حديد الإمارات
emirates steel
a SENAAT company إحدى شركات صناعات

Integrated Management System

Engineering Standards

Civil & Structure Engineering Standards

PRD-CS-GS-001

	Name	Title	Signature
Prepared by	Stuart Webster	Manager - Project Engineering	S. Webster.
Reviewed by	Abdel Moneim Tawfik	QA & Env. Manager	
Approved by	Anoop Nair	VP Marketing & Strategy	

1. PURPOSE

The purpose of the ES Engineering Standards is to provide information and guidelines for the design, erection, installation and commissioning of plant and equipment across ES Sites.

2. SCOPE

The standards referenced in this document are issued to all contractors and form an integral part of the contract documentation.

Compliance is mandatory by all Contractors, ES Departments and personnel, whilst designing, erecting, installing and commissioning plant and equipment within ES sites, and any deviations require the explicit written approval of ES.

3. DEFINITIONS / ABBREVIATIONS

ES - Emirates Steel

MOC - Management of Change

4. RESPONSIBILITIES

VP of Marketing & Strategy - Is responsible for approving the Standards, and delegating members of his department to review them on a periodical basis, and / or write new standards when deemed necessary.

Projects Construction Manager - Is responsible for ensuring that all projects undertaken within ES comply with these standards.

Engineering Manager Projects - Is responsible for revising the Standards as requested by the projects and operations departments.

5. DESCRIPTION

5.1 GENERAL REQUIREMENTS

The following Section is intended to supply additional information and guidelines to Contractors engaged in Civil and Structural Erection and Supply activities.

This information is specific and unique to ES's environment, climate and standard practice and shall be applied in conjunction with the Specifications, National and International Standards and other Rules and Regulations mentioned in this Document and contractually agreed upon.

Further information regarding Civil and Structural Work can be found in other Sections of this Standard and the Contractor shall familiarize himself with all those sections relevant to his work.

The Contractor shall submit Material Approvals to ES for ALL materials he intends to employ in his work. In addition, ES may, in certain circumstances, request the submission of specific Method Statements for approval, depending on the nature and complexity of the work the Contractor intends to undertake.

No work shall be carried out unless the relevant Material Approvals and Method Statements have been received and approved by ES.

The Contractor shall -unless specifically agreed with ES - ensure the safety, stability and uninterrupted operation of the existing plant and facilities at all times.

This Standard shall not be interpreted to prevent the Contractor from proposing alternative materials or methods of design and construction not specifically referred to herein, provided these materials and techniques have been approved by ES.

5.2 SITE PREPARATION

The Contractor shall be responsible for the provision of a dense, stable and drained site, graded in accordance with the drawing elevations and suitable for subsequent plant construction.

To this end, the Contractor's obligations shall include: -

- The clearing of any existing vegetation, humus, debris, and the like from the construction site area.
- The demolition and disposal of existing buildings, structures, roads and paved areas (if any and if applicable, as agreed with ES prior to commencement of works).
- The removal and/or re-routing of existing underground and/or above ground utility networks, pipelines, etc. (if any and if applicable, as agreed with ES prior to commencement of works).
- The rough grading of the site to designated plant levels, including all necessary excavation, filling and surface compaction.
- The flood protection works and the installation of a plant drainage system, including all ditches and culverts.
- The removal of all excavated material off site, unless otherwise agreed with ES.
- The installation of erosion protection measures, where appropriate.

- The installation of temporary and permanent fences or walls, gates and other protective measures required for the safety of the premises, including site security services, unless otherwise agreed with ES.
- The installation of all temporary facilities required for the construction (e.g. plants, offices, workshops, storage areas, etc.).
- The supply of temporary utilities for construction or connection to relevant Take-over Points as agreed with ES.

5.2.1 LEVELS

At commencement of the Works the Contractor shall set up an accurately ascertained site datum level and within one week from commencement carry out and record a level grid of the site and agree same with ES.

5.3 EARTHWORKS, FOUNDATIONS & DRAINAGE

5.3.1 SITE INVESTIGATIONS

The Contractor shall engage a specialist company to carry out a site investigation of the sub-surface conditions to provide all necessary information regarding the design parameters and construction factors.

The investigation shall establish a picture of the conditions at the site in sufficient detail so that all specific factors relevant to the project can be assessed with adequate confidence.

The site shall not be considered in isolation but rather in the larger context of which it forms a part. Thus, the relationship of the site to the general area topography, geology and drainage should be established before considering the site in detail.

The borings and tests shall reach depths adequate to explore the nature of the subsurface materials both around and beneath the proposed foundations and piles, including all strata likely to contribute significantly to settlement. Typology, dimensions and loading of foundations to be constructed shall be considered to set the proper surveying plan.

If instructed by ES, soil and rock samples shall be taken and soil tests shall be carried out during the process of installing bored piles.

All site investigations shall be at the Contractor’s expense.

5.3.2 EXCAVATION AND BACKFILLING

a. LEVELS

At commencement of the Works the Contractor shall set up an accurately ascertained site datum level and within one week from commencement carry out and record a level grid of the site and agree same with ES.

b. NATURE OF GROUND

The Contractor shall satisfy himself as to the nature of the ground to be excavated and no extra will be allowed by reason of his failure to do so.

The prices for excavation are to include for excavating in rubble, hardcore, rail ballast, in waterlogged ground or whatever any other material is encountered except old brickwork, concrete, reinforced concrete pavings etc., which will be measured.

The prices for excavation are also to include for grubbing up any disused service mains, pipelines, cables and drains that may occur and for sealing off drains, removing contaminated earth.

The conventional excavation volume will be measured 1 m from the finished foundation outline.

c. EXCAVATION

Excavation activities shall be in accordance with the recommendations and guidelines of the soil investigation reports.

Prior to commencing any work, the Contractor shall make all possible efforts to obtain the necessary information with regard to existing subsurface installations and services and, in the event of any damage, shall be responsible for their rectification and repair, and be liable for any loss in production incurred through the damage of such installations.

The Contractor shall assume full responsibility for maintaining the stability of all excavated areas until final acceptance of the works. The Contractor shall ensure that the surrounding ground, foundations of adjacent structures and buried services remain undisturbed during the works.

The Contractor shall place and maintain all temporary fences, guard rails, barricades, lights and other protective measures required for the safety of the site, also in compliance with ES Site Regulations (PRD-ES-190).

The Contractor shall be responsible for the removal of all excavated material off-site, unless otherwise agreed with ES. Excavated material approved for subsequent backfilling may be temporarily stored on site, subject to ES's approval regarding the location and duration of such storage. In any case the excavation material will be stored at least 1 m away from the edge of the trench and the stockpile limited to the adequate height to prevent uncontrolled slips and slides. Excavated material accepted by ES for permanent storage shall be deposited and graded according to ES's requests. The Contractor shall bear all costs connected with the handling and dumping and storage of excavated materials.

If unsuitable material is encountered during excavation, the Contractor shall report this condition to ES and obtain directions for corrective action before proceeding with the works.

Excavations shall be carried out by the Contractor in such a way as to avoid any disturbance or damage to the surrounding ground of adjacent buildings. The method to be used shall be agreed with ES.

Excavations shall be left open for as short a period as practicable.

d. SHORING AND TIMBERING TRENCHES AND EXCAVATIONS

The Contractor shall carry out all necessary plain or interlocking steel sheeting, timbering, strutting, shoring etc., to support the sides of excavations, also taking into account the solutions recommended by the site investigation reports, so as to ensure the safety of workmen and freedom from damage of any structure or services that may be affected and to secure the excavation from falling in and to prevent any movement. The Contractor shall be responsible for any injury to the permanent work and any consequential damage caused by the removal of timbering, plain or interlocking steel sheeting or other supports from excavations.

e. SLIPS AND FALLS

The Contractor shall take every precaution against slips and falls and should any occur the Contractor shall immediately make good to the satisfaction of ESI. If any slip or fall weakens any foundation or support which the work would otherwise have had or cause a space to exist outside the new work, the Contractor shall fill up the space or execute such additional work as directed by ES.

f. PREPARATION OF FORMATION AND FOUNDATIONS

The Contractor shall ensure that excavation in the first instance is stopped at 75mm above formation level and the bottoming up to formation shall be done by hand immediately prior to starting the construction of the permanent works.

As soon as possible after the formation has been prepared and approved by ES (ref. to clause 2.12), it shall be covered as necessary with blinding concrete, mass concrete or other approved materials or else the first layer of the permanent construction. Until such work is commenced, the formation shall be protected from deterioration by approved means.
If any loose, soft or bad ground is encountered the Contractor shall excavate the same to a solid foundation and shall fill up the excavation with 1:12 mass concrete on receiving written notice to do so from ES.

Permissible deviations from formation levels beneath ground bearing slabs and reinforced concrete foundations are +/- 15 mm and +/- 25 mm beneath mass concrete foundations.

g. EXCESS EXCAVATION

Where excavations have been made deeper than shown on the drawings and without instruction from ES such excavations shall be filled with 1:12 mass concrete to the level shown on the drawings, at the Contractor's expense.

h. PUMPING AND DEWATERING

The Contractor shall keep excavations free from water at all times and provide adequate pumping plant and equipment with means of conveying away the pumped water and shall arrange for the disposal of all water from excavations, form all sumps clear of excavation for permanent works and provide all necessary plant and equipment for dealing with any sub-soil condition that may be encountered.

If water is to be pumped into any site drain or sewer, the Contractor shall provide intercepting filters, traps or settlement tanks of adequate capacity so that any silt or sand can be settled out. The Contractor shall regularly inspect and clean such traps and remove the settled material from site.

Drainage, pumping and dewatering in general shall be arranged in a way that they will not disturb ground beneath existing structures or finished parts of the works or cause flowing of fine sand. The Contractor will be liable for any damage to adjacent properties or structures and for consequent remedial works and expenses.

A method Statement including but not limited to equipment description, installation procedures, working progress, calculations, installation schemes, etc. shall be prepared by the Contractor and submitted to ESI for approval prior to installation of any dewatering system.

i. SUB DRAINS

If necessary, in order to dewater the ground for the construction of the Works the Contractor shall lay sub-drains where directed to convey the water to pumping sumps. The sub-drains shall be laid un-jointed with the invert not less than 300mm below formation level of the permanent works and shall be covered with gravel to formation level.

The dewatering system shall be extended to a sufficient duration to allow the completion of the permanent concrete works and backfilling operations.

j. BACKFILLING TO STRUCTURES AND TRENCHES

The Contractor shall ensure that after the walls of permanent works contained in excavations have been completed and become sufficiently hardened, and after being approved the spaces between the walls and the sides of the excavations shall be backfilled.

All filling and backfilling shall be performed with selected and approved material. Laboratory tests shall be performed at Contractor's expenses to assess the quality of excavated material and their suitability for use in compacted fills.

All filling and backfilling shall be placed in layers of no more than 250 mm thickness when loose and in any case no more than such that the compaction requirements can be obtained with the type of equipment adopted. This material shall be compacted to no less than 100 % of the Standard Proctor density, according to ASTM D-698 test Method for testing density in place will be ASTM D-1556 standard or an equivalent suitable field density test according to the prevailing characteristics of the backfilling material.

When compacting, fill around existing structures and services, the Contractor shall take appropriate measures to prevent any damage to these installations.

Excavations shall be carried out by the Contractor in such a way as to avoid any disturbance or damage to the surrounding ground of adjacent buildings. The method to be used shall be agreed with the ES.

Excavations shall be left open for as short a period as practicable.

k. COMPACTED CRUSCED STONE LAYERS

The Contractor, to the extent required by the construction drawings, will import on site crushed stone material for general flooring layers (slabs on grade). The supply will include hauling, spreading, blinding with quarry dust, moistening and compaction to 100% of the Standard Proctor density.

l. INSPECTION

The Contractor shall give ES twenty-four hour's notice in writing when the excavation will be ready for inspection.

The bottom of every excavation will be inspected, and the level taken. No concrete or pipes shall be laid until ES has approved the bottom. Notwithstanding such approval any bottom which becomes water-logged or otherwise spoilt, after approval shall be cleaned and re-formed to ES's satisfaction before any concrete is placed.

m. SURPLUS

The Contractor shall clear away all surplus earth, soil and unsuitable backfill material arising from the trenches and excavations as the work proceeds.

The Contractor shall cart all surplus and unsuitable backfill material to a tip provided by the Contractor, and the streets, lands and works left clear in a good condition to the satisfaction of ES. The route that the Contractor shall use on the site shall be as directed by ES.

5.3.3 SOIL IMPROVEMENT

a. GENERAL

To enhance the geotechnical and mechanical properties of natural loose strata that may be encountered at site and to allow the construction of foundations or storage areas on such layers, a soil improvement technique may be adopted.

The Contractor shall choose a suitable method for soil improvement to achieve the final soil characteristics required by the design and considering the actual geotechnical conditions and the solutions recommended by the site investigation reports. For reference only, the soil improvement methods that may be considered are but not limited to: -

- Vibro-compaction.
- Vibro-replacement (stone columns).
- Dynamic consolidation.

- Soil replacement.

The soil improvement technique adopted shall be proposed by the Contractor and all preliminary design considerations (e.g. strata to be improved, spacing of densification spots, depth, dimensions, materials, etc.) shall be submitted to ES for approval prior to construction. A detailed Method Statement concerning employed equipment, working progress, proving methods, Quality Assurance procedures, etc. shall be prepared by the Contractor and submitted to ES for approval.
The extent of soil improvement shall follow the design requirements and the drawings relevant to the proposed structures of the plant. A certified surveyor shall be employed by the Contractor to carry out all setting out and surveying works during the execution of the soil improvement.

The Contractor shall take full responsibility for the design and suitability of any type of equipment and method of soil improvement. Any auxiliary work necessary for soil improvement must be considered by the Contractor at his own expenses. The method adopted shall follow all relevant local regulations and environmental norms. In addition, the Contractor must guarantee that the applied method will not cause any damage to existing underground services and networks, adjacent properties or structures already erected. In case of damage, costs for relevant remedial works shall be borne by the Contractor.

b. SOIL IMPROVEMENT TESTING

For verification of the soil improvement results, an independent third party approved by ES shall be employed by the Contractor to perform in situ tests.

Type (e.g. load plate test, Standard Penetration Test SPT, static Cone Penetration Test CPT, Proctor test, etc.) and extent of tests shall be proposed by the Contractor taking into account the nature of ground, the soil improvement technique adopted and the foundations or superstructures to be constructed and, in any case, shall be agreed with ES.

Tests shall be carried out according to the relevant international Standards previously agreed with ES and shall be performed before and after the soil treatment in order to measure the improvement of the soil characteristics achieved.

The above-mentioned tests shall be performed in the presence of ES. Detailed reports on these tests must be provided by the Contractor for the approval of ES within two (2) weeks after completion of testing, but in any case, prior to construction of the structures.

5.3.4 FOUNDATIONS

All major foundations shall be completely interconnected in two directions by ties approximately at right angles to each other or shall be restrained against differential lateral movement by other means. Below all foundations the Contractor shall place a layer of lean concrete in order to provide a clean and flat working surface. The thickness of this blinding layer shall be as indicated in the drawings and in any case not less than 75 mm.
The lean concrete below foundations shall have minimum compressive cube strength of 15 MPa.

Below the blinding layer, a polythene sheet of minimum 1200-gauge thickness shall be provided.

All concrete below ground shall receive two coats of bituminous paint.

All underground structures below water table level such as basements, tunnels, trenches, tanks, manholes and similar reinforced concrete structures shall be watertight and sloping drains discharging into sumps shall be provided. The water collected in sumps shall be discharged into the drainage system of the plant.

5.3.5 DRAINAGE

ES has three liquid wastewater systems: -

- Sanitary sewer, which is collected and routed towards the main system.
- Industrial wastewater which is collected and routed towards the main system.
- Storm water which is generally collected in percolation ponds or released into the storm water ditches surrounding ES.

For drainage of storm water, if an underground pipe network is adopted, the design shall be based on gravity system and shall be developed following the relevant international Standards agreed with ES.

The rainwater intensity for all drainage works and assumed uniform throughout the site shall be taken as follows: -

Rainwater Intensity mm/hr	Rain Duration
100	5 min
30	60 min
10	continuously

The design and construction of the storm water drainage system shall aim to prevent flooding of any area of the site.
The design of sanitary sewerage system shall be based on potable water supply and on the manning, level planned for the proposed plant. The sewer network shall be gravity type, unless pressure lines shall be required due to the site levels and outlet point level.

All drainage works below ground shall be constructed with due care, bearing in mind the aggressive nature of the subsoil and the ground water and the danger of damage from heavy vehicles on the plant surface. Minimum and peak flow conditions, scouring effect, settlement and self-cleaning velocity requirements shall be considered while designing size and gradient of pipes.

Minimum earth coverage of 1 m shall be provided over underground pipelines and the pipes are to be sized and designed for the imposed loadings. However, where 1 m coverage is not applicable, the pipes must be suitably protected by concrete encasing arch type.

Manholes of reinforced concrete construction shall be provided at every bend, junction, point of change in gradient or diameter and on straight sections of pipes at suitable spacing for inspection, cleaning and maintenance of the network. Manholes shall be provided with covers for access of inspection and maintenance personnel. Minimum diameter of pipes shall be 150 mm and pipes shall be of reinforced concrete or PVC or other material approved by ES.

All effluent lines shall be tested according to the relevant Standard. The minimum test pressure for free-flowing sewer lines shall be 1 bar.

