings to the pipeline shall be sealed using expanding disc stoppers, air bags or other methods agreed by the Engineer and the seals secured against movement.

Procedure: water test

5.4.4 The procedure for the water test shall be as follows:

(a) The pipeline shall be filled with water and shall be kept filled for two hours before testing starts to allow absorption to take place.

(b) A test pressure of 1.2 m head of water above the soffit of the pipe at the high end shall be applied at the standpipe and maintained for 30 minutes; the test pressure applied shall not exceed 6 m head of water at the invert of the low end of the pipe.

(c) The head of water at the standpipe shall be topped up at 5 minute intervals during the test, and shall be filled to the specified head at the end of the test period; the amounts of water added to the standpipe shall be measured using the measuring vessel.

(d) The leakage of water from the pipeline shall be measured as the amount of water added to maintain the specified head of water.

Procedure: 5.4.5 The procedure for the air test shall be as follows:

(a) Air shall be pumped into the pipeline until a test pressure of slightly more than 100 mm of water is registered on a U-tube manometer connected to the pipeline. Five minutes shall be allowed for stabilisation of the air temperature, and the air pressure shall then be adjusted to 100 mm of water.

(b) The pressure shall be read from the U-tube at the end of a five-minute period without further pumping.

Procedure: visual inspection 5.4.6 The inside of the pipeline shall be inspected visually, and infiltration or damage to pipes or joints shall be recorded.

Procedure: infiltration test 5.4.7 The procedure for the infiltration test shall be in accordance with BS 8005: Part 1 Clause 13.6.

Calculation 5.4.8 The permitted leakage of water from the pipeline during the water test shall be calculated from the equation:

$$\text{Permitted leakage} = d \times l \times \frac{t}{60} \quad \text{litre}$$

where:

- d is the internal diameter of the pipe (m),
- l is the length of pipeline tested (m),
- t is the test period (min).

Reporting of results 5.4.9 The following shall be reported:

(a) The nominal internal diameter of the pipe.

(b) The location and length of pipeline tested to the nearest 0.3 m.

(c) The test pressure applied during the water test to the nearest 0.01 m, and during the air test to the nearest 1 mm head of water.

(d) The test period to the nearest 1 min.

(e) The leakage and permitted leakage for the water test to the nearest 0.1 litre.

(f) The amount of infiltration for the infiltration test to the nearest 0.1 litre.

(g) Details of any discernable leakage of water from the pipe or from any joint during the water test.

(h) That the test method used was in accordance with this Specification.

APPENDIX 5.5

TESTS ON PRESSURE PIPELINES FOR DRAINAGE WORKS

Scope 5.5.1 This method covers the determination of the leakage of water from pressure pipelines for drainage works by means of a pressure test.

Equipment 5.5.2 The following equipment is required:

(a) Blank flanges or caps.

(b) Struts and wedges.

(c) Temporary concrete blocks or other anchors.

(d) Force pump.

(e) Pressure gauge, readable and accurate to 0.01 m head of water. The gauge shall be either a conventional circular type of at least 300 mm diameter or shall be a digital indicator type.

(f) Measuring vessel, readable and accurate to 0.01 litre.

Procedure 5.5.3 The procedure shall be as follows:

(a) Pipes and valves shall be cleaned and the operation of valves shall be checked. Air valves shall be isolated.

(b) Blank flanges or caps shall be fixed to the ends of the pipeline, or part of the pipeline, to be tested. Tests shall not be made against closed valves unless permitted by the Engineer.

(c) The blank flanges and caps and closed valves against which tests are made shall be secured with struts and wedges against temporary concrete blocks or other anchors. The blocks shall be completed and shall have hardened sufficiently before testing starts. Thrust and anchor blocks, pipe straps and other devices required to prevent movement of pipes and fittings shall be completed before testing starts.

(d) The pipeline shall be filled with water and all air shall be removed; measures shall be taken during filling to provide free outlets for air and to prevent water hammer.

(e) The pressure in the pipeline shall be increased to working pressure and the pipeline shall remain filled at this pressure for 2 hours to allow absorption to take place and to achieve conditions which are as stable as practicable.

(f) The pressure in the pipeline shall be increased slowly by pumping water into the pipeline using a force pump until the specified test pressure is reached at the lowest part of the pipeline being tested.

(g) The pressure in the pipeline shall be maintained at the specified test pressure, using the force pump if necessary, for a period of at least 1 hour.

(h) At the end of the 1 hour period the pressure shall be increased, if necessary, to the specified test pressure and pumps and water supply points shall be disconnected.

(i) The pipeline shall be left in this condition for a test period of 1 hour; no water shall be allowed to enter the pipeline during the test period.

(j) At the end of the test period the pressure in the pipeline shall be recorded.

(k) The pumps and water supply points shall be reconnected and the pressure shall be increased to the specified test pressure.

(l) Water shall be drawn off from the pipeline until the pressure in the pipeline is the same as at the end of the test period. The leakage of water from the pipeline shall be measured as the amount of water drawn off.

Calculation 5.5.4 (1) The average test pressure (P) shall be calculated as the average of the specified test pressure and the pressure at the end of the test period.

(2) The permitted leakage of water from the pipeline during the pressure test shall be calculated from the equation:

$$\text{Permitted leakage} = d \times l \times \frac{t}{12} \times P \quad \text{litre}$$

where:

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

Reporting of results 5.5.5 The following shall be reported:

(a) The nominal internal diameter of the pipe.

(b) The location and length of pipeline tested to the nearest 0.3 m.

(c) The test period to the nearest one minute.

(d) The specified test pressure to the nearest 0.01 m head of water.

(e) The pressure at the end of the test period to the nearest 0.01 m head of water.

(f) The average test pressure to the nearest 0.01 m head of water.

(g) The leakage and permitted leakage to the nearest 0.1 litre.

(h) Details of any discernable leakage of water from the pipeline during the test.

(i) That the test method used was in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 6

EARTHWORKS

SECTION 6

EARTHWORKS

GENERAL

Reclamation 6.01 Reclamation shall comply with Section 21 except as stated in this Section.

GLOSSARY OF TERMS

Areas of fill 6.02 Areas of fill are areas within the Site, including areas in embankments, platforms and slopes and in excavations for structures, pits and trenches, in which fill material is deposited and compacted as part of the permanent work.

Earthworks final surface 6.03 Earthworks final surface is the surface to which the work included in Section 6 is finished.

Earthworks material 6.04 Earthworks material may consist of soil, rock, crushed concrete or crushed inert demolition material which is on or below the Site at the commencement of the Contract, or which is imported to the Site to carry out the Works.

Formation 6.05 Formation is that part of the earthworks final surface on which a pavement, structure or utility, is constructed, or on which the blinding or bedding for a pavement, structure or utility is placed.

Intermediate areas of fill 6.06 Intermediate areas of fill are areas of fill which are stated in the Contract as such, and in which fill material is deposited and compacted directly into shallow water or onto naturally occurring soft ground.

Public fill 6.06A Public fill shall mean the inert material arising from construction and demolition activities such as site clearance, excavation, construction, refurbishment, renovation, demolition and roadworks. Public fill comprises material including stone, rock, masonry, brick, concrete, soil and other inert material. There is no size limitation on the public fill, and a small amount of timber mixed with otherwise suitable material is permissible. The public fill may also consist of wet soil.

MATERIALS

Fill material 6.07 (1) Fill material shall consist of naturally occurring or processed material which at the time of deposition is capable of being compacted in accordance with the specified requirements to form stable areas of fill.

(2) Fill material, other than public fill, shall not contain any of the following:

(a) material susceptible to volume change, including marine mud, soil with a liquid limit exceeding 65% or a plasticity index exceeding 35%, swelling clays and collapsible soils,

(b) peat, vegetation, timber, organic, soluble or perishable material,

(c) dangerous or toxic material or material susceptible to combustion, and

(d) metal, rubber, plastic or synthetic material.

(3) The different types of fill material shall have the particle size distributions within the ranges stated in Table 6.1.

(4) Special fill material shall consist of material which has a liquid limit not exceeding 45%, a plasticity index not exceeding 20% and a coefficient of uniformity exceeding 50.

(5) Granular fill material shall consist of clean, hard, durable material.

(6) Rock fill material shall consist of pieces of hard, durable rock of which in the opinion of the Engineer not more than 30% by mass is discoloured or shows other evidence of decomposition. Crushed rock or crushed concrete may be permitted subject to approval by the Engineer.

(7) The soluble sulphate content of fill material placed within 500 mm of concrete, cement bound material or cementitious material shall not exceed 1.9 grams of sulphate, expressed as SO_3, per litre.

(8) The total sulphate content, expressed as SO_3, of fill material placed within 500 mm of metalwork shall not exceed 0.5% by mass.

(9) The use of public fill as fill material for earthwork may be permitted and the size limitation, transportation, stockpiling, deposit, spreading, compaction and any particular requirements of such material shall be as stated in the Contract.

(10) Well-graded material shall consist of material which has a coefficient of uniformity exceeding 10.

(11) Uniform-graded material shall consist of material which has a coefficient of uniformity of 10 or less.

Table 6.1: Particle size distributions of fill material

Type of fill material	Percentage by mass passing					
	Size		BS test sieve			
	400 mm	200 mm	75 mm	20 mm	600 μm	63 μm
Fine fill material	-	-	100	-	-	-
General fill material	-	100	75-100	-	-	-
Special fill material	-	-	100	-	-	0-45
Granular fill material	-	-	100	-	0-5	-
Rock fill material (Grade 200)	-	100	20-75	0-50	-	-
Rock fill material (Grade 400)	100	20-75	10-30	0-25	-	-

SUBMISSIONS

Particulars of earthworks

6.08 (1) The following particulars of the proposed materials and methods of construction for earthworks shall be submitted to the Engineer:

(a) details of Constructional Plant and haulage vehicles,

(b) methods of excavation and of deposition and compaction of fill material,

(c) use of different types of excavated material and sources of imported fill material,

(d) arrangements for stockpiling excavated material and fill material and for disposing of earthworks material,

(e) methods of controlling the moisture content of fill material,

(f) methods of controlling surface water and groundwater and of protecting earthworks and earthworks material from damage due to water and from weather conditions which may affect the earthworks or earthworks material,

(g) methods of monitoring groundwater levels, and

(h) methods of monitoring the ground and structures for movements.

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

Particulars of blasting 6.09 (1) The following particulars of the proposed blasting procedures shall be submitted to the Engineer:

(a) any conditions or restrictions imposed by the Commissioner of Mines, including copies of applications, licences, permits and correspondence,

(b) names, qualifications and experience of the persons responsible for the design and supervision of blasting operations,

(c) location, diameter, inclination and depth of holes to be charged with explosive,

(d) type and total mass of explosive to be used and its mass and distribution in each hole,

(e) dimensions of stemming and decking,

(f) initiation sequence, delay periods and mass of explosive per delay,

(g) burden and bench height,

(h) ratio of diameter of explosive to diameter of hole,

(i) arrangements for and methods of instrumentation and monitoring the effects of blasting,

(j) details of velocity seismographs, including manufacturer's literature,

(k) method of controlled blasting,

(l) details of blasting trials, and

(m) protective measures.

(2) The particulars, other than particulars relating to blasting trials, shall be submitted to the Engineer at least 48 hours before the relevant blasting starts. Particulars relating to blasting trials shall be submitted to the Engineer at least 14 days before the blasting trials are carried out.

GENERAL EARTHWORKS REQUIREMENTS

Ownership of earthworks material 6.10 (1) Earthworks material within the Site at the commencement of the Contract shall remain the property of the Employer except as stated in Clause 6.10(2).

(2) Earthworks material which is required to be disposed of by the Contractor shall become the property of the Contractor when it is removed from the Site and shall be disposed of in tips provided by the Contractor, unless otherwise stated in the Contract.

Temporary Works for earthworks

6.11 The design of Temporary Works associated with earthworks, including temporary slopes, stockpiles and drainage, shall be such that the risk of failure is not more than that which would be adopted if the Temporary Works were to be permanent. Allowance may be made in the design of the Temporary Works for the shorter design life and for the risk to persons and property and the surface water and groundwater conditions which are likely to occur during construction.

Handling and storage of earthworks material

6.12 (1) Earthworks material shall not be handled or stored in a manner which will result in segregation, deterioration, erosion or instability of the material.

(2) Different types of earthworks material shall be kept separate from each other. Earthworks material which is suitable for use as fill material shall be maintained in a suitable condition and shall not be contaminated.

Protection from water and weather

6.13 (1) Earthworks after site clearance, excavation or filling and earthworks material after excavation shall be kept free from water and shall be protected from damage due to water and from exposure to weather conditions which may affect the earthworks or earthworks material. The measures to be taken shall include the following:

(a) As stated in Clauses 1.19 and 1.20.

(b) Surfaces shall be maintained in a stable condition and shall be formed to falls to shed water and to prevent ponding.

(c) The area of exposed surfaces shall be kept to a minimum.

(2) Excavations for structures, pits and trenches shall not be carried out on or adjacent to slopes unless measures are taken to drain the excavation and to prevent water from the excavation entering the slope.

Earthworks material allowed to become unsuitable or to deteriorate

6.14 (1) Earthworks 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) Earthworks material which is not stated in the Contract to be excavated and which the Contractor causes or allows to deteriorate such that in the opinion of the Engineer the permanent work will be affected shall be replaced or dealt with by methods agreed by the Engineer.

(3) Material provided to replace earthworks material which has been allowed to become unsuitable or which the Contractor causes or allows to deteriorate shall be an equivalent material approved by the Engineer. The replacement material shall have the same volume after compaction as the material replaced.

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

Additional excavation and stabilisation

6.15 (1) Earthworks material which is not stated in the Contract to be excavated but which in the opinion of the Engineer has inadequate strength, durability or stability shall be dealt with by additional excavation or filling as stated in Clause 6.15(2) or by stabilisation as stated in Clause 6.15(3) or by other methods instructed by the Engineer.

(2) Additional excavation shall be carried out and the resulting voids shall be dealt with as follows:

(a) General fill material, fine fill material or special fill material shall be deposited and compacted below areas of fill and below formations other than in rock.

(b) Grade 10 concrete shall be placed and compacted below formations in rock.

(c) Granular fill material shall be deposited below standing water.

(3) Stabilisation shall be carried out using rock fill material (Grade 400) deposited directly into the original unstable material and compacted to form a stable foundation on which to construct the subsequent work.

Removal of earthworks material 6.16 Earthworks material which is required for use in the permanent work as fill material shall not be removed from the Site unless permitted by the Engineer. The Contractor shall notify the Engineer before any earthworks material is removed from the Site.

EXCAVATION

Disposal of excavated material 6.17 (1) Excavated material which in the opinion of the Engineer cannot be selected, processed or mixed in a practical manner to make it suitable for use in the permanent work as fill material shall be disposed of by the Contractor unless otherwise stated in the Contract.

(2) Excavated material which is surplus to the requirements of the permanent work shall be disposed of by the Contractor unless otherwise stated in the Contract.

Use of excavated material 6.18 (1) Excavated material required for use in the permanent work which is capable of being selected, processed and mixed to make it suitable for use as fill material shall not be used for any other purposes unless permitted by the Engineer.

(2) Excavated material which is required for use in the permanent work as fill material and which the Engineer permits to be removed from the Site or used for other purposes shall be replaced by an equivalent material approved by the Engineer. The replacement material shall have the same volume after compaction as the material replaced.

Obstructions in excavations 6.19 (1) The Contractor shall inform the Engineer without delay of the nature and location of any unforeseen obstruction encountered during excavation.

(2) Boulders which intersect the earthworks final surface or formation shall be dealt with as excavation proceeds by methods agreed by the Engineer. Boulders shall not be left protruding unless permitted by the Engineer.

Excavation 6.20 (1) Temporary supports or other methods shall be used to maintain excavations in a stable condition and to prevent settlement of structures or utilities due to excavation or dewatering.

(2) Constructional Plant or other vehicles shall not be operated or parked adjacent to excavations and earthworks material or other materials shall not be placed adjacent to excavations unless this has been allowed for in the design of the Temporary Works for the support of the excavation.

Excavations adjacent to structures and utilities

6.21 (1) Excavations shall be carried out by hand adjacent to utilities that are known, proven or suspected to exist.

(2) Unless otherwise permitted by the Engineer excavations next to structures shall be carried out by hand.

Excavations for structures, pits and trenches

6.22 (1) Excavations for structures, pits and trenches shall be the minimum size necessary to construct the permanent work. The sides of excavations shall be vertical unless otherwise permitted by the Engineer.

(2) The length of trench excavation left open at any one time shall not exceed that agreed by the Engineer.

(3) Unless permitted by the Engineer, trenches for utilities in areas of fill shall not be excavated until the fill material has been deposited and compacted up to the earthworks final surface or formation or up to 1 m above the top of the utility, whichever is lower.

BLASTING TRIALS

Blasting trials

6.23 (1) Blasting trials shall be carried out for each proposed blasting procedure to demonstrate that:

(a) the procedure is safe,

(b) the resulting ground vibrations at locations stated in the Contract or instructed by the Engineer can be satisfactorily predicted, recorded and are within acceptable limits, and shall not adversely affect the safety and stability of adjoining structures, installations, slopes and land, and

(c) the specified tolerances for earthworks final surfaces and formations can be achieved.

(2) Blasting trials shall be completed at least 7 days before the related blasting starts.

(3) Blasting trials shall be carried out in accordance with the trial procedure submitted to and agreed by the Engineer. The location and size of blasting trials shall be as agreed by the Engineer.

Controlled blasting trials

6.24 Blasting trials for pre-splitting and other methods of controlled blasting shall be carried out to form a face at least 6 m wide by 6 m high. The blasting trials shall be carried out on rock which has similar properties to that of the earthworks final surface and which is at least 6 m away from the earthworks final surface.

Results of blasting trials 6.25 If in the opinion of the Engineer any aspect of the proposed blasting procedure as demonstrated by blasting trials is unsatisfactory, particulars of proposed changes to the procedure shall be submitted to the Engineer. Further blasting trials shall be carried out until the procedure is satisfactory.

Commencement of blasting 6.26 Blasting shall not proceed until in the opinion of the Engineer the procedure as demonstrated by the relevant blasting trials is satisfactory.

Changes in blasting procedure 6.27 Unless permitted by the Engineer, the satisfactory blasting procedure shall not be changed. Further blasting trials shall be carried out to demonstrate proposed changes to the procedure unless otherwise permitted by the Engineer.

BLASTING

Statutory requirements for blasting 6.28 Blasting operations and the supply, transportation, storage, use and disposal of explosives shall be in accordance with conditions and restrictions imposed by the Commissioner of Mines. The Contractor shall make all arrangements with and obtain all licences and permits from the Commissioner of Mines in connection with blasting operations.

Recording vibrations due to blasting 6.29 (1) Measurements of vibrations due to blasting shall be taken at locations stated in the Contract or instructed by the Engineer at all times when blasting is carried out. Records of the vibrations shall be kept by the Contractor on the Site and a copy provided for the Engineer. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) Vibrations due to blasting shall be measured in terms of peak particle velocity, peak particle acceleration and vibrational amplitude. The peak values shall be taken as the maximum resultant calculated by vector summation of the three components of velocity and amplitude respectively, measured as instantaneously as the resolution of the recording instrument permits.

(3) Measurements shall be made with velocity seismographs of a type agreed by the Engineer. Seismographs shall be capable of:

(a) recording vibrations in terms of peak particle velocity and vibrational amplitude over a frequency of 0 – 200 Hz in three mutually perpendicular directions, and

(b) producing a permanent record of vibrations by tracing an ultra-violet light beam on sensitised paper, or by other methods agreed by the Engineer.

(4) The accuracy of seismographs shall be checked before blasting trials are carried out and at regular intervals agreed by the Engineer.

Preparatory work for blasting 6.30 Before assessments of blasting safety precautions are made, all vegetation, overburden and soft or loose material shall be removed to expose the rock which is to be blasted.

Notification of blasting 6.31 The Contractor shall notify the Engineer by not later than noon of the previous day of his intention to bring any explosives to the Site or to carry out any blasting.

Storage of explosives 6.32 Explosives and detonators shall not be stored on the Site overnight unless permitted by the Commissioner of Mines. Explosives and detonators which are not used by the end of each day shall be disposed of as stipulated by the Commissioner of Mines.

Restrictions on blasting times 6.33 Blasting shall not be carried out at the following times:

(a) on General Holidays,

(b) before 8:30 a.m. or after 5:30 p.m. on any day,

(c) unless permitted by the Commissioner of Mines, when a Hong Kong Observatory thunderstorm warning is in force, and

(d) unless permitted by the Commissioner of Mines, when strong wind signal or storm signal No. 3 or higher is hoisted.

Blasting 6.34 (1) Unless otherwise permitted by the Commissioner of Mines, screens and other protective covers shall be erected to prevent the projection of flying fragments of material resulting from blasting. The screens shall be constructed using wire mesh securely supported on steel frames; the nominal diameter of the wire shall be at least 3.5 mm and the wire mesh size shall not exceed 25 mm.

(2) Unless permitted by the Commissioner of Mines, plaster blasting shall not be used.

(3) Unless otherwise permitted by the Commissioner of Mines blast holes shall be stemmed and decked using free-flowing granular material. Charges shall be covered with thick gunny sacking and 2 m by 2 m squares of steel fabric reinforcement weighed down with filled sandbags. Surface detonating cords, knots, detonating relay conductors and initiating detonators shall be covered with a 300 mm thickness of sand or soil.

(4) Unless permitted by the Commissioner of Mines electrical detonators shall not be used within 60 m of overhead power lines. The use of electrical detonators in the vicinity of static or mobile radio transmitters shall comply with BS 6657.

(5) Unless otherwise permitted by the Commissioner of Mines delay blasting with millisecond delays shall be used for all blasting, except as stated in Clause 6.35(5).

(6) Unless permitted by the Engineer blasting shall not be carried out within a distance of:

(a) 60 m from water retaining structures or water tunnels, and

(b) 6 m from water mains or other water supply structures or installations.

(7) Unless permitted by the Engineer the vibrations at structures and installations due to blasting measured in terms of peak particle velocity and vibrational amplitude shall not exceed the values stated in Table 6.2.

(8) Unless otherwise permitted by the Engineer, the vibration at adjoining slopes and land due to blasting measured in terms of peak particle acceleration and peak particle velocity shall not exceed the values stated in the Contract.

Table 6.2: Restrictions on peak particle velocity and vibrational amplitude

Type of structure or installation	Peak particle velocity (mm/s)	Vibrational amplitude (mm)
Water retaining structures Water tunnels	13	0.1
Water mains Other structures and pipes	25	0.2

Controlled blasting 6.35 (1) Earthworks final surfaces which are to be formed by blasting and which slope at a gradient exceeding 2 vertical to 1 horizontal and exceed 3 m in height shall be formed by pre-splitting. Other methods of controlled blasting shall not be used unless permitted by the Engineer.

(2) Pre-splitting and other methods of controlled blasting shall be carried out in such a manner that the rock mass is cleanly split on the required plane to within the specified tolerances and such that rock outside the earthworks final surface is not shattered or loosened.

(3) Faces formed by pre-splitting or other methods of controlled blasting shall not exceed 15 m in height in any one blasting operation unless permitted by the Engineer.

(4) If an earthworks final surface is to be formed by pre-splitting or other methods of controlled blasting:

(a) other blast holes shall be located at a sufficient distance from the earthworks final surface to avoid damaging the surface, and

(b) the row of blast holes nearest to that surface shall be parallel to the row of pre-splitting holes.

(5) Pre-splitting shall consist of a single row of holes drilled at the appropriate inclination along the line of the earthworks final surface. The holes shall be loaded with explosives not exceeding half the diameter of the hole. The explosives shall be detonated simultaneously or with the minimum amount of delay necessary to reduce ground vibrations.

(6) Holes for pre-splitting shall be at least 50 mm diameter and the ratio of the distance between the centre of the holes and the diameter of the hole shall not exceed 10. The holes shall be within a distance of 0.015 times the length of the hole from their designed position.

(7) Holes for pre-splitting shall not be drilled into the sub-grade below berm levels. Rock which remains in position on berms after blasting shall be removed by methods other than blasting.

DEPOSITION OF FILL MATERIAL

Types of fill material 6.36 Unless otherwise stated in the Contract, areas of fill shall be formed of general fill material.

Sources of fill material 6.37 Fill material shall be obtained from excavation within the Site. If there is insufficient fill material of the required types within the Site, imported fill material shall be provided by the Contractor from sources outside the Site.

Surface preparation for fill material 6.38 Except as stated in Clause 6.53, surfaces on which fill material is to be deposited 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 and other materials which in the opinion of the Engineer are unsuitable or unstable shall be removed.

(c) Watercourses shall be diverted as stated in the Contract.

(d) Benches shall be cut and sub-soil drainage systems installed as stated in the Contract.

(e) Voids shall be dealt with as stated in the Contract or instructed by the Engineer.

(f) Surfaces other than rock shall be scarified to a depth of 200 mm and compacted to the same standard as the fill material which is to be deposited.

Commencement of deposition of fill material 6.39 The permission of the Engineer shall be obtained before deposition of fill material starts in any area of fill.

Haulage of fill material 6.40 Haulage of fill material to an area of fill shall proceed only when the compaction plant operating at the area to be filled is sufficient to achieve the specified requirements for relative compaction of the fill material.

Deposition of fill material 6.41 (1) Fill material obtained from excavations within the Site shall be deposited in its final location as soon as practicable after it has been excavated.

(2) Fill material shall be deposited in layers of a thickness appropriate to the compaction method to be used.

(3) Unless otherwise permitted by the Engineer, layers of fill material shall be horizontal, except for any gradient required for drainage, and the thickness of each layer shall be uniform over the area to be filled.

(4) Except in excavations for structures, pits and trenches, if the difference in level between adjacent areas to be filled exceeds 1 m the edge of the higher area shall be benched before fill material is placed against it.

(5) The construction of the Works shall be controlled in such a manner that any compaction of the fill material resulting from the passage of Constructional Plant or haulage vehicles is uniform.

(6) Except as stated in Clause 6.53, fill material shall not be deposited by end-tipping, by pushing loose material down slope faces or by other methods which may result in segregation or inadequate compaction of the fill material.

Overfilling 6.42 In areas of fill formed of fill material other than rock fill material, earthworks final surfaces sloping at a gradient exceeding 1 vertical to 3 horizontal shall be formed by overfilling and cutting back after compaction. Over-filling shall extend beyond the earthworks final surface by a horizontal distance of 0.5 m or three times the thickness of the compacted layer, whichever is greater.

