STANDARD DESIGN CRITERIA (StDC)

CIVIL AND STRUCTURAL WORKS

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HOLCIM

Change Index

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TABLE OF CONTENT

HEALTH & SAFETY

Health and Safety is our core value. At Holcim, we want to do more than prevent accidents. We want to create a healthy and safe environment for our employees, contractors, communities and customers based on a true safety culture.

Health and Safety is at the center of everything we do, from the daily routines in our plants to our customers' project worksites and our actions in our neighboring communities. Our aspiration is to conduct our business with zero harm to people. We believe in visible leadership and personal accountability for Health and Safety at all levels and throughout our organization.

To reach this aspiration, we are committed to:

- Maintain a global Health and Safety Management System designed to continuously improve our performance and actively manage risk in our business
- Drive for operational discipline by instilling a mindset of safe execution and follow-up
- Communicate openly with all stakeholders on relevant health and safety issues

INTRODUCTION

Objectives of the Standard Design Criteria (StDC)

- Provide standard technical specifications to the Holcim community that is based on proven technologies and practical experiences from constructing, maintaining and operating plants.
- Achieve an optimized balance between high Overall Equipment Efficiency (OEE) and Mean Time Between Failures (MTBF) during the expected lifetime of the assets considering the lowest possible CAPEX.
- Ensure transparency and consistency among Supplier's offers to Holcim projects.

Application and General instructions

- The Standard Design Criteria (StDC) covers all engineering projects including Cement and Geocycle.
- The StDC is a reference guideline for designing new plants in Greenfield, Brownfield replacement and revamping projects. This document is also equally applicable and relevant for quarry & plant operation and maintenance teams for achieving efficient operation & maintenance which will ultimately improve the overall plant performance.
- All statements and paragraphs marked with  are design provisions for safe construction, operation and maintenance of the plant. Deviations and exceptions are not allowed.
- For non-safety related design variations, justification of the alternative must be properly recorded.
- The Basic Requirements document contains general specifications applicable for Mechanical, Electrical and Civil design.
- The Mechanical Equipment, Electrical Equipment and Systems, and Civil and Structural Works documents shall be used in conjunction with the Basic Requirements section.
- Specifications for Mechanical, Electrical and Civil components of the projects shall be reflected in the Data Sheets (where available). They are intended to standardize the way Suppliers present specifications to Holcim.
- The Standard Design Criteria lists certain codes and standards. In the event that any such specified codes and standards are inconsistent with any codes or standards enforced by law, the most stringent standard shall govern the Contractor's performance as far as not in conflict with local regulatory obligations.

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1. GENERAL

The following Design Criteria shall apply to Civil and Structural Design for Cement and Geocycle projects.

The given Design Criteria identify minimum civil and structural requirements.

All civil and structural buildings shall use State of the Art Design.

The structures shall suit all local climatic and operating conditions at the site.

Civil and structural design shall consider efficient and safe construction with optimized number of construction workers and equipment on site.

1.1 Health & Safety

The Holcim HSE standards as well as applicable local regulations must be complied with and taken into account while developing Civil Design of a new project or installation in order to eliminate and/or minimize the hazards inherent to the construction, operation and maintenance of the mentioned installation.

Fiber containing construction materials such as asbestos are not permitted.

1.2 Responsibility for Civil Engineering Design

The entire Civil Engineering Design (including Structural Steel Design) for buildings, structures, facilities and infrastructures shall be fully coordinated with the respective Mechanical and Electrical Process Equipment Design and shall include all interconnection with and to existing civil structures and infrastructures.

The Contractor shall provide everything required for the proper Civil Engineering Design of the Works as defined in the Contract, notwithstanding any omission or interference of Limits from the Owner's Specifications.

The Contractor is entirely responsible for the satisfaction of the General Design Criteria and for the adequate provision of safety factors to address all conditions of structural loadings.

1.3 Applicable Standards and Requirements

The applicable standards for Civil Engineering Design (including structural steel design) and materials shall be defined and agreed upon. After that, changes of design and material standards shall be formally requested in writing and the approval will remain pending and conditional to the review and formal approval by the Owner.

In addition to the most recent applicable local Civil Engineering Design standards and Codes, the latest Eurocodes EN 1990 – EN 1999 shall be fulfilled. Other international standards might be accepted but are subject to prior approval by the Owner's Representative/Owner.

The requirements as special loading, peak values for temperature, earthquake, wind, temporary strain, soil conditions (temporary construction loads need to be coordinated with the construction), shall be provided in accordance with the local conditions and the design of the pertaining Equipment. Sufficient allowance shall be made to avoid the influence of settlements (absolute and differential) on sensitive Equipment, plant operation, structures and neighboring buildings.

Allowance shall be made for eccentricity of loading in the dynamic condition, for all possible combinations of distributing material under normal operating conditions, for accumulation of material or by accident or breakdown, for vibration, impact, thermal movements and for all important environmental characteristics, such as dust precipitation and related load increase.

The dimensions of all buildings, structures and infrastructures shall provide sufficient space for operation, maintenance and safe removal of machine components as defined on drawings.