Sanitary sewerage, industrial waste water and storm water drainage systems will be provided up to the relevant Take-Off Points (on and off site) and shall be taken through settling tanks, purification plants and oil separators as required to ensure that the discharge from ES is within the limits required by the local Authorities and as defined in local binding environmental regulations.

In any case, the sanitary sewerage, industrial wastewater and storm water drainage systems proposed by The Tenderer shall be submitted to ES for approval.

5.4 PILING WORKS

5.4.1 GENERAL

In addition to the specification, the Contractor shall adhere to any requirements of ACI 318 – 08 and AIST Technical Report No. 13 or any other National or International Standard agreed upon with ESI. In case of conflict or discrepancies, the instructions herein enclosed shall take precedence.

The Contractor shall assume full responsibility for preventing any disturbance or damage to existing subsurface installations, networks, pipelines and other services and to surrounding foundations and structures during the execution of piling works. In the event of any damage caused by collapse, vibration, subsidence, lowering of water table level or any other effect related to the execution of the piling works, the Contractor shall be responsible for their rectification and repair, and be liable for any loss in production, claim, indirect expense, injury or accident incurred through the damage of such facilities.

5.4.2 PILE DESIGN

The Contractor shall carry out the pile design in accordance with the site investigation parameters and the certified drawings issued by ES.

5.4.3 TOLERANCES

a. SETTING OUT

Setting out of the main grid lines shall be carried out by the Contractor. The installation of marker pins at pile positions as required by the Contract shall be carried out from the main grid lines by the Contractor in accordance with the drawings. Prior to installation of the pile, the pile position relative to the main grid lines shall be checked.

b. POSITION

For a pile cut-off at or above ground level and for a pile belonging to a group of 3 or more piles, the maximum permitted deviation of the single pile centre from the centre-point shown on the setting-out drawing shall be 75 mm in any direction. For a single pile, 2-pile

group or 3 or more aligned pile group, the maximum permitted deviation of the single pile centre from the centre-point shown on the setting-out drawing shall be 25 mm laterally.

c. VERTICALITY

At the commencement of installation, the pile, or the relevant equipment governing alignment shall be made vertical to a tolerance of within 1 in 100. The maximum permitted deviation of the finished pile from the vertical is 1 in 75.

d. RAKE

The pile or other equipment governing the direction and angle of rake shall be set to give the correct alignment of the pile to within a tolerance of 1 in 50. The piling rig shall be set and maintained to attain the required rake. The maximum permitted deviation of the finished pile from the specified rake is 1 in 25 for piles raking up to 1:6 and 1 in 15 for piles raking more than 1:6.

5.4.4 PILING METHODS

The Contractor shall supply for ES's approval, all relevant details of the method of piling and the plant he proposes to use. The information to be provided in the Method Statement for piling construction shall include but not limited to the following: -

- Detailed sequence of construction phases.
- Details of temporary casing (if any).
- Specification for drilling fluid (e.g. bentonite mud, if any).
- Concrete mix design and concreting procedures.
- Precautions for boring near recently cast piles.
- Design calculations of all temporary works.
- Any applicable construction or erection drawing.
- Method of inspection.
- Material, equipment, tools and manpower schedules, with indications for productivity rates (e.g. m / rig day)

Any alternative method to that specified in the contractual Method Statement shall be subject to approval by ES.

5.4.5 RECORDS

The Contractor shall keep records as indicated in table 5.1 of the installation of each pile and shall submit two signed copies of these records to ES not later than noon of the next working day after the pile was installed. The signed records will form a record of the work.

Table 5.1 Records to be kept

Data	Bored cast-in-place concrete piles
Contract	
Pile reference number (location)	
Pile type (compression or tension)	
Nominal cross-sectional dimensions or diameter	
Nominal diameter of under ream/base	
Standing groundwater level from direct observation or given site investigation data	
Date and time of boring	
Weather conditions	
Date of concreting	
Concrete mix and method of concreting	
Ground level at pile position at commencement of installation of pile (commencing surface)	
Working level on which piling base machine stands	

Data	Bored cast-in-place concrete piles
Depth from ground level at pile position to pile toe	
Toe level	
Pile head level as constructed	
Pile cut-off level	
Length of temporary casing	
Length of permanent casing	
Soil samples taken and in situ tests carried out during pile formation or adjacent to pile position	
Length and details of reinforcement	
Volume of concrete supplied to pile where this can be measured in practice	
Type and model of equipment used	
All information regarding obstructions delays and other interruptions to the sequence of work	

After the completion of works, the Contractor shall prepare the piling as-built drawings incorporating all the changes on the design performed during the execution of works.

5.4.6 DAMAGE TO PILES

The Contractor shall ensure that during the work, displacement or damage which would impair either performance or durability does not occur to completed piles.

The Contractor shall submit to ES his proposed sequence and timing for boring piles, having regard to the avoidance of damage to the adjacent piles.

After completion, should any pile result in damage and show defects such as cracks, segregation or poor quality concrete, inclusion of soil, deformations, etc. or the position, verticality and rake are not within the tolerances specified in paragraph 3, the damaged piles may be rejected by ES. Consequently, the Contractor shall replace them or install supplementary piles at his own expenses, as directed by ES.

5.4.7 MATERIALS

a. CONCRETE

The specification for the concrete shall be as per the concrete specification in ES Engineering Standard 03-050.

b. REINFORCEMENT

Reinforcement shall be deformed bars, the Contractor shall use reinforcing bars conforming to ASTM A 615 Grade 40 for Medium Yield bars and ASTM A 615 Grade 60 for High Yield bars or equivalent Standards agreed upon with ES, as per design requirements. Reinforcement shall be stored above ground on platforms, skids or other approved supports and contact with the soil shall be avoided. Reinforcement shall be clean and free from corrosion.

Cutting and bending of reinforcement bars shall be carried out according to the relevant National or International Standard agreed upon with ES. Welding of reinforcing bars will not be allowed, unless otherwise instructed by ES.

5.4.8 BORING

a. BORING NEAR RECENTLY CAST PILES

Piles shall not be bored so close to other piles which have been cast less than 24 hours before or which contain workable or unset concrete, whichever is longer, that a flow of concrete could be induced from or damage caused to any of the piles.

b. TEMPORARY CASINGS

Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of a pile bore which might otherwise collapse.

Temporary casings shall be free from significant distortion and shall be adequate to bear all handling, construction and ground loads. They shall be of uniform cross-section throughout each continuous length and shall extend not less than 1m below the

unstable strata. During concreting they shall be free from internal projections and encrusted concrete which might adversely affect the proper formation of piles.

The use of a vibrator to insert and withdraw temporary casing may be permitted by ES subject to the method not causing disturbance of the ground which would adversely affect the construction or the capacity of piles.

Where piles are bored under water or bentonite suspension in an unlined state, concrete shall be cast by means of a tremie pipe in accordance with ACI 318 – 08 Standards. The insertion of a full-length loosely fitting casing to the bottom of the bore prior to placing concrete and free discharge of concrete into drilling fluid will not be permitted. Properties of fresh drilling fluid, drilling fluid taken from the bottom of the pile and re-cycled drilling fluid shall be checked on regular basis according to a method statement proposed by the Contractor and submitted to ES for approval.

Where permanent casing is specified to ensure the integrity of a pile, the Contractor shall submit for approval his proposals regarding the method of installation.

c. STABILITY OF PILE

Where boring takes place through unstable water-bearing strata, the process of excavation and the depth of temporary casing employed shall be such that soil from outside the area of the pile is not drawn into the pile section and cavities are not created outside the temporary casing as it is advanced.

d. PUMPING FROM PILE BORES

Pumping from pile bores shall not be permitted unless the bore has been sealed against further water entry by casing or unless the soil is stable and will allow pumping to take place without ground disturbance below or around the pile.

e. CONTINUITY OF CONSTRUCTION

For a pile constructed in a stable cohesive soil without the use of temporary casing or other form of support, the pile shall be bored, and the concrete shall be placed without such delay as would lead to significant impairment of the soil strength.

Generally, borings shall be covered when work is not in progress and shall be concreted within 24 hours unless otherwise agreed with ES.

f. ENLARGED PILE BASES

A mechanically formed enlarged base shall be no smaller than the dimensions specified and shall be concentric with the pile shaft to within a tolerance of 10% of the shaft diameter. The sloping surface of the frustrum forming the enlargement shall make an angle to the axis of the pile of not more than 35°.

g. INSPECTION

Each pile bore which does not contain standing water or drilling fluid shall be inspected directly or indirectly prior to concrete being placed in it. This inspection shall be carried out from the ground surface in the case of piles of less than 750 mm diameter. Torches or other approved means of lighting, measuring tapes, and a means of measuring verticality shall be provided.

For piles of 750 mm diameter or larger, equipment shall be provided by the Contractor to enable his representatives and ES to descend into the bore for the purpose of inspection. Contractor shall be responsible for the safe performance of such inspection, providing safety cage, air line, gas detector, lights, lifting cable, etc. and any other safety equipment required.

h. CLEANLINESS OF PILE BASES

On completion of boring and where inspection of a dry pile bore indicates the necessity, loose, disturbed or softened soil shall be removed from the bore. Where pile bores contain water or drilling fluid, a cleaning process shall be employed before concrete is placed.

Large debris and/or accumulated sediment shall be removed using appropriate approved methods, which shall be designed to clean while at the same time minimizing ground disturbance below the pile bases. Water or drilling fluid shall be maintained at such levels throughout and following the cleaning operation that stability of the bore is preserved.

Concreting operations shall start no later than 2 hours after the completion of the cleaning process.

5.4.9 REINFORCEMENT

The number of joints in longitudinal steel bars shall be kept to a minimum and when the total length of the main reinforcing bars will not exceed 12m jointing of longitudinal bars will be avoided, unless otherwise indicated on the drawings. Joints in reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made so that there is no detrimental displacement of the reinforcement during the construction of the pile.

Lap lengths shall be according to the drawings and in compliance with the relevant agreed standards.

Reinforcement cages shall be sufficiently rigid to ensure the correct position during their installation, concreting and withdrawal of temporary casing. Concrete spacers shall be provided at least every 3m.

5.4.10 PLACING CONCRETE

a. GENERAL

The method of placing and workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross-section is formed.

The concrete shall be placed without such interruption as would allow the previously placed batch to have hardened. The Contractor shall guarantee a sufficient concrete supply to ensure the complete cast of each pile from the same source without interruption. The method of placing shall be approved.

In the event of concreting in water or drilling fluid bore, concrete shall be cast by means of a tremie pipe in accordance with ACI 318 – 08 Standards. Free discharge of concrete into drilling fluid will not be permitted.

The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a temporary casing. No soil, liquid or other foreign matter which would adversely affect the performance of the pile shall be permitted to contaminate the concrete.

The actual volume of cast concrete against the calculated theoretical volume shall be measured for each pile. Should the difference between those values indicate a possible necking, the Contractor shall carry out any check or test required to ensure the adequacy of the pile, following ES instructions.

b. WORKABILITY OF CONCRETE

Slump measured at the time of discharge into the pile bore shall be in accordance with the standards shown in Table 10.1.

The concrete shall be of the workability approved in the mix design when in its final position and shall remain sufficiently workable for all pile construction procedures to be safely completed.

Internal vibrators shall not be used to compact concrete.

Approved measures shall be taken to ensure that the structural strength of the concrete placed in all piles is not impaired through grout loss, segregation or bleeding.
Concrete shall be directed vertically into the centre of each vertical pile so that grout is not lost form the initial discharges.

Table 10.1 Standards for concrete slum

Piling mix workability	Slump		Typical conditions of use
	Minimum, mm	Range, mm	
A	75	75-150	Placed into water-free unlined or permanently lined bore of 600mm diameter or over, or where casting level lies below temporary casing; reinforcement widely spaced, leaving ample room for free movement of concrete between bars.
B	100	100-200	Where reinforcement is not spaced widely; where cut-off level of concrete is within temporary casing; where pile bore is water-free, and the diameter is less than 600mm
C	150	150 or more	Where concrete is to be placed by tremie under water or drilling mud or by pumping

5.4.11 EXTRACTION OF CASING

a. WORKABILITY OF CONCRETE

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted. During extraction the motion of the casing shall be maintained in an axial direction relative to the pile.

b. CONCRETE LEVEL

When the casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated.

The concrete level within a temporary casing shall be topped up where necessary during casing extraction in such a way that the base of the casing is always below the concrete surface until the casting of the pile has been completed.

Adequate precautions shall be taken in all cases where excess heads of water or drilling fluid could occur as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the pile bore. Where two or more discontinuous lengths of casing (double casing) are used in the construction the proposed method of working shall be approved.

c. PILE HEAD CASTING LEVEL TOLERANCES

For piles cast in dry bores using temporary casing and without the use of a permanent lining, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 11.1 but shall not be above the commencing surface level. No pile shall be cast with its head below standing water level unless approved measures are taken to prevent inflow of water causing segregation of the concrete as temporary casing is extracted; and, where applicable, the standing water level for each pile shall be agreed with ES, and this level is to be treated as the cut-off level for the purpose of calculating tolerance.

For piles cast in dry bores within permanent lining tubes or permanent casings, or where their cut-off levels are in stable ground below the base of any casing used, pile heads shall be cast to a level above the specified cut-off so that, after trimming, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 11.2 shall not be above the commencing surface level.

For piles cast under water or drilling fluid, the pile heads shall be cast to a level above the specified cut-off so that, after trimming to remove all debris and contaminated concrete, a sound concrete connection with the pile can be made. The casting level shall be within the tolerance above the cut-off level shown in Table 11.3 but shall not be above the commencing surface level. Cut-off levels may be specified below the standing groundwater level, and where this condition applies the borehole fluid level shall not be reduced below the standing groundwater level until the concrete has set.

Where the cut-off level of piles lies at depths greater than 10 m below the commencing surface, then the tolerances given in Tables 11.1-11.3 will be varied after discussion with the Contractor and before the commencement of the piling to take account of the special conditions which apply.

Table 11.1 Casting tolerance above cut-off level for piles cast in dry bores using temporary casing and *without the use of a permanent lining*

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15 – 10.00	0.3 + *H*/12 + C/8 . where C= length of temporary casing below the commencing surface*

* If *H* is greater than C, then this tolerance is no longer applicable and the tolerances in Table 11.2 will apply

Table 11.2 Casting tolerance above cut-off level for piles cast in dry bores within permanent lining tubes or permanent casings, or where their cut-off levels are in stable ground below the base of any casing used

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15 – 10.00	0.3 + *H*/10

Table 11.3 casting tolerance above cut-off level for piles cast under water or drilling fluid.

Cut-off distance below commencing surface, *H*, m	Casting tolerance above cut-off level, m
0.15 – 10.00	1.0 + *H*/12 + C/8 where C= length of temporary casing below the commencing surface

* In cases where a pile is cast so that the cut-off is within a permanent lining tube, the appropriate tolerance is given by the deletion of the casing term C/8 in the table.

d. WATER LEVELS

During extraction of temporary casings, where circumstances are such that newly placed unset concrete is brought into contact with external groundwater, precautions shall be taken to ensure that the internal concrete pressure at all levels within the pile exceeds the external groundwater pressure.

5.4.12 TEMPORARY BACKFILLING ABOVE PILE CASTING LEVEL

After each pile has been cast, any empty bore remaining shall be protected and shall be carefully backfilled as soon as possible with approved materials.

5.4.13 DISPOSAL OF EXCAVATED MATERIAL

Excavated material may be used for backfilling purposes for further construction activities if suitable and approved by ES. Disposal of unsuitable and/or excess excavated material shall be carried out by the Contractor as necessary to facilitate the Works and to the satisfaction of ES

In case of boring with bentonite or similar, the discarded drilling fluid shall be promptly disposed by the Contractor in compliance with the local regulations, environmental norms and to the satisfaction of ES.

Upon completion of the works, cut-off pile heads, debris and any other waste material resulting from the piling construction shall be disposed according ES's instructions.

5.4.14 CUTTING OFF PILE HEADS

When cutting off and trimming piles to the specified cut-off level, the Contractor shall take care to avoid shattering or otherwise damaging the rest of the pile.

Reinforcement bars shall sufficiently extend above cut-off level and shall be cleaned, straightened and maintained in a vertical position to ensure an adequate bonding in the pile cap or capping beam.

Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level.

5.4.15 STATIC LOAD TESTING OF PILES

a. GENERAL

This section deals with the testing of a pile by the controlled application of an axial load. It covers vertical and raking piles tested in compression (i.e. subjected to loads or forces in a direction such as would cause the piles to penetrate further into the ground) and vertical or raking piles tested in tension (i.e. subjected to forces in a direction such as would cause the piles to be extracted from the ground).

The design and full details of the proposed load application system shall be satisfactory for the required test. When required these details shall be submitted to ES prior to the commencement of testing.

b. PARTICULAR SPECIFICATION

The following matters are, where appropriate, described in the Particular Specification

- type of pile
- type of test

- loads to be applied and procedure to be adopted in testing preliminary piles
- loads to be applied in proof-testing of working piles
- special materials to be used in construction of preliminary test piles where appropriate
- special construction detail requirements for test piles
- special requirements for pile-testing equipment and arrangement
- pile installation criteria
- time interval between pile installation and testing
- removal of Temporary Works
- special requirements for the application of a lateral load to a pile detailed in accordance with the expected conditions of loading (the principles of loading and other relevant details may be adapted from the Specification clauses which follow)
- details of work to be carried out to the test pile cap or head at the completion of a test.

c. DEFINITIONS

Allowable pile capacity: a load which is not less than the specified working load and which takes into account the pile's ultimate bearing capacity, the materials from which the pile is made, the required factor of safety, settlement, pile spacing, down drag, the overall bearing capacity of the ground beneath the piles and any other relevant factors. The allowable pile capacity indicates the ability of a pile to meet the specified loading requirements. Compression pile: a pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.