Deposition of fill material adjacent to structures and utilities 6.43 (1) Except as stated in Clause 6.43(4), fill material deposited within 0.5 m of a structure or utility shall be fine fill material unless otherwise stated in the Contract. In addition, the material may contain up to 5% by weight of fresh, slightly decomposed or moderately decomposed rock fragments of up to 200 mm provided that these do not cause any damage to structures, nor do they interfere with the compaction requirements.

(2) Fill material shall not be deposited adjacent to or above structures or utilities until the construction of the structure or utility is sufficiently advanced to accept the imposed forces without disturbance or damage.

(3) Fill material shall be deposited evenly on all sides of structures and utilities and in such a manner that the structure or utility is not disturbed or damaged.

(4) Unless otherwise stated in the Contract, fill material around water, sewage and drainage pipes which are constructed as part of the permanent work shall be special fill material. They shall be deposited in layers not exceeding 100 mm thick to a level of 300 mm above the top of the pipe. The fill material shall be deposited in such a manner that the layer on one side of the pipe is not more than 100 mm higher than the layer on the other side.

Deposition of rock fill material 6.44 (1) The final compacted thickness of each layer of rock fill material shall exceed 1.5 times and shall not exceed twice the nominal Grade size of the rock fill material.

(2) The surface voids of each layer of rock fill material shall be filled with fragments of rock before the next layer is deposited. The final surface of rock fill material shall also be blinded with fine fill material.

Deposition of fill material in excavations for structures, pits and trenches

6.45 If sheet piling, timbering or other temporary supports to excavations for structures, pits and trenches are not to be left in place, the sheet piling, timbering or supports shall be removed as deposition of fill material proceeds. The supports shall be removed in such a manner that the stability of the adjacent ground is maintained and the compacted fill material is not disturbed.

COMPACTION OF FILL MATERIAL

Compaction of fill material

6.46 (1) Fill material in areas of fill shall be compacted in layers to a stable condition as soon as practicable after deposition and in a manner appropriate to the location and to the material to be compacted.

(2) The permission of the Engineer shall be obtained before the next layer is deposited on each layer of compacted fill material.

(3) Except as stated in Clauses 6.48(2), 6.49A(1), 6.51(2) and 6.54, fill material shall be compacted to obtain a relative compaction of at least 95% throughout unless otherwise stated in the Contract.

Moisture content of fill material

6.47 Fill material other than rock fill material and material as stated in Clause 6.49A(1) shall be at optimum moisture content during compaction. The tolerance on the optimum moisture content percentage shall be ±3%, provided that the fill material is still capable of being compacted in accordance with the specified requirements to form stable areas of fill. All necessary measures shall be taken to achieve and maintain the specified moisture content.

Compaction of fill material adjacent to structures and utilities

6.48 (1) Fill material shall be compacted in such a manner that structures or utilities are not disturbed or damaged.

(2) Fill material around water, sewage and drainage pipes which are constructed as part of the permanent work shall be compacted by hand-rammers or manually operated power equipment. Fill material within 300 mm above the top of sewage and drainage pipes shall be compacted to obtain a relative compaction of at least 85% throughout.

Compaction of rock fill material

6.49 (1) Every layer of rock fill material shall be compacted by at least eight passes of a vibrating roller or by other equivalent compaction method approved by the Engineer. The final surface of rock fill material shall be compacted by at least two additional passes of a vibrating roller or by other equivalent compaction method approved by the Engineer.

(2) Vibratory rollers used for the compaction of rock fill material shall have a static load per 100 mm width of roll of at least 2 kN for layers with a compacted thickness not exceeding 500 mm and at least 4 kN for layers with a compacted thickness exceeding 500 mm.

Compaction of general fill material with a large portion of coarse material

6.49A (1) For general fill material of which less than 90% passing a 20 mm BS test sieve, it will be difficult to permit determination of the moisture content and maximum dry density according to Clauses 6.62(2), 6.62(3), 6.65(2), 6.68(5) and 6.68(6). This type of material shall be compacted to the requirements of Clauses 6.49A(2), 6.49A(3) and 6.49A(4).

(2) Spread and level each horizontal layer of general fill material with a thickness not less than 1.5 times of the maximum size of the general fill material and not exceeding the maximum depth of compacted layer in accordance with Table 6.2A. If this criterion is not met due to the presence of over-sized coarse material in the general fill, the over-sized coarse material shall be removed or broken down to sizes acceptable to the Engineer. Each layer shall be systematically compacted by a vibratory roller with the stipulated minimum number of passes corresponding to the minimum static load per 100 mm width of the roller.

(3) The number of passes of the roller shall only be counted when the roller is travelled on the material to be compacted at a speed of not more than 2 km per hour with full vibration. The plant other than vibratory roller to carry out material spreading or to provide some preliminary compaction only to assist the use of heavier plant shall be disregarded in counting the number of passes.

(4) Variation from the method or the use of plant different from that specified in Clause 6.49A(2) will be permitted only if the Contractor demonstrates at site trials that equivalent compaction is achieved by the alternative method or plant. The procedure to be adopted for these site trials shall be agreed with and approved by the Engineer.

(5) Without prejudice to the provision of the Conditions of Contract and in order that the Engineer may take proper provision for the supervision of compaction in the permanent work, the Contractor shall, not less than 24 hours before he proposes to carry out compaction processes, apply in writing to the Engineer for permission to do so.

(6) When materials of widely divergent grading are used in embankments and fill areas, they shall be spread and compacted in separate clearly defined areas.

(7) If more than one class of material is being used in such a way that in the opinion of the Engineer it is not practicable to define the areas in which each class occurs, compaction plant shall be operated as if only the material which requires the greatest compactive effort is being compacted.

Table 6.2A: Compaction requirement for general fill material with a large portion of coarse material

Force per 100 mm width	Well-graded material		Uniform-graded material	
(kN)	Maximum depth of compacted layer (mm)	Minimum no. of passes	Maximum depth of compacted layer (mm)	Minimum no. of passes
0.25 – 0.45			150	16
0.46 – 0.70			150	12
0.71 – 1.25	125	12	150	10
1.26 – 1.75	150	8	200	10
1.76 – 2.30	150	4	225	10
2.31 – 2.80	175	4	250	10
2.81 – 3.50	200	4	275	8
3.51 – 4.20	225	4	300	8
4.21 – 4.90	250	4	300	8

COMPLETION OF EARTHWORKS SURFACES

Completion of earthworks final surfaces

6.50 (1) Earthworks final surfaces shall be completed to a stable condition as soon as practicable after excavation or after deposition and compaction of fill material has been completed. The subsequent permanent work or surface protection shall be carried out as soon as practicable after the earthworks final surface has been completed.

(2) Earthworks final surfaces shall be completed to smooth alignments without abrupt irregularities unless otherwise stated in the Contract.

Completion of formations

6.51 (1) Formations above structures or utilities shall be completed after construction of the structure or utility.

(2) Except in excavations in rock and in areas of fill formed of rock fill material or fill material as stated in Clause 6.49A(1), formations shall be compacted to obtain a relative compaction of at least 98% to a depth of 200 mm below the formation.

(3) Unless otherwise permitted by the Engineer, proof rolling shall be carried out on formations. The formation shall be rolled in the presence of the Engineer by at least two passes of a non-vibrating rubber tyred roller. The roller shall have a static load per 100 mm width of roll of at least 4 kN and shall travel at a speed not exceeding 2 km/h. Any defect in the formation which is revealed during proof rolling by deformation of the formation which in the opinion of the Engineer is excessive shall be made good as instructed by the Engineer.

(4) After all other formation work and testing have been completed and damage caused by testing reinstated, formations for pavements shall be rolled with one pass of a smooth steel-wheeled non-vibrating roller. The roller shall have a load per 100 mm width of roll of at least 2 kN.

(5) Unless otherwise permitted by the Engineer, formations which will not be immediately covered by the subsequent permanent work shall be protected by methods agreed by the Engineer.

Protection of earthworks final surfaces and formations

6.52 (1) Earthworks final surfaces and formations shall be maintained in a stable condition and shall be protected from damage due to water or other causes and from exposure to conditions which may adversely affect the surface.

(2) Formations shall not be used by Constructional Plant or vehicles other than those which in the opinion of the Engineer are essential to construct the subsequent work.

INTERMEDIATE AREAS OF FILL

Deposition of fill material in intermediate areas of fill

6.53 Fill material may be deposited in intermediate areas of fill by end-tipping or by pushing into position until, in the opinion of the Engineer, it is sufficient to form a stable foundation on which to construct the subsequent work.

Compaction of fill material in intermediate areas of fill

6.54 Fill material in intermediate areas of fill up to the level stated in Clause 6.53 shall be compacted to a degree which in the opinion of the Engineer is practicable. Except as stated in Clause 6.49A(1), fill material above the level stated in Clause 6.53 shall be compacted to obtain a relative compaction of at least:

(a) 90% throughout,

(b) 95% within 1.5 m of earthworks final surfaces and formations, and

(c) 98% within 200 mm of formations.

TOLERANCES

Tolerances: earthworks final surfaces and formations

6.55 (1) Earthworks final surfaces and formations shall be within the tolerances stated in Table 6.3 of the specified lines and levels. The tolerances for formations do not apply for pipes or preformed structures which require to be supported over their complete length or area.

(2) In excavation, a positive tolerance refers to insufficient excavation and a negative tolerance refers to excess excavation. In areas of fill, a positive tolerance refers to excess fill material and a negative tolerance refers to insufficient fill material.

Table 6.3: Tolerances for earthworks final surfaces and formations

Type of surface	Method of forming surface	Tolerance (mm)	
		+	-
Formations for structures and utilities	Excavation except in rock	0	25
	Excavation in rock	0	150
	Deposition and compaction of fill material	0	25
Formations for pavements, including carriageways, footways, cycletracks, paved areas, aircraft pavements and railway trackbeds.	Excavation except in rock	0	50
	Excavation in rock	0	150
	Deposition and compaction of fill material	0	50
Earthworks final surfaces other than formations, with a gradient not exceeding 1 vertical to 10 horizontal	Excavation except in rock	0	100
	Excavation in rock	0	200
	Deposition and compaction of fill material	0	100
Other earthworks final surfaces	Excavation except in rock	100	100
	Excavation in rock	100	200
	Deposition and compaction of fill material	100	100

TESTING: FILL MATERIAL - GENERAL REQUIREMENTS

Batch: fill material 6.56 A batch of fill material is any quantity of fill material of the same type and which in the opinion of the Engineer has similar properties throughout. For the purpose of testing for moisture content and relative compaction a batch shall, in addition to the above, be fill material which is deposited in a single layer in any area of fill presented by the Contractor for testing on one occasion.

Samples: fill material 6.57 (1) Each sample of fill material shall consist of at least four increments taken from different parts of the batch. The increments shall be combined and thoroughly mixed and shall then be divided by quartering or by using a riffle box to obtain specimens of an appropriate size to carry out the individual tests.

(2) The size of samples of fill material other than rock fill material shall be in accordance with BS 1377, Part 1, Section 7. Each sample of rock fill material of Grade size not exceeding 200 shall have a mass of at least 250 kg and each sample of rock fill material of Grade size exceeding 200 shall have a mass of at least 1000 kg.

TESTING: FILL MATERIAL - PARTICLE SIZE DISTRIBUTION, LIQUID LIMIT, PLASTICITY INDEX, COEFFICIENT OF UNIFORMITY AND SULPHATE CONTENT

Samples: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content 6.58 Samples of fill material to be tested for particle size distribution, liquid limit, plasticity index, coefficient of uniformity and sulphate content shall be delivered at least 14 days, or such shorter period agreed by the Engineer, before deposition of the fill material starts. The number of samples to be provided from each batch shall be as stated in Table 6.4.

Table 6.4: Number of samples to be tested for particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content, optimum moisture content and maximum dry density

Description	Size of batch	No. of samples per batch
Special fill material	0 - 3,000 m^3	3
	exceeding 3,000 m^3	1 for each 1,000 m^3 or part thereof
Fill material other than special fill material	0 - 15,000 m^3	3
	exceeding 15,000 m^3	1 for each 5,000 m^3 or part thereof

Testing: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content

6.59 (1) Each sample of fill material taken as stated in Clause 6.58 shall be tested to determine the particle size distribution. In the case of special fill material testing shall include calculation of the coefficient of uniformity as stated in Clause 6.59(4). Unless otherwise agreed by the Engineer, each sample of fill material other than rock fill material shall be tested to determine the liquid limit and the plasticity index of that portion of the fill material passing a 425μm BS test sieve. Each sample of fill material which will be deposited within 500 mm of concrete, cement bound material, cementitious material or metalwork shall be tested to determine the soluble sulphate content.

(2) The method of testing shall be in accordance with the following tests as stipulated in GEO Report No. 36 – Methods of Test for Soils in Hong Kong for Civil Engineering Purposes (Phase 1 Tests):

Particle size distribution	: Clause 6.59(3)
Liquid limit	: Test 2.4.3
Plasticity index	: Test 2.5.3
Soluble sulphate content	: Test 3.5.5
Total sulphate content	: Test 3.5.5.

(3) The particle size distribution of fill material passing a 75 mm BS test sieve shall be determined in accordance with GEO Report No. 36, test 2.9.2A or 2.9.2B, whichever as instructed by the Engineer. The size of particles of fill material which do not pass a 75 mm BS test sieve shall be taken as the largest dimension measured in any plane.

(4) The coefficient of uniformity (Cu) shall be calculated from the equation:

$$Cu = D_{60}/D_{10}$$

where:

- D_{60} and D_{10} are the equivalent sieve sizes in millimetres, interpolated from the particle size distribution curve, through which 60% and 10% of the fill material would pass respectively.

Non-compliance: particle size distribution, liquid limit, plasticity index, coefficient of uniformity, sulphate content

6.60 (1) If the result of any test for soluble sulphate content of fill material does not comply with the specified requirements for soluble sulphate content, each sample shall be tested to determine the total sulphate content.

(2) If the result of any test for particle size distribution, liquid limit, plasticity index, coefficient of uniformity or total sulphate content of fill material 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 6.4.

TESTING: FILL MATERIAL - OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY

Samples: optimum moisture content, maximum dry density

6.61 (1) Samples of fill material to be tested for optimum moisture content and maximum dry density shall be delivered at least 72 hours, or such shorter period agreed by the Engineer, before deposition of the fill material starts. The number of samples to be provided from each batch shall be as stated in Table 6.4.

(2) The Contractor shall inform the Engineer of the exact location in which the fill material from which each sample is taken is to be deposited.

(3) Samples to be tested for optimum moisture content and maximum dry density shall also be taken after the fill material has been deposited in its final position, at intervals of not more than 28 days.

(4) Samples shall not be provided from:

(a) fill material including rock fill material which contains an insufficient proportion of particles passing a 20 mm BS test sieve to permit determination of the moisture content and maximum dry density, and

(b) fill material which is to be deposited as stated in Clause 6.53.

Testing: optimum moisture content, maximum dry density

6.62 (1) Each sample of fill material taken as stated in Clause 6.61 shall be tested to determine the optimum moisture content and the maximum dry density.

(2) The method of testing shall be in accordance with the following:

Optimum moisture content	: GEO Report No. 36, test 4.3.3A, 4.3.3B, 4.3.4A or 4.3.4B, whichever as instructed by the Engineer
Maximum dry density	: GEO Report No. 36, test 4.3.3A, 4.3.3B, 4.3.4A or 4.3.4B, whichever as instructed by the Engineer

(3) If agreed by the Engineer, the Hilf method stated in Appendix 6.4 may be used instead of the methods stipulated in Clause 6.62(2) to determine the optimum moisture content and maximum dry density.

(4) If in the opinion of the Engineer there is any undue discrepancy between the results of tests for optimum moisture content of fill material using methods stipulated in Clause 6.62(2) and the results of tests using the Hilf method, the results of tests using methods stipulated in Clause 6.62(2) shall prevail.

Consistency: optimum moisture content, maximum dry density

6.63 If the result of any test for optimum moisture content or maximum dry density of fill material indicates that the batch contains material which in the opinion of the Engineer differs to such an extent that subsequent tests for relative compaction may be affected, the batch shall be divided into smaller batches; each of the smaller batches shall comprise material with similar properties throughout. Additional samples shall be provided from each of the smaller batches and additional tests for optimum moisture content and maximum dry density shall be carried out. The number of additional samples shall be as stated in Table 6.4.

TESTING: FILL MATERIAL - MOISTURE CONTENT:

Samples: moisture content

6.64 (1) Samples of fill material to be tested for moisture content shall be taken during deposition and compaction of fill material and shall be delivered not more than 1 hour after the fill material has been deposited in its final position.

(2) The number of samples to be provided from each batch shall be as stated in Table 6.5. Samples shall not be provided if, in accordance with Clause 6.61(4)(a) or (b), the optimum moisture content has not been determined.

Testing: moisture content

6.65 (1) Each sample of fill material taken as stated in Clause 6.64 shall be tested to determine the moisture content.

(2) The method of testing shall be in accordance with one of the following methods:

(a) Method 1 : GEO Report No. 36, test 2.3.2A or test 2.3.2B, whichever as instructed by the Engineer

(b) Method 2 : Microwave oven drying method as stated in Appendix 6.2.

Method 1 shall be used unless otherwise agreed by the Engineer.

Compliance criteria: moisture content

6.66 If in the opinion of the Engineer there is any undue discrepancy between the results of tests for moisture content of fill material using Method 1 and the results of tests using Method 2 in Clause 6.65, the results of tests using Method 1 shall prevail.

Non-compliance: moisture content

6.67 If the result of any test for moisture content of fill material differs from the optimum moisture content by more than the specified amount and if instructed by the Engineer, the moisture content of the whole of the batch of fill material shall be adjusted. Additional samples shall be provided from the same batch and additional tests for moisture content shall be carried out. The number of additional samples shall be as stated in Table 6.5.

Table 6.5: Number of samples to be tested for moisture content and number of tests for relative compaction

Description	Size of area of fill in batch	No. of samples/No. of tests per batch
Areas of fill in excavations for structures, pits and trenches and on formations	0 - 100 m^2	3
	100 - 500 m^2	2 for each 100 m^2 or part thereof
	exceeding 500 m^2	1 for each 100 m^2 or part thereof
Other areas of fill	0 - 1 ha	4 for each 1000 m^2 or part thereof
	1 - 10 ha	3 for each 1000 m^2 or part thereof
	exceeding 10 ha	2 for each 1000 m^2 or part thereof

TESTING: FILL MATERIAL - RELATIVE COMPACTION

Testing: relative compaction

6.68 (1) Unless otherwise agreed by the Engineer, each batch of fill material shall be tested to determine the relative compaction. Tests shall be carried out after the fill material has been deposited and compacted in its final position. The number of tests on each batch shall be as stated in Table 6.5. Tests shall not be carried out on:

(a) fill material including rock fill material which contains an insufficient proportion of particles passing a 20 mm BS test sieve to permit determination of the relative compaction, and

(b) fill material which has been deposited as stated in Clause 6.53.

(2) Tests shall be carried out at positions which in the opinion of the Engineer are representative of the batch of compacted fill material as a whole.

(3) Testing will be carried out by the Engineer.

(4) The relative compaction of fill material shall be determined in accordance with one of the following methods:

(a) Method 1: The relative compaction (RC) shall be calculated from the equation:

RC = IDD/MDD x 100%

where:

- IDD is the in-situ dry density determined as stated in Clause 6.68(5)

- MDD is the maximum dry density determined as stated in Clause 6.62(2)

(b) Method 2: The relative compaction (RC) shall be calculated from the equation:

RC = IBD/MCBD x 100%

where:

- IBD is the in-situ bulk density determined as stated in Clause 6.68(5)

- MCBD is the maximum converted bulk density determined by the Hilf method as stated in Appendix 6.4

Method 1 shall be used unless otherwise permitted by the Engineer.

(5) The in-situ bulk density and the in-situ dry density of fill material shall be determined in accordance with one of the following methods:

(a) Method 1: GEO Report No. 36, test 9.2.1 or 9.2.2 as appropriate to the grain size of the fill material

(b) Method 2: Nuclear densometer method as stated in Appendix 6.3.

Method 1 shall be used unless otherwise permitted by the Engineer.

(6) The maximum converted bulk density of fill material of which more than 5% is retained on a BS 20 mm test sieve shall be adjusted as stated in Appendix 6.5.

Compliance criteria: relative compaction

6.69 If in the opinion of the Engineer there is any undue discrepancy between the results of tests for relative compaction of fill material using Method 1 and the results of tests using Method 2 in Clause 6.68, the results of tests using Method 1 shall prevail.

Non-compliance: relative compaction

6.70 If the result of any test for relative compaction of fill material does not comply with the specified requirements for relative compaction, additional tests for relative compaction shall be carried out on the same batch. The number of additional tests shall be as stated in Table 6.5.

APPENDIX 6.1

TEST METHODS FOR FILL MATERIAL

General 6.1.1 The definitions, terms, abbreviations symbols, and grouping of materials stated in BS 1377 shall apply except as stated in Clauses 6.1.2 and 6.1.3.

Terms and symbols 6.1.2 Terms used in the GS, and in BS 1377 are identified in the GS by the abbreviations and symbols stated in Table 6.1.1.

Table 6.1.1: Abbreviations and Symbols

Abbreviation/ Symbol	Term
BD	bulk density
CBD	converted bulk density
DD	dry density
IBD	in-situ bulk density
IDD	in-situ dry density
MDD	maximum dry density
MCBD	maximum converted bulk density
RC	relative compaction
w	moisture content
w_i	in-situ moisture content
w_o	optimum moisture content

Grouping of material 6.1.3 (1) Fine grained material is material of which at least 90% passes a 2 mm BS test sieve.

(2) Medium grained material is material of which at least 90% passes a 20 mm BS test sieve and more than 10% is retained on a 2 mm BS test sieve.

APPENDIX 6.2

DETERMINATION OF THE MOISTURE CONTENT OF FINE GRAINED AND MEDIUM GRAINED MATERIAL BY THE MICROWAVE OVEN DRYING METHOD

Scope

6.2.1 This method covers the determination of the moisture content of fine grained and medium grained material as a percentage of the mass of the dry material.

Apparatus

6.2.2 The following apparatus is required:

(a) A microwave oven with a timer and an adjustable power setting.

(b) An airtight container of microwave safe and non-reflective material.

(c) A balance readable and accurate to 0.01g.

(d) A desiccator containing anhydrous silica gel.

Procedure

6.2.3 The procedure shall be as follows:

(a) The container shall be cleaned, dried and weighed to the nearest 0.01g (m_1).

(b) A specimen shall be crumbled and placed loosely in the container and the lid shall be replaced. Each specimen of fine grained material shall be at least 30 g and each specimen of medium grained material shall be at least 300 g. Specimens of medium grained material may be tested in several parts each less than 300 g and the results aggregated.

(c) The container and contents shall be weighed to the nearest 0.01g (m_2).

(d) The lid of the specimen container shall be removed and the container with its lid and contents shall be placed in the microwave oven and dried. The specimen shall be considered to be dry when, after an initial drying period, successive weighings at intervals of 1 minute produce results which are the same to the nearest 0.01g. Alternatively, the oven may be set to an appropriate time and power setting to dry the specimen as determined by calibration of the oven on soil of a similar type.

(e) After drying, the container and contents shall be removed from the microwave oven and placed in the desiccator to cool.

(f) The lid shall be replaced and the container and contents shall be weighed to the nearest 0.01g (m_3).

Calculation 6.2.4 The moisture content of the material (w) shall be calculated as a percentage of the dry mass of the material from the equation:

$$w = (m_2 - m_3)/(m_3 - m_1) \times 100\%$$

where:

- m_1 is the mass of the container (g)
- m_2 is the mass of the container and contents before drying (g)
- m_3 is the mass of the container and contents after drying (g)

Reporting of results 6.2.5 The following shall be reported:

(a) Source and identification of the soil.

(b) The moisture content of the material to the nearest 0.1%.

(c) That the test method used was in accordance with this Specification.

APPENDIX 6.3

DETERMINATION OF THE IN-SITU BULK DENSITY AND THE IN-SITU DRY DENSITY OF FINE GRAINED AND MEDIUM GRAINED MATERIAL BY THE NUCLEAR DENSOMETER METHOD

Scope

6.3.1 This method covers the determination of the in-situ bulk density of fine grained and medium grained material by the attenuation of gamma rays and calculation of the in-situ dry density using a moisture content determined in accordance with either GEO Report No. 36, test 2.3.2A or 2.3.2B or Appendix 6.2, whichever as instructed by the Engineer.

Apparatus

6.3.2 The following apparatus is required:

(a) A nuclear device for the measurement of density (densometer). The details of construction of the densometer may vary but the following general requirements shall apply:

- The probe shall be an adjustable probe containing a gamma source which can be readily positioned in a preformed hole. The probe assembly shall be graduated in increments not exceeding 50 mm and shall be constructed in such a manner that it will be securely held in the test depth position.

- The instrumentation shall display the results directly in metric units.

(b) A reference standard of uniform and constant density to establish the background count and count reproducibility.

(c) Site preparation equipment, such as spades, straight-edges, scoops and brushes, required to prepare a suitably cleared and level surface to accommodate the densometer.

(d) A hole forming device, such as an auger or steel pin, to form a hole to accommodate the probe. The device shall have a nominal diameter which exceeds the probe diameter by not more than 3 mm and shall be graduated to indicate the depth of the hole. The device shall have a guide which will ensure that the hole is formed normal to the prepared surface.

(e) Sampling equipment, such as augers, spades, picks, small digging tools, scoops, airtight containers and bags, to obtain samples of the material.

(f) Apparatus for the determination of the moisture content in accordance with either GEO Report No. 36, test 2.3.2A or 2.3.2B or Appendix 6.2, whichever as instructed by the Engineer.

Procedure: comparability of test methods

6.3.3 The procedure for comparing test methods shall be as follows:

(a) Before using the densometer on material for which it has not previously been used, the results of determinations of in-situ bulk density using the densometer shall be compared with the results of determinations of in-situ bulk density in accordance with GEO Report No. 36, test 9.2.2. The location of each determination in accordance with GEO Report No. 36, test 9.2.2 shall correspond to the midpoint of the densometer probe and the gamma sensor. A minimum of ten pairs of determinations shall be carried out.

(b) If the difference between any pair of results does not exceed 0.08 Mg/m^3 and if the densometer produces results which are both higher and lower than those produced in accordance with GEO Report No. 36, test 9.2.2, the densometer may be used without correction.