Constant rate of penetration (CRP) test: a test in which the pile is made to penetrate the soil from its position as installed at a constant controlled speed, while the force applied at the top of the pile to maintain the rate of penetration is continuously measured. The purpose of the test is to derive the ultimate bearing capacity of a pile and not its load – settlement characteristics.

Constant rate of uplift (CRU) test: the same in principle as the CRP test, but the pile is subject to uplift rather than compression. The purpose of the test is to determine the `pullout' capacity of a pile.

Design verification load (DVL): a load which will be substituted for the specified working load for the purpose of a test and which may be applied to an isolated or singly loaded pile at the time of testing in the given conditions of the Site. This load will be particular

to each preliminary or other test pile and should take into account the maximum specified working load for a pile of the same dimensions and materials, allowances for soil-induced forces such as down drag (which may act in reverse under the temporary loading conditions), and any other particular conditions of the test such as a variation of pile head casting level.

Kentledge: dead load used in a loading test.
Maintained load test: a loading test in which each increment of load is held constant either for a defined period or until the rate of movement (settlement or uplift) falls to a specified value.
Preliminary pile: a pile installed before the commencement of the main piling works or a specific part of the Works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity.

Proof load: a load applied to a selected working pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed the design verification load plus 50% of the specified working load.

Raking pile: a pile installed at an inclination to the vertical.

Reaction system: the arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.
Specified working load (SWL): the specified load on the head of a pile as shown on the drawings.

Tension pile: a pile which is designed to resist an axial force such as would cause it to be extracted from the ground.

Test pile: any pile to which a test is, or is to be, applied.

Ultimate bearing capacity: the load at which the resistance of the soil becomes fully mobilized.

Working pile: one of the piles forming the foundation of a structure.

d. CONSTRUCTION OF A PRELIMINARY PILE TO BE TESTED

1. **NOTICE OF CONSTRUCTION**

   The Contractor shall give ESI at least 48 hours' notice in writing of the commencement of construction of any preliminary pile which is to be test-loaded.

2. **METHOD OF CONSTRUCTION**

   Each preliminary test pile shall be constructed in a manner similar to that to be used for the construction of the working piles and using similar equipment and materials. Any variation will be permitted only with prior approval. Extra reinforcement and concrete of increased strength will be permitted in the shafts of preliminary piles at the discretion of ES.

3. **BORING OR DRIVING RECORD**

   For each preliminary pile which is to be tested, a detailed record of the conditions experienced during boring, or of the progress during driving, shall be made and submitted to ES daily, not later than noon on the next working day. Where ES requires soil samples to be taken or in situ tests to be made, the Contractor shall present the results without delay.

4. **CONCRETE TEST CUBES**

   Four test cubes shall be made from the concrete used in the preliminary test pile and from the concrete used for building up working piles. If a concrete pile is extended or capped for the purpose of testing, a further four cubes shall be made from the corresponding batch of concrete. The cubes shall be made and tested in accordance with the specification.

   The pile test shall not be started until the strength of the cubes taken from the pile exceeds twice the average direct stress in any pile section under the maximum required test load, and the strength of the cubes taken from the cap exceeds twice the average stress at any point in the cap under the same load. Variation of procedure will be permitted only if approved by ES.

5. **PREPARATION OF A WORKING PILE TO BE TESTED**

   If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by ES in accordance with clauses 15.2, 15.6.5 and 15.6.6.

6. **CUT OFF LEVEL**

   The cut-off level for a preliminary test pile shall be approved by ES. Where the cut-off level of working piles is below the ground level at the time of pile installation and

where it is required to carry out a proof test from that installation level, either allowance shall be made in the determination of the design verification load for friction which may be developed between the cut-off level and the existing ground level, or the pile may be sleeved appropriately or otherwise protected to reduce substantially or eliminate friction which develops over the extended length.

e. SUPERVISION

The setting-up of pile testing equipment shall be carried out under competent supervision and the equipment shall be checked to ensure that the setting-up is satisfactory before the commencement of load application.

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

f. SAFETY PRECAUTIONS

1. GENERAL

Design, erection and dismantling of the pile test reaction system and the application of load shall be carried out according to the requirements of the various applicable statutory regulations concerned with lifting and handling heavy equipment and shall safeguard operatives and others who may from time to time be in the vicinity of a test from all avoidable hazards.

2. KENTLEDGE

Where kentledge is used the Contractor shall construct the foundations for the kentledge, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflexion of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it becoming unstable because of deflexion of the supports or for any other reason.

The weight of kentledge for each test shall be greater than the maximum test load for that test, and if the weight is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed.

Additional kentledge required shall be determined considering the accuracy of positioning of the centre of gravity of the stack.

3. TENSION PILES, REACTION PILES AND GROUND ANCHORAGES

Where tension piles, reaction piles or ground anchorages are required to provide the necessary load reaction, they shall be so designed that they will resist the forces applied to them safely and without excessive deformation which could cause a safety hazard during the work. Such piles (which unless approved will not be working piles) or anchorages shall be placed in the specified positions, and bars, tendons or links shall be aligned to give a stable reaction in the direction required. Any welding employed to extend or to fix anchorages to a reaction frame shall be carried out so that the full strength of the system is adequate and unimpaired.

4. TESTING EQUIPMENT

In all cases the Contractor shall ensure that when the hydraulic jack and load-measuring device are mounted on the pile head the whole system will be stable up to the maximum load to be applied.

If in the course of carrying out a test any unforeseen occurrence should take place, further loading shall not be applied until a proper engineering assessment of the condition has been made and steps have been taken to rectify any fault. Reading of gauges should, however, be continued where possible and if it is safe to do so.

Where an inadequacy in any part of the system might constitute a hazard, means shall be provided to enable the test to be controlled from a position clear of the kentledge stack or test frame.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a pressure of 1.5 times the maximum pressure used in the test without leaking.

The maximum test load expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

5. PILE HEAD FOR COMPRESSION TEST

For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

Any pile cap shall be concentric with the test pile; the joint between the cap and the pile shall have a strength equivalent to that of the pile.

Sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that, at the maximum expected settlement, load is not transmitted to the ground by the cap.

6. PILE CONNECTION FOR TENSION TEST

For a pile that is tested in tension, means shall be provided for transmitting the test load axially without inducing moment in the pile. The connection between the pile and the loading equipment shall be constructed in such a manner as to provide a strength equal to the maximum load which is to be applied to the pile during the test, with an appropriate factor of safety on the structural design.

g. REACTION SYSTEMS

1. COMPRESSION TESTS

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages. Kentledge shall not be used for tests on raking piles except where the test arrangement has been specifically designed for such use and has been approved by ES.

Where Kentledge is to be used, it shall be supported and positioned so that the centre of gravity of the load is as close as possible to the axis of the pile. The bearing pressure shall be such as to ensure stability of the kentledge stack.

2. TENSION TESTS

Tension tests may be carried out using compression piles, rafts or grillages constructed on the ground to provide the necessary reaction. In all cases the resultant force of the reaction system shall be coaxial with the test pile.

Where inclined piles or reactions are proposed, full details shall be submitted for approval prior to the commencement of testing.

3. WORKING PILES

Working piles shall not be used as reaction piles without approval. Where working piles are used as reaction piles their movement shall be measured and recorded to within an accuracy of 0.5 mm

4. SPACING

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the kentledge stack in contact with the ground shall be not less than 1.3 m.

The centre-to-centre spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2 m, whichever is the greatest, except in the case of piles of 300 mm diameter (or equivalent) or less, in which case the latter dimension may be reduced to 1.5 m. Where a pile to be tested has an enlarged base, the same criterion shall apply with regard to the pile shaft, with the additional requirement that no surface of a reaction pile shall be closer to the base of the test pile than one half of the enlarged base diameter.

Where ground anchorages are used to provide a test reaction for loading in compression, no section of fixed anchor length transferring load to the ground shall be closer to the test pile than three times the diameter of the test pile. Where the pile to be tested has an enlarged base the same criterion shall apply with regard to the pile shaft, with the additional requirement that no section of the fixed anchor transferring load to the ground shall be closer to the pile base than a distance equal to the base diameter.

5. ADEQUATE REACTION

The reaction frame support system shall be adequate to transmit the maximum test load in a safe manner without excessive movement or influence on the test pile. Calculations shall be provided to ES when required to justify the design of the reaction system.

6. CARE OF PILES

The method employed in the installation of the reaction system shall be such as to prevent damage to any test pile or working pile.

h. EQUIPMENT FOR APPLYING LOAD

The equipment used for applying load shall consist of a hydraulic ram or jack. The jack shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. Proposals to use more than one ram or jack will be subject to approval by SMI of the detailed arrangement. The complete system shall be capable of safely transferring the maximum load required for the test. The length of stroke of a ram shall be sufficient to cater for deflexion of the reaction system under load plus a deflection of

the pile head up to 15% of the pile shaft diameter unless otherwise specified or agreed prior to commencement of test loading.

i. MEASUREMENT OF LOAD

A load measuring device shall be used and in addition a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. In interpreting the test data, the values given by the load measuring device shall normally be used; the pressure gauge readings are required as a check for gross error.

The load measuring device may consist of a load measuring column, pressure cell or other appropriate system. A spherical seating of appropriate size shall be used to avoid eccentric loading. Care shall be taken to avoid any risk of buckling of the load application and measuring system. Load measuring and application devices shall be short in axial length in order to secure stability. The Contractor shall ensure that axial loading is maintained.

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at intervals appropriate to the type of equipment. The pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to ES.

j. CONTROL OF LOADING

The loading equipment shall enable the load to be increased or decreased smoothly or to be held constant at any required value.

k. MEASURING PILE HEAD MOVEMENT

1. MAINTAINED LOAD TEST

In a maintained load test, movement of the pile head shall be measured by one of the methods in clauses 15.11.3, 15.11.4, 15.11.5 and 15.11.6 in the case of vertical piles, or by one of the methods in clauses 15.11.3, 15.11.5 and 15.11.6 in the case of the raking piles, as required.

2. CRP AND CRU TEST

In a CRP or a CRU test the method in clause 15.11.3 shall be used. Check-levelling of the reference frame or the pile head shall not be required. The dial gauge shall be graduated in divisions of 0.02 mm or less.

3. REFERENCE BEAMS AND DIAL GAUGES

An independent reference beam or beams shall be set up to enable measurement of the movement of the pile to be made to the required accuracy. The supports for a beam shall be founded in such a manner and at such a distance from the test pile and reaction system that movements of the ground do not cause movement of the reference beam or beams which will affect the accuracy of the test. The supports of the beam or beams shall be at least three test pile diameters or 2 m from the centre of the test pile, whichever distance is the greater.

Check observations of any movements of the reference beam or beams shall be made, and a check shall be made of the movement of the pile head relative to a remote reference datum at suitable intervals during the progress of the test.

The measurement of pile movement shall be made by four dial gauges rigidly mounted on the reference beam or beams, bearing on prepared flat surfaces fixed to the pile cap or head and normal to the pile axis. Alternatively, the gauges may be fixed to the pile and bear on prepared surfaces on the reference beam or beams. The dial gauges shall be placed equidistant from the pile axis and from each other. The dial gauges shall enable readings to be made to an accuracy of at least 0.1 mm and have a stem travel of at least 25 mm. Machined spacer blocks may be used to extend the range of reading. Equivalent electrical displacement-measuring devices may be substituted.

4. OPTICAL LEVELLING METHOD

An optical levelling method by reference to a remote datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two reliable independent datum points shall be established. Each datum point shall be so situated as to permit a single setting-up position of the level for all readings.

No datum point shall be located where it can be affected by the test loading or other operations on the Site.

5. REFERENCE WIRES AND SCALES

Two parallel reference wires, one on either side of the pile, shall be held under constant tension at right angles to the test pile axis between supports formed as in

the method in clause 15.11.3. The wires shall be positioned against scales fixed to the test pile head in an axial direction and the movements of the scales relative to the wires shall be determined.

Check observations of any movements of the supports of the wires shall be made and a check shall be made on the movement of the pile head at approved time intervals. Readings shall be taken to within an accuracy of 0.5 mm.

6. OTHER METHODS

The Contractor may submit for approval any other method of measuring the movement of the test pile head.

l. PROTECTION OF TESTING EQUIPMENT

1. PROTECTION FROM WEATHER

Throughout the test period all equipment for measuring load and movement shall be protected from adverse effects of sun, wind and precipitation.

2. PROTECTION OF DISTURBANCE

Construction activity and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measuring apparatus. Full records shall be kept of any intermittent unavoidable activity and its effects.

m. NOTICE OF TEST

The Contractor shall give ES at least 24 hour's notice in writing of the commencement of the test. No load shall be applied to the test pile before the commencement of the specified test procedure.

n. TEST PROCEDURE

1. PROOF LOAD TEST PROCEDURE (WORKING COMPRESSION PILES)

The maximum load which shall be applied in a proof test shall normally be the sum of the design verification load (DVL) plus 50% of the specified working load (SWL). The loading and unloading shall be carried out in stages as shown in Table 15.1. Any requirements given in the Particular Specification shall be complied with.

Following each application of an increment of load, the load shall be maintained at the specified value for not less than the period shown in Table 15.1 and until the rate of settlement is less than 0.25 mm/h and slowing down. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Each stage of unloading shall proceed after the expiry of the period shown in Table 15.1. For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load, at not more than 5 minute intervals up to 15 minutes, at approximately 15 minute intervals up to 1 hour, at 30 minute intervals between 1 hour and 4 hours, and 1 hour intervals between 4 hours and 12 hours after the application of the increment of load.

Where the methods of measuring pile head movement given in clauses 15.11.4 and 15.11.5 are used, the periods of time for which loads must be held constant to achieve the specified rates of settlement shall be extended as necessary to take into account the lower levels of accuracy available from these methods and to allow correct assessment of the settlement rate.

Table 15.1- Loading Requirements

Load	**Minimum time if holding load**
25% DVL	30 minutes
50% DVL	30 minutes
75% DVL	30 minutes
100% DVL	1 hour
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour
100% DVL	6 hours
100% DVL + 25% SWL	1 hour
100% DVL + 50% SWL	6 hours
100% DVL + 25% SWL	10 minutes
100% DVL	10 minutes
75% DVL	10 minutes
50% DVL	10 minutes
25% DVL	10 minutes
0	1 hour

*SWL denotes specified working load; DVL denotes design verification load

2. TEST PROCEDURE FOR PRELIMINARY COMPRESSION PILES

The procedure to be adopted for carrying out preliminary load tests on compression piles shall be in accordance with requirements specified in clause 15.2 and either the extended proof load test procedure or the constant rate of penetration testing procedure given below. A normal proof load test will constitute the first stage of such a preliminary test unless otherwise specified.

Extended proof load test procedure

Where verification of the required minimum factor of safety is called for, the loading procedure may be carried out as a continuation of the proof load testing procedure given in clause 15.14.1.

Following the completion of the proof load test, the load shall be restored in two stages (DVL, DVL + 50%SWL), and shall subsequently be increased by stages of 25% of the specified working load or other specified amount until the maximum specified load for the test is reached. Following each application of an increment of load, the load shall be maintained at the specified value for not less than 30 minutes and until the rate of settlement is slowing down and is less than 0.25 mm/h or other approved rate appropriate to the stage of loading and its proximity to a failure condition. The rate of settlement shall be calculated from the slope of the line obtained by plotting values of settlement versus time and drawing a smooth curve through the points. Reduction of load at the end of the test shall be gradual as required by clause 15.14.1 and the final recovery of the pile head shall be recorded.

Permissible settlement at the load corresponding to the required minimum factor of safety called for in the design will not normally be specified. (The mobilization of ultimate load for compression piles normally involves settlements of at least 10% of the pile base diameter in clay and more in granular soils. The settlement of piles bearing on rock requires special consideration, and failure of pile materials may precede failure of the rock.)

Constant rate of penetration (CRP) testing procedure

Where it is required to determine the ultimate load of a preliminary compression pile, and particularly where piles are largely embedded in and bearing on clay soils, the CRP testing procedure will normally be specified.

The rate of movement of the pile head shall be maintained constant in so far as is practicable and shall be approximately 0.01 mm/s for piles in predominantly cohesive soils and 0.02 mm/s for piles in predominantly cohesion-less soils.

Readings of loads, penetration and time shall be made simultaneously at regular intervals; the interval chosen shall be such that a curve of load versus penetration can be plotted without ambiguity.

Loading shall be continued until one of the following results is obtained: -

(a) the maximum required test load as specified in accordance with clause 15.2 is reached

(b) a constant or reducing load has been recorded for an interval of penetration of 10 mm

(c) a total movement of the pile base equal to 10% of the base diameter, or any other greater value of movement specified, has been reached.

The load shall then be reduced in five approximately equal stages to zero load, penetration and load at each stage and at zero load being recorded.

3. TESTING OF PILES DESIGNED TO CARRY LOAD IN TENSION

The testing of piles designed to carry load in tension shall follow the same procedure as specified in clauses 15.14.1 and 15.14.2. In testing by the constant rate of uplift method, overall movements of the pile head will normally be less than those expected in a constant rate of penetration test. The rate of movement of the pile head shall be maintained at approximately 0.005 mm/s in so far as is practicable.

o. PRESENTATION OF RESULTS

1. RESULTS TO BE SUBMITTED

During the progress of a test, all records taken shall be available for inspection by ES. Results shall be submitted as:

(a) a preliminary copy of the test records to ES, unless otherwise directed, *within* 24 hours of the completion of the test, which shall show:

1) for a test by maintained load: for each stage of loading, the period for which the load was held, the load and the maximum pile movement at the end of the stage

2) for a CRP or CRU test: the maximum load reached and a graph of load against penetration or load against uplift

(b) the completed schedule of recorded data as prescribed in clause 15.15.2 *within* 10 days of the completion of the test.

2. SCHEDULE OF RECORDED DATA

The Contractor shall provide information about the test pile in accordance with the following schedule where applicable.

(a) General

Site location

Contract identification

Proposed structure Main contractor Piling Contractor Engineer

Client/Employer

Date and time of test

(b) Pile details

All types of pile

Identification (number and location)

Specified working load (SWL)

Design verification load (DVL)

Commencing surface level at pile position Head level at which test load was applied Type of pile

Vertical or raking, compression or tension

Shape and size of cross-section of pile, and position of any change in cross-section

Head details

Length in ground

Level of toe

Dimensions of any permanent casing

Concrete piles

Concrete mix/grade

Aggregate type and source

Cement type and cement replacement and type where used

Admixtures

Slump

Cube test results for pile and cap

Reinforcement

(c) Installation details

All piles

Dates and times of boring and concreting of test pile

Difficulties and delays encountered

Date and time of casting concrete pile cap

Bored piles

Type of equipment used and method of boring

Temporary casing — diameter, type and length

Full log of pile borehole

Method of placing concrete

Volume of concrete placed

(d) Test procedure

Mass of Kentledge

Tension pile, ground anchorage or compression pile details

Plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles or ground anchorages, and supports to pile movement reference system

Jack capacity

Method of load measurement

Method(s) of penetration or uplift measurement

(e) Test results

In tabular form

In graphical form: load plotted against pile head movement Ambient temperature records during test

p. COMPLETION OF A TEST

1. REMOVAL OF TEST EQUIPMENT

On completion of a test and subject to the approval of ES, all measuring equipment and load application devices shall be dismantled and checked. All other test equipment, including kentledge, beams and supporting structures shall be removed from the test pile location. Measuring and other demountable equipment shall be stored in a safe manner so that it is available for further tests or removed from the Site as approved by ES.

Temporary tension piles and ground anchorages shall be cut off below ground level, and off-cut materials removed from the Site. The ground shall be made good to the original commencing surface level.

2. PRELIMINARY TEST PILE

Unless otherwise specified, the head of each preliminary test pile shall be cut off below ground level, off-cut material shall be removed from the Site and the ground made good to the original commencing surface level.

3. PROOF TEST PILE CAP

On completion of a test on a proof pile, the test pile cap shall be prepared as specified and left in a state ready for incorporation into the Permanent Works. Any resulting off-cut materials shall be removed from the Site.

5.4.16 INDIRECT METHODS FOR TESTING PILES

a. INTEGRITY-TESTING OF PILES

1. GENERAL

Integrity-testing of piles is designed to give information about the physical dimensions, continuity and consistency of materials used in piles, and not to give direct information about the performance of piles under the conditions of loading. The methods available are normally applied to preformed concrete piles made in a single length, to steel piles and to cast-in-place concrete piles. The constituent material of any pile should have a large differential modulus of elasticity compared with the ground in which it is embedded.

This type of testing will not be regarded as a replacement for static load testing, but as a source of supplementary information.

There is normally a limit to the length/diameter ratio of pile which can be successfully and fully investigated in this way, depending on the ground conditions.

In the event that any anomaly is found in the results of such testing, ES may call for further testing to be carried out or for the relevant part of the pile to be exposed where practicable for inspection, in order to investigate the cause, nature and extent of the anomaly and whether the pile is satisfactory for its intended use. Should the further investigation confirm the failure of the integrity test, defected piles may be rejected by ES and will be replaced, or additional piles will be installed by the Contractor at his own expenses.

In addition to integrity tests described herein, ES may call for proof coring of pile shaft to assess concrete strength and quality. The test consists of drilling a vertical core hole of 50mm min diameter in the central part of the pile shaft up to the

required depth not later than 28 days after pile concreting. At 28 days, unconfined compression test shall be performed on minimum six samples obtained from a core of a single pile to check the actual strength of the concrete against the minimum resistance required by the design. After testing the core hole in the pile shall be grouted. Number of working piles to be tested by core drilling shall be determined by ES.

2. PARTICULAR SPECIFICATION

The following matters are, where appropriate, described in the Particular Specification

(a) the type or method of test to be carried out

(b) the number and location of piles to be tested

(c) the stage in the programme of works when integrity-testing is to be carried out

(d) the number and location of piles in which ducts are to be placed if appropriate to the method specified

(e) preparation of pile head for testing where appropriate.

3. METHOD OF TESTING

Where integrity-testing is called for, but the method is not specified, the method to be adopted shall be approved by the Engineer and shall be one of the following

(a) the sonic method

(b) the vibration method

(c) the sonic logging method.

Other methods may be adopted subject to the approval of SMI and subject to satisfactory evidence of performance.

4. AGE OF PILES AT TIME OF TESTING

In the cast of cast-in-place concrete piles, integrity tests shall not be carried out until 7 days or more have elapsed since pile-casting unless otherwise approved.

5. PREPARATION OF PILE HEADS

Where the method of testing requires the positioning of sensing equipment on the pile head, the head shall be clean, free from water, laitance, loose concrete, over spilled concrete and blinding concrete, and readily accessible for the purpose of testing.

6. SPECIALIST TESTING CONTRACTOR

The testing shall be carried out by an approved specialist firm.

7. INTERPRETATION OF TESTS

The interpretation of tests shall be carried out by competent persons and the full test results and findings shall normally be given to ES within 10 days of the completion of each phase of testing.

Full details of the ground conditions, pile dimensions and construction method shall be made available to the specialist firm when required in order to facilitate interpretation of the tests.

b. DYNAMIC PILE-TESTING

1. GENERAL

Dynamic pile-testing involves monitoring the response of a pile to a heavy impact applied at the pile head. The impact is often provided by the pile-driving hammer and response is normally measured in terms of force and acceleration or displacement close to the pile head.

The results directly obtained refer to dynamic loading conditions. Interpretation in terms of static loading requires soil- and pile-dependent adjustments, and corroboration from experience may be required to correlate testing of this kind with normal static load tests.

Details of the equipment to be used and of the method of analysis of test results shall be provided to ES before the commencement of testing.

2. PARTICULAR SPECIFICATION

The following matters are, where appropriate, described in the Particular Specification:

(a) the number, type and location of piles to be tested
(b) the stage in the programme of works when testing is to be carried out
(c) the static pile capacity to be demonstrated
(d) details of work to be carried out on a pile head following a test.

3. MEASURING INSTRUMENTS

All instruments affixed to the pile for the purpose of measuring stress and movement, and all equipment for receiving and processing data shall be suitable for the purpose. The equipment required to be attached to the pile shall be appropriately positioned and fixed to the approval of ES.

4. HAMMER

The hammer and all other equipment used shall be capable of delivering an impact force sufficient to mobilize the equivalent specified test load without damaging the pile.

5. PREPARATION OF PILE HEAD

The preparation of the pile head for the application of the dynamic test load shall involve, where appropriate, trimming the head, cleaning and building up the pile using materials which will at the time of testing safely withstand the impact stresses. The impact surface shall be flat and at right angles to the pile axis.

6. INTERPRETATION OF RESULTS

The interpretation of the tests shall be carried out by competent and experienced persons and the report on each test shall normally be given to the Engineer within 10 days of the completion of the test.

7. TIME OF TESTING

Dynamic load tests shall be carried out at appropriate and approved times after pile installation. The time between the completion of installation and testing for a preformed pile shall normally be more than 12 hours, and in the case of a cast-in-place pile shall be such that the pile is not damaged under the impact stresses.

8. RESULTS

Initial results shall be provided to ES within 24 hours of the completion of a test. These shall include

(a) the maximum force applied to the pile head
(b) the maximum pile head velocity
(c) the maximum energy imparted to the pile.

Subsequently a full report shall be given to ES, normally within 10 days of the completion of testing, including:

(a) date of pile installation
(b) date of test
(c) pile identification number and location
(d) length of pile below commencing surface
(e) total pile length, including projection above commencing surface at time of test
(f) length of pile from instrumentation position to toe
(g) hammer type drop and other relevant details
(h) blow selected for analysis
(i) test load achieved (i.e. total mobilized deduced static load)

(j) pile head movement at equivalent design verification load

(k) pile head movement at equivalent design verification load plus 50% of specified working load

(l) pile head movement at maximum applied test load

(m) permanent residual movement of pile head after each blow

(n) temporary compression.

9. PROVISION OF INFORMATION

All available details of the ground conditions, pile dimensions, and construction method shall be provided to the specialist firm carrying out the testing in order to facilitate interpretation of tests.

5.4.17 NUMBER OF WORKING PILES TO BE TESTED

a. STATIC LOAD TESTING

The Contractor shall carry out load tests on several working piles selected and approved by ES. 3% of the total number of piles shall be tested unless the results are unsatisfactory, in which case more tests will be required.

If any pile fails under the test it shall be replaced or supplementary piles installed by the Contractor at his own expense and according to ES's instructions.

b. INDIRECT METHODS FOR PILE TESTING

All working piles (100%) shall be integrity tested. Dynamic pile testing shall be carried out on working piles selected and approved by ES and verified using the results obtained from the load tested piles.

5.5 CONCRETE STRUCTURES

5.5.1 GENERAL

In addition to this specification, the Contractor shall adhere to any requirements of ACI 318-08, AIST Technical Report No. 13 and CIRIA "Guide to the Construction of Reinforced Concrete in the Arabian Peninsula" or any other National or International Standard agreed upon with ESI.

Concrete of the following classes (nominal compressive cube strength at 28 days) shall be used for all civil works: -

- Blinding concrete below foundation (lean concrete) and plain concrete for filling purpose (mass concrete) 15 MPa.
- General reinforced concrete construction ≥ 30 MPa.

5.5.2 DURABILITY REQUIREMENTS

Durability shall be allowed for in the design of reinforced concrete structures by determining the applicable Exposure Classification in accordance with Section 2.1 below and complying with the appropriate requirements in the remainder of this Standard.

For determining the cover requirements, the Exposure Classification shall be taken as the classification for the surface from which the cover is measured.

a. EXPOSURE CLASSIFICATIONS

The following Exposure Classifications are applicable: -

Surface and Exposure Environment	Maximum Free Water/Cement Ratio	Exposure Classification
All above-ground structures unless mentioned below. (**)	0.45	A MILD
All foundations and members in contact with the ground unless mentioned below.	0.42	B MODERATE
Members in environments subject to repeated wetting and drying. (**) Members in soft or running water. Members used to contain liquids. Tunnel, Basements, Cellars and other walled structures below ground. Structural elements in contact with seawater.	0.40	C SEVERE

(**) For the purpose of this rule, members exposed only to rainwater are not considered to be subject to frequent wetting and drying.

b. COVER REQUIREMENTS FOR CORROSION PROTECTION

For corrosion protection, the concrete cover shall be at least: -

- 30mm for Exposure Classification A
- 50mm for Exposure Classification B
- 70mm for Exposure Classification C.

The above values are valid where standard formwork and compaction are used. Where Concrete is cast directly on or against the ground the above covers shall be increased by 20mm.

Inside bored piles, the cover shall not be less than 90mm.

c. ABRASION REQUIREMENTS

In addition to the other durability requirements of this section, concrete for members subject to abrasion from traffic shall have nominal compressive strengths as follows:

- Footpaths and industrial floors not subject to vehicular traffic 25 N/mm^2
- Pavements and floors subject to heavy pneumatic-tyre traffic 35 N/mm^2
- Non pneumatic-tyre traffic 40 N/mm^2
- Steel-wheeled traffic 50 N/mm^2

d. RESTRICTIONS ON CHEMICAL CONTENT IN CONCRETE

The maximum acid-soluble chloride-ion content per unit volume of reinforced concrete as placed shall not exceed 0.8 kg/m3 or 0.3% weight of cement.

Chloride salts or chemical admixtures containing chlorides shall not be added to reinforced concrete.

The sulphate content of concrete as placed, expressed as the percentage by mass of acid soluble SO3 to cement, and shall not be greater than 2%.

Other strongly ionized salts, such as nitrates, shall not be added to concrete unless it can be shown that they do not adversely affect durability.

e. FIRE RESISTANCE

Since the resistance to fire of a reinforced concrete member is affected considerably by the extent of the concrete cover, cover thicknesses in excess of those specified in Section 2.2 above may be required, particularly for slabs, walls and columns.

Reinforced concrete members subject to prolonged high temperatures shall, in addition to their normal reinforcement requirements, is fitted with a thin and closely spaced galvanized wire mesh which shall be placed near the surface to prevent spalling.

5.5.3 MATERIALS

a. CEMENT

1. ASTM Type I Ordinary Portland Cement

Type I Ordinary Portland Cement shall be used for all concrete structures subject to Exposure Classifications A and B. The Tricalcium Aluminate content of the cement shall not be less than 7%.

2. ASTM Type V Sulphate Resistant Portland Cement

Should not be used, unless strictly necessary or recommended by the soil investigation report.

3. **ASTM Type I Ordinary Portland Cement with Pozzolanic Additions**

   Type I Ordinary Portland Cement with Pozzolanic Additions shall be used for all concrete structures subject to Exposure Classification C as defined in Section 2.1 above. The Tricalcium Aluminate content of the cement shall be between 7% and 14%.

b. AGGREGATES

Materials used as aggregates shall be chemically inert, strong, hard, durable, of limited porosity and free from adhering coatings and organic or other impurities that may cause corrosion of the reinforcement or may impair the strength and durability of the concrete.
Unless otherwise specified, aggregates shall have 20mm maximum diameter. Fine aggregate shall be sharp and well graded; dune and beach sand alone shall not be used.

The grading, physical properties and deleterious substances of all aggregates shall be continuously monitored and are subject to approval by ES.
The aggregates shall be such that concrete shall not show a drying shrinkage greater than 0.05%.

Chlorides in aggregates are a major cause of corrosion of reinforcement. Generally, coarse aggregates shall have a maximum content of 0.03% by weight of chlorides as acid-soluble chloride-ion and fine aggregates of 0.06%. Coarse or fine aggregates shall have a maximum content of 0.40% by weight of sulphates as SO3. To ensure that the total quantity of chloride and sulphates salts incorporated in concrete does not exceed recommended limits it is necessary to frequently check and monitor the chloride/sulphate content of the materials used for making the concrete.

c. MIXING WATER, ADMIXTURES AND ADDITIVES

The water used for mixing concrete shall be of potable quality. Generally, the water used shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials, and other substances that may be deleterious to concrete or the reinforcement.
The following chemical admixtures may be used: -

- Air Entrainment Additives
- Water Reducing and Retarding Admixtures

- High Range Water Reducing Admixtures (Superplasticizers)

Admixtures shall be free of calcium chloride or chloride salt.
If the use of retarding or workability agents is approved by ESI, this use shall be subject to the following conditions: -

- No reduction of target mean strength compared with additive-free concrete of the same class.
- No reduction of cement content below the minimum specified for the class of concrete concerned.
- Dosage and admixture strictly in accordance with the manufacturer's instruction in respect of the specific conditions obtained.

The only pozzolanic materials accepted by ES are silica fumes (i.e. Micro silica, Micropoz, or equivalent). The amount of silica fumes used, either in blended cement or added separately in the mixer, shall conform to the manufacturer's recommendation but shall not be less than 7.14% by weight (equivalent to one 25 kg bag of Micro silica per 350 kg of cement) of the total cementitious material in the concrete. Samples of the proposed silica fumes and the manufacturer's product information shall be submitted to ES for testing and approval.

Micro silica is dosed on a dry weight basis as a percentage of the cement content. Water reducing admixtures (superplasticizers) shall be used to ensure enough workability whilst keeping the water/cement ratio to 0.40.

d. REINFORCEMENT

Reinforcement shall be deformed bars or welded wire fabric except that plain bars or wire may be used for fitments.

The Contractor shall use reinforcing bars conforming to ASTM A 615 Grade 40 for Medium Yield and ASTM A 615 Grade 60 for High Yield bars or equivalent Standards agreed upon with ES as shown on the drawings.

Non-magnetic steel reinforcement, where required by the technological operations (e.g. EAF trafo cabin area) shall be in accordance with AISI 304L (Stainless Steel) or agreed equivalent.