(c) If either of the criteria stated in Clause 6.3.3(b) is not met, the densometer shall not be used.

Procedure: routine densometer check

6.3.4 The procedure for carrying out a routine densometer check shall be as follows:

(a) The densometer shall be warmed up in accordance with the manufacturer's recommendations.

(b) A standard count shall be carried out in accordance with the manufacturer's recommendations. The standard count shall be carried out by placing the reference standard on a hard, level surface consisting of material with a density of at least 1.6 Mg/m^3. The reference standard shall be placed at a distance of at least 10 m from any other nuclear device and at least 3 m from any large object. At least three count readings shall be taken and the mean of the three readings shall be determined. The mean shall be the standard count reading for the day.

(c) The standard count reading for the day shall be compared with the mean of the standard count readings for the previous 4 days. If the difference is greater than that recommended by the manufacturer or if no recommendation is made and the difference is greater than 1%, the densometer shall not be used.

(d) The densometer shall be left switched on with the probe in the locked position. If the densometer is switched off a further standard count shall be carried out in accordance with Clause 6.3.4(b) and (c).

Procedure: determination of in-situ bulk density

6.3.5 The procedure for determination of the in-situ bulk density shall be as follows:

(a) A level surface of sufficient size to accommodate the densometer shall be prepared and cleared of all disturbed and loose material. The depth of any depression below the densometer shall not exceed 3 mm. Depressions exceeding 3 mm in depth shall be filled using fine sand or material taken from the adjacent soil which passes a 600 μm BS test sieve.

(b) A suitable hole for the probe shall be prepared using the hole forming device. The hole shall be normal to the prepared test area and at least 50 mm deeper than the intended test depth. If a driven pin is used to form the hole, the pin shall be rotated every two or three blows to facilitate its removal.

(c) The test depth shall be the same as the maximum depth required for determination of the in-situ bulk density in accordance with GEO Report No. 36, test 9.2.1 or 9.2.2 as appropriate to the grain size of the material.

(d) The probe shall be positioned and inserted into the hole in such a manner that the gamma source is shielded at all times. The probe shall be seated firmly against the side of the hole nearest to the back of the densometer by gently pulling the densometer backwards until contact is achieved. The operator shall ensure that the densometer is correctly seated and the depth setting on the control panel is the same as the probe depth.

(e) The operator shall ensure that there are no other radioactive sources within 10 m of the densometer.

(f) Three readings of the in-situ bulk density shall be taken in accordance with the manufacturer's recommendations and the mean determined. If any one reading differs from any other reading by more than 0.015 Mg/m^3, additional readings shall be taken until three consecutive readings which do not differ by more than 0.015 Mg/m^3 are obtained and the mean determined. The mean of the three readings shall be taken as the in-situ bulk density (IBD). If the above criterion is not met after six readings, the densometer shall not be used.

(g) The densometer shall be removed and a minimum 500 g sample of the material directly beneath the densometer position shall be taken for determination of the moisture content. The sample shall be obtained by augering or digging to the test depth. The sample shall be placed in a moisture tight container and the lid replaced. The moisture content (w) shall be determined in accordance with either GEO Report No. 36, test 2.3.2A or 2.3.2B or Appendix 6.2, whichever as instructed by the Engineer.

(h) If a sample of material at the same location as the densometer test is required for determination of the maximum dry density or the maximum converted bulk density, the sample shall be obtained by digging to the test depth, keeping the sides of the excavation vertical and the bottom flat and level. The appropriate quantity of material required for the test shall be taken, placed in a moisture tight container and the container sealed.

Calculation 6.3.6 The in-situ dry density of the material (IDD) shall be calculated from the equation:

$$IDD = IBD/\left(1 + \frac{w}{100}\right) Mg/m^3$$

where:

- IBD is the in-situ bulk density of the material (Mg/m3)
- w is the moisture content of the material (%)

Reporting of results 6.3.7 The following shall be reported:

(a) The location of the test.

(b) The in-situ dry density to the nearest 0.01 Mg/m3.

(c) The moisture content to the nearest 0.1%.

(d) That the test method used was in accordance with this Specification.

APPENDIX 6.4

DETERMINATION OF THE MAXIMUM CONVERTED BULK DENSITY BY THE HILF METHOD

Scope

6.4.1 This method covers the determination of the maximum converted bulk density and the difference between the optimum moisture content and the in-situ moisture content of a material by relating the converted bulk density and the moisture added.

Apparatus

6.4.2 The following apparatus is required:

(a) Apparatus in accordance with GEO Report No. 36, test 4.3.3A or 4.3.3B, whichever as instructed by the Engineer.

(b) Apparatus for determination of the moisture content in accordance with either GEO Report No. 36, test 2.3.2A or 2.3.2B or Appendix 6.2, whichever as instructed by the Engineer.

(c) Apparatus to extract specimens from the mould.

(d) Apparatus, such as a warm air blower, for rapid drying of the material.

Procedure

6.4.3 The procedure shall be as follows:

(a) A sample of material shall be taken immediately after completing the in-situ bulk density test at the same location as the test. The sample shall be obtained by digging to the same depth as that of the in-situ bulk density test, keeping the sides of the excavation vertical and the bottom flat and level. The size of the sample shall be sufficient to yield a minimum of 10 kg after screening over a 20 mm BS test sieve.

(b) The sample shall be weighed to the nearest 0.01 g.

(c) The sample shall be screened over a 20 mm BS test sieve, ensuring that moisture loss is kept to a minimum and that any free moisture appearing in the containers is worked back into the sample.

(d) The amount retained on the sieve shall be weighed to the nearest 0.01 g and expressed as a percentage of the mass of the sample. If the percentage exceeds 5%, an adjustment for coarse material shall be made in accordance with Appendix 6.5. If the percentage does not exceed 5%, no adjustment is required.

(e) The material to be tested shall be thoroughly mixed and divided by quartering or by using a riffle box to obtain a minimum of four specimens of at least 2500 g each, ensuring that moisture loss is kept to a minimum. Alternatively, if it has previously been ascertained that the material is not susceptible to crushing, a single specimen of at least 2500 g may be used for repeat testing.

(f) Each specimen shall be weighed to the nearest 0.01 g and the result shall be taken as the mass of the specimen at the in-situ moisture content.

(g) Each specimen and any remaining material shall be placed in separate moisture-tight containers and the containers sealed.

(h) The converted bulk density of at least three specimens shall be plotted against the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content (z) on a graph as shown in Civil Engineering Department Standard Drawing No. C2006, in accordance with the procedure stated in Clause 6.4.3(i) to (o).

(i) The first point on the graph shall be obtained as follows:

- A specimen shall be compacted at its in-situ moisture content in accordance with GEO Report No. 36, test 4.3.3A, Clause 4.3.3.A.4 or test 4.3.3B, Clause 4.3.3.B.4, whichever as instructed by the Engineer.

- A diametrical slice of approximately 400 g to 500 g shall be cut from the specimen along its entire length. The in-situ moisture content of the slice (w_i) shall be determined in accordance with either GEO Report No. 36, test 2.3.2A or 2.3.2B or Appendix 6.2, whichever as instructed by the Engineer.

- The bulk density (BD_1) shall be calculated as stated in Clause 6.4.4(1) and plotted on the 0% ordinate of the graph as the converted bulk density (CBD_1).

(j) The second point on the graph shall be obtained as follows:

- A second specimen shall be examined and, if the in-situ moisture content obviously exceeds the optimum moisture content, the procedure stated in Clause 6.4.3(k) shall be followed.

- The moisture content of the specimen shall be increased by adding an amount of water equal to 2% of the mass of the specimen. The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.4.3(i).

- The bulk density (BD_2) shall be calculated as stated in Clause 6.4.4(1), adjusted to converted bulk density (CBD_2) as stated in Clause 6.4.4(2) and plotted on the +2% ordinate of the graph.

(k) If the in-situ moisture content of the second specimen obviously exceeds the optimum moisture content, the specimen shall be dried until the amount of water removed is approximately 2% of the mass of the specimen and cooled. The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.4.3(i). The amount of water removed shall be determined. The bulk density (BD_2) shall be calculated as stated in Clause 6.4.4(1),

adjusted to converted bulk density (CBD_2) as stated in Clause 6.4.4(2) and plotted on the negative ordinate of the graph at a point which corresponds to the amount of water removed.

(l) The third point on the graph shall be obtained as follows:

- If the plotted value of CBD_2 is equal to or greater than the plotted-value of CBD_1, the moisture content of a third specimen shall be increased by adding an amount of water equal to 4% of the mass of the specimen. Alternatively, if the procedure stated in Clause 6.4.3(k) has been followed, the specimen shall be dried until the amount of water removed is approximately 4% of the mass of the specimen after cooling.

- If the plotted value of CBD_2 is less than the plotted value of CBD_1, the third specimen shall be dried until the amount of water removed is approximately 2% of the mass of the specimen after cooling. Alternatively, if the procedure stated in Clause 6.4.3(k) has been followed, the moisture content shall be increased by adding an amount of water equal to 2% of the mass of the specimen.

- The specimen shall be thoroughly mixed and compacted in accordance with the method stipulated in Clause 6.4.3(i). The amount of water removed shall be determined.

- The bulk density (BD_3) shall be calculated as stated in Clause 6.4.4(1), adjusted to converted bulk density (CBD_3) as stated in Clause 6.4.4(2) and plotted on the graph at a point which corresponds to the amount of water added or removed.

(m) If the centre point of the three points plotted is lower than one of the other two points, or is higher than one point and equal to the other, an additional point or points shall be obtained by proceeding in 2% increments or decrements as appropriate.

(n) If it is apparent that the moisture condition of the material is such that a total of five points will not result in the determination of the optimum moisture content, increments and decrements of 3% moisture content may be adopted for the entire procedure.

(o) A smooth approximately parabolic curve shall be drawn to the plotted points. The peak value of the curve shall be determined as the maximum converted bulk density (MCBD).

(p) The amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density shall be determined (z_m).

(q) The value of the moisture correction curve passing through the peak value of the plotted parabolic curve shall be determined (z_c). If there is no moisture correction curve passing through the peak value of the curve, a moisture correction curve shall be drawn through the peak by interpolating to the nearest 0.1%.

Calculation 6.4.4 (1) The bulk density (BD) shall be calculated from the equation:

$$BD = (m_2 - m_1)/V \quad Mg/m^3$$

where:

- m_1 is the mass of the mould and base (g)
- m_2 is the mass of the mould, base and wet material (g)
- V is the volume of the mould (mL)

(2) The converted bulk density (CBD) shall be calculated from the equation:

$$CBD = BD/(1+z/100) \quad Mg/m^3$$

where:

- z is the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content
- z is negative for values below the in-situ moisture content

(3) The difference between the optimum moisture content (w_o) and the in-situ moisture content (w_i) of the material shall be calculated from the equation:

$$w_o - w_i = z_m + z_c \quad \%$$

where:

- z_m is the amount of water added or removed as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density (%)
- z_c is the value of the moisture correction curve passing through the peak value of the plotted parabolic curve (%)

(4) The optimum moisture content (w_o) shall be calculated from the equation:

$$w_o = w_i + (1 + w_i/100)\, z_m \quad \%$$

where:

- w_i is the in-situ moisture content of the material (%)

(5) The maximum dry density (MDD) shall be calculated from the equation:

$$MDD = MCBD/(1 + w_i/100) \quad Mg/m^3$$

where:

- MCBD is the maximum converted bulk density of the material (Mg/m^3)

(6) The relative compaction (RC), if required, shall be calculated from the equation:

RC = IBD/MCBD x 100%

where:

- IBD is the in-situ bulk density of the material determined in accordance with GEO Report No. 36, test 9.2.1 or 9.2.2 as appropriate to the grain size of the material or in accordance with Appendix 6.3

Reporting of results 6.4.5 The following shall be reported:

(a) Source and identification of the soil.

(b) The graph showing the plotted points and the parabolic curve passing through them.

(c) The maximum converted bulk density to the nearest 0.01 Mg/m^3.

(d) The optimum moisture content to the nearest 0.1%.

(e) The maximum dry density to the nearest 0.01 Mg/m^3.

(f) The relative compaction to the nearest 0.1%, if determined.

(g) The percentage retained on the 20 mm BS test sieve and the percentage retained on the 37.5 mm BS test sieve to the nearest 1%, if applicable.

(h) Whether the test was carried out using individual specimens or repeat testing of a single specimen.

(i) Whether a manual or an automatic compaction rammer was used.

(j) That the test method used was in accordance with this Specification.

APPENDIX 6.5

ADJUSTMENT OF THE MAXIMUM CONVERTED BULK DENSITY FOR THE DETERMINATION OF THE RELATIVE COMPACTION

Scope

6.5.1 This method covers the adjustment of the maximum converted bulk density determined in accordance with Appendix 6.4 for the determination of the relative compaction of a material containing more than 5% of the mass of the material at the in-situ moisture content retained on a 20 mm BS test sieve.

Apparatus

6.5.2 The following apparatus is required:

(a) Apparatus in accordance with Appendix 6.4.

(b) A 20 mm and a 37.5 mm BS test sieve.

(c) A mould with collar as used for determination of the California Bearing Ratio (CBR mould).

(d) An extrusion device as used for determination of the California Bearing Ratio.

Procedure

6.5.3 The procedure shall be as follows:

(a) If the amount of material retained on the 20 mm BS test sieve exceeds 5% and does not exceed 20%, the material passing the sieve shall be compacted in accordance with Appendix 6.4. The maximum converted bulk density ($MCBD_{20}$) shall be determined and adjusted as stated in Clause 6.5.4.

(b) If the amount of material retained on the 20 mm BS test sieve exceeds 20%, the retained material shall be screened over the 37.5 mm BS test sieve. The procedure stated in either Clause 6.5.3(c) or Clause 6.5.3(d) as appropriate shall be followed.

(c) If the amount of material retained on the 37.5 mm BS test sieve does not exceed 5%, the procedure stated in Clause 6.5.3(e) shall be followed.

(d) If the amount of material retained on the 37.5 mm BS test sieve exceeds 5% and does not exceed 20%, the retained material shall be replaced with an equal mass of material which is of a similar nature and which is retained on a 20 mm BS test sieve but passes a 37.5 mm BS test sieve. The procedure stated in Clause 6.5.3(e) shall be followed.

(e) The procedure stated in Appendix 6.4 shall be followed except that the material shall be compacted into the CBR mould and each layer shall be subjected to 62 blows of the rammer.

Calculation

6.5.4 The maximum converted bulk density (MCBD) shall be calculated from the equation:

$$MCBD = MCBD_{20}\left[1 + \frac{m}{1 + \frac{z}{100}}\left(1 - \frac{MCBD_{20}}{G_s}\right)\right] Mg/m^3$$

where:

- $MCBD_{20}$ is the maximum converted bulk density of the material passing the 20 mm BS test sieve (Mg/m^3)
- z is the amount of water added as a percentage of the mass of the specimen at the in-situ moisture content corresponding to the maximum converted bulk density (%)

Reporting of results

6.5.5 The following shall be reported:

(a) The source and identification of the soil.

(b) The results in accordance with Appendix 6.4.

(c) The mass of the original material not passing the 20 mm and 37.5 mm BS test sieve as a percentage of the mass of the material at the in-situ moisture content to the nearest 0.1%.

(d) The type of mould used.

(e) The number of blows per layer.

(f) Whether the specific gravity was measured or assumed and, if measured, the method used.

(g) That the test method used was in accordance with this Specification, and the results have been adjusted in accordance with this Appendix.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 7

GEOTECHNICAL WORKS

SECTION 7

GEOTECHNICAL WORKS

PART 1: GENERAL REQUIREMENTS

GENERAL

General requirements	7.01	The works and materials specified in Clauses 7.02 to 7.05 shall comply with the sections stated, unless otherwise stated in this Section.
Site clearance	7.02	Site clearance shall comply with Section 2.
Drainage works	7.03	Drainage works shall comply with Section 5.
Earthworks	7.04	Earthworks shall comply with Section 6.
Concrete	7.05	Concrete shall comply with Section 16.
Prestressed ground anchors	7.06	Prestressed ground anchors shall comply with the requirements stated in the Contract.
Reinforced fill structures	7.07	Reinforced fill structures shall comply with the requirements stated in the Contract.

TRIALS

Trials for geotechnical works	7.08	Details of trials to be carried out for geotechnical works shall be as stated in the Contract.

PART 2: GROUND INVESTIGATION

GLOSSARY OF TERMS

Block sample	7.09	Block sample is an undisturbed sample recovered by in-situ hand trimming of a block of material from the surrounding soil.
Bulk sample	7.10	Bulk sample is a sample of at least 10 kg mass which is representative of the grading of the material at the point of sampling.
Inspection pit	7.11	Inspection pit is a pit for locating and identifying underground utilities and structures.
Jar sample	7.12	Jar sample is a disturbed sample of at least 0.7 kg mass contained in a transparent airtight jar which has a screw cap with an airtight sealing ring.
Mazier sample	7.13	Mazier sample is an undisturbed sample recovered by rotary drilling using a Mazier triple tube core barrel which has inner tubes protruding proud of the outer tube to protect the material being sampled from disturbance.
Sample	7.14	Sample is any quantity of material obtained from the ground for the purposes of inspection, logging or testing.
Slope surface stripping	7.15	Slope surface stripping is the removal of surface protection and vegetation from existing slopes to expose underlying soil or rock for inspection.
Trial pit	7.16	Trial pit is a pit for inspecting and logging the ground and in which to carry out in-situ testing and sampling.
U 100 and U 76 samples	7.17	U 100 and U 76 samples are undisturbed samples recovered by advancing a thin-walled tube with a cutting edge into the soil.
Undisturbed soil sample	7.18	Undisturbed soil sample is a sample complying with Class 1 or Class 2 of BS 5930.

SUBMISSIONS

Particulars of ground investigation 7.19 (1) The following particulars of proposed materials and methods for ground investigation shall be submitted to the Engineer:

(a) details of drilling and in-situ testing equipment,

(b) details of sampling equipment, and

(c) details of filter materials and fill materials for drilling and testing,

(2) The particulars shall be submitted to the Engineer for approval at least 7 days before the relevant work starts.

INSPECTION PITS, TRIAL PITS AND SLOPE SURFACE STRIPPING

Inspection pits 7.20 Inspection pits shall be formed by manual methods.

Trial pits 7.21 (1) The plan dimensions at the bottom of a trial pit shall be at least 1.2 m x 1.2 m; the sides of trial pits shall be vertical.

(2) The sides of trial pits shall be trimmed by manual methods to remove all disturbed material. Supports to the sides of trial pits shall be such that the cut surface is clearly visible throughout the height of each face.

(3) The permission of the Engineer shall be obtained before fill material is deposited in trial pits.

Slope surface stripping 7.22 (1) Slope surface stripping shall start at the top of the slope and shall proceed downwards. All loose material remaining on the slope after stripping shall be removed.

(2) Access shall be provided for inspection by the Engineer.

(3) Stripped areas shall be covered up at the end of each working day and during rainstorms to prevent the ingress of water into the slope.

(4) Stripped areas shall be reinstated in form, colour and conditions similar to the original. The permission of the Engineer shall be obtained before reinstatement starts.

Records of inspection pits 7.23 Records of inspection pits shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 3 days after each inspection pit has been excavated. The report shall contain details of the positions, depths and dimensions of all utilities and structures encountered in each inspection pit.

Records of trial pits and slope surface stripping 7.24 (1) Each trial pit shall be photographed as soon as excavation is complete. The full face of each of the sides and the bottom of the trial pit shall be photographed individually. One copy of specimen prints of 127 mm x 76 mm size shall be submitted to the Engineer for approval before fill material is deposited in the trial pit. The photographs shall contain the following information:

(a) number of trial pit and site reference,

(b) measuring scale bar, and

(c) a suitable colour comparison chart placed alongside the trial pit face.

(2) Records of trial pits shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 7 days after each trial pit has been excavated. The report shall contain the following:

(a) details shown, and in the format shown in Figure 7 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government 1987,

(b) details of depths and rate of groundwater seepage,

(c) details of water levels, including dates and details of fluctuation,

(d) four sets of photographs or composite photographs as stated in Clause 7.24 (1); the photograph of each face shall occupy the full height of an A4 size page.

(3) Records of slope surface stripping shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 7 days of the surface stripping. The report shall contain a detailed geological description of the materials exposed, and details and locations of groundwater seepage.

DRILLING FOR GROUND INVESTIGATION

Drilling rigs for ground investigation 7.25

(1) Drilling rigs for ground investigation shall be the hydraulic feed type and shall have a rating of at least 26.5 kW to drive a rotary tool tipped with diamonds or tungsten carbide. Drilling rigs shall be capable of drilling in the specified sizes and to the specified depths without excessive vibration.

(2) The weight of each rig shall be such that a force of 12 kN can be applied to the drilling bit without movement of the rig.

(3) Drilling rigs shall be capable of providing stable drill-string rotation at speeds of between 50 r/min and 1250 r/min and have a ram stroke length of at least 600 mm. The rigs shall be fitted with a tachometer and a hydraulic feed pressure gauge, both of appropriate scales, and a device for measuring the rate of penetration of the drill strings.

(4) Triplex or similar type pumps shall be used when the flushing medium is water; the pumps shall be equipped with a gear box and shall be capable of delivering up to 2 L/s. The pumps shall incorporate a surge bottle to reduce fluctuations in water pressure and the suction hose shall be fitted with a suitable filter. The pumps shall have a by-pass system allowing full control of water flow at all pump delivery rates.

Drilling equipment for ground investigation 7.26

(1) The core barrels, drill rods and drill bits of drilling equipment for ground investigation shall be of a type appropriate to the purpose of the drilling and sampling. Accessories and spare parts shall be compatible with the equipment in use and with each other. Spare drill bits shall be available for use during drilling.

(2) The size of casings shall be appropriate to the drilling, coring, sampling, testing and other installation requirements.

(3) Core barrels for sampling soil shall be equipped with a sediment catcher tube. The tube shall have the same external diameter as the core barrel and shall be approximately 0.75 m long.

(4) Casings shall be used to stabilize caving ground. The size of casing and drill rod in use shall be appropriate to the size of core barrel in use. Casings and drill rods shall be straight and in good condition and shall be clean at the time of drilling and free from scale, dirt and other loose material.

(5) Only regular lengths of casings and drill rods shall be used and imperial and metric lengths shall not be mixed.

(6) Short lengths of drill rods shall be used to enable continuous coring to be carried out in such a manner that each core run can be completed within one ram stroke.

(7) Short lengths of casing not exceeding the ram stroke length shall be used to enable casings to be advanced after each core run where necessary.

(8) Core barrels and drill rods shall be stored on steel frame trestles.

Drilling for ground investigation

7.27 (1) Drillholes for ground investigation shall be sunk by rotary methods. The methods and equipment used shall be such that:

(a) the overall hole alignment is within 2% for vertical drillholes and is within 5% of the specified alignment for non-vertical drillholes,

(b) the soil encountered and the levels at which changes in ground conditions occur can be accurately identified,

(c) the specified sampling requirements can be achieved,

(d) in-situ tests can be carried out and field installations can be incorporated at any depth in the drillhole, and

(e) consistency of measurement and minimal disturbance of the ground is achieved.

(2) Casings shall be advanced concurrently with the removal of material in such a manner that loss of ground is avoided.

(3) Larger casings shall be set concentric with drillholes which are being reamed.

(4) The flushing medium for drilling shall be clean water; other substances or materials shall not be introduced into drillholes unless permitted by the Engineer. The flushing medium for drilling shall be passed through a sedimentation basin and shall either be reused or be discharged to surface drains or natural stream courses. Measures shall be taken to prevent flushing mediums seeping through the ground.

(5) The flushing medium for drilling shall not be discharged to stream courses which are used as a supply of drinking water.

Sampling from drillholes

7.28 (1) Jar samples from drillholes shall be taken from the cutting shoe of each undisturbed sample, from any anomalous material, from each standard penetration test and at other locations as instructed by the Engineer.

(2) All loose material and material disturbed by drilling or in-situ tests shall be removed from the sides and bottom of the drillhole before each undisturbed sample is taken.

Filling drillholes

7.29 (1) Granular fill material of a type agreed by the Engineer, or 4:1 cement bentonite grout where instructed by the Engineer, shall be deposited in drillholes for ground investigation and compacted to the same relative compaction as the surrounding ground. The casing shall be gradually withdrawn; the fill material shall be kept above the bottom of the casing during withdrawal. Subsequent depressions in the ground surface shall be filled and reinstated. The drillhole position shall be marked with a metal marker and flag or a 300 mm x 300 mm x 150 mm thick concrete block; the hole number shall be inscribed on the surface and highlighted in red paint.

(2) The permission of the Engineer shall be obtained before fill material is deposited in drillholes and before the casing is withdrawn. The ground surface around drillholes shall be reinstated as soon as practicable after the fill material has deposited and compacted in each drillhole.

Records of drillholes

7.30 (1) Records of drillholes for ground investigation shall be kept by the Contractor on the Site and two copies of a preliminary drillhole log, stamped PRELIMINARY, shall be submitted to the Engineer within 3 days after completion of each drillhole. Drillhole logs shall be comprehensive and shall be in a form similar to that shown in Figure 44 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987; soil and rock descriptions shall comply with those stated in the insert titled `Checklist for Soil Descriptions' and `Checklist for Rock Descriptions' in `Geoguide 3: Guide to Rock and Soil Descriptions', Hong Kong Government, 1988 or with any other system agreed by the Engineer.

(2) Drillhole logs shall be drawn to a constant vertical scale of 1:50 unless otherwise agreed by the Engineer and shall contain the following details:

(a) information shown and in the format in Figure 44 and paragraphs 40.2.6 (2), (4) and (5) of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987,

(b) reduced levels of observation well bases, piezometer tips, and sand filter layers,

(c) details of utilities identified in the inspection pit excavated at the drillhole location.

SAMPLING FOR GROUND INVESTIGATION

Sampling equipment for ground investigation

7.31 Sampling equipment and containers for ground investigation shall comply with BS 5930 and the following:

(a) For general purpose open tube samples and thin-walled samples, the sample tube and cutting shoe shall be free from rust, pitting, burring or any other defect. The use of oil inside the sampler shall be limited to the minimum practical. Each sample tube shall have a unique reference number and the word `TOP' engraved on its exterior at one end. The sample tube shall be driven with the end marked `TOP' uppermost. The dimensions, construction and condition of each sample tube, cutting shoe and adaptor head shall be approved by the Engineer prior to sampling. The adaptor head shall be fitted with a ball valve to permit the exit of air or water during driving and to assist in retaining the sample during withdrawal, and it shall have an allowance for over-driving. In soil of low cohesion such as silts and silty fine sands the sampler shall be equipped with a basket core retainer to enhance core recovery.

(b) U100, U76 and U40 thin-walled samplers shall be approved 102 mm (for U100), 78 mm (for U76) and 42 mm (for U40) diameter open drive sample tubes made from thin-walled seamless cadmium plated or stainless steel not less than 450 mm (for U100), 350 mm (for U76) and 200 mm (for U40) in length fitted with a cutting shoe tapered at an angle not exceeding 20°. The area ratio of the sampler as defined in Figure 13 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987 shall not exceed 30%.

(c) Piston samplers shall be a thin-walled fixed piston sampler to the approval of the Engineer. The piston sampler shall be capable of operating to a depth of at least 20 m below ground level with no lateral movement during the actual sampling operation. The design and maintenance of the sampler shall be such that a partial vacuum is formed over the retained sample in the tube. The minimum recovered sample length shall be 900 mm. The thin-walled tube shall have an external diameter of 75 mm or 100 mm as instructed by the Engineer. The area ratio of the sampler as defined in Figure 13 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987 shall not exceed 10%.

(d) Mazier samplers shall be a Mazier triple-tube core barrel fitted with a detachable rigid PVC inner tube, 2 mm thick, 74 mm internal diameter by 1000 mm long having a detachable projecting cutting shoe which perforates the soil and insulates the core sample from the drilling fluid. The internal diameter of the projecting shoe should not differ by more than 2 mm. The dimensions of the sampler shall not differ by more than ±0.50 mm from those shown in Table 7.1 unless approved by the Engineer. A basket core retainer shall be fitted at the bottom of the PVC inner tube to assist in recovery of the core. The length of the sample recovered shall not be less than 750 mm. A triple-tube core barrel of alternative design may be submitted for the Engineer's approval.

(e) Split spoon samplers for the standard penetration test shall be provided with a thin smooth stainless steel or similar approved liner of 35 mm internal diameter.

Table 7.1 Dimensions of Mazier Core Barrel Sampler

Item		Dimension (mm)
Inner Barrel Cutting Shoe	ID	72.0
	OD	77.2
Core bit	OD	101.1
Liner tube	ID	74.0
Inner tube barrel	ID	78.0
	OD	88.5
Outer tube barrel	OD	98.5

Sampling for ground investigation

7.32 (1) A reference number shall be assigned to each soil sample taken from a drillhole or trial pit. The number shall be unique for that drillhole or trial pit and shall be in order of depth below ground level.

(2) The visible ends of each undisturbed sample shall be trimmed of any disturbed material immediately after recovery from the ground. The sides of the tube or box shall be cleaned and the ends of the sample shall be coated with three successive thin films of just-molten microcrystalline wax. A metal foil disc or plate shall be added and followed by more molten wax to give a total thickness of at least 20 mm. Any space remaining in the ends of the sample tube or box shall be solidly filled with damp sawdust and the ends of the sample tube shall be covered with tight fitting rubber caps.

(3) Each sample shall be identified by a label. The label shall be written with permanent ink and protected from moisture, damage and loss. The minimum labelling requirements shall be as follows:

(a) All labels shall contain the following information:

- name of contract,
- name or reference number of the site,
- reference number, location and angle of borehole,
- reference number of sample,
- date of sampling,
- brief description of the sample,
- depth of the top and the bottom of the sample below ground level,
- location and orientation of the sample if taken from a trial pit.

(b) For jar samples, a stick-on label covered with a transparent plastic cover shall be secured with adhesive tapes to the body of the jar.

(c) For undisturbed and bulk samples, a permanent or stick-on label covered with a transparent plastic sheet shall be secured with adhesive tape to the body of the container. An additional label giving the sample reference number and depth of sample shall be sealed in with the sample.

(d) For core samples stored in core boxes, a stapled card, stick-on label or permanent ink shall be used externally on the front of the box and repeated inside. The hole reference number shall be written in permanent ink or paint on each end of the core box.

Storage and delivery of samples for ground investigation 7.33 (1) Samples for ground investigation shall be delivered to, and stored at, a core store at a location agreed by the Engineer. Samples shall be delivered to the testing laboratory at a time agreed by the Engineer.

(2) Undisturbed soil samples shall be stored and delivered in a wooden crate of appropriate dimensions. The samples shall be kept in an upright position with a separate compartment for each sample. The compartment shall be properly padded and the lower end of the sample shall be placed in the bottom of the compartment.

(3) The samples shall not be disturbed during transportation, handling and storage.

Bulk samples 7.34 Bulk samples shall be obtained from undisturbed ground. Each bulk sample shall be sealed into a metal or plastic container immediately after it has been taken.

Mazier samples 7.35 Mazier samples shall be taken by a Mazier sampler or an equivalent triple-tube core barrel approved by the Engineer and in accordance with Clause 7.31.

U 100/76 samples 7.36 (1) Sample tubes shall be advanced by jacking action unless otherwise permitted by the Engineer. The jack shall be arranged to align with the sampler. Measures shall be taken to prevent lateral movement during the sampling operation.

(2) Each U 100 sample shall contain at least 300 mm net length of undisturbed material and each U 76 sample shall contain at least 200 mm net length of undisturbed sample.

Block samples 7.37 (1) Block samples shall be taken from the sides or bottom of trial pits at locations and orientations instructed by the Engineer.

(2) Each block sample shall be at least 230 mm x 230 mm x 230 mm and shall be excavated, trimmed, cut, wrapped, waxed and packed in metal or wooden boxes in accordance with the procedure stated in Part A of Des. E-2 of the United States Bureau of Reclamation Earth Manual.

Rock cores 7.38 (1) Rock cores obtained from drillholes shall be removed from the core barrel without damage by gentle hammering with a wooden mallet on the side of the core barrel to free wedges pieces; other methods shall not be used.

(2) As the rock core is extruded, it shall be arranged in the box in sequence starting with the shallowest core on the left side of the box against the hinge and working along the slat and subsequently outwards towards the staple. The depths at which each core run started and finished shall be recorded within the box by painting on wooden blocks which fit between the dividing slats. Fractured rock core shall be spread throughout its length and packed securely. Rock core losses shall be shown by wooden blocks or polystyrene of a square cross section to fill the core box; the length of the wooden block or polystyrene shall be equal to the length of core lost.

IN-SITU TESTING

Standard penetration tests 7.39 (1) The apparatus and procedure for standard penetration tests shall comply with BS 1377:1975, test 19. The drive hammer shall be a type incorporating an automatic trip mechanism to ensure free fall. The 60° solid core shoe shall be used in soil containing coarse gravel.

(2) A thin smooth stainless steel or aluminum liner of 35 mm internal diameter shall be fitted in the split-spoon sampler during the standard penetration test. After the sampler has been withdrawn from the drillhole, the liner and the retained soil shall be treated in the same manner as an undisturbed sample.

(3) Standard penetration tests shall be carried out below the level of the casing. The base of the drillhole shall be fully cleaned before the test starts. Jar samples shall be taken from the split-barrel shoe after each test.

(4) The number of blows of the drive hammer required to achieve each 75 mm of shoe penetration until a total penetration of 450 mm has been achieved shall be recorded. The N-value shall be recorded as the sum of the number of blows of the drive hammer required to achieve the last 300 mm of shoe penetration. The number of blows recorded for the initial 150 mm of shoe penetration shall not be included in the N-value calculation. If any increment of 75 mm of shoe penetration is not achieved after 100 blows of the drive hammer, the number of blows and the penetration achieved shall be recorded and the test shall be terminated.

GEO probe tests 7.40 GEO probe tests shall be carried out in accordance with Appendix 7.1. The GEO probe hole shall be sealed with cement grout on completion of the test for at least the top 600 mm of the hole. The grout shall consist of cement and water in the proportions 0.4:1 by mass.

In-situ density test 7.41 (1) In-situ density tests shall be carried out by the sand replacement method in accordance with Clause 6.68(5) and (6) or by other methods permitted by the Engineer.

(2) A jar sample shall be taken at each location where an in-situ density test is carried out.

Rising and falling head permeability tests

7.42 (1) Rising and falling head permeability tests shall be carried out using the apparatus described in Figure 27 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987. The method of testing shall be in accordance with Figure 30 of `Geoguide 2: Guide to Site Investigation', the method of flushing of the bottom of the drillhole stated in Clause 7.42(4) shall be used. The type of filter material and sand to be used shall be in accordance with Clause 7.218(2), and shall be placed in the drillhole using a tremie pipe.

(2) Rising head permeability tests shall be carried out by lowering the water level in the standpipe by approximately 3 m. The water level in the standpipe shall be allowed to rise to equalise with the ground water level and the time for each 0.2 m rise in water level shall be recorded.

(3) Falling head permeability tests shall be carried out by raising the water level in the standpipe by approximately 3 m. The water level in the standpipe shall be allowed to fall to equalise with the ground water level and the time for each 0.2 m drop in water level shall be recorded.

(4) The method of flushing of the bottom of the hole for field permeability tests shall be as follows:

(a) Clean water shall be introduced to the cased hole through a 38 mm diameter pipe fed from a storage tank. The feed pipe shall contain a perforated section 480 mm in length consisting of 20 rings of holes, at 25 mm centres, each containing 4 holes of 6 mm diameter. The complete perforated section shall be positioned such that it is just below the existing ground water level in the borehole. The end of the perforated section of pipe shall be capped.

(b) The flushing water shall be withdrawn from the casing through a 38 mm diameter pipe positioned with its open end between 150 mm and 200 mm above the base of the borehole. The discharge shall be by means of a pump of sufficient capacity to extract the flushing water from the base of the borehole. Control of the flow of clean water and discharge water shall be by means of valves positioned on the inflow pipe and the discharge pipe.

Constant head permeability tests

7.43 (1) Constant head permeability tests shall be carried out using the apparatus described in Clause 7.42(1). Clean water shall be fed into the standpipe at a constant rate and the time for each 0.2 m rise in water level shall be recorded until either a constant water level is established or until the water level is 0.3 m below the top of the casing. The constant rate of inflow which is required to maintain a constant head shall be recorded.

(2) After a constant water level has been achieved as stated by Clause 7.43(1), the cumulative inflow readings required to maintain the constant head shall be recorded in the following sequence:

(a) 4 readings at 15 second intervals,

(b) 9 readings at 1 minute intervals,

(c) 4 readings at 5 minute intervals, and

(d) readings at 10 minute intervals until two consecutive readings differ by less than 0.5 litre.

Records of in-situ testing

7.44 (1) Records of each in-situ test shall be kept by the Contractor on the Site. The permission of the Engineer shall be obtained before test apparatus is dismantled.

(2) The results of standard penetration tests shall be recorded on drillhole logs as stated in Clauses 7.30 and 7.45.

(3) The results of GEO probe tests shall be recorded as stated in Clause 7.40 and shall be submitted to the Engineer within 3 days after the test.

(4) The results of in-situ density tests shall be recorded in a form agreed by the Engineer and shall be submitted to the Engineer within 24 hours after the test.

(5) The results of rising, falling and constant head permeability tests shall be recorded as stated in Clauses 7.42 and 7.43 and shall be submitted to the Engineer within 3 days after the test. The results of the rising and falling head permeability tests shall be recorded in the format shown in Figure 30 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government, 1987.

REPORTS FOR GROUND INVESTIGATION

Reports for ground investigation

7.45 (1) Daily records of ground investigation operations shall be kept by the Contractor on the Site and two copies of the records shall be submitted to the Engineer within 3 days after the ground investigation operation to which they refer. The daily records shall contain the following information in a form agreed by the Engineer:

(a) Contractor's name, job and contract number, borehole reference number and inclination, site name, rig type and number, operator, hours worked with times, date, weather, ground level at borehole and measured water levels in the borehole at various times.

(b) The daily site record shall also include, for each sample, drilling or core run for each test, installation or strata encountered, the following where applicable:

- start and finish depths below ground level,
- start and finish times,
- casing diameter and depth,
- bit number and type,
- sample reference number and type,
- SPT test result in number of blows recorded,
- percentage water returns and core recovery,
- a description of the soil and rock strata or sample,
- a description of field tests or instruments installed.

(2) A final report on ground investigation operations shall be prepared by the Contractor and shall be submitted to the Engineer within 15 days after all comments on the preliminary drillhole logs have been received from the Engineer. The report shall contain the drillhole logs and test records.

PART 3: SLOPE TREATMENT WORKS

MATERIALS

Cement mortar 7.46 (1) Cement mortar for in-filling joints in rock faces, for bedding rock for masonry infilling and for surfacing slopes shall consist of OPC and sand in the proportions 1:3 by volume.

(2) OPC shall comply with BS 12.

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

Rock for masonry infilling 7.47 Rock for masonry infilling shall not exceed 300 mm in size and shall be obtained from a source approved by the Engineer.

Soil-cement 7.48 (1) Soil-cement shall consist of OPC, sand and inorganic soil in the proportions 1:3:12 by mass.

(2) OPC shall comply with BS 12.

(3) Sand shall comply with BS 1200.

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

Chunam 7.49 (1) Chunam for surfacing shall consist of OPC, hydrated lime and inorganic soil in the proportions 1:3:20 by mass.

(2) OPC shall comply with BS 12.

(3) Hydrated lime shall comply with BS 890, Class A.

(4) Inorganic soil shall be as stated in Clause 7.48 (4).

Aggregates for sprayed concrete 7.50 The nominal maximum aggregate size of aggregates for sprayed concrete shall not exceed 10 mm.

Reinforcement for sprayed concrete 7.51 Unless otherwise approved by the Engineer fabric reinforcement for sprayed concrete shall be to BS 4483.

Protective mesh and fixings 7.52 (1) Protective mesh for slopes shall be PVC coated galvanized steel wire woven into a double twist hexagonal mesh; each hexagon shall be 80 mm x 60 mm. The steel wire shall be at least 2.2 mm diameter and the PVC coating shall be at least 0.4 mm thick.

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

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

(4) Bolts for permanent protective screens shall be galvanized to a minimum average mass coating of 610 g/m^2.

(5) Galvanizing shall comply with BS 729.

Rock bolts 7.53 (1) Rock bolts shall be a proprietary type approved by the Engineer. Rock bolts shall comply with CS 2 and shall be mild steel or high yield deformed steel as stated in the Contract. Rock bolts shall be galvanized to a minimum average mass coating of 610 g/m^2 in accordance with BS 729.

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

Grout for rock bolts 7.54 Grout for rock bolts shall be as stated in Clauses 7.114 and 7.122 except that the water cement ratio shall not exceed 0.45.

Rock dowels 7.55 Rock dowels shall comply with CS 2 and shall be mild steel or high yield steel as stated in the Contract.

Grout for rock dowels 7.56 Grout for rock dowels shall be as stated in Clauses 7.114 and 7.122.

SUBMISSIONS

Particulars of access 7.57 Particulars of the proposed means of access for slope treatment works, including access structures and reinstatement, shall be submitted to the Engineer for approval at least 14 days before the slope treatment works start.

Particulars of sprayed concrete 7.58 (1) The following particulars of the proposed materials and methods of construction shall be submitted to the Engineer:

(a) type and performance of mixing and spraying plant,

(b) details of water sprays and associated pumps for surface spraying,

(c) method of curing,

(d) details of trial panels and test panels,

(e) methods of measuring surface temperature and moisture content of the soil, and

(f) methods of achieving the specified thickness of sprayed concrete and the specified cover to reinforcement and methods of measuring the thickness and cover after spraying.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before sprayed concrete is used.

Particulars of rock bolts

7.59 (1) The following particulars of the materials and methods of construction for rock bolts shall be submitted to the Engineer:

(a) details of rock bolts, anchorages and centralizers,

(b) methods of tensioning and grouting,

(c) proposed working loads,

(d) previous performance records, and

(e) details of equipment for testing rock bolts, including test and calibration certificates.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before pull-out trials start.

Samples of materials

7.60 A sample of a complete rock bolt shall be submitted to the Engineer for approval of the source and type of rock bolt at the same time as particulars of rock bolts are submitted.

PRELIMINARY WORK

Access to slopes

7.61 (1) Means of access consisting of scaffolding constructed of sound bamboo or other materials agreed by the Engineer shall be installed to enable the Engineer to examine slope treatment works. The scaffolding shall allow access to within 0.8 m of the slope face; hand and foot holds for climbing shall be provided by bamboo members at centres not exceeding 0.5 m vertically and 0.8 m horizontally.

(2) A system of safety ropes shall be installed on the scaffolding; safety ropes shall be 12 mm diameter and shall have a breaking force of at least 18 kN. The system of safety ropes shall consist of:

(a) vertical ropes at not more than 3 m centres horizontally securely anchored to the crest of the slope, and

(b) horizontal ropes at not more than 3 m centres vertically.

The system of safety ropes shall be constructed in such a manner that the ropes are tied at not more than 3 m spacings in both directions to form a net.

Protection fences and barriers

7.62 (1) Protection fences and barriers for slope treatment works shall be constructed as stated in the Contract before slope treatment work starts.

(2) Damage to protection fences and barriers shall be repaired immediately. The permission of the Engineer shall be obtained before protection fences and barriers are dismantled.

Preparation for slope treatment works

7.63 (1) Vegetation shall be cleared and existing impermeable surfaces and topsoil shall be removed from existing soil slopes before slope treatment works start.

(2) Loose material shall be removed from the surface of new soil slopes and the surface shall be trimmed and scarified before slope treatment works start. The surface shall be moistened immediately before the slope surface treatment works start.

(3) Rock faces and joints, and the surface and joints of retaining walls shall be cleaned of moss, vegetation and loose material, immediately before slope treatment works start, and surplus water shall be removed by an air jet. Water flowing from or across the rock face shall be diverted by relief drains or by other methods agreed by the Engineer before the application of impermeable surfaces.

ROCK SLOPE TREATMENT WORKS

Scaling and trimming of rock slopes 7.64 Scaling and trimming of rock slopes shall be carried out in such a manner that soil and rock is removed from the slope face without affecting the stability and integrity of the slope. Measures shall be taken to prevent uncontrolled falls of debris arising from scaling and trimming works. Scaling and trimming of rock slopes shall be carried out using hand-held tools. All material removed or excavated by scaling and trimming and loose fragments of soil and rock shall be removed from the slope. Rock faces shall be cleaned using a water jet coupled to compressed air after scaling and trimming is complete.

Rock splitting 7.65 Rock splitting shall be carried out using percussive hammers, drills, hydraulic splitters, chemical expanding agents, hand-tools or other methods agreed by the Engineer.

Removal of boulders 7.66 Boulders which are to be removed from slopes shall be broken down by means of line drilling, expansive grouts, rock breakers or other methods agreed by the Engineer.

Sealing and infilling of rock joints 7.67 Joints in rock faces shall be sealed with Grade 20/20 concrete, cement mortar or masonry as stated in the Contract. Rock for masonry infilling shall be bedded in cement mortar. Relief drains instructed by the Engineer shall be installed before rock joints are sealed or infilled.

Concrete buttresses 7.68 (1) Concrete for buttresses shall be Grade 20/20 unless otherwise stated in the Contract.

(2) Drainage which is required behind buttresses shall consist of relief drains connected to 50 mm diameter PVC outlet pipes laid at a gradient of at least 1 in 50; the PVC pipes shall be securely fixed to the formwork before concreting starts.

SOIL-CEMENT FILL

Mixing soil-cement 7.69 Soil-cement shall be thoroughly mixed in a concrete mixer; small quantities of soil-cement shall not be hand mixed unless permitted by the Engineer.

Deposition and compaction of soil-cement fill

7.70 (1) Soil-cement fill shall be deposited in its final position and compacted within 30 minutes after the cement has been added to the mix.

(2) Soil-cement fill shall be compacted as stated in Clauses 6.46 to 6.48 to obtain a relative compaction of at least 95% throughout. Soil-cement fill shall be at optimum moisture content during compaction. The tolerance on the optimum moisture content percentage shall be ±3.

CHUNAM SURFACES

Trial panel

7.71 A trial panel 50 mm thick and at least 3 m x 3 m shall be constructed for chunam surfaces.

Mixing chunam

7.72 The cement and lime for chunam shall be mixed dry before adding the soil. The materials shall then be mixed thoroughly, with water sprinkled, until the colour and consistency are uniform.

Placing and compacting chunam

7.73 (1) Bamboo dowels shall be driven into the face of the slope on which chunam will be placed at 1.5 m centres on a staggered pitch to leave a 25 mm projection from the slope face to receive the chunam. Bamboo dowels shall be at least 25 mm in diameter and shall be 150 mm long. Bamboo dowels shall not be used on slopes less than 30° to the horizontal.

(2) The chunam shall be laid to a total thickness of 50 mm in two equal layers; the layers shall be well compacted by ramming. The bottom layer of chunam shall be left with a rough finish to provide bonding for the top layer.

(3) The top layer of chunam shall be thoroughly wetted and rubbed with sacks to fill any cracks immediately before the chunam hardens. The surface shall be sprinkled with water and finished by trowelling to form a smooth uniform surface.

Joints in chunam

7.74 Joints in chunam shall be neat and straight and panels shall be rectangular. Joints in the top and bottom layers shall not coincide unless permitted by the Engineer.

Weepholes in chunam

7.75 50 mm diameter PVC weepholes shall be constructed at 1.2 metre staggered centres in each direction before chunam is placed; the weepholes shall penetrate at least 50 mm into the soil.

Temporary chunam surfaces

7.76 Temporary chunam surfaces to the faces of slopes or excavations shall consist of a single layer of chunam 20 mm thick, without bamboo dowels. Temporary chunam drainage channels shall be constructed by building up the chunam to an appropriate shape or by cutting a channel into the slope and lining with chunam. Temporary chunam shall be removed in stages before deposition of fill material or slope treatment works start.

SPRAYED CONCRETE

Trial panel 7.77 A trial panel at least 50 mm thick and at least 3 m x 3 m shall be constructed for sprayed concrete on the surface to be treated. The average percentage rebound shall be estimated for each trial panel and shall be used in the calculations of the cement content of the applied concrete.

Preparation of slope surfaces 7.78 (1) Weak material along joints or seams in slope surfaces to which sprayed concrete will be applied shall be removed to a depth equal to the width of the weak zone.

(2) When the soil surface temperature exceeds 25°C or the moisture content is less than 10%, the surface to be sprayed shall be watered using sprays unless otherwise instructed by the Engineer. Hoses without sprays shall not be used. Spraying of water onto the slope surface shall be carried out not more than 1 hour before spraying of concrete starts.

Fixing reinforcement 7.79 Fabric reinforcement for sprayed concrete shall be fixed securely to the slope by steel nails or rawl bolts and shall be laid without sharp bends or creases. The cover to the reinforcement shall be at least 20 mm and laps between adjacent sheets shall be at least 150 mm.

Weepholes in sprayed concrete 7.80 50 mm diameter weepholes shall be constructed at 1.2 m staggered centres in each direction; the weepholes shall extend to the full thickness of the sprayed concrete.

Equipment for spraying concrete 7.81 Equipment for spraying concrete shall be the dry mix delivery type with water added at the nozzle. The equipment shall be fitted with weighbatching facilities. The equipment shall be capable of projecting a mixture of cement, fine and coarse aggregate and water at high velocity on to the surface of the slope to produce a dense homogeneous cover.

Spraying concrete 7.82 (1) The surface temperature and moisture content of the soil shall be measured, and the results submitted to the Engineer, immediately before sprayed concrete is applied.

(2) The aggregate and sand for sprayed concrete shall be kept dry before mixing. The water shall be added at the nozzle at the instant of application. The air and water supply, the rate of application and all other factors affecting the quality of the work shall be adjusted to produce dense concrete with no sloughing. Rebound material shall not be reused and shall be removed within 8 hours after spraying.

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

Curing sprayed concrete 7.83 Sprayed concrete shall be cured for at least 4 days after application by either Method 2 or Method 3 as stated in Clause 16.46.

Inspection of sprayed concrete 7.84 Completed areas of sprayed concrete shall be sounded using a wooden mallet; areas which in the opinion of the Engineer are substandard or hollow shall be removed and resprayed.

Records of sprayed concrete 7.85 Records of sprayed concrete operations shall be kept by the Contractor on the Site and shall be submitted daily to the Engineer. The records shall contain details of the quantities of all materials used at each location.

PROTECTIVE MESH FOR SLOPES

Fixing protective mesh for slopes 7.86 Protective mesh for slopes shall be suspended down the rock face and bolted into the slope face at 250 mm centres at the top and sides of the mesh and at 5 m intervals at the toe of the slope. Laps in the mesh shall be at least 300 mm and each side of the lap shall be tied at 125 mm centres with galvanised and PVC coated binding wire.

ROCK BOLTS

Trials for rock bolts 7.87 The design bond length of rock bolts with bonded anchorages shall be determined for each rock type by a pull-out trial. The proof load of a pull-out trial shall be twice the working load. Pull-out trials shall be carried out on two bolts for each combination of rock bolt and rock type. Unless otherwise permitted by the Engineer the bolts used in trials shall be discarded and shall not form part of the permanent works, and the hole shall be sealed by grouting.

Drilling, preparing and testing rock bolt holes 7.88 (1) Holes for rock bolts shall be drilled at the locations instructed by the Engineer. The diameter of the hole shall be at least 20 mm larger than the diameter of the rock bolt or the outer diameter of the connectors, if used, whichever is larger. The method of drilling shall be rotary or rotary percussive with water flush or air flush accompanied by the operation of an effective dust extraction and filtering device. Holes shall be drilled to provide 50 mm cover to the end of bolts for which cement grout is used to form the bond length.

(2) Holes for rock bolt shall be flushed with clean water before rock bolt installation starts until the return water runs clear. Standing water shall be blown out from the hole using compressed air after flushing.

(3) Holes for rock bolts shall be tested by the Packer test as stated in Clauses 7.102, 7.103 and 7.104 and the results of the tests shall be submitted to the Engineer for approval, before installation of rock bolts starts.

Fixing rock bolts 7.89 (1) The permission of the Engineer shall be obtained before installation of rock bolts starts.

(2) Rock bolts shall be installed in accordance with the manufacturer's recommendations.

(3) Rock bolts shall be fully grouted after stressing.

(4) Installation of rock bolts, including grouting of the free length and installation of head protection, shall be completed as soon as practicable and not more than 14 days after completion of the drillhole.

(5) Rock bolts with a grouted anchorage shall not be stressed until the grout crushing strength has attained a value of 21 MPa when tested in accordance with Clauses 7.134, 7.135 and 7.136.