5.5.4 MIX DESIGN

a. MIX DESIGN REQUIREMENTS

The mix design shall be carried out by the Contractor to include the following requirements:

1. Specification Requirements

Design Code ACI 318

Characteristic Strength (fcu or fc)

Cement Type

Mineral Additions (type and content)

Maximum free water/cement ratio

Minimum & maximum cement content

Maximum concrete temperature at placement

Maximum aggregate size and type

Maximum chloride and sulphate contents of hardened concrete

Time from mixing to placing

Requirements for fresh concrete

Bleed

Air content

Bulk density (for yield calculations)

Requirements for hardened concrete

Chloride permeability Water permeability

Water absorption or penetration

Initial surface absorption

Flexural strength

Early compressive strength

Surface finish

2. Construction Requirements

Workability at placement (depend on casting configuration and placement method)

Pumpability

Workability retention (based on environmental conditions, transport time, placement time, concrete temperature, absorption and evaporation).

Retardation (e.g. for extending transport time, piling and massive pours).

Initial setting time

Cohesiveness

Target design strength (based on code margin)

High early strength (precast, slip forming)

Low early strength (continuous bored piling)

Special finishes

b. ADMIXTURES

When the free water/cement ratio and the cementitious content are fixed, either by specification or durability requirements, the free-water content is also fixed. Workability at the time of placement is therefore controlled solely by the type and amount of plasticiser added. Ambient and concrete temperatures vary considerably, both daily and seasonally and these have a distinct effect on both workability and workability retention. Different placing operations may require different degrees of workability. These factors may require variations in the dosage and type of plasticisers added.

Provided these variations are within the range of applications and doses recommended by the manufacturer and the concrete remains cohesive and workable up to the time of placement, they shall be accepted as being within the current mix design.

c. FULL SCALE TRIALS

The trials shall be carried out using the batching plant that is to be used for the works. It is as much a trial of the plant itself, and its ability to produce the type of concrete required, as of the concrete.

When the trial is to be carried out at a ready-mixed installation, which may have several batching plants with common, or identical, ancillary arrangements, it will normally be acceptable to approve these similarly, without additional trials.

If a producer has batching plants in a ready-mixed yard, or installed on site, of different types to those proposed for production use, it is necessary to trial all these types separately. It is not uncommon for one type of plant to be trialed and approved for certain classes (grades) of concrete and other types of plant for other classes. An 'identical' plant would include a similar model from the same manufacturer differing only in rated output, but a similar generic type of plant.

d. TESTING PROGRAM

The testing program for each class of concrete and each batch within that class shall be determined in advance. Tests on the fresh concrete should normally be carried out on each separate batch. It is recommended that all tests are carried out and specimens

are made within a relatively short time, the Contractor must ensure that enough staff and equipment are available to complete the program for each batch.

It is recommended that at least three separate batches of concrete are produced for testing the fresh concrete and manufacturing specimens for tests on the hardened concrete. A separate batch of concrete shall be produced for the trial of workability retention.

1. TESTS ON FRESH CONCRETE

It is recommended that each batch of concrete (all classes, including mass concrete) used for making test specimens for evaluating compliance shall be tested as follows: -

- Two slump tests
- One measurement of concrete temperature.
- The following tests should be carried out on even-numbered batches (second, fourth, etc.)
- one air content test, for entrapped air
- one fresh density test
- one test for initial and final setting time
- one test for bleeding.

2. TESTS ON HARDENED CONCRETE

At least 52 individual cubes or cylinders shall be made to evaluate compliance with the compressive strength criterion, and tested as 3 pairs at 7 days, 3 pairs at 14 days and 20 pairs at 28 days. Casting 20 pairs (at the specified test age) enables the standard deviation to be estimated, both within and between batches.

For trials on blinding or mass concrete, only 12 individual specimens need to be made; with 2 pairs tested at 7 days and 4 pairs at 28 days.

A trial will normally require about 18 cubes or cylinders to be cast per trial batch per class of concrete.

5.5.5 SITE OPERATIONS

a. STORAGE AND HANDLING OF MATERIALS

1. AGGREGATES

The Contractor shall store the fine and coarse aggregates separately in stockpiles on concrete foundations constructed in such a manner that water can readily drain away from the stockpile.

The stockpile for each size of material shall be divided into two so that when one section is being used the other is being refilled and allowed to drain.
If material becomes mixed together, becomes dirty or coated with cement, they shall be rejected.

Sufficient fine and coarse aggregate shall be stockpiled for 3 days to allow the material to drain to as uniform moisture content as possible. The bottom 300mm of each stockpile shall not be used in concrete but left to act as a drainage layer. Fine material which accumulates at the bottom of the storage heaps shall be removed at frequent intervals so that the specified grading is maintained.

2. CEMENT

The Contractor shall use bulk cement which shall be transported in vehicles built specifically for the purpose. The Contractor shall provide adequate storage consisting of a silo which shall be completely weatherproof and clean internally. Special cement shall be held in a separate building or silos and protected from deterioration in accordance with the manufacturer's instructions.

b. BATCHING

Weigh batching plant shall be used. Accuracy of all measuring devices shall be accurate to ±0.4% of the total scale capacity when statically tests at each quarter point.
Batching Tolerance Criteria shall be as the table below: -

Constituent Material	Batching Tolerance Criteria
1. Cement, blended cements and dry powdered cement additions	-2% to +3%
2. Added water (when no ice used)	-3% to +2%
3. Flaked ice	-4% to +3%
4. Total water added and ice	-3% to +2%
5. Silica fume slurry	±2%
6. Each single size coarse aggregate and each individual sand	±3%
7. Total coarse aggregate and sand	±2%

8. Liquid admixtures	±3%

The Contractor shall ensure that the Quality Assurance scheme operated either by the ready mixed supplier or the site-based plant is sufficient to ensure a reliable supply of consistent concrete. This should not relieve the Contractor from his responsibility to make test samples on site as specified in Section 5.9

c. HANDLING AND PLACING CONCRETE

The Contractor shall strictly adhere to the agreed quality control procedures when concrete is to be poured. No concrete shall be placed prior to ES's approval and the Contractor shall ensure that the relevant quality control forms have been signed before commencing such work.

The maximum permissible water-cement ratio, inclusive of aggregate moisture and liquid admixtures, shall not exceed 0.45. Indicatively the permissible slump for concrete without chemical admixtures shall not exceed 75 mm. When super-plasticizers are used the slump may reach up to 120mm, for piling see ES Engineering Standard 03-040 Section 10.2.

Concrete shall not be placed if its temperature exceeds 32°C or if the ambient temperature is higher than 35°C on a rising thermometer or both. To keep within these limits, the Contractor may, among other means, spray aggregates with water and use chilled mixing water, or add ice directly into the mixer providing no ice is present in the mix when discharged from the mixer. When concreting in hot weather all material used shall be protected from direct sunlight. Concreting operations shall not be carried out during heavy rains or dust storms.

Forms should be kept cool prior to pouring concrete; either by shading or by spraying with concrete quality water, but all excess water shall be removed before any concrete is placed.

When placing, concrete shall not fall more than 1.5m. If necessary, the Contractor shall incorporate special provisions in the formwork to comply with this provision.

Slump tests shall be taken prior to casting and the slump cones to be left in place until they have been inspected by ES.

All concrete shall be placed and compacted within 30 minutes of the water being added to the mix. No water shall be added to the mix after it has left the mixer.

The Contractor shall regard the compaction of the concrete work of fundamental importance and shall produce a concrete of maximum density compatible with the concerned mix. Compacting shall be done by poker vibration, taking care not to involve the vibration of reinforcement or formworks. Spare plant shall always be available in case of a breakdown.

Concreting of mass structures shall be performed in blocks and each block must be completely poured in one continuous operation. Adequate control of the temperature of the mix and the setting of the concrete shall ensure a sound uncracked structure.

No concrete shall be used after it has developed initial set and batch or part of a batch which has commenced to set before being used shall be rejected.

All concrete after mixing shall be conveyed to the work in such a manner that no segregation of the mix takes place.

A sufficient number of machines shall be provided and shall be constantly moving inside the shutters to effect maximum compaction and to avoid segregation. Under no circumstances shall the vibrator be used to move the concrete horizontally.

The surfaces of the concrete where exposed shall be given a float finish and left with a hard-smooth face.

The whole of the exposed surface of the concrete shall be maintained as nearly horizontal as possible throughout.

In reinforced concrete work the concrete shall be well packed between and around the bars.

Openings, holes and embedded ducts for electrical and mechanical works shall be fixed according to the design and checked for the correct positioning before concreting.

As bleeding water will not appear when silica fume modified concrete is used, the finishing of the concrete shall be done immediately after pouring. In order to eliminate plastic shrinkage proper curing is essential.

1. NOTICE OF INTENTION TO CONCRETE

The Contractor shall give ES 24 hours notice of his intention to concrete to enable the necessary checks, to reinforcement, formwork anchor bolts etc., to be made. This notice is to be made in writing.

a. ADDITION OF ADMIXTURES ON SITE

If admixtures are to be added to the concrete in the truck directly before placement, this shall only be done in accordance with a pre-determined procedure which has been proven by trials and is subject to rigorous quality control.

b. FORMWORK

The materials, design and construction of formwork shall be in accordance with the relevant ACI Standard and manufacturer recommendations

Formworks shall be free from cracks or bends and shall be designed to provide necessary rigidity to support the concrete pressure and all loads placed upon without settlement and deformation.

Supporting props to decking shall be erected as per the approved design. Adequate cross bracings shall be provided in suitable positions to prevent the supporting frames and members from bending and buckling. In multi-storey buildings, supports of an upper floor shall rest on the lower floor only after the lower floor has developed enough strength to bear the load.

Shuttering activities shall include all cutting and waste as raking, curved or circular cutting and cutting and notching around pipes, ducting and fittings.

Joints of formwork shall be levelled to form a smooth monolithic finish on the concrete surface. In the event of holes and gaps at formwork surface, they shall be sealed in order to avoid bleeding of concrete.

Bolts and other metal fittings used in formwork erection shall facilitate their easy removal without damage to the concrete and upon their removal the cavities left

are as small as possible. All cavities left in the concrete shall be filled with mortar and finished to the satisfaction of ES. No permanently embedded metal part shall have less than 40 mm cover to the finished concrete surface or the specified cover to the reinforcement, whichever is the greater.
All visible concrete edges shall receive chamfers proportional in size to the concrete dimensions.

Unless otherwise approved by ES, top shuttering shall be provided to concrete faces where the angle of the top slope exceeds 15o to the horizontal.

Prior to their installation, all formwork surfaces shall be adequately and uniformly treated with a suitable anti-sticking chemical agent or mould oil and all excess shall be carefully removed before placing the formwork in position.

Forms shall not be stripped or any formwork supports removed until the part of the member which will be left unsupported has attained sufficient strength to support, with safety and without detriment to its intended use, its own weight and any superimposed loads due to concurrent or subsequent construction works.

The removal of formwork supports shall be carried out in a planned sequence so that the concrete structure will not be subject to any unnecessary deformation, impact, or eccentric loading during the process.

Formwork shall not be removed from vertical surfaces for at least 24 hours.

Where control samples have been taken and tested, soffit forms may be stripped from between the formwork supports of reinforced beams and slabs if;

- the elapsed time between the casting of the concrete and the commencement of stripping is greater than 3 days, and
- spans between the remaining formwork supports are such that the member will remain un-cracked under the action effects of bending and shear due to the maximum concurrent or subsequent construction loads.

c. REINFORCEMENT

Reinforcement shall be stored above ground on platforms, skids or other approved supports and contact with the soil shall be avoided. Reinforcement shall be clean and free from corrosion.

All reinforcement shall be accurately and securely fixed in position to prevent any movement of the bars before or during concreting. Bar supports and accessories shall be made from plastic, plastic coated wire or precast concrete spacer blocks.

Cutting and bending of reinforcement bars shall be carried out according to the relevant National or International Standard agreed upon with ES. All reinforcement shall be bent cold. The preheating, re-bending or welding of reinforcement shall be avoided and may only be carried out in exceptional circumstances and with ES's explicit approval. Tack welding shall not be use.

Any bar projecting from concrete shall not be bent except in extreme circumstances and such bending shall be subject to ES’s approval.

Laps and joints shall be made only by the methods specified and agreed upon ES. All lapped joints are to provide the lap length required by the drawings or agreed Standards and mechanical joining of bars will only be permitted in certain approved locations and where the type of joint and its preparation has previously approved by ES.

d. CURING AND PROTECTION OF CONCRETE

All concrete shall be cured continuously and shall start immediately after finishing, in order to protect it from but not limited to the following: -

- Premature drying out, particularly by solar radiation and wind.
- Leaching out by rain and flowing water.
- Rapid cooling during the first few days after placing.
- High internal thermal gradients.
- Thermal shock.
- Low temperature.
- Shock, vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

- Premature or excessive temporary or permanent loading.

Prior to commencing curing the Contractor shall submit appropriate curing and protection methods to ES for approval. On-site curing shall be done with water in preference to chemical means and the minimum curing times are as follows: -

Exposure Conditions A and B min. 10 days

Exposure Condition C min. 21 days.

e. REJECTION OF CONCRETE

ES may reject plastic concrete if, after completion of mixing but prior to site handling: -

- The slump differs from the slump specified by more than the tolerances permitted by the approved Standard, or
- The time since the completion of mixing is outside the time interval allowed in the approved Standard, or
- The appearance and cohesiveness of that quantity is significantly different from previously supplied quantities of the same specification.
- If a mix fails to achieve the requirements for fresh concrete, the batch shall be rejected, and no further concrete of that class shall be placed until the cause of failure has been rectified by the Contractor.

Hardened concrete shall be liable to rejection by ES if: -

- It is porous, segregated or honeycombed, or contains surface defects in breach of the finish demanded, or
- It does not satisfy the approved Standard requirements regarding compressive strength testing, or
- If it fails to comply with any other requirements of the approved Standards.
- If the 28 days compressive strength of any test cube is less than the minimum compressive strength given in the approved standards, the concrete it represents shall be broken out and disposed of away from site unless, at his sole discretion, ES approves otherwise. Where hardened concrete is liable to rejection, the concrete may be accepted if it can be demonstrated that the structural adequacy and intended use of the affected members are not significantly impaired. However, the rejection or acceptance of such members shall be solely decided by ES.

Unsatisfactory concrete works or works not fulfilling the requirements of these Standards shall be cut out and re-casted by the Contractor or made good by alternative remedial works as required and directed by ES.

f. SAMPLING AND TESTING

1. GENERAL

The Contractor shall sample and test all concrete for its compressive strength in accordance with the relevant Standards agreed upon with ES.
Both cube and cylinder tests are acceptable to ES, provided the specimens are prepared, cured, stored and tested as prescribed in the agreed Standards.

Compressive test samples (either cylinders or cubes) shall be prepared in sets of 6 specimens for each test. These specimens shall be obtained at random but from the same batch of concrete.

The testing of specimens shall be carried out at an independent established laboratory, or at the Contractor's site laboratory, as agreed and approved with ES. The Contractor shall make all the necessary arrangements and provide all transport and labour to convey the cubes to the approved laboratory.

All sampling shall be carried out as specified in the agreed Standards and the Contractor shall ensure that his nominated Quality Control Officer is present for this work. Sufficient warning must be given to external staff (laboratory technicians etc.) if they must come on site for this purpose.

No concrete which requires sampling shall be poured unless the above conditions are fully met.

2. RATE OF SAMPLING

The rate of sampling shall be as follows: -

- One set for each 50m3 of concrete placed on any one day. At least one set shall be obtained for each structure or foundation, except that,
- When pouring a number of items, each item smaller than 15m3, one set for each 15 m3 shall suffice.

If, after a period of time, it can be shown that the test results achieved are consistently high, ES may agree to a reduced rate of sampling.

All test specimens shall be immediately stored under wet, clean sand or hessian for approximately 24 hours after preparation. Vibration and impact shall be avoided during this critical period.

3. SITE CONTROL TESTING

The specimens shall be tested to determine the actual strength of the concrete at site, which, owing to inadequate compaction, segregation, or adverse curing conditions, may be of inferior quality when compared with laboratory specimens stored under ideal conditions at the batching plant.

The specimens shall, after the first 24 hours of moist curing, be stored at their place of origin on the site and cured, protected and otherwise treated in exactly the same way as the concrete pour which they represent.

4. TEST PROCEDURES

Each set of six specimens shall be tested as follows: -

- specimens at 7 days, at which time the specimens shall have attained at least 60% of the required strength grade.
- specimens at 28 days

The Contractor shall forward copies of all test reports to ES for evaluation and approval and shall submit the originals to ES at the end of the contract period as part of the final documentation.

5. ADDITIONAL TESTING

If requested by ES, the Contractor shall provide drilled concrete cores for evaluation and testing. Core drilling will only be asked for if:

- The compression test specimens have not reached their required strength, or
- In order to evaluate segregation or honeycombing defects, or
- To check the bond at construction joints.

In addition, the Contractor shall carry out any other destructive or non-destructive testing on plastic or hardened concrete requested by ES.

All concrete testing shall be at the Contractor's expense.

5.5.6 JOINTS

a. GENERAL

Joints shall be provided, where necessary,

- To break the structure into sections convenient for economical construction,

- To control possible cracking resulting from excessive stresses and strains, and
- To comply with design assumptions, and are to incorporate water stops wherever appropriate.

Joints are to facilitate displacement or rotation, or both, without affecting the structural integrity or permeability of the structure.

The number of construction joints shall be as few as possible consistent with reasonable precautions against shrinkage. Concreting shall be carried out continuously up to construction joints.

The location and type of construction joints shall be agreed by ES before any work commences.

Construction joints shall be at right angles to the general direction of the member and shall generally be in the centre of the span for beams and slabs.

b. NON-MOVEMENT JOINTS

Construction joints shall be located to provide convenient breaks in the construction of structures and shall be specified on the drawings. They shall be made so that the load carrying capacity and serviceability of the structure is unimpaired by the inclusion of the joints.