Grouting rock bolts 7.90 (1) Grouting for rock bolts shall be in accordance with Section 7, Part 4, except as stated in Clause 7.90(2) and (3).

(2) Grout shall be introduced at the lower end of drillholes with downward inclinations and shall displace all air and water through the top of the drillhole.

(3) Packers and return ducts which maintain a head on the grout until the grout has set shall be used for drillholes with upward inclinations or with inadequate downward inclinations. The packers and ducts shall be such that separate grouting of the anchorage zone and free-length zone of the drillhole can be carried out. The head to be maintained on the grout shall be as approved by the Engineer.

Proving rock bolts 7.91 Each installed rock bolt shall be proved as stated in Clauses 7.105 to 7.107. Rock bolts shall be locked off at 1.1 times the working load after proving. The complete bolt head assembly shall be encased by a concrete block after locking off.

Records of rock bolts 7.92 Records of installation of rock bolts shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 7 days after each installation operation. Records shall contain the following:

(a) rock bolt identification number,

(b) drilling details, including:
- date and time drilling started and finished
- machine and operator identification
- location, level, inclination, bearing, length and diameter of drillhole
- rate of penetration at 0.5 m intervals,

(c) watertightness of drillhole, including:
- date and time water test started and finished
- details of any pre-grouting and redrilling
- length of test zone
- water pressure applied
- duration of test
- measured water absorption rate,

(d) details of steel bolts, including:
- type and diameter
- bond length
- overall length
- number and type of centralising spacers
- stressing record and lock-off load, and

(e) details of grouting, including:
- date and time grouting started and finished
- details of any packers used and length of grouted zones
- head maintained on grout during setting
- volume of grout accepted

- identification marks of grout cubes.

ROCK DOWELS

Drilling and preparation of rock dowel holes 7.93 The drilling and preparation of holes for rock dowels shall be as stated in Clause 7.88(1) and (2).

Grouting rock dowels 7.94 (1) Grouting for rock dowels shall be in accordance with Section 7, Part 4, except as stated in Clause 7.94(2).

(2) Rock dowels shall be grouted over the complete length of the drillhole in which the dowel is installed. Centralisers as stated in the Contract shall be fitted to rock dowels before grouting to ensure an even annulus of grout.

Records of rock dowels 7.95 Records of installation of rock dowels shall be kept by the Contractor and a copy shall be submitted to the Engineer within 7 days after each installation operation. The records shall contain details of the location, length, inclination and level of each rock dowel installed.

TESTING: OPTIMUM MOISTURE CONTENT AND MAXIMUM DRY DENSITY OF SOIL-CEMENT FILL

Testing: Optimum moisture content and maximum dry density of soil-cement fill 7.96 The maximum dry density and optimum moisture content of soil-cement fill shall be as stated in Clauses 6.61 to 6.67 except that the method of testing shall be the Vibrating Hammer Test Method in accordance with BS 1924.

TESTING: CONCRETE CORES FROM SPRAYED CONCRETE

Testing: test panels for sprayed concrete 7.97 (1) The strength of sprayed concrete shall be determined from concrete cores cut from a test panel constructed at the same time as sprayed concrete is applied.

(2) One test panel shall be constructed for each area of sprayed concrete of 500 m^2 or part thereof.

(3) The test panel shall be 250 mm thick and shall be at least 1 m x 1 m. The mould shall be securely fixed in position at the same height and inclination as the surface being sprayed. The panel shall be constructed by spraying concrete into the mould at the same time as the concrete to be tested is applied. The test panel shall be cured by the same method as the sprayed concrete.

Samples: concrete cores from sprayed concrete 7.98 (1) Three concrete cores shall be provided from each test panel; cores shall not be taken within 125 mm from the edges of the panel.

(2) Concrete cores shall be 100 mm diameter and shall be the full depth of the test panel.

(3) The method of taking concrete cores shall be in accordance with CS1.

Testing: concrete cores from sprayed concrete

7.99 (1) Each concrete core shall be tested to determine the compressive strength and density.

(2) The method of preparing and testing the cores to determine the compressive strength shall be in accordance with CS1; the method of testing the cores to determine the density shall be in accordance with CS1. Three concrete cores shall be tested at 28 days.

Compliance criteria: concrete cores from sprayed concrete

7.100 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 minimum compressive strength of concrete cores, converted to estimated in-situ cube strength in accordance with BS 6089 shall be 20 MPa at 28 days.

Non-compliance: concrete cores from sprayed concrete

7.101 If the result of any test for compressive strength or density of concrete cores from sprayed concrete does not comply with the specified requirements for the property, particulars of proposed changes to the materials, mix design, methods of production or methods of construction shall be submitted to the Engineer; further trial mixes shall be made and further trial panels shall be constructed unless otherwise permitted by the Engineer.

TESTING: PACKER TESTS ON DRILLHOLES FOR ROCK BOLTS

Testing: Packer test

7.102 (1) The water loss from drillholes for rock bolts shall be determined by the Packer test. The number of drillholes to be tested shall be instructed by the Engineer.

(2) The Packer test shall be carried out on the bond length of the drillhole at a test pressure of 100 kPa. The method of testing shall be as stated in Clause 7.137.

Compliance criteria: Packer test

7.103 The water loss determined by the Packer test in the grouted hole shall not exceed 5 Lugeons when measured over a 10 minute period.

Non-compliance: Packer test

7.104 If the result of any Packer test on drillholes for rock bolts does not comply with the specified requirements for the test, the drillhole shall be grouted, re-drilled and retested. Grouting, re-drilling and retesting shall be continued until the result of the Packer test complies with the specified requirements for the test.

TESTING: ROCK BOLTS

Testing: rock bolts	7.105	Each installed rock bolt shall be tested to determine the loss in stress by applying a test load of 1.5 times the working load for 5 minutes.
Compliance criteria: rock bolts	7.106	The loss in stress in installed rock bolts shall not exceed 5% of the test load in 5 minutes.
Non-compliance: rock bolts	7.107	(1) If the result of any test for loss in stress of installed rock bolts does not comply with the specified requirements for the test, an additional test for loss of stress shall be carried out on the rock bolt. (2) If the result of any additional test for loss of stress of installed rock bolts does not comply with the specified requirements for the test, the rock bolt shall be replaced.

PART 4: GROUTING FOR GEOTECHNICAL WORKS

GLOSSARY OF TERMS

Ground 7.108 Ground, for the purpose of grouting for geotechnical works, is fill material, soil and rock and the interfaces between fill material, soil and rock and any structures.

Grout 7.109 Grout, for the purpose of grouting for geotechnical works, is cement grout, cement-sand grout, cement-bentonite grout and proprietary grout approved by the Engineer.

Grouting 7.110 Grouting, for the purpose of grouting for geotechnical works, is the mixing and injection of grout through predrilled or preformed holes.

Grouting stage 7.111 Grouting stage, for the purpose of grouting for geotechnical works, is the discrete length of drillhole into which grout is to be injected in a continuous operation.

Lugeon 7.112 Lugeon is a water loss of 1 litre per minute per metre length of hole tested at an effective pressure of 1 MPa.

MATERIALS

Materials for grout 7.113 Materials for grout shall comply with Section 16 except as stated in this Section.

Grout for geotechnical works 7.114 (1) Cement grout for geotechnical works shall consist of OPC, sand and water. Admixtures shall not be used unless permitted by the Engineer.

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

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

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

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

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

Standpipes 7.115 Unless otherwise approved by the Engineer standpipes for grouting shall be standard black metal pipe complying with BS 1387.

Particulars of grouting for geotechnical works

7.116 (1) The following particulars of the proposed materials and methods of construction for grouting for geotechnical works shall be submitted to the Engineer:

(a) details of drilling, grouting and testing equipment,

(b) details of grout mix, including admixtures,

(c) methods of storing, mixing and injecting grout,

(d) methods of drilling, cleaning, capping and sealing grout holes,

(e) methods of grouting, including grouting stages, order of working and regrouting methods, and

(f) methods of controlling surface water, groundwater, leakage and ground movement, including methods of monitoring and instrumentation.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before grouting starts.

Trials for grouting

7.117 Unless otherwise permitted by the Engineer a grouting trial shall be carried out. The extent and depth of holes for grouting trials and the tests to be carried out shall be as stated in the Contract.

DRILLING FOR GROUTING FOR GEOTECHNICAL WORKS

Drilling for grouting for geotechnical works

7.118 (1) Holes in rock for grouting for geotechnical works shall be drilled using rotary or percussion type drills. The tolerance for the holes shall be as stated in Clause 7.27(1). Grease and other lubricants shall not be used in the flushing medium or on the rods, except around the threads at the ends of the rods. Drilling methods which result in drill cuttings causing blockages such that grouting cannot be performed satisfactorily shall not be used.

(2) The flushing medium for drilling shall be clean water or air accompanied by the operation of an effective dust extraction and filtering device.

(3) The minimum size of hole for grouting in rock shall be 40 mm.

(4) Holes in soil for grouting for geotechnical works shall be drilled by a method which is suitable to the ground conditions and which is approved by the Engineer.

(5) The location of all underground obstructions and utilities shall be determined by the Contractor before drilling starts and the drilling pattern shall take account of the location of obstructions and utilities.

(6) Casings required to prevent the collapse of grout holes shall be as stated in Clause 7.26. Casings shall be removed immediately before or simultaneously with the grouting or sleeve grouting operation in such a manner that the grout hole will not collapse and the injection of grout will not be hindered.

(7) Grout holes shall be flushed clean with water or compressed air introduced at the bottom of the hole after drilling is complete. The holes shall be protected with capping pipes or standpipes to prevent subsequent collapse or clogging after flushing.

(8) Grout holes which have been drilled more than one day before grouting of the hole starts shall be reflushed with water or compressed air immediately before grouting is commenced and excess flushing water shall be removed by air jet. Holes drilled in soft ground or in ground other than rock and in which sleeve grouts are proposed as part of the grouting operation shall be sleeve grouted as soon as practicable after drilling.

Standpipes and capping pipes

7.119 (1) Unless otherwise permitted by the Engineer, grout holes shall be capped after drilling and before grouting. Capping shall be by a suitably sealed grout connection, standpipe, packer or other methods agreed by the Engineer. The cap shall seal the hole to prevent contamination or clogging of the hole until grouting operations start.

(2) Standpipes, if stated in the Contract, shall be installed in holes after drilling. The pipe shall be sealed into the hole using cement grout consisting of OPC and water in the proportions 1:1 by volume.

GROUTING FOR GEOTECHNICAL WORKS

Monitoring of grouting operations

7.120 (1) Instrumentation shall be installed to monitor heave, bulging, settlement, lateral movement, deformation or fracturing of the ground or structures due to grouting operations. Records of monitoring shall be kept by the Contractor on the Site and a copy provided for the Engineer. Arrangements for installing instruments and taking measurements inside and outside the Site shall be made by the Contractor.

(2) The accuracy of the instruments shall be checked before grouting starts and at regular intervals agreed by the Engineer.

Grouting equipment

7.121 (1) Grouting equipment for geotechnical works shall be a type, quantity and size suitable for the grouting required; the equipment shall be kept clean and in good working order.

(2) Standby grouting equipment shall be available at all times and shall be capable of being brought into operation immediately in the event of breakdowns during grouting operations.

(3) Grout mixers shall be high speed colloidal mixers having a rotor speed of at least 1000 r/min and capable of producing a colloidal grout mix. Mixers shall be fitted with a water volume measuring device for batching purposes.

(4) Holding tanks shall be fitted with an agitator to provide continuous agitation of the grout at 100 r/min. The tank shall be fitted with a dipstick to allow continuous measurement of the volume of grout in the tank. A 2.36mm removable screen shall be provided between the tank and the pump or grout lines.

(5) Grout pumps shall be a positive displacement type. Pumps shall be fitted with bypass valves to allow a standby pump to be brought into operation.

(6) Working pressure gauges shall be accurate to within 3% and shall be calibrated against a test gauge before grouting starts and at weekly intervals. A test gauge with accompanying calibration certificates shall be kept on the Site for the purpose of calibrating working gauges. Working gauges shall be numbered and a record shall be kept of gauge number, shifts worked, calibration dates and repairs undertaken; records shall be kept on the Site and shall be available for inspection by the Engineer at all times.

(7) Packers shall be such that they seal holes in rock at the specified level and shall be capable of withstanding the maximum grout or water pressure to be used at that level without leakage. Packers may be of the mechanical or inflatable rubber type. A sufficient number of packers of a size to suit the holes shall be available on the Site.

Mixing grout 7.122 (1) Grout for geotechnical works shall be mixed by volume. The mix proportions may be adjusted if approved by the Engineer depending on the results of the trial grouting, water tests in the hole or the results of previously grouted holes.

(2) Grout shall be mixed by adding approximately two-thirds of the cement to the water adding any admixture and adding the remaining one-third of cement. Other mixing procedures shall not be used unless permitted by the Engineer.

(3) The time for which grout shall be mixed in high speed mixers shall be suitable for the type of mixer used. Grout shall be continuously agitated in a holding tank after mixing and shall be screened before being circulated in the grout lines. Mixed grout shall be continuously circulated in such a manner that grout which is not taken in a hole can be returned to the holding tank.

(4) Grout to which a retarding agent has not been added, and which is not used within 30 minutes after mixing, shall not be used for grouting.

Grouting for geotechnical works 7.123 (1) Holes in rock shall be grouted in grouting stages not exceeding 3 m. Grouting may be carried out in either an upstage or a downstage sequence.

(2) Ground other than rock shall be grouted in such a manner that grout can be injected at various points along the grout hole in a multi-stage operation. The grouting method shall employ perforated pipes with rubber sleeve valves unless otherwise permitted by the Engineer.

(3) Grouting pressures shall initially be 100 kPa per 4 metre depth of hole and shall not exceed the overburden pressure unless permitted by the Engineer.

(4) Holes shall be grouted in a continuous operation at the grouting stages and pressures stated in the Contract. Unless otherwise permitted by the Engineer grouting shall be carried out by injecting the grout under pressure into each grouting stage of the hole until the grouting stage refuses to take further grout.

(5) If in the opinion of the Engineer grouting of any hole or grouting stage has not been completed due to excessive grout takes, low pressures, excessive leakage or other causes, the hole shall be redrilled or flushed out with water and re-injected with grout.

Loss or leakage of grout

7.124 (1) If during the grouting of any hole, grout is found to flow from adjacent grout holes in quantities which in the opinion of the Engineer are sufficient to interfere seriously with the grouting operation or to cause appreciable loss of grout, the holes shall be temporarily capped. If in the opinion of the Engineer capping is not essential, ungrouted holes shall be left open to allow air and water to escape.

(2) If during the grouting of any hole grout is found to flow from joints in the geological formation at the Site or any other location, the leaks shall be plugged or caulked in a manner agreed by the Engineer.

(3) If during the grouting of any hole the grout take increases suddenly by a significant amount, the Engineer shall be informed immediately.

Making good holes

7.125 (1) Grout holes through concrete shall be made good using concrete agreed by the Engineer; the concrete shall be firmly compacted and shall be finished to match the adjacent surface.

(2) Uncapped holes in rock shall be topped up after grouting using cement grout consisting of OPC and water in the proportions 1:1 by volume, or 1:3 cement sand mortar.

Records of grouting for geotechnical works

7.126 (1) Records of grouting for geotechnical works shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. Records shall include the following details:

(a) hole location and reference number,

(b) depth of hole,

(c) type of grout and grout mix proportions,

(d) volume of grout injected,

(e) grouting pressures, and

(f) times and details of any interruptions, leakages and equipment malfunctions.

(2) A record of grouting for each hole shall be submitted to the Engineer within 24 hours after completion of grouting of the hole. The record shall contain the following details:

(a) hole location and reference number,

(b) grouting stage numbers and lengths,

(c) collar level and hole inclination,

(d) details of grout injections including the information stated in Clause 7.126(1), and

(e) details of the grouting procedure, including any stoppages, leaks to other holes, surface leaks and ground movement.

(3) A record of the testing for each hole, including test results, shall be submitted to the Engineer within 24 hours after completion of testing of a hole. Records of Packer tests shall contain the following details:

(a) hole location and reference number,

(b) depth of packer in the hole,

(c) date and time of test,

(d) type of gauge or meter and identifying reference number,

(e) test readings for each 5 minute period,

(f) calculated test results in Lugeons, and

(g) details of any equipment malfunctions, sudden water losses or blockages, surface leakage or other variations in test procedure.

(4) A report of grouting for each part of the Works as stated in the Contract, including record drawings and logs of holes, shall be submitted to the Engineer within one week after completion and testing of grouting for that part of the Works. The form of records, logs and record drawings shall be as agreed by the Engineer.

TESTING: GROUT - GENERAL REQUIREMENTS

Batch: grout for geotechnical works 7.127 A batch of grout for geotechnical works is any quantity of grout used for grouting geotechnical works in one continuous operation in one day.

TESTING: GROUT - BLEEDING

Samples: bleeding of grout 7.128 (1) One sample of grout shall be provided from each batch of grout for geotechnical works to determine the amount of bleeding of the grout.

(2) Samples shall be provided not more than 30 minutes after the grout has been mixed and shall be protected from moisture content changes before the tests for amount of bleeding are carried out.

Testing: bleeding of grout 7.129 (1) Each sample of grout taken as stated in Clause 7.128 shall be divided into three specimens; each specimen shall be tested to determine the amount of bleeding.

(2) Grout for geotechnical works shall be tested for bleeding in accordance with Clause 17.60.

Non-compliance: bleeding of grout 7.130 If the result of any test for amount of bleeding of grout for geotechnical works does not comply with the specified requirements for amount of bleeding, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer; further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT - FLOW CONE EFFLUX TIME

Samples: flow cone efflux time of grout 7.131 One sample of grout shall be provided from each batch of grout for geotechnical works to determine the flow cone efflux time of the grout.

Testing: flow cone efflux time of grout 7.132 Each sample of grout taken as stated in Clause 7.131 shall be tested to determine the flow cone efflux time. The method of testing shall be in accordance with ASTM C939.

Non-compliance: flow cone efflux time of grout 7.133 If the result of any test for flow cone efflux time of grout does not comply with the specified requirements for flow cone efflux time, particulars of proposed changes to the materials, grout mix or methods of production shall be submitted to the Engineer; further grouting trials shall be carried out unless otherwise permitted by the Engineer.

TESTING: GROUT - CRUSHING STRENGTH

Samples: crushing strength of grout 7.134 (1) One sample of grout shall be provided from each batch of grout for geotechnical works to determine the crushing strength of the grout.

(2) Samples shall be provided not more than one hour after the grout has been mixed and shall be protected from moisture content changes before test cubes are made.

Testing: crushing strength of grout 7.135 (1) Nine 100 mm test cubes shall be made from each sample of grout taken as stated in Clause 7.134. Three test cubes shall be tested to determine the crushing strength at 3 days, three test cubes shall be tested to determine the crushing strength at 7 days and three test cubes shall be tested to determine the crushing strength at 28 days.

(2) The method of making, curing and testing the test cubes shall be as stated in Clause 16.59(2), (3) and (4).

Non-compliance: crushing strength of grout 7.136 If the result of any test for crushing strength of grout for geotechnical works does not comply with the specified requirements for grout, particulars of proposed changes to the materials, grout mix or method 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: PACKER TESTS ON DRILLHOLES FOR GROUTING AND GROUTED DRILLHOLES

Testing: Packer tests 7.137 (1) The water loss from drillholes for grouting and from grouted and regrouted drillholes shall be determined by the Packer test.

(2) The number of drillholes for grouting to be tested to determine the water loss shall be as instructed by the Engineer.

(3) Every grouted drillhole and every regrouted drillhole shall be tested to determine the water loss.

(4) Packer tests shall be carried out in accordance with BS 5930, Chapter 21.5 and Clause 7.137(5) to (8)

(5) Tests shall be carried out using clean water, in grouting stages not exceeding 3 m in length. The rate of flow of water in the test shall be determined to an accuracy of 10% for flows exceeding 1 L/min.

(6) The test pressure shall be equal to the overburden pressure and shall not exceed the specified maximum grouting pressure for the grouting stage being tested.

(7) The test shall be carried out between a packer and the base of the hole for grouting stages at the base of a hole and shall be carried out between two packers in other cases.

(8) The test shall be carried out by pumping water at the specified pressure into the grouting stage being tested and measuring with a volume meter the water loss over three consecutive 10 minute periods. The result shall be calculated in Lugeons for each 10 minute period.

Compliance criteria: Packer tests 7.138 The water loss determined by the Packer test in the grouted hole shall not exceed 5 Lugeons when measured over a 10 minute period.

Non-compliance: Packer test on drillholes for grouting 7.139 If the result of any Packer test on drillholes for grouting does not comply with the specified requirements for the test, the drillhole shall be grouted, re-drilled and retested. Grouting, re-drilling and retesting shall continue until the result of the Packer test complies with the specified requirements for the test.

Non-compliance: Packer test on grouted and regrouted drillholes 7.140 If the result of any Packer test on grouted drillholes or regrouted drillholes does not comply with the specified requirements for the test, the grout shall be removed and the drillhole shall be regrouted and retested. Removal of grout, regrouting and retesting shall continue until the result of the Packer test complies with the specified requirements for the test.

PART 5: GROUNDWATER DRAINAGE AND CONTROL

GLOSSARY OF TERMS

Caisson drain	7.141	Caisson drain is an excavated vertical shaft, with or without raking drains, to provide drainage by intercepting and lowering the groundwater level in the vicinity.
Geotextile filter	7.142	Geotextile filter is a permeable sheet of synthetic material used like a granular filter for filtration and in-plane drainage.
Filter pipe	7.143	Filter pipe is a perforated or non-perforated pipe used for draining groundwater.
Granular filter	7.144	Granular filter is a graded sand or gravel placed against a soil to prevent the migration of fine particles out of the soil caused by water flow, and graded such that free discharge of water flowing into the filter is allowed.
Prefabricated band drain	7.145	Prefabricated band drain is a synthetic drain which, when installed in a soil strata, acts as a drainage medium for dissipation of pore water pressure.
Raking drain	7.146	Raking drain is a drillhole, with or without perforated filter pipes and geotextile filter sheath, installed generally at an upward inclination for groundwater lowering by gravity flow.
Relief drain	7.147	Relief drain is a synthetic drain installed on slope surfaces or in excavations to divert water seepage before applying sprayed concrete, chunam, masonry dentition or other construction.
Trench drain	7.148	Trench drain is a trench wholly or partly filled with granular material or clean crushed rock, with or without filter pipes and geotextile filter.

MATERIALS

Granular filter material	7.149	Granular filter material for granular filter, trench drains and caisson drains shall consist of durable, inert, natural material free from clay, organic material and other impurities. Granular filter material shall have the particle size distribution stated in the Contract.
Geotextile filter	7.150	Geotextile filter shall be a proprietary type approved by the Engineer and shall have the properties stated in the Contract.

Filter pipes 7.151 (1) Filter pipes shall comply with the following:

Precast concrete pipes	: BS 5911
Vitrified clay pipes	: BS 65
DI pipes	: BS 4772
Steel pipes	: BS 534
Porous concrete pipes	: BS 1194
Perforated concrete pipes	: BS 5911
Pitch fibre pipes	: BS 2760
UPVC pipes	: BS 4660 or BS 3506
Corrugated polyethylene tubing	: AASHTO Designation M252

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

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

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

Raking drains 7.152 (1) Type O raking drains shall be unlined raking drains; drain holes shall be at least 40 mm diameter.

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

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

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

(5) Pipes for raking drains shall be as stated in Clause 7.151(1) and (2); the openings and slots in pipes with non-perforated inverts shall cover approximately two-thirds of the circumference of the pipe.

(6) Geotextile filter sheaths for raking drains shall be formed of woven or non-woven geotextile filter complying with Clause 7.150.

Fill material for trench drains 7.153 (1) Fill material to be used with geotextile filter in trench drains shall be clean crushed rock. Type A and Type B fill material shall have the particle size distributions stated in Table 7.2.

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

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

Table 7.2: Particle size distribution of fill material for trench drains

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

Caisson liners 7.154 Caisson liners shall be concrete tapered rings at least 100 mm thick and not exceeding 1 m deep. The liners shall be constructed with well-compacted concrete of Grade 20/20 or greater.

Prefabricated band drains 7.155 (1) Prefabricated band drains shall consist of a core and a filter. The drains may be manufactured as a single unit or the filter may be wrapped around the core, and overlapped and sealed to contain the core. The drains shall be made from chemically treated paper, polyethylene, polyester, polyolefine or other synthetic material or combination of such materials.

(2) Prefabricated band drains shall be provided with an outer casing or mandrel of rhomboidal or rectangular cross section for use during installation. The drains shall also be provided with an anchor to ensure embedment of the drain during extraction of the mandrel.

(3) The strength of the materials in prefabricated band drains shall be such that the drains will withstand all forces resulting from handling and installation.

(4) The filter jacket for prefabricated band drains shall be a type which:

(a) has been previously proved effective under similar soil and pressure conditions,

(b) is in all cases able to prevent excessive migration of soil particles into the core, and

(c) has a permeability not less than that of the surrounding soil.

(5) Prefabricated band drains shall be able to conform to soil deformation without buckling or crimping of the core.

SUBMISSIONS

Particulars of granular filters

7.156 (1) The following particulars of the proposed materials and methods of construction for granular filters shall be submitted to the Engineer:

(a) whether granular filter material is to be supplied ready mixed or is to be mixed on the Site,

(b) source of supply, including name of supplier of ready mixed material,

(c) quantity of each constituent if the material is to be mixed on the Site,

(d) Constructional Plant and methods of mixing for material mixed on the Site,

(e) method of storage and location of storage areas on the Site,

(f) methods of deposition and compaction of material, and

(g) results of three tests for particle size distribution of the fill material against which the granular filter is to be placed.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before deposition of granular filter material starts.

Particulars of geotextile filter

7.157 (1) The following particulars of the proposed materials and methods of construction for geotextile filter shall be submitted to the Engineer:

(a) manufacturer's name and source of supply,

(b) details of geotextile filter including manufacturer's literature,

(c) a certificate for the geotextile filter showing the manufacturer's name, the date and place of manufacture and showing that the geotextile filter complies with the requirements stated in the Contract, and including results of tests stated in the Contract,

(d) calculations showing that the geotextile filter complies with the filtration characteristics stated in the Contract,

(e) details of previous uses of the geotextile filter.

(f) details of quantities to be supplied in each delivery,

(g) method of storage,

(h) methods of cutting and jointing geotextile filter,

(i) method of repairing small batches, and

(j) methods of laying and holding in position.

(2) The particulars, including certificates, shall be submitted to the Engineer for approval at least 28 days before the first delivery of the geotextile filter to the Site. Certificates shall be submitted for each batch of geotextile filter delivered to the Site.

Particulars of trench 7.158 (1) The following particulars of the proposed materials and methods of construction for trench drains shall be submitted to the Engineer:

(a) method of excavation of trench and installation of geotextile filter,

(b) details of granular fill material as stated in Clause 7.153, and

(c) details of geotextile filter as stated in Clause 7.157.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before installation of trench drains starts.

Particulars of raking drains 7.159 (1) The following particulars of the proposed materials and methods of construction for raking drains shall be submitted to the Engineer:

(a) method of connecting adjacent sections of pipes,

(b) proportions of sealant mix, and

(c) details of geotextile filter sheath.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before installation of raking drains starts.

Particulars of relief drains 7.160 (1) The following particulars of the proposed materials and methods of construction for relief drains shall be submitted to the Engineer:

(a) details of relief drains and outlets, and

(b) method of fixing relief drains to the slope face.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before fixing of relief drains starts.

Particulars of caisson drains 7.161 (1) The following particulars of the proposed materials and methods of construction for caisson drains shall be submitted to the Engineer:

(a) methods of excavation and installation and removal of caisson liners,

(b) method of compaction of fill material,

(c) details of granular filter material as stated in Clause 7.156, and

(d) details of geotextile filter as stated in Clause 7.157.

(2) The particulars shall be submitted to the Engineer for approval at least 14 days before construction of caisson drains starts.

Particulars of prefabricated band drains

7.162 (1) The following particulars of the proposed materials and methods of construction for prefabricated band drains shall be submitted to the Engineer:

(a) details of type of drain, including manufacturer's literature,

(b) a certificate showing the manufacturer's name, the date and place of manufacture and showing that the drains comply with the requirements stated in the Contract,

(c) details of previous installations by the Contractor using similar drains,

(d) method of installation, and

(e) details of installation mandrel, drain anchor, method of penetration and method of recording depth of installation.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of prefabricated band drains starts.

Particulars of filter pipes

7.163 (1) The following particulars of the proposed materials and methods of construction for filter pipes shall be submitted to the Engineer:

(a) details of type of pipes, including manufacturer's literature,

(b) a certificate showing the manufacturer's name, the date and place of manufacture and showing that the pipes comply with the requirements stated in the Contract,

(c) details of previous installations by the Contractor using similar pipes, and

(d) method of installation.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of the filter pipes starts.

Particulars of groundwater control, drawdown and monitoring

7.164 (1) The following particulars of the proposed materials and methods of construction for groundwater control, drawdown and monitoring shall be submitted to the Engineer:

(a) Constructional Plant and materials for dewatering,

(b) timing and sequence of dewatering operations,

(c) details of silt traps,

(d) methods of monitoring flow rates and volumes of silt, including monitoring intervals, and

(e) methods and locations for discharging groundwater.

(2) The particulars shall be submitted to the Engineer for information at least 14 days before the relevant work starts.

Samples of materials 7.165 Samples of the following proposed materials shall be submitted to the Engineer for approval of the source and type of each material at the same time as particulars of the material are submitted:

(a) granular filter material,

(b) geotextile filter and two pieces of geotextile filter joined in accordance with the manufacturer's recommendations for each type of joint, and

(c) relief drains.

HANDLING, DELIVERY AND STORAGE OF MATERIALS

Handling and storage of granular filter material 7.166 (1) Granular filter material shall not be handled or stored in a manner which will result in mixing of the different types and sizes or in segregation, contamination, deterioration or erosion of the material.

(2) Stockpiles of granular filter material shall be placed on well-drained, prepared areas and shall be separated by dividing walls of sufficient height to keep the different materials separate.

Delivery and storage of geotextile filter 7.167 (1) Geotextile filter shall be delivered in secure wrappings to ensure that the geotextile filter is dry and protected from damage, contamination and exposure to conditions which may adversely affect it.

(2) Geotextile filter shall be stored on a level surface and shall be kept in a secure and dry condition, which will not result in damage to the fabric or in contamination of the fabric.

Storage of filter pipes 7.168 Coils of plastic tubing for filter pipes shall be stored flat.

Delivery and storage of prefabricated band drains 7.169 (1) Prefabricated band drains shall be supplied in rolls, securely packed in light-proof wrappings.

(2) Prefabricated band drains shall be stored in a clean, dry environment.

GRANULAR FILTERS

Mixing granular filter material 7.170 Granular filter material shall be thoroughly mixed by the method approved by the Engineer. Material which has been stockpiled shall be remixed before deposition.

Deposition and compaction of granular filter material 7.171 (1) Granular filter material shall be deposited and compacted as stated in Clauses 6.39 to 6.49.

(2) Granular filter material shall be deposited in a manner which will not result in segregation or contamination of the material.

(3) Granular filter material shall be deposited in such a manner that a continuous free draining zone is formed. The surface of each layer shall be cleaned and scarified before the next layer is deposited unless otherwise permitted by the Engineer.

GEOTEXTILE FILTER

Damage to geotextile filter 7.172 (1) The total period for which geotextile filter is exposed to daylight or other sources of ultra-violet radiation during handling, delivery, storage and installation shall not exceed 7 days.

(2) Geotextile filter which has been damaged or exposed to daylight or other sources of ultra-violet radiation for longer than the period stated in Clause 7.172(1) shall not be used in the permanent work unless permitted by the Engineer.

(3) Repairs to geotextile filter which has been torn or damaged during installation shall be carried out using a patch of the same material extending at least 300 mm beyond the edge of the damaged area. Repairs shall not be carried out on geotextile filter which has been damaged during storage or storage before installation.

Laying geotextile filter 7.173 (1) Geotextile filter shall be installed in such a manner that the individual yarns, webs or layers of the fabric retain their intended orientation and relative positions with respect to each another.

(2) Geotextile filter shall be installed, cut and jointed in accordance with the manufacturer's recommendations.

(3) Laps in sheets of fabric reinforcement which are not stated in the Contract to be jointed shall be at least 300 mm.

Protection of geotextile filter 7.174 Constructional Plant and other vehicles shall not operate on installed geotextile filter unless in the opinion of the Engineer it is adequately protected by a cover of fill material or other means agreed by the Engineer.

Records of geotextile filter 7.175 Records of installation of geotextile filter shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer each day. Records shall contain the following details:

(a) identification of structures and sections of work where geotextile filter is installed,

(b) type of geotextile filter, including identification of batch,

(c) date of first exposure of geotextile filter to ultra-violet radiation before installation,

(d) type of joint, amount of overlap, method of holding in place and any repairs to geotextile filter carried out during installation,

(e) date of installation of geotextile filter, and

(f) date of final covering of geotextile filter.

RAKING DRAINS

Installation of raking drains

7.176 (1) The length of raking drains assembled before installation shall not exceed 12.5 m. Connections between adjacent pipes shall be secured in such a manner that the cumulative longitudinal extension of a 12.5 m assembled length of pipe does not exceed 5 mm when pulled by hand.

(2) Pipes for Type 2 and Type 3 raking drains which are to be wrapped in geotextile filter sheath shall be placed along the centre of a strip of geotextile filter of sufficient width to allow a lap of at least 50 mm. The strip of geotextile filter shall be drawn around the pipe and fixed to the pipe along the pipe invert and fixing with non-metallic ties at 300 mm centres to prevent dislocation during installation. The ends of pipes shall be marked to ensure that the impermeable invert is correctly positioned during installation.

Drilling for raking drains

7.177 (1) Drilling lubricants other than clean air or fresh water shall not be used for drilling holes for raking drains. Casings shall be used to prevent collapse of the hole and to permit unobstructed insertion of the pipes and geotextile filter sheath.

(2) The drillhole entry point shall be positioned within a tolerance of ±75 mm. Deviation in alignment shall not exceed 1 in 20. Deviation from straight shall not exceed 20 mm in any 3 m length of drillhole. A positive gradient shall be maintained throughout the complete length of the hole. The inclination of holes shall be measured by a method agreed by the Engineer.

(3) Drilling and sampling for undisturbed soil samples and rock cores instructed by the Engineer to be recovered from drillholes shall be as stated in Clauses 7.25 to 7.38.

(4) Drillholes shall be temporarily plugged or otherwise protected to prevent entry of deleterious material after drilling.

Records of drillholes for raking drains

7.178 Records of drillholes for raking drains shall be kept by the Contractor on the Site and a drillhole log for each drillhole shall be submitted to the Engineer before installation of the raking drain starts. The borehole log shall contain the following details:

(a) drain reference number,

(b) location, inclination, bearings, diameter and length of hole,

(c) details of drilling progress,

(d) details of water seepage related to drilling progress, and

(e) details of samples taken.

TRENCH DRAINS

Excavation for trench drains 7.179 The width of trench drains shall be at least 450 mm. The width of trench drains with filter pipes not exceeding 150 mm diameter shall be at least four times the nominal diameter of the pipe. The width of trench drains for pipes exceeding 150 mm diameter shall be at least the same as the external diameter of the pipe plus 450 mm.

Geotextile filter surround for trench drains 7.180 Geotextile filter surround for trench drains shall be installed as stated in Clause 7.173.

Bed for trench drains 7.181 (1) Concrete bed for filter pipes in trench drains shall be at least 75 mm thick and shall be Grade 20/20 concrete.

(2) Granular bed for filter pipes for trench drains shall have a thickness at least the same as the diameter of the pipe or 150 mm, whichever is greater.

Deposition and compaction of fill material for trench drains 7.182 (1) The material for granular bed for trench drains shall be deposited in the trench in layers not exceeding 150 mm thick and for the complete width of the trench. Each layer shall be compacted with six passes of a plate vibrator or by other methods agreed by the Engineer.

(2) Fill material around filter pipes in trench drains shall be deposited and compacted as stated in Clauses 6.43(2) and (3) and 6.48. The permission of the Engineer shall be obtained before fill material is deposited around filter pipes.

RELIEF DRAINS

Trials for relief drains 7.183 A trial length of relief drains of at least 2 m shall be constructed.

Fixing relief drains 7.184 Relief drains shall be fixed in position before surface protection or remedial measures are applied. Fixing shall be carried out in a manner which will not affect the serviceability of the relief drains or outlets. Water collected in relief drains shall be discharged to outlets agreed by the Engineer.

CAISSON DRAINS

Construction of caisson drains 7.185 (1) Excavation for caisson drains shall be carried out by manual methods in stages not exceeding 1.0 m depth unless otherwise permitted by the Engineer. Dewatering shall be carried out for excavation below the groundwater level so that work may be carried out, as near as may be practicable in the circumstances, in dry conditions. Dewatering shall be carried out as stated in Clauses 7.189 and 7.190.

(2) Unless otherwise permitted by the Engineer, the caisson drain shaft shall be supported at all times during construction using concrete liners. Voids between liners and excavated faces shall be filled with no fines concrete. Caisson liners for each 1.0 m stage shall be installed on the same day as that stage is excavated.

(3) Softened and loose material shall be removed from the base of the caisson drain immediately before granular filter material is deposited in the caisson drain.

(4) Part or all of the concrete liner adjacent to the granular filter layer shall be removed before granular filter material or fill material is deposited. Debris from the concrete liner shall be removed from the caisson drain.

(5) Granular filter material shall be deposited in layers not exceeding 500 mm and shall be compacted by methods approved by the Engineer.

Discharge of water from caisson drains

7.186 Water collected in caisson drains shall be discharged to the outlets stated in the Contract.

Records of caisson drains

7.187 (1) Records of caisson drains shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 14 days after completion of construction of caisson drains. The records shall contain the following details:

(a) record of work carried out each day, and

(b) drawings showing the exact locations of caisson drains and the final depths relative to PD.

(2) Detailed face logs of caisson drains shall be kept by the Contractor on the Site and shall be available for inspection by the Engineer at all times. The logs shall contain the information required in Clause 7.24(2)(b), (2)(c) and (2)(d) and the format shall be as shown in Figure 10 of `Geoguide 2: Guide to Site Investigation', Hong Kong Government 1987.

PREFABRICATED BAND DRAINS

Installation of prefabricated band drains

7.188 (1) The installed location of prefabricated band drains shall be within 300 mm of the specified location in plan on the ground surface and the drain shall be within 2% of the installed length to the vertical.

(2) Each prefabricated band drain shall be installed in one continuous length without joints.

(3) The depth of penetration of prefabricated band drains shall be as stated in the Contract; modified as instructed by the Engineer during installation based on the resistance of the soil to penetration. The Contractor shall notify the Engineer immediately of any sudden change in the penetration resistance to the mandrel.

GROUNDWATER CONTROL AND DRAWDOWN

Drawdown of groundwater table

7.189 The groundwater table shall not be drawn down to more than 2 m below the earthworks final surface as defined in Clause 6.03 for excavation.

Dewatering

7.190 (1) Dewatering shall be carried out in such a manner that no loss of fines from the ground occurs.

(2) Silt traps shall be provided and shall be regularly maintained; all dewatering pumps shall discharge into silt traps.

(3) Pumped groundwater shall not be discharged onto roads, footpaths, kerb channels or adjacent land. The Contractor shall make all arrangements with and obtain the necessary approvals from the relevant authorities for discharging water to drainage systems, watercourses or the sea. Dewatering shall not start until the approved arrangements for disposal of the water have been implemented. Water entering the Site shall not be discharged into the same silt traps as are used for dewatering.

(4) The total capacity of pumps available on the Site for dewatering shall be at least equal to twice the rate of flow measured through the silt traps at any time when the groundwater table is maintained at maximum drawdown.

(5) Half of the total pump capacity shall be equipped with a secondary motive power source in addition to the primary motive power. The secondary motive power source shall commence operation automatically in the event of failure of the primary motive power source or an effective alarm system shall be set up which will warn of failure of the primary motive power source. The maximum allowable delay between failure of the primary motive power source and full operation of the secondary motive power source shall not exceed 15 minutes.

(6) A full-time attendant shall be available on the Site at all times to execute the changeover if manual operation of equipment is required to bring the secondary motive power into operation.

(7) The operation of the changeover of motive power equipment shall be demonstrated before the relevant work starts unless otherwise permitted by the Engineer.

Groundwater recharge

7.191 (1) If groundwater recharge is to be carried out to maintain the specified groundwater levels at any location, the groundwater recharge system shall have the means to regulate and measure the rate of recharge and to provide an adequate continuous supply of water for recharge. Only clean fresh water shall be used.

(2) The capacity of pumps and the power sources which are to be used for groundwater recharge shall be as stated in Clause 7.190(4) except that the rate of flow shall refer to the maximum rate of groundwater recharge required.

(3) The groundwater table at any location shall not be raised above the background groundwater table measured before the relevant work starts.

Monitoring of groundwater control and drawdown

7.192 (1) Monitoring of groundwater levels shall be carried out at locations stated in the Contract or instructed by the Engineer at all times when groundwater control and drawdown in carried out. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) The survey marks for monitoring shall be located in position and level to the Hong Kong standard survey grid and to PD to within 10 mm in every direction.

(3) Monitoring stations and monitoring shall be as stated in Clauses 7.201 to 7.218.

(4) Groundwater levels shall be measured to an accuracy of 20 mm. Settlements shall be measured to an accuracy of 3 mm.

(5) The Contractor shall notify the Engineer immediately if any incremental settlement reading exceeds 5 mm or if the accumulated settlement exceeds the maximum allowable settlement stated in the Contract.

Records of settlement, groundwater control and drawdown

7.193 Records of monitoring of settlement, groundwater control and drawdown shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 24 hours of taking readings.

TESTING: GRANULAR FILTER MATERIAL

Batch: granular filter material

7.194 A batch of granular filter material is any quantity of granular filter material of the same type and grading delivered to the Site at any one time.

Samples: granular filter material

7.195 (1) One sample of granular filter material shall be provided from each 500 m^3 or part thereof of the material delivered to the Site.

(2) Unless otherwise permitted by the Engineer, one sample of granular material shall be provided from each 500 m^3 or part thereof of granular filter material which has been deposited and compacted.

(3) The size of each sample taken as stated in Clause 7.195(1) shall be 10 kg. The method of sampling shall be in accordance with BS 812: Part 102.

(4) Samples taken as stated in Clause 7.195(2), shall consist of material excavated from the compacted layer to form a flat bottomed, steep sided hole of approximately 0.13 m^2 to the complete depth of the compacted layer; a template shall be used to fix the edges of the hole if necessary. The sides and bottom of the hole shall be at least 50 mm from other types of fill material.

Testing: granular filter material

7.196 (1) Each sample of granular filter material shall be tested to determine the particle size distribution.

(2) The method of testing shall be in accordance with the wet sieving method stated in GEO Report No. 36, test 2.9.2B.

Non-compliance: granular filter material 7.197

(1) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 7.195(1) does not comply with the specified requirements for particle size distribution, additional samples shall be provided from the same batch and additional tests for particle size distribution shall be carried out.

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

(3) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 7.195(2) does not comply with the specified requirements for particle size distribution, additional samples shall be provided from the same batch and additional tests for particle size distribution shall be carried out.

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

TESTING: FILL MATERIAL FOR TRENCH DRAINS

Batch: fill material for trench drains 7.198

A batch of fill material for trench drains is any quantity of fill material for trench drains of the same type delivered to the Site at any one time.

Samples: fill material for trench drains 7.199

(1) Unless otherwise permitted by the Engineer, one sample of fill material for trench drains shall be provided from each batch of fill material for trench drains delivered to the Site.

(2) The size of each sample and the method of sampling shall be in accordance with Clause 7.195(3).

Testing: fill material for trench drains 7.200

(1) Each sample of fill material for trench drains shall be tested to determine the particle size distribution; fill material passing a 425 μm BS test sieve shall also be tested to determine the plasticity index.

(2) The method of testing to determine the particle size distribution shall be in accordance with GEO Report No. 36, test 2.9.2B. The method of testing to determine the plasticity index shall be in accordance with GEO Report No. 36, tests 2.4.3 and 2.5.3.

PART 6: GEOTECHNICAL INSTRUMENTATION

GLOSSARY OF TERMS

Datum station 7.201 Datum station is a mark for which horizontal or vertical values, or both, have been fixed, and which is used as a datum for monitoring or control surveys.

Geotechnical instrumentation 7.202 Geotechnical instrumentation is the installation and monitoring of instruments in the ground or structures to provide information on soil and rock parameters, and to monitor specific variations in the condition of the ground or structures for the purposes of geotechnical design, construction control and performance monitoring.

Monitoring mark 7.203 Monitoring mark is a mark, fixed or installed, on a structure to be monitored.

Reference point 7.204 Reference point is a mark placed close to another important survey mark to aid recovery or replacement.

Survey station 7.205 Survey station is a mark on a stone, concrete, metal or wooden block, pipe, peg or other item defining a surveyed position.

SUBMISSIONS

Particulars of geotechnical instrumentation 7.206 (1) The following particulars of the proposed geotechnical instrumentation shall be submitted to the Engineer:

(a) details of instruments and any alternative instruments proposed by the Contractor,

(b) manufacturer's specifications,

(c) test and calibration certificates,

(d) method of installation,

(e) method of acceptance testing,

(f) details of ancillary measuring equipment,

(g) schedule for installing instrumentation in relation to other work,

(h) documents showing that the instruments are capable of measuring within the ranges and accuracies stated in the Contract,

(i) name and experience of persons responsible for installation, testing and monitoring of instruments,

(j) details of standpipe piezometer tips, including manufacturer's specification, and

(k) details of the form of records.

(2) The particulars shall be submitted to the Engineer for approval at least 28 days before installation of instrumentation starts.

GENERAL GEOTECHNICAL INSTRUMENTATION REQUIREMENTS

Instruments for geotechnical instrumentation

7.207 (1) Instruments for geotechnical instrumentation and their accessories shall be provided complete with all appropriate tubing, connections, monitoring equipment, read-out units and any other tools necessary for the installation calibration, setting to work and maintenance of the instruments.

(2) Instruments shall be manufactured by companies with proven experience and only instruments which are well proven and have been in successful use shall be used, unless otherwise agreed by the Engineer.

(3) Installed instruments shall become the property of the Employer. Detachable tubing, connections, monitoring equipment and read-out units shall become the property of the Contractor upon the expiry of the Maintenance Period.

(4) Instruments shall be handled, stored, installed and used in accordance with the manufacturer's recommendations and in such a manner that the performance of the instruments will not be impaired.

(5) Instruments shall be protected from damage and measures shall be taken to ensure that the instruments suffer the minimum practicable amount of disturbance.

(6) Instruments shall be calibrated by a laboratory approved by the Engineer. Instruments shall be calibrated at intervals recommended by the manufacturer and at other intervals instructed by the Engineer. Calibration certificates shall be provided to the Engineer within 24 hours after calibration.

(7) Installation, testing and monitoring of the instruments shall be carried out under the supervision of a suitably qualified technician. Particulars of the technician, including qualifications and experience, shall be submitted to the Engineer at least 7 days before commencement of work relating to geotechnical instrumentation.

Location and arrangement of instruments

7.208 (1) The locations and arrangement of instruments for geotechnical instrumentation shall be as stated in the Contract or as agreed with the Engineer before installation.

(2) The positions and alignments of instruments shall be recorded after installation and surveys shall be carried out at times and frequencies agreed by the Engineer to detect any displacement of the instruments.

(3) At least two reference points shall be established for each survey station or monitoring mark.

(4) The survey station which has the least chance of being disturbed shall be selected as datum station. The datum station shall be stainless steel and shall be protected from damage. At least three reference points shall be established for each datum station.

(5) The survey network shall be related to the territorial control points provided by the Engineer.

Installation of instruments

7.209 (1) The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before the installation of each instrument for geotechnical instrumentation starts.

(2) Instruments shall be installed, fixed and protected in a manner which will ensure that the instruments will function satisfactorily. Tests shall be carried out after installation to demonstrate that the instruments have been correctly installed and are functioning correctly. Instruments which are not correctly installed or are not functioning correctly shall be reinstalled or replaced as instructed by the Engineer.

(3) All installed instruments, tubes and wires shall be clearly marked with a unique and conspicuous identification number.

Tubes and cables for instruments

7.210 (1) Tubes and cables attached to instruments for geotechnical instrumentation for remote reading shall be impervious to air and water, and shall have sufficient strength and stiffness to withstand the internal and external pressures. Tubes and cables shall be protected from mechanical damage and from the harmful effects of direct sunlight, heat and ultra violet radiation at all times.

(2) Tubes and cables shall be free from defects and shall be marked with identification colours and numbers at 5 m intervals. The tubes and cables shall be wound onto reels in such a manner that kinks are not formed and strain is not induced. Open ends of tubes and cables shall be blocked with stop ends at all times.

(3) Tubes and cables shall be buried at least 0.5 m below ground level.

(4) Tubes and cables shall be laid with sufficient slack, loops and bends to allow for settlement and other ground movements. The routing of tubes and cables shall be as agreed by the Engineer and shall be in straight lines unless otherwise permitted by the Engineer. The radius of bends shall be at least 300 mm. Each tube or cable shall be laid from the measuring instrument to the terminal duct in one continuous length without joints.

Maintenance of instruments

7.211 (1) Instruments for geotechnical instrumentation shall be maintained in good working order until the expiry of Maintenance Period. Instruments, survey marks and stations shall be protected by suitable barricades, notices, signs, marker-buoys or by other methods agreed by the Engineer. Construction shall be carried out in a manner which will avoid damage to the instruments.

(2) The Contractor shall inform the Engineer immediately of any instruments found damaged or instruments found not to be in working order. Replacements shall be installed for read-out units which are faulty or under repair.

Records of geotechnical instrumentation

7.212 (1) Records of activities relating to installation of geotechnical instrumentation shall be kept by the Contractor on the Site and a copy shall be submitted to the Engineer within 24 hours after installation of the instrument is complete.

(2) A drawing showing the locations and identification of installed instruments shall be prepared by the Contractor and submitted to the Engineer within 24 hours after installation of the instrument is complete.

(3) A drawing showing the locations and details of survey stations, monitoring marks and reference points shall be prepared by the Contractor and submitted to the Engineer within 3 days after the survey network has been established.

MONITORING AND RECORDING

Recording readings

7.213 (1) Instrument readings and processed data for geotechnical instrumentation shall be recorded by the Contractor on agreed record sheets, and shall be submitted to the Engineer within 24 hours after recording. The form of record sheets shall be as agreed by the Engineer. Unless otherwise agreed by the Engineer, readings shall be taken in the presence of the Engineer.

(2) Initial readings shall be taken immediately after the instruments have been installed and after the effects of installation have subsided. The initial readings shall be submitted to the Engineer and shall form the basis of comparison of subsequent readings. The instruments and the initial readings shall be replaced if the initial readings are not repeatable.

(3) The frequencies for reading instruments shall be as agreed with the Engineer. The Contractor shall inform the Engineer immediately of sudden or significant changes in the readings.

(4) All installed instruments shall be left in correctly functioning condition after final readings have been taken or at the end of the Maintenance Period. Keys for locks shall be tagged to identify the instrument number and shall be handed over to the Engineer.

SETTLEMENT PLATES

Installation of settlement plates

7.214 (1) Settlement plates for geotechnical instrumentation shall be securely founded on level ground free from obstructions and shall be immediately surveyed for level and position and plotted on a plan.

(2) Settlement plates shall be protected from damage and shall be kept in position by a 600 mm thick layer of granular fill material or bags of sand which shall be placed by manual methods and shall extend 600 mm beyond the edges of the plate. The initial survey of levels and positions shall be taken immediately after the fill material or bags of sand have been placed.

(3) The metal rod fixed to the centre of the plate shall be in an upright position, and protected by a tubular sleeve. The sleeve and the metal rod shall be extended as fill material is placed such that at any time the sleeve and rod are at least 500 mm above the level of the surrounding fill material or high water mark, and the metal rod is within 2% of the embedded length to the vertical.

(4) The level of the top of the metal rod shall be recorded immediately before and immediately after each extension piece is added. Marker-buoys shall be fixed to the tops of tubular sleeves installed in water, unless otherwise permitted by the Engineer.

TILTMETER SYSTEM

Installation of tiltmeter system 7.215 (1) Tilt-plates for geotechnical instrumentation shall be orientated to correspond with the specified direction of measurement and fixed in place on the rock or structure. The installed direction shall be recorded to an accuracy of ±3°.

(2) A protective cap or cover shall be fitted to protect the tilt-plates from damage.