Reinforcement shall pass continuously through the joint and, where water tightness or long-term corrosion protection is required, water stops or surface joint sealants, or both, shall be used.

Construction joint surfaces shall be prepared for subsequent continuity as follows: All laitance shall be removed from the concrete and the aggregate shall be exposed, so that a satisfactory aggregate interlock can take place. Before concreting is resumed against the joint, the roughened joint surface shall be thoroughly cleaned by air jetting free from loose mortar and slightly wetted.

- All water stops, joint filers and sealants shall be shown to be durable in the environment or usage to which they will be exposed. Joints between floors and walls shall be constructed with a small 'kicker' to allow for the easy and tight assembly of subsequent wall formwork.

c. MOVEMENT JOINTS

As all movement joints are a potential source of problems, the Contractor shall minimize their use. However, sufficient movement joints shall be provided to assure the appropriate flexibility of the structure.

1. EXPANSION JOINTS

Expansion joints shall be designed to accommodate all anticipated longitudinal movements in a structure. The reinforcement shall stop clear of the joint and a gap shall be left which is to be filled with compressible filler. Where water tightness must be considered, water stops are usually required.

If relative transverse movements between the sides of the joint are to be prevented, or if shear forces must be transmitted across a joint, dowel bars may be used. These bars shall be accurately located to allow the joint to move freely. One end of the dowel bar shall be cast into the concrete and the other end shall preferably be sleeved (using a PVC pipe sleeve taped over on one end to prevent concrete entering the sleeve). Alternatively, bond breaking tape or de-bonding compound is also acceptable.

2. CONTRACTION JOINTS

Full contraction joints shall consist of a discontinuity of both the reinforcement and the concrete across the joint. Where water tightness must be considered, water stops are essential. If there is any possibility of debris entering the joint, appropriate sealants shall be provided.

Dowel shall be installed if shear forces must be transferred across the joint. Shear keys within the concrete thickness shall be avoided if possible.

Partial contraction joints may be constructed by inducing cracks at predetermined locations. At such joints, the thickness of the concrete shall be reduced (by saw cutting or other means) by 25% to 35%, and the amount of continuous reinforcement across the joint shall be reduced by 50%.

3. SLIDING JOINTS

Sliding joints shall have a complete discontinuity with respect to both concrete and reinforcement and shall allow movement with minimal restraint in the plane of the joint. The surface of the concrete shall be very smooth and flat, and a separating layer of suitable material shall be provided to allow movement to take place.

Sliding joints shall be used at the base of pre-stressed concrete tanks and the like, where relatively large displacements between the wall and the foundation must be considered.

5.5.7 CONCRETE LIQUID RETAINING STRUCTURES

When designing concrete structures for retaining liquids, the loading shall include appropriate design temperature gradients and shrinkage and swelling strains.

The extent of cracking shall be controlled by reducing the allowable tensile stresses in the reinforcing steel, considering the most unfavorable load combination.

Particular attention shall be given to the design, construction and maintenance of joints. If requested by ES, the Contractor shall test liquid retaining structures for liquid retention.

Any necessary remedial treatment of the concrete to cracks or joints shall, where practicable, be carried out from the liquid face.

5.5.8 EMBEDDED ITEMS

a. GENERAL

Embedded items include pipes and conduits, sleeves, permanent inserts for fixings and other purposes, anchor bolts and other supports. All embedded items shall be securely fixed by rigid templates prior to pouring any concrete, so that they comply with their dimensional tolerances after the concrete has set.

All embedded items shall be protected from corrosion or deterioration and to this end shall be effectively coated, covered or otherwise treated to prevent chemical action between the metal and the concrete and electrolytic action between the metal and the reinforcing steel.

Embedded steel items (such as edge steel and lining angles) shall be avoided if possible if the concrete is subject to Exposure Classification C.

Untreated aluminium shall not be embedded in structural concrete

b. FIXINGS

Anchor bolts fixing systems shall comply with relevant Standards agreed with ES and with technological suppliers Standards.

In addition, all fixings, including anchor bolts, inserts, ferrules and the like, shall comply with the following: -

- A fixing shall be designed to transmit all forces likely to act on it and shall yield before its ultimate failure in the event of overload.
- Fixings which are intended for lifting purposes shall have a ratio of ultimate strain to yield strain of no less than 3.
- In the case of shallow anchorages, the edge distance, the spacing, and the effect of the concrete strength at the time of loading shall be considered.
- All anchor bolts shall be accurately fixed in position by the Contractor using all necessary templates etc. The anchor bolts shall be fixed sufficiently rigidly to ensure that they are not at all affected by the placement and compaction of the concrete etc. The Contractor shall carry out checks whilst the concrete is being poured to ensure that no movement has taken place.

c. CLEANING

The section of all anchor bolts that is to be set into the concrete shall be free from all oil, dirt, paint, loose rust, mill scale or other deleterious matter immediately before placing.

The exposed section shall be cleaned and greased, care shall be taken to ensure that concrete does not harden on the exposed section of the bolts.

d. TOLERANCES

The Contractor shall fix all anchor bolts to the following tolerances or as specified on the drawings: -

- Perfectly plumb
- Horizontal tolerance +/- 3mm
- Vertical tolerance +/- 6mm in elevation.

Should any anchor bolts be out of their correct position then they shall be rectified by the Contractor, at his own expense, by a method to be determined by ES.

5.5.9 AUXILIARY STEELWORKS

Auxiliary Steelworks shall consist of covers, gratings, handrails, stairs and ladders and shall be in accordance with DIN Standards (St 37) or equivalent and according to technological and operational requirements.

All Auxiliary Steelworks shall be protected from corrosion by means of hot dip galvanizing treatment or painted according to ES Engineering Standards 08-010 and 08-020.

5.5.10 GROUTING

a. PREPARATION

The foundation surface shall be free of oil, dust, dirt, paint and other deleterious matters and shall be soaked for at least 12 hours prior to grouting. At the time of grouting, the surfaces shall be damp, but all standing water shall have been removed.

The formwork, if required, shall be firm, grout-tight and well secured to prevent any movement during the grouting operation. Edges shall be chamfered.

b. MATERIALS

Grouting materials shall be designed for the severe conditions of a steel plant and shall be able to resist the stresses of heating/cooling and wetting/drying.

Major mechanical equipment and structural steel columns shall be grouted using a pre-packaged cement based non-shrink grouting material, which shall require only the addition of water on site. In the plastic state, the free expansion of the grout shall be between 2% and 4%. When using such grout, the manufacturer's instructions must be strictly adhered to.

Epoxy based grouts shall be used for equipment which imparts high shock and/or vibration loads on the foundations.

Small or minor mechanical equipment and steel members may be grouted or dry packed using a sand/cement mix with an expansive additive.

All grouting materials shall conform to the agreed Standards and their intended use require the prior approval of ES.

c. EXECUTION

The gap between the concrete foundation and the metal base plate or equipment support steelwork shall not exceed 75mm. If this requirement cannot be met, a concrete reinforced pedestal shall be provided if so, requested by ES.

No grouting shall be done if levelling-or shim plates protrude beyond the base plate. Unless otherwise agreed, grout shall only be placed up to the underside of the base plate. Grout embedded base plates are generally not acceptable.

Grout shall be poured continuously and a constant hydrostatic head of at least 150 mm shall be maintained. Cement, sand, gravel or admixtures shall not be added to the grouting mix. Mixing water temperature shall not exceed 27oC and cold or chilled water may be used to extend working time in hot weather or large placements. Overworking, segregation and vibration shall be avoided.

If large areas must be grouted, lengths of chains or metal strapping shall be provided to assist grout flow and eliminate air pockets.

All shuttering shall be removed after the grout has hardened. Finishing and cure shall be in accordance with the manufacturer's recommendations.

5.5.11 CONCRETE PROTECTION AND FINISHING

a. GENERAL

The Contractor shall design and supply all the concrete protection and finishing according to the function and usage of the area concerned. In addition to the provisions specified in the below paragraphs, where appropriate, non-slip, dust free, oil, acid or abrasion resistant surfaces shall be provided. In any case, solutions and materials proposed shall be submitted to ES for approval.

No other finishing or rendering of concrete surfaces for cosmetic purposes are allowed.

b. UNDERGROUND CONCRETE

All concrete below ground shall be protected at least with two coats of bitumen paint.

In addition to this minimum requirement, the Contractor shall provide an adequate protective coating against chlorides and sulphates (if and where required) for concrete surfaces exposed to the ground, considering the results and recommendations of the geotechnical soil reports/foundation engineering reports.

c. FLOORING

Industrial concrete floors will include sub-base, base, lean concrete and concrete slab (thickness as per design requirements) with reinforcing, joints, quartz hardener on top and all applicable finishing.

The base below shall be of compacted crushed stone/gravel materials, blinded with quarry dust (thickness 500 mm minimum) placed over a well-compacted sub-grade.

d. CONCRETE LIQUID RETAINING STRUCTURES

The concrete surface in contact with liquids (e.g. water tanks, basins, pits, etc.) will be coated and waterproofed with a suitable lining.

e. REFRACTORY LINING

The Contractor will design, supply and install refractory bricks on concrete surfaces for heat protection including refractory mortar as required by technological operations.

The minimum composition requirements for bricks and mortar will be as follow: -

- Al2O3 > 60%
- SiO3 = 30%
- Fe2O3 = 1%
- Minimum density: d = 2.53 kg/m3.

f. SCALE FLUSHING PROTECTION

The Contractor will supply and install an anti-wear coating on scale flushing channels (flume) in relevant production areas to protect concrete surfaces from scale erosion.

5.6 STEEL STRUCTURES

5.6.1 GENERAL

a. DESIGN AND CONSTRUCTION STANDARDS

The highest standard of design and construction shall be used in the construction of the steel structures which shall be of proven design and in accordance with best industry practice. The Contractor shall accept full responsibility for ensuring that the buildings are safe and fully suited for the duties assigned.

Materials used in the construction of the steel structures shall be new and of the best quality.

The steel structures shall be designed, fabricated and erected in accordance with the following codes: -

- Uniform Building Code – 1997 Edition
- A.I.S.E. Technical Report No.13 – Guide for the Design and Construction of Mill Buildings – 2003 Edition.
- A.I.S.C. American Institute of Steel Construction – Specification for Structural Steel Buildings – 2005 Edition
- A.I.S.C. American Institute of Steel Construction – Manual of Steel Construction – (ASD 9th edition or LRFD 1st Edition)
- A.I.S.C. American Institute of Steel Construction – Seismic Provisions for Structural Steel Buildings. (Including Supplement no. 1) – 2005 Edition

A Design Statement, the detailed design, G.A. drawings, and Architectural plans & elevations shall be submitted for approval by ESI before the preparation of the shop drawings can commence.

Wind and seismic loads applied to the steel structures shall comply with ES Standards No. 02-000 - Site Conditions and No. 02-010 - General - Site Information.

All applicable load conditions and combinations shall be considered in the design, in compliance with the above listed codes and standards and local regulations. Stresses corresponding to each load combination shall be calculated according the adopted static scheme. Stability, buckling, deformation, vibrations and fatigue shall be verified as well for each load combination.

Deflection of members shall follow the limits specified in the above-mentioned Standards.
To prevent uncontrolled stress on structures due to temperature differentials, expansion joints shall be provided.
N.B. The column base plate bearing pressure on the grout shall be limited to between 7 N/mm2 and 8 N/mm2.

Longitudinal column bracing system of “K” type shall be used to the maximum possible extent in order to not interfere with the technological installations and operations.
It shall be the Contractor’s responsibility to obtain the necessary building design & drawing approval from the relevant Authorities.

b. COMPLIANCE WITH SPECIFICATION, STANDARDS AND REGULATIONS

All materials, drawings, procedures and instructions shall conform in all respects to the requirements of this Specification and with appropriate International Standards and with the regulations, manuals and specification of the local authorities.

c. DOCUMENTATION

ES Engineering Standard 09-010 – Engineering Documentation shall apply.

d. DESIGN CHANGES

Design changes shall be submitted to ES for approval and shall not be incorporated or proceeded with unless this approval has been obtained.

e. PLACES OF MANUFACTURE

The Contractor shall provide the names of manufacturers, places of manufacture, testing and inspection for major items of the steel structures. Subsequent to the issue of instructions to proceed the Contractor shall issue a detailed supplier/manufacturer list for approval by ES.

f. ENVIRONMENTAL IMPACTS

The Contractor is required to provide data for any environmental impact that will result from their Scope of Work.

g. SAFETY

The Contractor shall ensure that the steel structures including walkways and ladders etc. comply with the safety requirements in normal international usage and those specified in the ES Engineering Standard 14-010 - Site Regulations.

h. MEASUREMENT UNITS

The SI system of measurement shall be used.

5.6.2 MATERIALS

a. STEEL SECTIONS

All materials to be used in the construction shall be new.
Metric sections and section designation shall be used throughout.

The Contractor shall submit to ES for approval the specification and grade of steel proposed for the following: -

- Built up members
- Hot rolled members
- Cold formed sections
- Holding down bolts
- Connection bolts
- Checkered plates and/or gratings

Structural steel for built-up and hot rolled members shall have minimum yield strength of 235 MPa.

For heavy duty and high capacity EOT cranes, crane runway beams shall consist of single web built-up section with bearings and intermediate stiffeners. Crane runway girders can be designed as simply supported or continuous, but for spans longer than 18m they shall be preferably designed as simply supported.

The materials shall be in accordance with the approved Standards and mill test reports to certify the grade, quality and strength of the steel products used shall be submitted to ES.

b. ROOF AND WALL CLADDING

All roof and wall cladding shall be single skin at least 0.8mm thick and corrugated and be designed for a maintenance free life with no significant deterioration to finish/appearance for a minimum period of 10 years. Consideration shall be given to the harsh climate conditions and the highly corrosive atmosphere and the industrial environment of a steelworks site. Noncombustible materials shall be used throughout.

If insulated panels are required, the heat transfer coefficient K of the assembled panels shall be at least: -

- K <0.50 W/m2 °C for roof panels, and
- K <0.90 W/m2 °C for wall panels.

Samples of proposed materials shall be submitted for approval to ES and some evidence or satisfactory use shall be provided.

All roof and wall sheeting shall be supplied complete with all necessary flashing, trims and edges of the same material, thickness and finishing of the main sheeting. Where required, wall framing made of intermediate stanchions and girder shall be supplied.

c. ACCESSORIES

The Contractor shall supply the steel structural buildings complete with all applicable accessories, including but not limited to: -

- Gutters, downspouts and downpipes
- EOT crane rails and fasteners, crane stops, beams for monorail for maintenance hoists
- Gates, doors and windows
- Louvers and aerators
- Earthing and lightning protection systems.

The specification for all the accessories shall take into consideration the harsh climate conditions and the highly corrosive atmosphere and the industrial environment of a steelworks site.

Samples of proposed materials shall be submitted for approval to ES and some evidence of satisfactory use shall be provided.

Design of rainwater goods shall be based on the maximum rainfall according to the site conditions. Generally, all steel buildings shall have gutters, downspouts and downpipes except for minor ones where a rounded continuous link between roofs and side walls shall be provided if agreed by ES.

Rails for EOT cranes runways shall comply with the ES Engineering Standard 011 “Cranes & Hoists”.

Wherever practical and to the maximum possible extent, side and roof windows shall ensure the natural lighting of the buildings. Generally, windows shall consist of translucent sheets; material and thickness shall cope with the working conditions of a steel plant and shall be approved by ES.

All gates and doors shall be provided with heavy-duty accessories, with galvanised or painting finishing. Generally, sliding gates shall be considered; for dimensions larger than 4m x 4m gates shall be electrically operated, but in case of emergency they can be also manually operated. Personnel doors shall be provided with anti-panic opening devices.

Unless otherwise agreed with ES, main process buildings shall be provided with a natural ventilation system to keep the air temperature of walking areas (+1.5m above floor level) within +5oC above the outside temperature. The Contractor shall perform a tailored natural ventilation design for the concerned plant buildings. Local site conditions in terms of temperatures and wind velocity / directions shall be considered, as well as the internal heating sources (technological heat loads, radiation, lighting, etc.).

Where possible and compatible with the technological operations, air inlets shall consist of openings alongside and front walls, otherwise streamline fixed or adjustable (manually or electrically operated) louvers shall be provided.

Air outlets consist of fixed static roof aerators of type, shape and dimensions according to air flow, temperature differential and wind conditions calculated in the ventilation design. For minor buildings and where no specific technological requirements are foreseen, standard roof monitors may be supplied, provided ES approval.

5.6.3 PLATFORMS, WALKWAYS, LANDINGS, STAIRWAYS & LADDERS

a. MATERIALS AND WORKMANSHIP

Where steel pipe is used for guard rails, handrails or posts, it shall be of seamless, welded or drawn welded manufacture. Split pipe shall not be used.

Galvanized steel may be employed, provided the Contractor takes due care when welding such material, to minimize the damage to the internal and external galvanizing.

Any damage shall be made good by cold galvanizing, the application of a zinc-rich paint or equivalent protection approved by ES.

All un-galvanized material shall be protected by an ES approved painting system.
All ends of pipes shall be provided with metal end caps to prevent the ingress of moisture.

Locknuts shall be provided for fixing stair treads to stringer beams.