(3) Tilt-plates and the tiltmeter shall be cleaned and inspected for damage before readings are taken. The tiltmeter shall be accurately located on the tilt-plate and a reading taken. The tiltmeter shall then be removed and the contact surface recleaned. The procedure shall be repeated until consistent readings are obtained. The tiltmeter shall then be rotated through 180° and the procedures repeated.

(4) The accuracy of the tiltmeter and its readout system shall be checked both before and after the readings taken each day. Instrument errors shall be investigated and immediately corrected; a record of calibrations and adjustments shall be submitted to the Engineer together with the monitoring data.

TELLTALES

Installation of telltales 7.216 Unless otherwise approved by the Engineer telltales for geotechnical instrumentation shall be as shown in Figure 10.5 of `The Geotechnical Manual for Slopes', Hong Kong Government, 1984. Telltales shall be rigidly fixed across cracks to enable any movement across the cracks to be determined. Telltales shall be labelled and marked with the date of installation.

STANDPIPE PIEZOMETERS

Standpipe piezometers 7.217 Standpipe piezometer tips for geotechnical instrumentation shall be porous ceramic or plastic material at least 200 mm long and with a bore of at least 19 mm; the permeability shall be at least 10^{-4} m/s. The piezometer tip shall be connected to rigid PVC standpipes with a bore of at least 19 mm and with a wall thickness of at least 3 mm. The standpipes shall be jointed together and to the porous tips in such a manner that the joints remain leak-proof under the anticipated head of water.

Installation of standpipe piezometers 7.218 (1) Standpipe piezometers for geotechnical instrumentation shall be installed in drillholes at the depths instructed by the Engineer.

(2) The sand filter surrounding the piezometer tip shall be between 1000 mm and 1500 mm long and shall consist of sand between the sizes of 200 μm and 1210 μm. Measurements shall be made to determine the actual location of the sand filter column.

(3) A seal shall be formed above the sand filter by placing 500 mm of bentonite pellets of between 10 mm and 15 mm in size. The pellets shall be placed in the hole and tamped with a suitably shaped tamper to form a homogeneous plug to the hole.

(4) If the depth of the completed hole is greater than the depth at which the piezometer tip and sand filter are to be placed, the bottom of the drillhole shall be grouted with grout consisting of cement and bentonite in the proportions 1:1 by mass together with sufficient water to achieve the required workability. The drillhole above the plug shall be grouted with the same type of material.

(5) The water level in the piezometer shall be measured after the standpipe piezometer has been installed and the standpipe shall be topped up with clean water. The rate of drop of water level or pressure head shall be recorded at times of 0, 1/4, 1/2, 1, 2, 4, 8, 15, 30 minutes or until the water has returned to its initial level.

(6) The water level shall be measured by an electrical type water level probe agreed by the Engineer; the water shall be salted if necessary for response to the probe.

(7) Measurements of the depth of piezometer tip and sand filter and the readings taken as stated in Clause 7.218(6) shall be submitted to the Engineer for approval within 24 hours after completion of installation of the piezometer standpipe.

APPENDIX 7.1

GEO PROBE TEST

Scope 7.1.1 This method covers the determination of the penetration resistance of soil using the GEO probe.

Apparatus 7.1.2 The following apparatus is required:

(a) GEO Probe as shown in Figure 36 of `Geoguide 2: Guide to Site Investigation,' Hong Kong Government 1987. The anvils shall be rigidly fixed to the guide rod, the lower anvil shall also be rigidly fixed to the extension rods. The mass of the lower anvil shall be between 1.5 kg and 1.8 kg. The combined mass of the lower anvil, guide rod and upper anvil shall not exceed 5.0 kg.

(b) Extension rods with a length of 1000 mm ±10 mm. The rods shall be attached to bear against each other by means of external couplers.

Procedure 7.1.3 The procedure shall be as follows:

(a) The lower end of the probe shall be rested against the ground at the test location, with the first extension rod and guide rod in a vertical position.

(b) The hammer shall be raised to bear against the upper anvil, and shall be allowed to fall freely. It shall not be connected to objects which may influence its acceleration and deceleration, and shall be stationary when released in the upper position. The fall shall be 300 mm ± 5 mm.

(c) The hammer shall be used to drive the probe into the ground, with a rate of driving between 20 and 60 blows per minute.

(d) Additional extension rods shall be added as necessary. The rods shall be rotated clockwise one full turn each time a rod is added to ensure that screw joints are tight.

(e) The blow count for every 100 mm of penetration shall be recorded, or at refusal the penetration distance for 50 blows of the hammer. Interruptions exceeding 5 minutes shall be recorded.

Reporting of results 7.1.4 The following shall be reported:

(a) Blow count for every 100 mm penetration or at refusal the penetration distance for 50 blows of the hammer.

(b) Interruptions exceeding 5 minutes.

(c) GEO probe record as shown in Figure 37 of `Geoguide 2: Guide to Site Investigation,' Hong Kong Government 1987.

(d) That the test was carried out in accordance with this Specification.

GENERAL SPECIFICATION
FOR
CIVIL ENGINEERING WORKS

SECTION 8

PILING WORKS

SECTION 8

PILING WORKS

GENERAL

General requirements 8.01 The works and materials specified in Clauses 8.02 to 8.09 shall comply with the sections stated, unless otherwise stated in this Section.

Earthworks 8.02 Earthworks shall comply with Section 6.

Reinforcement 8.03 Steel reinforcement shall comply with Section 15.

Concrete 8.04 Concrete shall comply with Section 16.

Materials for grout 8.05 Materials for grout for piling works shall comply with Section 16.

Grouting 8.06 Grouting for piling works shall comply with Section 17.

Prestressing 8.07 Prestressing shall comply with Section 17.

Steelwork 8.08 Steelwork shall comply with Section 18.

Marine works 8.09 Marine works shall comply with Section 21.

Code of practice for piling works 8.10 Piling works shall comply with the BS 8004, except as stated in this Section.

Safety of piling works 8.11 Reference shall be made to the following documents regarding matters relating to the safety of piling works:

Code of Practice for Foundations : BS 8004

Code of Practice for Safety Precautions in the Construction of Large Diameter Boreholes for Piling and Other Purposes : BS 5573

Section 7 of `Guidance Notes on Hand-Dug Caissons' Hong Kong Institution of Engineers,1981

GLOSSARY OF TERMS

Hand-dug caisson 8.12 A hand-dug caisson is a pile shaft which is excavated manually and which is unlined, or lined with a ring wall following each incremental advance of the excavation, or partly unlined and partly lined.

Barrette 8.13 A barrette is a pile which is excavated using grabs and chisels through a thixotropic suspension of bentonite or other agent which supports the sides of the shaft as excavation proceeds, and which is concreted in one continuous operation.

Minipile 8.14 A minipile is a pile with a diameter of less than 250 mm in which the load bearing element consists of a steel tube or one or more steel reinforcement bars.

MATERIALS

Steel piles 8.15 (1) Steel bearing piles and steel sheet piles shall comply with BS 5950: Part 2.

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

Pile shoes 8.16 (1) Cast iron pile shoes for precast concrete piles shall be manufactured from chill hardened iron as used for making grey iron castings complying with BS 1452, Grade 150. The chilled iron point of the shoe shall be free from major blow holes and other surface defects.

(2) Steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS 4360, Grade 43A.

(3) Cast steel pile shoes for precast concrete piles shall be manufactured from steel complying with BS 3100, Grade A.

(4) Straps and fastenings for cast pile shoes for precast concrete piles shall be manufactured from steel complying with BS 4360, Grade 43A and shall be cast into the point of the shoe to form an integral part of the shoe.

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

(6) Cast steel pile shoes for steel bearing piles shall be manufactured from steel complying with BS 3100, Grade A.

(7) Welded fabricated pile shoes for steel bearing piles shall be manufactured from steel complying with BS 4360, Grade 43A.

Epoxy paint 8.17 Epoxy based paint for epoxy coatings to steel piles shall be a proprietary type approved by the Engineer.

Bituminous coating material 8.18 Bituminous coating material for steel piles shall be hot-applied filled or unfilled bituminous material complying with BS 4147.

Grout for piling works 8.19 (1) Grout for piling works shall consist of OPC and water. Sand, PFA and admixtures may be used with the approval of the Engineer.

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

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

(4) Grout used in minipiles shall have a minimum crushing strength of 30 MPa at 28 days.

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

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

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

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

Reinforcement connectors 8.20 Reinforcement connectors for minipiles shall be capable of transmitting the total pile load in tension or compression as appropriate.

SURFACE TREATMENT OF STEEL PILES

Surface treatment of steel piles 8.21 (1) Surface preparation and application of protective coatings other than bituminous coatings to steel piles shall be carried out in a fully enclosed well-ventilated workshop.

(2) The method of application of protective coatings to steel piles, the ambient temperature and humidity at the time of application and the time interval between the application of successive coats shall be in accordance with the manufacturer's recommendations. The complete coating shall be applied in and around clutches.

Surface preparation of steel piles 8.22 The surfaces of steel piles to which protective coatings will be applied shall be prepared by blast cleaning to second quality of surface finish in accordance with BS 4232 or Sa 2½ in accordance with SIS 05 59 00.

Epoxy coatings to steel piles 8.23 (1) Epoxy coatings to steel piles shall consist of three coats of epoxy based paint, each coat having a minimum dry film thickness of 75 μm. The first coat shall be applied within two hours of blast cleaning.

(2) The finished surface of epoxy coatings shall be smooth with a dense and uniform texture and shall be free from sharp protuberances and pinholes. The thickness and continuity of completed epoxy coatings shall be measured using a magnetic thickness gauge or by other methods agreed by the Engineer.

(3) Damaged areas of epoxy coatings shall be repaired by cleaning the damaged areas to bare metal, feathering back the adjacent areas with coarse grade sandpaper and re-applying the coating.

Bituminous coatings to steel piles

8.24 (1) Bituminous coating material, or primer if the bituminous coating consists of a built-up system, to steel piles shall be applied within two hours of blast cleaning. The thickness of bituminous coatings shall be at least 300 μm.

(2) Damaged areas of bituminous coatings shall be overcoated with the same bituminous coating material to restore the specified thickness.

Surface treatment of extended steel piles

8.25 The splice areas of steel piles which are extended in-situ shall be prepared by blast cleaning and the protective coating shall be applied to the area. Steel piles for marine works shall be spliced and the surface treatment applied to the splice areas before the piles are driven unless otherwise permitted by the Engineer.

Removal of protective coatings to steel piles

8.26 Protective coatings shall be removed from the heads of steel piles which will be encased in concrete by blast cleaning, flame cleaning or by other methods agreed by the Engineer. The coatings shall be removed to a level of 75 mm above the underside of the concrete into which the pile will be encased.

SUBMISSIONS

Particulars of piling works

8.27 (1) The following particulars of the proposed materials and methods of construction for piling works shall be submitted to the Engineer:

(a) details of Constructional Plant,

(b) methods and sequence of installation of piles, including methods of avoiding damage to adjacent piles, structures and utilities and measures to be taken to deal with hard material and obstructions,

(c) calculations of driving stresses,

(d) methods of jointing and lengthening piles,

(e) methods of controlling groundwater, or groundwater treatment,

(f) anticipated ground vibration, ground movement and groundwater drawdown and methods of instrumentation and monitoring,

(g) methods and sequence of excavation, including methods of supporting excavations and of cleaning the excavation,

(h) methods of concreting,

(i) details of protective coatings to steel piles, including manufacturers' literature,

(j) details of preliminary piles, and

(k) methods of testing, including details of the specialist firm for non-destructive testing of welds and the programme for integrity testing.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant preliminary piles are constructed; if preliminary piles are not required, the particulars shall be submitted to the Engineer at least 21 days before the relevant piling works start.

Particulars of construction using bentonite slurry

8.28 (1) The following particulars of the proposed materials and methods of construction using a slurry containing bentonite or other agent shall be submitted to the Engineer:

(a) a certificate for bentonite showing the type, the manufacturer's name, the date and place of manufacture and including details of the apparent viscosity range in Pa.s and the gel strength range in N/m^2 for solids in water,

(b) characteristics of the bentonite slurry in a freshly mixed condition and in the excavation immediately before concreting,

(c) methods of quality control, sampling, testing, mixing, storing, recirculating, removing silt and sand, preventing spillages and disposal from the Site,

(d) head of bentonite slurry, including stability calculations,

(e) details of guide walls,

(f) methods of placing concrete by tremie, and

(g) sequence of construction.

(2) The particulars shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

Particulars of hand-dug caissons

8.29 Particulars of the proposed materials and methods of construction for hand-dug caissons, including details of linings, shall be submitted to the Engineer at least 21 days before the relevant excavation starts.

Particulars of minipiles

8.30 (1) The following particulars of the proposed materials and methods of construction for minipiles shall be submitted to the Engineer:

(a) details of reinforcement or pipe section, including spacers and couplings,

(b) details of grout mix as stated in Clause 17.13, and

(c) sequence and timing of grouting, including details of secondary pressure grouting.

(2) The particulars shall be submitted to the Engineer at least 7 days before trial mixes for grout are made.

HANDLING AND STORAGE OF MATERIALS

Handling and storage of piles

8.31 (1) The identification number, grade of steel and length of pile shall be marked on steel piles. The identification number, date of casting and length of pile shall be marked on precast concrete piles.

(2) Piles shall be stored horizontally off the ground on level supports and in a manner which will not result in damage or deformation to the piles or in contamination of the piles. Coated piles shall be handled and stored in a manner which will not result in damage to the coatings. Bituminous coated piles shall not be stacked.

(3) Different types and sizes of piles shall be stored separately.

Handling and storage of bentonite

8.32 Bentonite shall be handled and stored in a manner which will not result in spillages on the Site.

GENERAL PILING WORKS REQUIREMENTS

Commencement of piling works

8.33 Piling works, including groundwater control and ground treatment for piling works, shall not commence until the relevant proposed materials and methods of construction, including construction and testing of preliminary piles, have been approved.

Prevention of damage due to piling works

8.34 (1) The position of existing utilities shall be determined and underground utilities adjacent to the piles shall be exposed or otherwise accurately located before piling works start.

(2) All necessary measures shall be taken to minimise the settlement of the ground and adjacent structures and utilities and to prevent the formation of cavities in the ground resulting from piling works.

(3) The vibrations due to piling works at structures, utilities and previously installed piles measured in terms of peak particle velocity shall not exceed 25 mm/s.

Monitoring of noise, vibration, ground movement and groundwater level

8.35 (1) Measurements of noise level, vibration, ground movement and groundwater level shall be taken at locations and time intervals stated in the Contract or instructed by the Engineer when piling works are being carried out. Records of the measurements shall be kept and a copy of the records supplied to the Engineer. Arrangements for installing instruments and taking measurements both inside and outside the Site shall be made by the Contractor.

(2) Measurements of noise level and vibration shall be made with instruments of a type agreed by the Engineer.

(3) Sufficient numbers of piezometers and survey points shall be installed to allow the changing groundwater levels and the effects on structures, utilities and previously installed piles to be measured. Measurements shall be taken at regular intervals when groundwater control is carried out and until such time as the groundwater has resumed its natural regime.

(4) The Contractor shall inform the Engineer immediately of any unanticipated change in measurements.

(5) If the specified limits, or limits agreed by the Engineer, on vibration, groundwater movement or groundwater level are exceeded, the work causing the limits to be exceeded shall be stopped and particulars of proposed changes to the methods of construction shall be submitted to the Engineer for approval.

Ground investigation for piling works 8.36 (1) Before piling works start, boreholes of minimum NX size shall be sunk and piezometers shall be installed at locations stated in the Contract or instructed by the Engineer to determine the soil characteristics and the groundwater regime and to determine the founding level of non-displacement cast-in-situ piles.

(2) Soil samples and rock samples stated in the Contract or instructed by the Engineer shall be taken from pile excavations for visual inspection and testing. The method of sampling and testing shall be as stated in Section 7.

Founding levels 8.37 (1) The Contractor shall allow the Engineer to inspect the material at the proposed founding level and shall inform the Engineer immediately the founding level is reached.

(2) If instructed by the Engineer the founding level shall be proved by drilling to a depth of 4.5 m or three times the pile diameter, whichever is greater, below the founding level and obtaining samples of NX size.

PRELIMINARY PILES

Preliminary piles 8.38 (1) Preliminary piles shall be constructed using the materials and methods of construction proposed for the working piles and which have been submitted to the Engineer. The location and details of preliminary piles shall be as instructed by the Engineer.

(2) Unless otherwise permitted by the Engineer the relevant piling works shall not commence until the construction, testing and records of the preliminary piles stated in the contract or instructed by the Engineer have been approved.

(3) Preliminary piles shall be left in position, cut off, incorporated in the permanent work or withdrawn and disposed of as stated in the Contract. Preliminary piles intended to be incorporated in the permanent work and which do not comply with the specified requirements shall be removed and disposed of or dealt with as instructed by the Engineer.

DRIVEN PILES

Supports for driven piles 8.39 (1) Driven piles shall be supported and restrained by means of leaders, trestles, temporary supports or other guide arrangements in such a manner that:

(a) the piles are maintained in position and alignment,

(b) the piles are not loosened in the ground, and

(c) damage resulting from oscillation, vibration or movement of free-standing piles does not occur.

The supports and restraints shall be maintained at all times during driving and until the piles are incorporated into the structure.

(2) Unless otherwise permitted by the Engineer, driven piles for marine works shall be driven from fixed stagings. The stagings shall be rigid and strong enough to ensure that the piling works can be carried out efficiently and accurately.

Followers 8.40 Followers or long dollies shall not be used unless permitted by the Engineer; if permitted, the set shall be revised by the Contractor and agreed by the Engineer, to allow for the reduction in effectiveness of the hammer blows.

Marking of piles 8.41 Piles, including temporary and permanent casings, shall be marked at 1 m intervals before pitching.

Driving piles 8.42 (1) Unless otherwise permitted by the Engineer each pile, other than sheet piles, shall be driven without interruption until the required depth or set has been achieved. If a minimum depth of penetration is stated in the Contract, the Contractor shall submit to the Engineer his proposals for achieving this requirement and it shall be his responsibility to ensure that the minimum penetration and set are achieved without causing damage to the pile.

(2) The sequence and method of driving piles shall be such as to minimise the detrimental effects of heave and lateral displacement of the ground and to cause the least possible displacement to previously installed piles. Piles, including casings, shall not be driven within a centre to centre distance of 3 m or five times the diameter of the pile or casing, whichever is less, from an unfilled excavation or from an uncased concrete pile which has been cast for less than 48 hours.

(3) The Contractor shall inform the Engineer without delay of any sudden change in driving characteristics.

Driving concrete piles 8.43 (1) Concrete piles shall not be driven until the concrete has attained the specified grade strength.

(2) The driving stresses in precast reinforced concrete piles and prestressed concrete piles shall not exceed one half of the specified grade strength of the concrete; calculations of the driving stresses shall be submitted to the Engineer.

Displaced piles 8.44 Piles which have been displaced as a result of driving adjacent piles shall be corrected. Particulars of the method of correction and measures to be taken to avoid displacement in subsequent driving shall be submitted to the Engineer for approval.

Re-drive checks 8.45 No re-drive checks shall be carried out within 24 hours of completion of first driving.

Lengthening driven piles 8.46 The strength of piles at joints shall not be less than the strength at any normal section of the pile. Lengthened piles shall not be driven until the joint has developed the designed strength. Pile joints shall be tested as stated in the Contract or as instructed by the Engineer.

Measurement of set of driven piles 8.47 (1) Set shall be measured for each driven pile at times agreed by the Engineer and in the presence of the Engineer. The final set shall be measured as either:

(a) penetration per 10 blows, or

(b) the number of blows required to produce 25 mm penetration.

(2) If driving is interrupted for more than 30 minutes, except as otherwise agreed by the Engineer, set shall not be measured after driving restarts until at least 20 blows of the same driving energy as at final set have been struck.

(3) When final set is measured:

(a) the exposed part of the pile shall be in good condition without damage or distortion,

(b) the dolly and packing shall be in sound condition,

(c) the hammer blow shall be in line with the axis of the pile and the impact surfaces shall be flat and at right angles to the axes of the pile and hammer, and

(d) the hammer shall be in good condition and operating correctly.

(4) The temporary compression of each driven pile shall be measured.

(5) The Contractor shall inform the Engineer at least 1 hour before final set and temporary compression are to be measured.

CAST-IN-SITU CONCRETE PILES

Excavation for cast-in-situ piles 8.48 (1) Except as stated in Clause 8.49(1), excavation for cast-in-situ concrete piles shall be carried out by mechanical methods; blasting and compressed air shall not be used unless permitted by the Engineer.

(2) The stability of excavations for cast-in-situ concrete piles shall be maintained where necessary by:

(a) temporary casings,

(b) permanent casings, or

(c) a thixotropic slurry containing bentonite or other agent.

(3) The bottom of casings shall be kept sufficiently deep to prevent the flow of soil into the casing.

HAND-DUG CAISSONS

Excavation for hand-dug caissons

8.49 (1) Excavation for hand-dug caissons shall be carried out using manual methods or power tools; blasting shall not be used unless permitted by the Engineer. If blasting is permitted:

(a) the position of blast holes and the size of charges shall be such that shattering of rock beyond the caisson is minimised,

(b) the rock face shall not be shattered within the toe-in or bell-out zone at the bottom of the caisson, and

(c) the caisson opening shall be covered to prevent the projection of fragments of material.

(2) The stability of excavations for hand-dug caissons shall be maintained where necessary by linings.

(3) In-situ concrete tapered rings used as permanent liners shall be at least 100 mm thick and shall not exceed 1 m deep. The rings shall be constructed with well-compacted concrete of Grade 20/20 or greater.

(4) Shaft linings shall be placed as soon as practicable and not more than 24 hours after each increment of excavation is complete.

(5) Voids between the lining and face of the excavation shall be filled with concrete of the same grade as the lining or with other materials agreed by the Engineer.

Sealing and scaling of hand-dug caissons

8.50 (1) Leakages of groundwater through liners or into unlined shafts of hand-dug caissons shall be stopped by a method agreed by the Engineer.

(2) Loose rock on the faces of unlined shafts shall be scaled off and removed before concreting.

BARRETTES

Excavation for barrettes

8.51 (1) Excavation for barrettes shall be carried out by mechanical methods; blasting shall not be used unless permitted by the Engineer.

(2) The stability of excavations for barrettes shall be maintained by a thixotropic slurry containing bentonite or other agent.

(3) The height of guide walls for barrettes shall be such that the head of slurry is sufficient to ensure the stability of excavations and that excessive movements of the adjacent ground will not occur. The position, alignment and level of guide walls shall be checked at regular intervals agreed by the Engineer.

MINIPILES

Excavation for minipiles 8.52 (1) The stability of excavations for minipiles shall be maintained where necessary by temporary casings or by other methods approved by the Engineer.

(2) Temporary casings shall be used if excavation is carried out by wash boring methods or when coring water or air is used as a flushing medium.

Grouting trials for minipiles 8.53 Grouting trials shall be carried out to demonstrate accurate control of water/cement ratio, consistency of mixing, satisfactory workability and achievement of strength requirements. The trial shall be carried out on one minipile which is representative of those which will be used in the permanent work and at a location agreed by the Engineer.

CONSTRUCTION USING BENTONITE SLURRY

Excavation using bentonite slurry 8.54 (1) Excavations for piles using bentonite slurry shall be filled with the slurry from the time that excavation commences until concreting is complete. The slurry shall be maintained at a level of at least 1 m above the level of the external groundwater and such that the slurry pressure exceeds the pressure exerted by the soil and ground water.

(2) If there is a loss of bentonite slurry from the excavation which is sufficient to result in a lack of stability and if instructed by the Engineer, the excavation shall be immediately filled with material agreed by the Engineer. The cause of the loss of slurry shall be investigated and excavation shall not recommence until remedial measures have been approved by the Engineer.

Mixing of bentonite slurry 8.55 (1) Bentonite shall be thoroughly mixed with water in a colloidal mixer. The water shall be taken from the public supply of potable water and shall be at a temperature of at least 5°C. The temperature of the bentonite slurry shall be at least 5°C when supplied to the excavation.

(2) If the groundwater is excessively saline or chemically contaminated, the bentonite shall be prehydrated or the bentonite slurry shall be modified such that the slurry is suitable for the support of the excavation.

Disposal of bentonite slurry 8.56 Bentonite slurry which will not be reused shall be disposed of from the Site as soon as practicable.

FIXING REINFORCEMENT FOR PILES

Fixing reinforcement for piles 8.57 Prefabricated reinforcement cages for piles shall be marked and fitted with spacers to ensure that the cage is correctly orientated and positioned within the pile.

PLACING CONCRETE IN PILES

Cleaning and drying excavations for piles

8.58 (1) The bases of excavations for piles shall be cleaned by air lifting or by other methods agreed by the Engineer before concrete is placed. If excavation is carried out under water, cleaning shall continue until the water is clear and free from particles of soil. Measures shall be taken to prevent the accumulation of silt and other material at the base of the excavation.

(2) If the rate of ingress of water does not exceed 0.3 L/s, the base of excavations for piles shall be dried immediately before concrete is placed.

Placing concrete in piles

8.59 (1) Each pile shall be concreted as soon as practicable after the permission of the Engineer has been obtained. Concrete shall be placed without interruption until the complete pile is concreted.

(2) If excavations for piles are supported by bentonite slurry or if the rate of ingress of water exceeds 0.3 L/s, the following shall be complied with:

(a) concrete shall be placed by tremie unless otherwise permitted by the Engineer,

(b) the minimum cementitious content of the concrete shall be 375 kg/m^3,

(c) the level of the top of the concrete in piles shall be at least 750 mm above the specified cut-off level,

(d) if the top of the guide wall for barrettes is at the specified cut-off level, concrete shall continue to be placed until the top of the pile is free from contamination, and

(e) after the concrete has hardened, excess concrete shall be removed to the specified cut-off level.

(3) Operations which in the opinion of the Engineer are likely to disturb or affect the concrete or placing of the concrete shall not be carried out unless agreed by the Engineer.

Removal of temporary casings to piles

8.60 (1) A sufficient quantity of concrete shall be maintained within temporary casings which are being withdrawn to ensure that the pressure from external water or soil is exceeded and that the pile is not reduced in section or contaminated.

(2) Temporary casings which are in contact with concrete and which are not withdrawn before the initial set of the concrete has taken place shall be left in place.

Empty bores above piles

8.61 Empty bores and shafts which remain above the pile after concrete has been placed shall be temporarily protected or filled with material agreed by the Engineer as soon as practicable.

INSPECTION OF PILING WORKS

Inspection of excavations for piles

8.62 The Contractor shall allow the Engineer to inspect excavations for piles before placing concrete in the pile and at other times required by the Engineer. The Engineer shall decide on the most suitable method to be used for inspecting excavations and the Contractor shall provide all the necessary facilities and equipment to enable the Engineer to carry out the inspection in a safe manner. The Contractor shall inform the Engineer 24 hours, or such shorter period agreed by the Engineer, before placing concrete in piles.

Inspection of installed piles

8.63 (1) If instructed by the Engineer, installed piles shall be exposed for inspection or testing. Excavations for exposing piles shall be of a depth agreed by the Engineer, and the face of the excavation shall be at least 750 mm from the face of the pile. The excavation shall be maintained in a stable condition and kept free from water.

(2) The surface of the pile shall be washed clean of all silt, mud or other adhering materials to permit inspection.

(3) After inspection, excavations for exposing piles shall be filled using special fill material which shall be compacted to obtain a relative compaction of at least 95% above the groundwater table.

TOLERANCES

Tolerances: steel bearing piles

8.64 Dimensional tolerances of steel bearing pile sections shall comply with the relevant BS stated in Clause 18.04. Fabrication tolerances for steel bearing piles and related steelwork shall comply with BS 5950: Part 2.

Tolerances: precast concrete piles

8.65 The manufacturing tolerances for precast concrete piles shall comply with the following requirements:

(a) The external cross-sectional dimensions shall be within 0 mm and +6 mm of the specified dimensions.

(b) The wall thickness of hollow spun concrete piles shall be within 0 mm and +25 mm of the specified thickness.

(c) There shall be no irregularity exceeding 6 mm in a 3 m length along the face of the pile measured using a 3 m straight edge.

(d) There shall be no irregularity exceeding 25 mm in a 3 m length along the internal face of hollow spun concrete piles measured using a 3 m straight edge.

(e) The centroid of any cross-section of the pile shall not be more than 12 mm from the straight line connecting the centroids of the end faces of the pile; for the purpose of determining the centroid, the centroid of any cross-section of a hollow pile shall be determined by assuming that the pile has a solid section.

Tolerances: hand-dug caissons 8.66 The centre of each section of the shaft shall lie within 50 mm of the centreline of the whole shaft.

Tolerances: pile installations 8.67 (1) Piles, including hand-dug caissons and mini-piles, shall be installed to within the tolerances stated in Table 8.1.

(2) Piles which do not comply with the specified tolerances shall not be forcibly corrected.

Table 8.1: Tolerances of installed piles

Description	Tolerance	
	Land piles	Marine piles
Deviation from specified position in plan, measured at cut-off level	75 mm	150 mm
Deviation from vertical	1 in 75	1 in 25
Deviation of raking piles from specified batter	1 in 25	
Deviation from specified cut-off level	25 mm	
The diameter of cast in-situ piles shall be at least 97% of the specified diameter.		

RECORDS OF PILING WORKS

Records of piles delivered 8.68 Records of prefabricated piles shall be kept by the Contractor on the Site and submitted to the Engineer at the time the piles are delivered to the Site. The records shall include test certificates, analyses and mill sheets for steel piles and proprietary piles.

Records of pile driving 8.69 Records of pile driving shall be kept by the Contractor on the Site and submitted to the Engineer within 24 hours after the driving or installation of each pile has been completed. The records shall be kept on standard forms as shown in Appendices 8.2 to 8.5 and shall be available for inspection by the Engineer.

Records of bentonite slurry 8.70 Records of tests on bentonite slurry shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer at times agreed by the Engineer. The records shall be kept on standard forms as shown in Appendix 8.6 and shall be available for inspection by the Engineer.

Records of load tests on piles 8.71 Records of load tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 48 hours after the test has been completed. The records shall be kept on standard forms as shown in Appendix 8.7 and shall be available to the Engineer for inspection. The records shall include graphs showing load and settlement versus time, plotted in the format shown in BS 8004, Figure 15(a).

Records of integrity tests on piles

8.72 Records of integrity tests on piles shall be kept by the Contractor on the Site and a report shall be submitted to the Engineer within 3 days after the test has been completed. The records shall be available to the Engineer for inspection. The report shall contain the following details:

(a) details stated in Clause 1.42,

(b) pile reference numbers,

(c) measured pile length,

(d) defects such as cracks, fractures or discontinuities, and

(e) pile stiffness.

Record drawings

8.73 Record drawings of installed piles shall be prepared by the Contractor and two copies shall be submitted to the Engineer within 14 days of completing the piles, including cutting and trimming, in each pile group or building block. The drawings shall include the as-constructed co-ordinates of the centre of each pile at cut-off level, the final depth and cut-off level of each pile and other information required by the Engineer.

TESTING: LOAD TESTS ON PILES

Testing: load tests on piles

8.74 (1) The number of piles to be tested by load testing shall be as stated in the Contract, or as instructed by the Engineer.

(2) The piles shall be tested to determine the settlement of the pile under load. Testing shall be carried out in accordance with a procedure agreed by the Engineer. The method of testing shall be as stated in Appendix 8.1.

(3) Piles shall not be tested until the concrete or grout has attained sufficient strength to withstand the tests. The tests shall be carried out within 28 days of the Engineer's instruction to carry out the test unless otherwise agreed by the Engineer.

Compliance criteria: load tests on piles

8.75 Unless otherwise stated in the Contract, on completion of testing in accordance with Clause 8.74 the results of load tests on piles shall comply with the following requirements:

(a) the settlement at any load shall be less than twice the settlement at 90% of that load (Brinch Hansen's criteria),

(b) under working load the gross pile head settlement shall not exceed 20 mm for buildings and 10 mm for other structures, and

(c) the preliminary pile shall have a factor of safety of at least 2.

Non-compliance: load tests on piles

8.76 If the result of any load test on piles does not comply with the specified requirements for settlement, the Contractor shall submit remedial proposals to the Engineer for approval.

TESTING: CONCRETE CORES FROM PILES

Samples: concrete cores from piles

8.77 (1) The number of concrete cores to be provided for testing from concrete piles shall be as stated in the Contract or as instructed by the Engineer. The positions from which the cores are taken shall be as instructed by the Engineer.

(2) Concrete cores shall be 100 mm diameter.

(3) The method of taking concrete cores shall be in accordance with CS1.

(4) Holes formed by taking concrete cores from piles shall be reinstated using an approved concrete mix or an approved grout mix.

(5) Prestressed precast concrete piles from which concrete cores have been taken shall be abandoned.

Testing: concrete cores from piles

8.78 (1) Each concrete core from a pile 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, inspecting and testing concrete cores shall be as stated in Clause 16.64(2).

Compliance criteria: concrete cores from piles

8.79 The compliance criteria for concrete cores from piles shall be as stated in Clause 16.65.

Non-compliance: concrete cores from piles

8.80 (1) If the result of any test on a concrete core from a pile does not comply with Clause 16.65 additional cores shall be taken from the same pile and additional tests shall be carried out.

(2) Additional concrete cores shall be 100 mm diameter for concrete of 20 mm nominal maximum aggregate size and 150 mm diameter for concrete of 40 mm nominal maximum aggregate size. The number of additional cores shall be as instructed by the Engineer.

(3) If the result of any additional test does not comply with the compliance criteria for concrete cores the Contractor shall submit remedial proposals to the Engineer for approval. The number of additional piles and additional tests shall be as instructed by the Engineer.

TESTING: NON-DESTRUCTIVE TESTS ON WELDS IN PILES

Testing: non-destructive tests on welds in piles

8.81 (1) The number and type of non-destructive tests on welds in piles shall be as stated in the Contract or instructed by the Engineer.

(2) Radiographic tests shall comply with BS 2600: Part 1 and ultrasonic tests shall comply with BS 3923: Part 2.

Non-compliance: non-destructive tests on welds in piles

8.82 If the result of any test on a weld in a pile does not comply with the specified requirements, the complete weld shall be cut out, the joint shall be re-welded and the weld shall be tested.

TESTING: INTEGRITY TESTS

Testing: integrity tests on piles

8.83 (1) The number and type of integrity tests to be carried out on piles shall be as stated in the Contract.

(2) Integrity testing shall be carried out in sufficient time before the relevant piling works start to permit the tests to be carried out.

(3) The results of integrity tests shall be used to enable the Engineer to select piles for further testing.

Non-compliance: integrity tests on piles

8.84 If the result of any integrity test on a pile does not comply with the specified requirements, additional tests shall be carried out. The number of additional tests shall be as instructed by the Engineer.

TESTING: BENTONITE SLURRY

Samples: bentonite slurry

8.85 (1) Samples of bentonite slurry shall be provided for testing at a frequency agreed by the Engineer. Samples for testing to determine the density of the slurry shall be provided each day. A sample of bentonite slurry taken from the base of the excavation shall be tested to determine the density of the slurry before placing of concrete.

(2) The method of sampling and the sampling apparatus shall be as agreed by the Engineer.

Testing: bentonite slurry

8.86 (1) Each sample of bentonite slurry shall be tested to determine the density, viscosity, shear strength and pH value.

(2) The method of testing shall be as stated in Table 8.2.

(3) The measuring device for testing density shall be readable and accurate to ± 0.005 g/mL.

(4) Samples to be tested for viscosity using the Fann viscometer shall be screened before testing using a 300 μm BS test sieve.

Compliance criteria: bentonite slurry

8.87 (1) The results of tests on bentonite slurry shall be as stated in Table 8.2.

(2) Tests to determine the shear strength and pH value shall be discontinued if the results of tests indicate that a consistent working pattern has been established, taking account of the mixing process, blending of freshly mixed and previously used slurry and processes used to remove impurities from previously used slurry. If there is a subsequent change in the established working pattern, the tests to determine shear strength and pH value shall be reintroduced unless otherwise permitted by the Engineer.

Non-compliance: bentonite slurry

8.88 If the results of tests for density and viscosity do not comply with the specified requirements, or if the results of tests for shear strength or pH value do not indicate a consistent working pattern, the bentonite slurry shall be deemed unsuitable for the work and concrete shall not be placed in the slurry. The slurry shall be replaced or its composition adjusted before concrete is placed.

Table 8.2: Properties of bentonite slurry and methods of testing

Property at 20°C	Test results	Method of testing
Density as supplied to excavation	≤ 1.10 g/mL	Mud density balance
Density at base of excavation before placing concrete	≤ 1.25 g/mL	Mud density balance
Viscosity	30 – 50 seconds	Marsh cone method or
	≤ 0.02 Pa.s	Fann viscometer
Shear strength (10 minute gel strength)	1.4 – 10 N/m^2	Shearometer or
	4 – 40 N/m^2	Fann viscometer
pH value	8 – 12	pH indicator paper strips or electrical pH meter

APPENDIX 8.1

DETERMINATION OF THE SETTLEMENT OF PILES BY LOAD TEST

Scope

8.1.1 This method covers the determination of the settlement of piles by means of a load test.

Equipment

8.1.2 The following equipment is required:

(a) Kentledge, anchor piles or other anchorages supported or installed at suitable locations to provide adequate reactions against jacking.

(b) A load measuring device which shall consist of a load column, pressure cell, or other appropriate system, calibrated before and after each series of tests, or whenever adjustments are made to the device, or at time intervals recommended by the manufacturer of the equipment.

(c) Four deflectometers accurate to 0.025 mm.

(d) Precision levelling equipment accurate to 0.25 mm.

(e) A reference frame for supporting deflectometers and providing a datum for deflectometer measurements.

(f) Working platforms.

(g) Screens and protection from exposure to conditions which may affect the test.

(h) Hydraulic loading equipment.

Procedure: before testing

8.1.3 The procedure before testing shall be as follows:

(a) The kentledge, anchor piles or other anchorages shall be installed. The centre of each anchor pile shall be at least 2 m or three times the pile diameter, whichever is greater, from the centre of the pile to be tested and from the centre of any adjacent pile.

(b) If required, the pile to be tested shall be extended from cut-off level to ground level. The strength of piles at joints shall not be less than any normal section of the pile.

(c) A temporary square pile cap designed by the Contractor shall be constructed.

(d) Working platforms, screens and protection shall be installed.

(e) The reference frame shall be set up on supports which are at least 2 m or three times the pile diameter, whichever is greater, from the test pile and anchor pile. The four deflectometers shall be mounted on the reference frame to measure the deflection of the four corners of the temporary pile cap.

Procedure: load test

8.1.4 The procedure for the load test shall be as follows:

(a) Preliminary piles shall be tested to not less than twice the working load of the pile or other loads stated in the Contract. Working piles shall be tested to not less than 1.8 times working load. Reductions for group or boundary effects shall not be made in determining the test loads.

(b) Test loads shall be applied and removed in three stages as stated in Table 8.1.1.

(c) Unless otherwise permitted by the Engineer, the test loads shall be applied in increments, and removed in decrements, of 25% of the working load. Increments of load shall not be applied until the rate of settlement of the pile is less than 0.1 mm in 20 minutes.

(d) The full test loads for Stage I shall be applied in increments and shall then be maintained for at least 24 hours after the rate of settlement has reduced to less than 0.1 mm per hour. The test loads shall be removed in decrements and the recovery of the pile determined before loading is resumed.

(e) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage II loading.

(f) The procedure stated in Clause 8.1.4(d) shall be repeated for Stage III loading unless the Engineer instructs the loading to be maintained for a longer period.

(g) The settlement of the pile shall be measured at hourly intervals or other intervals agreed by the Engineer. The settlement of the pile under each increment and decrement of loading shall be measured. The exact times at which increments are applied and decrements are removed shall be recorded. Settlements shall be measured and times shall be recorded in the presence of the Engineer.

(h) The level of the reference beam shall be checked at regular intervals agreed by the Engineer during the test.

Table 8.1.1: Test loading stages

Stage	Test load
I	25% of max. test load
II	50% of max. test load
III	100% of max. test load

Procedure: after testing

8.1.5 After testing, equipment shall be removed, temporary pile caps shall be demolished and pile extensions shall be removed to cut-off level. Unless otherwise permitted by the Engineer, anchor piles shall be withdrawn.

Reporting of results 8.1.6 The following shall be reported:

(a) The loads applied to the nearest 0.05 t.

(b) The settlement of the pile to the nearest 0.05 mm at hourly intervals and under each increment and decrement of loading.

(c) The exact times at which increments were applied and decrements removed.

(d) The levels of the reference beam, to the nearest 0.05 mm.

APPENDIX 8.2

PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

Contract No. _____ Title _____

Contract No. _____

Pile data

Reference No. _____ Location _____

Type _____ Size _____ Rake _____

For precast concrete and steel piles; Preformed length _____

For precast concrete piles; Date of casting _____

Drive system data

Hammer: type _____ mass _____ kg drop (at set) _____ mm rated energy _____ kJ

Helmet, dolly & anvil: type _____ mass _____ kg

Packing: type _____ condition _____ thickness _____ mm

Levels

Commencing ground/sea bed* level (PD/CD)* _____

Depth of overburden/height of working platform above sea bed level _____

Reference working level/platform level* _____

Date & Time	Drop (m)	Depth pene-trated (m)	No. of blows +	Cumulative No. of blows	Length of individual segments, location of splices and tests carried out	Remarks (State details of obstruction, delays, interruptions and location of concrete samples)++

\+ per 0.25 m for top 3.0 m of pile
++ for cast in place piles

(*delete as appropriate)

PILE DRIVING RECORD

(Precast concrete, prefabricated steel and driven cast-in-place piles)

Temporary compression record (on graph paper graduated in millimetres to be pasted in space below)

Final penetration depth _____ mm

Temporary compression _____ mm

Final set _____ mm/last 10 blows

or _____ blows/25 mm

Deviation from plumb or rake 1 in _____

Top of pile level _____

Cut off level

Pile head level _____

Final toe level _____

Deviation at cut-off level x-x _____ mm

y-y _____ mm

For driven cast-in place piles:

Length of temporary casing _____ m

Length of permanent casing _____ m

Length of cage reinf. _____ m

Concrete grade _____ Date of concreting _____

Theoretical volume of concrete required _____ m^3

Actual volume of concrete placed _____ m^3

Reported by _____
Contractor's Representative

Verified by _____
*IOW / Engineer / Architect

Date _____ Date _____

(*delete as appropriate)

APPENDIX 8.3

PILE DRIVING RECORD

(Bored cast-in-place piles)

Contract No. _____ Title _____

Contractor _____

Pile data

Reference No. _____ Location _____

Type _____ Diameter _____ mm Design Length _____ mm Rake 1 in _____

Bore hole record

Commencing ground/sea bed* level (P.D./C.D.)* _____

Depth of overburden/height of working platform above sea bed level _____ m

Casing/drilling fluid* type _____

Reference working level/platform level* _____

Date & Time	Depth penetrated	Details of strata penetrated/ground water level	Details of soil testing, proving of bedrock and under-ream	Remarks (State details of obstruction, delays interruptions, and location of concrete samples)

Deviation from plumb or rake 1 in _____ Deviation at cut-off level x-x _____

y-y _____

Length of temporary casing _____ m Length of permanent casing _____ m

(*delete as appropriate)

PILE DRIVING RECORD

(Bored cast-in-place piles)

Bore hole condition prior to concreting

Bottom Visible/invisible* Measured depth of bore _____ m

Depth of water/drilling fluid* _____ m

Damage and debris observations _____

Concrete record

Concreting in dry/by tremie* Water inflow rate _____ litres/second

Concrete grade _____ Slump _____

Actual concreted level _____ Cut off level _____

Overall $\frac{Lt}{La} =$ _____ %

Length of cage reinforcement _____ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theore-tical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}$ %	Cumulative length placed (m)	Remarks (Inter-ruptions in placing, cause of excessive $\pm \frac{Lt}{La}$ %, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by _____ Verified by _____

Contractor's Representative *IOW / Engineer / Architect

Date _____ Date _____

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.4

PILE RECORD

(Piles cast in-hand-dug Caissons)

Contract No. _____ Title _____

Contractor _____

Pile data

Reference No. _____ Location _____

Caisson Type _____ Diameter _____ mm Design Length _____ mm

Excavation Data

Commencing ground level (PD) _____ Depth of overburden _____ m

Date	Depth reached (m)	Details of Strata penetrated/surrounding ground water level	Details of soil testing, proving of bedrock, and under-ream	Remarks (State details of obstructions, interruptions and delays)

Deviation from plumb 1 in _____ Deviation at cut-off level x-x _____ mm

y-y _____ mm

Bedrock level* _____ Water level* _____

Base level of shaft _____ Diameter of bell-out* _____ mm

Length of toe-in* _____ mm Depth of bell-out _____ mm

* If none write 'N/A'

PILE DRIVING RECORD

(Piles cast in hand-dug caissons)

Concrete record

Concreting in dry/by tremie* Water inflow rate _____ litres/second

Concrete grade _____ Slump _____

Actual concreted level _____ Cut off level _____

Overall $\frac{Lt}{La} = \_\_\_\_\_ \%$

Length of cage reinforcement _____ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theoretical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}\%$	Cumulative length placed (m)	Remarks (Interruptions in placing, cause of excessive $\pm\frac{Lt}{La}\%$, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by _____ Verified by _____

Contractor's Representative *IOW / Engineer / Architect

Date _____ Date _____

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.5

PILE RECORDS

(Barrettes)

Contract No. _____ Title _____

Contractor _____

Pile data

Reference No. _____ Location _____

Size of barrette _____ Shape _____

Design Length _____ m

Excavation Data

Commencing ground level (PD) _____ Depth of overburden _____ m

Guide wall levels: top _____ bottom _____

Date	Depth reached (m)	Details of Strata penetrated/surrounding ground water level	Details of soil testing, proving of bedrock, and under-ream	Remarks (State details of obstructions, interruptions and delays)

Deviation from plumb 1 in _____ Deviation at cut-off level x-x _____ mm

y-y _____ mm

Base level of excavation _____

Depth of base from top of guide wall _____ m

PILE RECORD

(Barrettes)

Concrete record

Concrete grade _____ Slump _____

Actual concreted level _____ Cut off level _____

Overall $\frac{Lt}{La} =$ _____ %

Length of cage reinforcement _____ m

Date & Time	Delivery note No./ Truck load No.	Quantity (m^3)	Theoretical length filled Lt (m)	Actual Length Placed La (m)	$\frac{Lt}{La}$ %	Cumulative length placed (m)	Remarks (Interruptions in placing, cause of excessive $\pm \frac{Lt}{La}$ %, Location of concrete samples, Ref. No. of cubes taken, etc.)

Reported by _____ Verified by _____

Contractor's Representative *IOW / Engineer / Architect

Date _____ Date _____

Note: The Engineer shall be informed of any deviation greater than ±10% from the expected (theoretical) level of concrete placed.

(*delete as appropriate)

APPENDIX 8.6

BENTONITE SLURRY RECORD

Contract No. _____ Title _____

Contractor _____

Sample data

Ref. No. of pile _____ Location _____

Source of test sample: (a) freshly mixed slurry*
(b) as supplied to excavation*
(c) from bottom of excavation prior to placing concrete

Date & time of sampling _____

	Test Method and Apparatus Used	Test Result
Density (g/mL)		
Viscosity (seconds)		
pH		
Sand Content (%)		
Fluid Loss (mL)		
Temperature (°C)		

Remarks:- _____

Reported by _____ Verified by _____
Contractor's Representative *IOW / Engineer / Architect

Date _____ Date _____

(*delete as appropriate)

APPENDIX 8.7

PILE LOAD TEST RECORD

(Test result)

Contract No. _____ Title _____

Contractor _____

Pile data

Reference No. _____ Location _____

Type _____ Size _____

Pile dia/diagonal width (D) _____ Cross pile length (Lp) _____

Sectional area (A) _____ Young's modulus (E) _____

Testing data

Design working load (P) _____

Test load (Q) = 2 (P) _____

Pressure gauge No. _____ Calibration Certificate ref. _____ Date _____

Dial gauge number	1	2	3	4
Serial number				
Calibration certificate ref.				
Date of calibration				

Level of fixed point on load reaction system: before testing _____

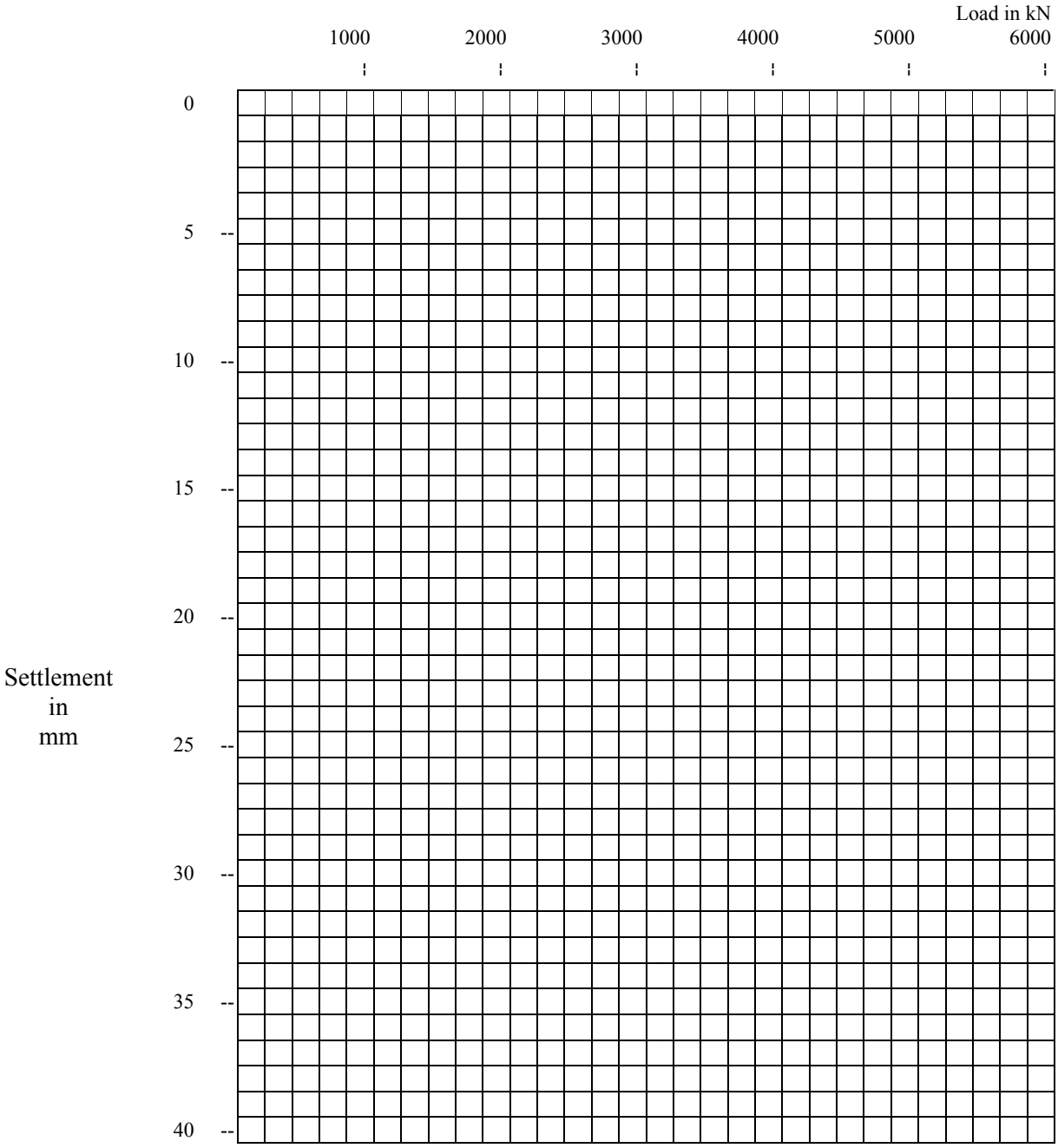
after testing _____

ground settlement = _____

Date & Time	Load (kN)	Pressure Gauge Reading	Dial Gauge Readings					Cumulative Settlement (mm)	Remarks
			Dial 1	Dial 2	Dial 3	Dial 4	Average		

PILE LOAD TEST RECORD

(Testing result)



Maximum settlement at working load: (Allowable = 20 mm for buildings and 10 mm for all other structures.)

Actual = _____

Settlement at maximum test load (S_1): (Allowable = S_1 less than twice settlement at 90% of maximum test load ($2S_2$).)

Actual S_1 = _____ $2S_2$ = _____

Reported by _____ Verified by _____

Contractor's Representative *IOW / Engineer / Architect

Date _____ Date _____

(*delete as appropriate)