Bolts less than 12mm diameter shall not be used for attaching guard railing posts, supports or brackets to platforms, walkways or stairways, or for attaching ladders to the main supporting structure. If welding is employed for this purpose, it shall be continuous and in accordance with the ES Engineering Standard 040-070 – Welding.

b. PLATFORMS, WALKWAYS AND LANDINGS

Among the others, maintenance platforms for cranes and hoist shall be provided according the design.

Walkways may have a slope within the range of 0 degrees to 20 degrees, but if the slope exceeds 1 in 8 (7 degrees) metal grating shall be provided.

Unless otherwise approved, the clear width of platforms, walkways and landings shall be not less than 800mm and the vertical clearance above such structures shall be at least 2.00m.

Continuous guard railing shall be provided, except at points of access from a stairway or ladder or along permanent structures giving equal protection.

A toe-board shall be provided at the edge of a platform, walkway or landing where an object could fall more than 2.0m. The toe-board shall be firmly attached to the floor or posts, and any gap between the toe-board and the floor shall not exceed 10mm. The top of the toe-board shall be not less than 100mm above the top of the floor.

Where it is impracticable to provide fixed guard railing, hinged, sliding or removable guard railing shall be provided.

c. STAIRWAYS

Stairways shall be not less than 800mm wide between handrails. The angle of slope between the stiles and the horizontal shall be not less than 20 degrees nor more than 45 degrees.

Rises and treads shall conform to the following dimensions: -

- The height of each rise shall be between 150mm and 215mm.
- The width of each going shall be between 215mm and 305mm.
- The product of the rise and the going in millimeters shall be between 45,000 and 48,000.
- The actual tread shall be not less than the going and there should be a minimum overlap of 10mm.

The head clearance shall be not less than 2.0m measured vertically from the nosing of the tread.

Guard railing shall comply with the section above, although toe-boards shall be omitted on stairways.

Every stairway shall be provided with at least one handrail which shall have a smooth continuous surface through the length of each stairway flight. Where the width of the stairway exceeds 1.0m, a handrail shall be provided on each side.

A tubular handrail shall have at least 30mm diameter and shall have a hand clearance of not less than 60mm.

d. FIXED LADDERS

Where fixed ladder access is provided through a horizontal opening, the stiles or handrails shall, where possible, be extended 900mm above the opening. Handgrips above the level of the opening shall be provided in other cases.

e. STEP TYPE LADDERS

The angle of slope of step-type ladders shall be not less than 60 degrees nor more than 70 degrees to the horizontal.

In step-type ladder installations, the vertical distance between landings shall not exceed 6.0m. Where the vertical height of the installation exceeds 6.0m, the alternate ladders should change direction, or if this is not practicable, be staggered at each landing level.

Treads shall be at least 100mm wide and shall be spaced between 200mm and 250mm apart.

Handrails shall be as described previously and shall be provided on each side of the ladder. The clear space between the handrails shall be between 600mm and 750mm.

The bottom of the handrails shall commence at a point not more than 900mm above the floor or lower landing and shall extend above the upper landing to a height of not less than 900mm and be connected to the guard railing of the landing.

f. RUNG TYPE LADDERS

The angle of slope of step-type ladders shall be not less than 70 degrees to the horizontal and shall in no case overhang the person climbing the ladder.

The vertical distance between landings in a rung-type ladder installation shall not exceed 6.0m, except where the nature of the installation makes it impracticable to provide an intermediate landing.

A ladder cage shall be provided where a person could fall from a ladder more than 4.0m. The width of ladders shall be between 400mm and 550mm.

Stiles shall be secured with fastenings both at the top and at the foot of the ladder and shall be secured at intervals of not more than 3.5m.

Rungs shall be of round solid material and shall have a diameter of not less than 24mm. Where they enter or contact the stiles they shall be completely sealed. The rung spacing shall be uniform and between 250mm and 300mm.

Ladder cages shall comply with the following: -

- The cage shall extend not less than 900mm or to the height of the handrail, if provided, above the top of the platform landing, unless other adequate protection is provided and shall terminate not less than 2.0m above the base of the ladder.
- The bottom portion of the cage may be flared out.
- The rear half of the cage shall be approximately semicircular, and the sectional dimensions of the cage shall be so that an internal width of 700mm and a clearance of 750mm between the back of the cage and the front of the rungs is provided.

Individual rung ladders shall only be used where the vertical rise does not exceed 6.0m and it is not practicable to use any other type of ladder.

5.6.4 FABRICATION AND ERECTION REQUIREMENTS

a. FABRICATION

Workmanship for the fabrication and quality control for the steel structures shall be to the requirements of Section M of the A.I.S.C. — Specification for Structural Steel Buildings, and A.I.S.E. Technical Report No.13.

Material certification shall be provided to ES.

ES and/or its representatives shall have unrestricted access to the works where the steelwork is being fabricated to inspect the work.

ES and/or its representatives shall be empowered to reject any work which does not comply with the specification or with accepted good practice.

b. ERECTION

1. GENERAL

Erection of the steelwork shall be to the requirements of section M of A.I.S.C. and A.I.S.E. Technical Report No. 13.

a) STEEL WORK

A steel face which is to be in contact with concrete or other steelwork shall be cleaned to remove all loose mill scale, loose rust, oil, grease, dirt, globules of weld metal, weld slag and other foreign matter. Steel to steel surfaces shall be dry when contact is made. Steel to concrete interfaces shall be shop primed only.

Site welded connections shall be avoided wherever possible and are subject to ES's explicit approval.

Continuous plates shall be plug welded to intermediate support beams. Joints in floor plates shall occur only over supports.

Gas cutting shall not be permitted on site without the explicit approval of ES.

Anchoring bolts shall be provided with positioning templates and assembly levelling shims.

C-type girts, and channels shall be installed with the flanges pointing downwards to prevent the collection of dust and debris.

During the erection of a structure, the steelwork shall be made safe against erection stresses and loading conditions, including those due to erection equipment and its operation and wind. Permanent connections shall not be made in those parts of a structure that will be stiffened thereby until the correct alignment has been obtained.

After erection of all or part of a structure, the Contractor shall demonstrate that the relevant tolerance limits have been adhered to. To this end, periodical alignment protocols shall be provided which require the approval of ES.

b) BOLT ASSEMBLY AND TENSIONING

Each bolt and nut shall be assembled with at least one washer. Where the angle between the axis of the bolt and the joint surface is more than 3 degrees off normal, a tapered washer shall be used against the tapered surface. Packing shall be provided wherever necessary to ensure that the load-transmitting plies

are in effective contact when the joint is tightened to the 'snug-tight' position as defined below. All packing shall be steel with a surface condition like that of the adjacent plies.

Snug-tightening and final tensioning of the bolts shall proceed from the stiffest part of the joint towards the free edges. Final tensioning shall not commence until all bolts in the joint are snug-tight in their correct sequence.
The re-tensioning of bolts which have been fully tensioned shall be avoided. If re-tensioning must be carried out it shall only be permitted once and only where the bolt remains in the same hole in which it was originally tensioned and with the same grip.

Under no circumstances shall bolts which have been fully tensioned be re-used in another hole.

Unless otherwise agreed with ES, the tensioning of bolts and nuts shall be by the part-turn method in accordance with the following procedure:

- On assembly, all bolts and nuts in the joint shall be first tightened to a 'snug-tight' condition to ensure that the load-transmitting plies are brought into effective contact. 'Snug-tight' is defined as the tightness attained by a few impacts of an impact wrench or by the full effort of a man using an ordinary spud wrench.
- After completing this preliminary tightening to 'snug-tight', location marks shall be established to mark the relative position of bolt and nut and to control the final nut rotation specified in the agreed Standards. The location marks shall be permanent to allow inspection by ES.
- During the final tensioning, the component not turned by the wrench shall not rotate.

If required by ES, the Contractor shall arrange bolt tensioning inspections, both at the 'snug-tight' stage and when bolts are fully tensioned. Up to 10% of all bolts in one connection shall be tested, but no less than two bolts. The Contractor shall supply inspection wrenches and all other tools required for this purpose.

No cranes or other mechanical equipment shall be operated unless the bolt tensioning has been approved by ES. Appropriate Quality Control forms shall be provided by the Contractor and the said forms shall form part of the final documentation.

The holding down bolts for all the main columns shall be positioned using a steel template. Groups of bolts shall be set so that the centerlines of the group at the level of the underside of the baseplate shall not deviate from the true centerline by ±3 mm in any direction. Similarly, bolts set by steel template shall be within ±2 mm of their theoretically correct position. No bolt shall deviate from the vertical by more than 1 in 1000.

2. ROOF AND WALL SHEETING

Sheeted roofing shall have a pitch of not less than 1:10 (5.71 Degrees).

All roof and wall panels shall be roll formed to required lengths to minimize the requirement for end laps.

The panels shall have a longitudinal overlap of not less than 200mm and sealing strips shall be provided at all end laps. Laterally, roof sheeting shall be overlapped by two full high ribs to provide a double siphon break and make the use of a side lap mastic.

Side laps shall be secured by stitch screws midway between supporting members at the crown of the rib.

All hardware items (screws, nuts, bolts etc.) shall be made from stainless steel; neoprene gaskets, fit for the design temperatures, shall be provided.

Roof sheeting shall be fixed to the purlins at the crown of the ribs.

Wall cladding shall be fixed to the girts at the valley of the ribs.

The cutting of sheets shall be avoided, but if necessary, only hacksaws shall be used.

5.6.5 PAINTING AND PROTECTION

All fabrications shall be prepared and painted before delivery to site in accordance with ES Engineering Standards 08-010 and 08-020. The Contractor shall prepare a specification for painting and protection for approval by ES prior to implementation. The specification shall take account of the harsh climate conditions, the highly corrosive atmosphere, and the industrial environment of a steelwork site.
Roof purlins, wall girts, staircases, ladders and handrails may be hot dip galvanized, as an alternative to the painting finishing.

All bolts shall be painted, galvanized or otherwise protected.

Site paint touch-up shall be performed by the Contractor. Colour scheme shall be agreed with ES.

5.6.6 QUALITY ASSURANCE

Refer to ES Engineering Standard 3-010 - Quality Assurance - Procurement.

5.7 MASONRY WORKS

5.7.1 GENERAL

All masonry works will consist of concrete hollow block with maximum 50% of hollow (or equivalent) and reinforced with steel bars if required, elevated so as not to be in contact with the ground for at least a height of 300 mm.

Masonry walls shall not be considered as load bearing structures. All masonry walls shall be designed according to the agreed Standards

5.7.2 BLOCKS

Blocks shall be hollow concrete blocks procured from the approved manufacturer/supplier and the types and dimensions shall be as indicated on the construction drawings. Tolerance in the given total dimensions (length or width or height) shall not exceed +/-3mm at any point.

Concrete blocks shall be made with natural aggregates and ordinary Portland cement. Blocks in contact with the ground shall be coated with two coats of bituminous painting.

The compressive strength of the concrete blocks shall not be less than 7 N/mm2.
External masonry walls of air-conditioned buildings shall have a coefficient of heat transfer K not greater than 0.90 W/m2Co.

5.7.3 MORTAR

Cement and sand mortar (1:3) composed of one part of cement (cement conforming to ASTM – Type II) to three parts of sand by volume shall be used in block work.

Sand for mortar shall be clean, sharp, well screened building sand and shall be free from impurities of any kind. Sands shall be stored separately according to type.

If the Contractor wishes to use any plasticizers in the mortar, he shall submit full details of them to ES for approval.

The method of gauging materials for mortar and the type of mechanical mixer used shall be subject to ESI approval. No mortar shall be deposited on the ground and mortar which has partially set shall not be revived or reused.

5.7.4 WALL TIES

All block walls shall be bonded to adjacent reinforced concrete structures by means of approved stainless-steel ties (minimum 200 mm long) at every third course on to the mortar as per manufacturer recommendations.

5.7.5 EXECUTION

All blocks shall be well soaked before being used and tops of walls left off wetted before work is restarted. All blocks shall be well buttered with the appropriate mortar before being laid and all hoists shall be thoroughly flushed up as the work proceeds. All joints shall be uniform and shall not exceed 12 mm. The block work shall be carried out in a uniform manner, not any portion being raised more than 1000 mm at one time. Where appropriate, movement joints shall be provided to prevent thermal cracking. This joint shall be sealed with an approved sealant.

All block walls and partitions shall be properly cured by keeping them shaded and protected from drying winds and sprinkling sweet water for a period of not less than four (4) days after completion of laying the course. All facing work is to be kept perfectly clean and free from mortar splashes at all times.

The surface of walls and partitions which must receive rendering, shall have the joints raked out 15 mm from the face of the wall to form key for the plaster and for the others the joint is finished flush. Any wall or partition necessarily left at differed levels shall be

raked back. All perpends, internal and external angles etc. shall be strictly true and square.

Partitions shall be bonded to the main walls by toothing every third course into the main walls to a depth of not less than 100 mm. On both vertical sides of door or window openings and over a minimum of half a block width, the block cavities shall be filled with concrete or stiffener columns or provided, or works are carried out as per the project construction drawings. The block wall shall not be packed up to the soffit of the beam or slab, approved joint filler 10mm thick shall be used as a compressible filler between the block wall & soffit of beam or slab.

All fire stopping where cables and pipes pass through internal holes or trenches in block work shall be the responsibility of the Contractor. The system offered shall be approved by ES and shall be installed in accordance with the manufacturer's instructions.

5.7.6 RENDERING

Masonry wall panels exposed to the open shall either be plastered or painted, whilst on the inside the finishing works shall be appropriate to the final building function. Sealing joints and damp-proof membranes shall be provided where necessary.

Where rendering is to be applied, the render shall consist of two coats of cement/sand mortar in proportions to be agreed and according to the type of blocks used. The first coat shall include an approved waterproofing additive and shall be allowed to dry before the application of the final coat. The rapid drying of either coat shall be prevented by shading, spraying and protection from drying winds. Where rendering is to be applied, the joints shall be raked back 10 mm.

5.8 ROADS AND TRAFFIC LOADS

5.8.1 GENERAL

In general terms, concrete roads shall be provided in the vicinity of furnaces and other plant areas where hot product is manufactured or processed and in areas where heavy vehicles remain stationary for long periods of time, i.e. material loading and dispatching bays and the like.

Elsewhere, heavy duty asphaltic concrete roads shall be provided, all asphalted roads shall have a kerbstone, which will be either full height or level with the asphalt depending on the location or application.

Where appropriate, hard stands comprising interlocking bricks or concrete blocks may be installed, if so, approved by ES.

All roads shall generally comply local legislation and regulations for two-lane local roads but must be set out to suit ES's unusually large plant vehicles.

The construction of the road subbase, base course and wearing surface shall take due account of the abnormal axle loads encountered within ES and shall be built to minimize road maintenance works.
In addition to the above, the design of the roads shall also include the combined effects of expansion and contraction due to moisture and temperature changes, the weather, foundation friction and fatigue.

The Contractor shall submit his road design proposals for approval to ES.
The installation and compaction of the subbase shall be as per the agreed Standards, but Standard Proctor density values below 100 % according to ASTM D-698 test (field density test as per ASTM D-1556 standard or equivalent according to the backfilling material properties) will not be accepted.

The Contractor shall bear the cost for all tests in conjunction with road construction and shall carry out such tests as and when instructed by ES.

5.8.2 ROAD LAYOUT WITHIN ESI

As a guide, the roads within ES shall be set out as follows: -

- 12.0m wide roads installed in areas of heavy plant movement, i.e. in scrap basket car movement areas.
- Main roads and thoroughfares are 8.0m wide and generally have a road centerline horizontal radius of 20.0m. In exceptional circumstances, the latter may be reduced to 15.0m.
- Minor roads are 6.0m wide and have a road centerline horizontal radius of no less than 10.0m.
- For drainage purposes all road cross-sections are crowned and sloped at 2%.
- Road shoulders, constructed, where possible, on both sides of external roads, are 1.5m wide and are sloped at 5 %. Adjacent to these shoulders a shallow drainage trench of 1.0m width has been provided.

Depending on the road function, the following layers shall be installed: -

Road Type And Purpose	Sand Sub-Base Mm	Marl Base Mm	Asphalt Base Course Mm	Asphalt Wearing Course mm
Extra Heavy Duty 50 t Axle Load	300	350	250	80
Truck Traffic 20 t Axle Load	300	250	120	50
Normal Roads for Car Traffic	300	250	100	50
Side Walks	-	250	60	25
Marl Roads	-	250		

5.8.3 VEHICLE CONFIGURATIONS AND LOADS

As a guide, the heavy plant vehicles currently employed at ES are as follows: -

- Front Loaders
- Scrap Bucket Carriers

5.8.4 PROTECTION BARRIERS AND SIGNS

The Contractor shall supply and install impact protection barriers wherever appropriate and as required by ES. These shall consist of either: -

- permanent single or multiple interconnected concrete filled and safety painted steel tubes, approximately 1.0m high and cast and embedded in the ground, or
- movable U-shaped precast reinforced concrete elements, approximately 1.0m high and equipped with lifting lugs.

An official system of road traffic signs and carriage way markings will be provided, in accordance with local legislation and regulations and ES's requirements.

5.8.5 WALKWAYS AND ROAD CROSSINGS

As required by ES's, the Contractor shall provide walkways and road crossings for the safe passage of pedestrian traffic.

These walkways shall be separated from production equipment, storage bays equipped with overhead travelling cranes and other hazardous areas by hand railing or fencing or any other means agreed with ES.

Road crossings shall be marked with luminous paint in black and yellow stripes.

5.8.6 ROAD AND YARD LIGHTING

The Contractor shall supply and install the road and yard lighting system, including the electrical equipment (lamps, cables, post) and the relevant civil works.

Lighting poles foundations, electric manholes (where applicable) in reinforced concrete construction and cable routings made of underground PVC (or equivalent) pipes are to be provided by the Contractor. All relevant works such excavation, sand layer and backfilling shall be included.

5.9 STRUCTURES, BUILDINGS & INSTALLATIONS

5.9.1 STRUCTURES, BUILDINGS, ROOMS AND INSTALLATIONS

The following Section is intended to provide some information regarding typical installations existing, proven and accepted by ES. The information supplied is neither comprehensive nor does it cover all civil and structural features present at a Steelworks site.

However, many of the items have been included because they have in the past been executed poorly or not at all and have, in some cases, caused some considerable and unnecessary problems with everyday production and maintenance at the Steelworks site.

The information given shall, however, not be interpreted to prevent the use of materials and methods of design and construction not specifically referred to hereunder. The Contractor should feel free and is encouraged to propose alternative methods and procedures to ES for consideration and approval.

5.9.2 STRUCTURES

5.9.3 STRUCTURES FOR TRANSFORMERS IN THE OPEN

The design, construction and detailing of Transformer Stations in the open shall be carried out in accordance with the guidelines published by the German Working Association for Industrial Constructions, AGI, Work Sheet J 21 (or agreed equivalent).

5.9.4 BUILDINGS

a. GENERAL BUILDING FEATURES

All finishes to floors and walls shall be designed and constructed suitable for the function and usage of the area concerned. Where appropriate, non-slip, dust free, oil, acid or abrasion resistant surfaces shall be provided.

For buildings that can be safely accessed by people with mobility disabilities, then the buildings should be designed such that they can be accessed by and have suitable facilities to cater for those with mobility disabilities.

Where applicable, floating floors shall be provided as specified in the drawings to allow the routing of electrical, control and data/signals cables to the various units inside electrical rooms, control rooms, offices and other service rooms. The floating floor panels and their supporting arrangements will be adequate for all probable loads expected. Fixing arrangements of the selected typology of panels shall be simple to facilitate easy removal and replacement of panels in case of maintenance. Unless otherwise specified, top of floating floor panels shall be PVC finished of appropriate thickness. Suspended ceiling shall be provided as specified in the drawings as well.

In all cases, finishes shall be to the requirements of ES.

Where necessary due to Air Conditioning installation, operational and technological requirements, the buildings shall be provided with adequate thermal and acoustic insulation.

Standard types of doors and windows shall be used to the maximum possible extent. Doors and windows shall be of approved make and type. Unless agreed otherwise, windows shall be double glazed in aluminium frames. Sun shields or internal retractable louvres shall be provided where appropriate. Tinted glass shall be considered where glare might be a problem. Wire reinforced glass shall be used if required by the applicable Fire Regulations or as instructed by ES.

In specific locations, where liquid steel is foreseen (e.g. EAF, LF and CCM areas), control rooms shall be provided with special glazing to comply with mechanical high resistance, thermal shock resistance, heat insulation and sound proofing requirements. The glass will guarantee a noise proofing of +/- 60 dB(A) and a maximum global heat transmission coefficient K <= 2.1 W / m2 °C.

Doors and door frames shall generally be of double skin pressed steel with a lightweight core. Locks, fitted with a master key system in accordance with the requirements of ES's Industrial Safety and Security Department, shall be installed throughout and at the Contractor’s expense.

Emergency exits, fitted with illuminated emergency exit signs, shall be provided where needed. Emergency exit doors shall be fitted with a panic bar or other approved means of escape.

Ventilation louvers shall be of a type designed to prevent the ingress of dust.

Where appropriate, provision shall be made for alternative means of escape from all areas in case of fire or explosion.

Potable water system, hot water system for sanitary services, sanitary fixtures, plumbing and relevant manholes, rain and sewerage discharging system, embedded electric cable conduits for lighting and power sockets, embedded electric junction boxes, embedded electric switch boxes and the like referred to civil construction buildings will be provided by the Contractor as part of his scope of work.

Unless otherwise agreed with ESI, GRP/PVC pipeline and concrete or GRP manholes shall be provided for the drainage and sewerage system inside the buildings according to the discharge flows as per applicable Standards. Hydraulic water distribution shall be provided by PVC pipes for cold water and by copper pipes for hot water.

The colour schemes to be used for finishing of different units of the buildings will be agreed with ES and in accordance with ES Engineering Standard 080 – “Painting”

b. SUBSTATIONS

1. GENERAL

Substation buildings shall be planned, designed and constructed considering all the following:

- The layout of all rooms shall be such that the equipment to be housed can be installed and operated in accordance with the relevant International Standards and Local Regulations and Guidelines.
- All rooms shall be fully protected against the ingress of ground and flood waters.
- All equipment shall be easily exchangeable and appropriate transport routes and facilities shall be provided.
- All rooms shall be equipped with a fully automatic firefighting system where flammable equipment is present.

All substation walls, ceilings and floors shall remain dry at all times. Piping systems carrying liquids, steam or flammable gas shall not be installed either below or above switch rooms. If this is unavoidable, the Contractor shall obtain ESI's explicit approval to proceed in this way and take appropriate measures to protect the structure and the equipment within.

The rooms for switch, control and automation equipment are to be separated into High Voltage Rooms, Converter Rooms, Low Voltage Rooms, PLC-rooms, Control Rooms, etc.

All individual substation storeys and operational areas must be separated and isolated from each other so that fires cannot spread from one area or storey to another.

Special measures must be adopted regarding the reinforced concrete construction of Reactor Rooms, ensuring that the magnetic flow through the reinforcement steel is completely eliminated. Although the dimensions of the various rooms are dependent on the type, size, arrangement and operation of the equipment required, the Contractor shall use the provisions in DIN VDE 0101 to ascertain the minimum safe distances and gangway widths. As a guide, an escape corridor of at least 750 mm width shall always be maintained, even when the equipment doors on either side of opposing cupboards are simultaneously and fully (90°) open.

All Computer Rooms, Offices and other areas occupied by personnel shall be appropriately sound proofed.

All Switch- and Control Rooms are to be equipped with adequate Cable Rooms.

These Cable Rooms shall be so dimensioned that, after all air-conditioning, fire-fighting and other equipment (Battery Rooms and the like) has been installed, the required size of the Cable Rooms is not diminished.

The Cable Rooms are to be partitioned into appropriate sealed firefighting zones and are to be equipped with a drainage system if firefighting liquids are to be utilized.

Substation exits are to be arranged so that the escape path from any area within the Substation does not exceed 40 m in length. Substations more than 7 m long must have at least two exits, one of which may be an emergency exit. The Contractor shall ensure that the exit paths and emergency exits are clearly marked. All emergency exit doors shall open outwards and be equipped with panic locks.

The internal surfaces of the Substation walls shall be smooth and flat. Sills and other surfaces where dust can accumulate shall be avoided wherever possible. Unless otherwise specified by ESI, walls and ceilings shall be finished with water emulsion painting.

Floors shall be constructed so that they can be easily cleaned. They shall be hard, have a non-slip surface and shall be abrasion resistant. Due consideration shall be given to the highly concentrated local pressures which occur when heavy equipment is moved in and out of the Substation.

Substation windows shall be secured against unauthorized entry by providing one of the following:

- barred windows
- windows whose underside is at least 1.8 m above the external ground, or
- a fence around the Substation of at least 1.8 m height.

All switch room doors shall open outwards and be a minimum of one hour fireproof.

2. VENTILATION AND AIR CONDITIONING

The ventilation and air-conditioning of all substation rooms must be designed so that condensation cannot occur. Unless specifically agreed to the contrary with ES, the Contractor shall adhere to the DIN VDE 0101 Recommendations regarding this matter. As a guide, the minimum standard shall be: -

- a maximum relative humidity of below 70%, and
- a highest and lowest room temperature, expressed as a 24-hour mean, of below +35°C and above +10°C respectively.

In order to minimize air pollution and dust contamination, all substation rooms are to be equipped with air filters and shall be adequately pressurized. The air vents necessary for this purpose shall be secured against rain, splashing water, rodents

and other small animals. For openings less than 2.50 m above ground, some special protection against malicious damage shall be provided.

3. EHV STATIONS

EHV Stations shall be equipped with a maintenance bay and a crane installation, both appropriate for the size and weight of the heaviest equipment component installed. The stations shall be Air-Conditioned (including filters) and pressurized.

4. PRESSURE RELIEF

Short circuits in the electrical equipment may produce considerable switch-room over-pressure. In order to minimize the damage caused by such events, the Contractor shall install suitable pressure relief openings which fulfil the following criteria: -

- they shall be normally closed and safe against the entry of dust, rain, splashing water, rodents and other small animals,
- they shall self-activate at an over pressure of below 10 mbar, and
- they shall be installed in an area which is normally free of personnel.

The Contractor shall ensure that during the pressure relief operation all installed parts remain in place and are not dislodged.

5. CABLE INSTALLATIONS

Within substations, cables shall be in fully serviceable cable cellars. Pipes and covered cable channels shall only be used if explicitly approved by ES.

Pipes shall only be used for the installation of single cables. They are to be installed straight and sloping, so that water cannot accumulate inside. The Contractor shall ensure that the appropriate bending radii of the cables are fully complied with.

If agreed with ESI, covered cable tunnels may be used for the installation of multiple cables. The width and depth of each tunnel shall depend on the number of cables housed and the tunnels shall be equipped with a fire alarm system capable of reporting the location of the fire. The tunnel covers shall be fire resistant, non-slip, rattle-free, flush with the surrounding surface and strong enough to accommodate all possible transport and equipment loadings. The tunnels shall be positioned and constructed in such a way that they allow personnel to work safely inside without requiring the disconnection of the power supply.

Cable tunnels shall be fitted with fire barriers incorporating personnel doors at a maximum spacing of 50m.

Normally, serviceable cable cellars shall be installed. Considering the lighting and ceiling-suspended cable trays, the free room height shall be no less than 2.10 m from the cellar floor to the cellar roof or roof beams.

The cables may be installed in cable trays or on appropriate and approved wall and slab fixings.

The Contractor shall ensure the provision of exit paths and clearly marked emergency exits. All doors shall open outwards, be airtight and one-hour fireproof and shall be equipped with panic locks.

5.9.5 ROOMS

a. BATTERY ROOMS

The design, construction and detailing of Battery Rooms shall be carried out in accordance with the guidelines published by the German Working Association for Industrial Constructions, AGI, Work Sheet J 31. Unless specifically agreed otherwise with ES, battery room floors and walls up to +2m level shall be provided with an adequate anti-acid coating.

b. TRANSFORMER ROOMS

The design, construction and detailing of Transformer Rooms shall be carried out in accordance with the guidelines published by the German Working Association for Industrial Constructions, AGI, Work Sheet J 11. Unless specifically agreed otherwise with ES, transformer room floors and walls up to +2m level shall be provided with an adequate anti-oil protection.

c. SWITCH ROOMS

The design, construction and detailing of Switch Rooms shall be carried out in accordance with the guidelines published by the German Working Association for Industrial Constructions, AGI, Work Sheet J 12.

d. A/C ROOMS

Where Air Conditioning equipment is accommodated in purpose-built rooms, the equipment located therein shall be so placed as to provide sufficient space to carry out all regular service and maintenance tasks. Provisions shall also be made to allow the

removal and/or replacement of individual components and complete A/C units if required.

Unless otherwise specified by ES, walls and ceilings shall be finished with water emulsion painting.

e. OIL AND HYDRAULIC CELLARS

Unless specifically agreed otherwise with ES, oil and hydraulic cellar floors and walls up to +2m level shall be provided with an adequate anti-oil protection.

f. OFFICES, SERVICE ROOMS, CORRIDORS AND STAIRCASES

Unless specifically agreed otherwise with ES, office and service room floors shall be rendered with a vinyl coating or floating floors shall be installed. Walls and ceilings shall be finished with water emulsion painting.

g. WASHROOMS AND TOILETS

Unless specifically agreed otherwise with ES, washroom and toilet floors and walls up to +2m level shall be lined with ceramic tiles. Ceilings shall be finished with water emulsion painting. All sanitary fixtures and fittings shall be provided.

5.9.6 INSTALLATIONS

a. REVERSED ROOFS

Unless otherwise agreed, all reinforced concrete roofs shall be fitted with a proven 'Reversed' roofing system consisting, from the top down, at least of the following: -

- a 100 mm thick gravel layer
- a water penetrable woven separation layer
- a polystyrene or equivalent thermal insulation layer
- a polyester or equivalent protective sliding layer
- a waterproofing membrane, at least 4 mm thick
- the reinforced concrete roof, either sloping or level with a sloping screed.

Aluminum counter flashing and acrylic sealing shall be provided as required. Any mechanical equipment installed on the roof shall be located on appropriate concrete pedestals. If required, a walkway and/or hardstand shall be provided to service such equipment. Guard railing shall be provided if the equipment is located near the edge of the roof.

The roof shall be properly drained, have a parapet wall all around and shall be accessible.

b. GUTTERS AND DOWNPIPES

The roof drainage system shall be designed to cope with the heavy rainstorms often encountered in this area during the winter months. The rainfall intensity shall be taken from Standard 02-000 – Site Conditions.

Gutters and downpipes shall be galvanized.

Gutters subject to ponding are not acceptable and the gutter shall be installed in a manner that prevents the accumulation of standing water.

At ground level, all downpipes shall be provided with a PVC flushing facility if they are connected to an underground sewer system.

c. MANHOLES

Manholes are to be constructed in accordance with the approved Standards, except that the following shall be observed: -

- Manholes inside roads shall have heavy duty covers capable of withstanding the anticipated traffic loads.
- Off-road manhole covers shall have a hinged chequer plate cover which fits over a raised steel frame and shall have retracting handles.
- Side walls raised above the ground shall be painted with black and yellow striped warning paint.
- For easy access, ladders shall be provided.

d. UNDERGROUND CABLING AND DUCTING

The pipe or cable route shall be marked out by the Contractor according to the installation plans and shall be approved by ES prior to commencing any work.

Unless agreed otherwise, the pipe or cable trench shall be excavated to a depth of 1.50m.

1. MULTI-WAY DUCT BANKS

PVC pipes shall be used for all ducting. Prior to placing the ducts, the trench floor shall be smooth and suitably compacted. The ducts shall be correctly and firmly positioned, and spacers shall be used if multiple ducts are placed.

All duct banks shall be straight and sloping to prevent the accumulation of water inside the pipes.

Joints shall be smooth and without internal protrusions. Externally, they shall be taped and sealed with mortar.

After positioning the pipes and shuttering the trench walls as necessary, the trench shall be filled with lean mix concrete to the level required, which shall be at least 300 mm above the top layer of the pipes.

Under roads and other heavily loaded areas the ducts shall be bedded on a 100 mm thick lean concrete layer. The concrete capping shall be reinforced.
At road crossings, the ducts shall project at least 500 mm into the unendangered area. Pull wires with a diameter of 3 mm shall be drawn through the cable ducts.

Manholes shall be installed wherever the ducting changes direction and, if straight, at least every 120 m. The manholes shall be constructed as described in Section 5.3 above but shall be provided with a concrete cover slab which fits flush into the top of the pit and has an opening as described in Section 5.3. All joints shall be sealed and watertight. At the bottom of the manhole a sump to collect seepage water shall be provided.

At each manhole, and unless instructed to the contrary, the cable bending radius shall be at least 15 times the outer diameter of the largest cable.
All spare cable ducts shall be tightly sealed at the ends.
Pipes and multi-way cable ducts in buildings used for routing cables from inside the building to ducts laid outside in the ground shall be bedded into the external wall and slope towards the outside. The ends of all cable ducts inside a building, whether in use or spare, shall be sealed using an approved waterproof and fireproof sealant. Concrete shall not be used for this purpose. In addition, internal openings in partition walls through which cables pass shall also be sealed with fireproof sealant.

2. DIRECTLY BURIED CABLES

The trenches for such cables shall be firm and smooth and free from stones, roots, sharp objects and any other matter likely to damage the cables. The depth of the cable trench shall be such that the topmost cable is at least 1.0 m below ground

level. Lesser depths require ES's explicit approval and these exceptions shall be noted in the 'as built' cable installation drawings.

Prior to laying the cables, a 100 mm thick sifted layer of fine sand shall be placed continuously over the whole width of the trench. After laying the cables, a further 50 mm thick layer of the same sand shall be placed similarly over the top of the uppermost cable. 50 mm thick Red coloured concrete slabs, sized in accordance with the number of cables buried, shall be placed on the topmost sand layer along the entire length of the cable installation. Next, the protective concrete elements shall be covered with a 50 mm thick stone free layer of sand, followed by the previously excavated material. The final fill shall be machine compacted to the standards required for the surface finish.

3. IDENTIFICATION OF CABLE ROUTES

Cable routes shall be permanently marked at all changes of direction and at maximum distances of 100m. Markers shall comprise concrete blocks projecting above the local ground level indented with the words ‘ELECTRIC CABLE’

6. SUPPORTING DOCUMENTS

7. REVISION HISTORY

Issue No.	Date	Page/s	Cause of Revision
0	17.11.2019	All	First Issue