Fire resistance of structures shall fulfill Eurocode EN 1991-1-2 for actions on structures, EN 1992-1-2 for concrete and EN 1993-1-2 for steel structures and all locally required standards.

Drawings, calculations and diagrams covering all aspects of the civil design and structural steel works shall be provided as required by the Conditions of the Contract.

The StDC set forth herein have been prepared for use in the design of all structures and infrastructures. The purpose of this Specification is to facilitate the work of the designer, to provide consistency of the design and to avoid any aspect of the Design Criteria is overlooked. In addition, any relevant regulations, applicable standards and approval procedures of the competent Local Authorities have to be applied. All workmanship shall be executed in accordance with recognized good practice and in accordance with the appropriate and actual codes of practice that are applicable to the particular category of work.

2. DESIGN LOADS

The following loads shall be used as minimum loads and they have been categorized as follows: Dead Loads, Live Loads, Environmental Loads and Extraordinary Loads. The given loads are characteristic values, not yet multiplied with load factors.

2.1 Dead Load

Consist on the weight of all construction materials incorporated into the building and fixed machinery and equipment.

Weight of materials:

a)	Concrete self-weight	25.0 kN/m³
b)	Structural Steel self-weight	78.5 kN/m³
c)	Utilities	According to requirements

2.2 Dust Load

These loads shall be considered on all the structures due to the potential accumulation of dust and can be considered as temporary or permanent load.

a)	Dust Load	1.0 kN/m2
b)	Dust Load on roofs inclined > 30°	0.5 kN/m2

2.2.1 Dust Load inside Ducts

Dust Load inside Ducts for the design of structural supports:

a)	Slopes less than 15°:	min. 50% of cross sectional area. In case of risk of >50% duct filling due to operational condition, higher design limits to be applied.
b)	Slopes greater than 15° but less than 45°:	min. 25% of cross-sectional area
c)	Slopes greater than 45°:	min. 5% interior area of duct filled with dust, or 50 mm thick dust caking on inside perimeter, whichever is greater

2.3 Live Load

2.3.1 Roof Live Load

The roofs are categorized by their occupancy as accessible and not accessible.

a) Roofs accessible with occupancy:
- Distributed Load (horizontally projected) 1.5 kN/m2
- Concentrated Load 1.5 kN

b) Roofs not accessible except for extraordinary maintenance and repair:

c) Distributed Load (horizontally projected) 0.5 kN/m2

d) Concentrated Load 1.5 kN

e) Roofs hanging cable trays, conduits, etc. 5.0 kN/m2

f) If the design load exceeds the above value, then the effective load shall be considered.

g) Equipment load data of Solar panels as per supplier specification.
Dust load can be reduced accordingly as per Owner's approval but shall not be less than 0.5 kN/m2.

2.3.2 Floor Live Load

Floor live loads shall consider maintenance and loading zones for equipment lifting in addition to Equipment loads and shall not be reduced for large floor areas.

Minimum floor loads other than listed below shall be in accordance with the standards and local codes.

The minimum loads to be considered are:

a) Office buildings:
- Office area 2.5 kN/m2
- Archive and storage area 5.0 kN/m2

b) Industrial structures and buildings:
- Ground floors
(Not accessible for heavy equipment or forklifts) 5.0 kN/m2
- Elevated Platforms 2.5 kN/m2

c)	Conveyor walkways	1.5 kN/m2
d)	Gangways	1.5 kN/m2
e)	Stairs	2.5 kN/m2
f)	Horizontal load on handrails	0.8 kN/m
g)	Electrical control panel areas and control rooms	5.0 kN/m2
h)	Clinker Cooler burner floor	5.0 kN/m2
	• In storage areas for refractory (area to be defined)	20.0 kN/m2
	• For column and foundation design	15.0 kN/m2
i)	Preheater main floors (local design for slabs & beams)	5.0 kN/m2
	• In storage areas for refractory (area to be defined)	10.0 kN/m2
	• Moving load of one refractory pallet	15.0 kN
	• Columns and foundations	5.0 kN/m2
	• Cyclones clogging load conditions need to be considered as extraordinary (accidental) load.	
j)	Empty bag storage area in packing plant to be defined as purpose of use, dedicated storage area to be marked and approved by Owner	

2.3.3 Traffic Load

Vehicle loads on roads and ground floors accessible for trucks and forklifts

a)	Uniform load on floor slab	20.0 kN/m2
b)	Axle load (2 wheels per axle) (In areas accessible for heavy Equipment, special loads have to be provided)	140.0 kN/axle
c)	Pavement load for non-motorized traffic area	5.0 kN/m2

2.3.4 Traffic Impact Load

All structural columns placed near truck and forklift traffic are to be designed against horizontal impact loading according to the relevant standards. Alternatively, impact protection barriers shall be constructed to protect the structural columns.

2.3.5 Dynamic Operation Load

All structures shall be designed to resist the dynamic loads that are involved when the equipment is in operation.

2.3.6 Crane Load

Crane loads shall be applied according to manufacturer's recommendations, fatigue to be considered by reduction of permissible stresses.

Design of crane supporting structures shall follow Eurocode (e.g. EN 1993-6 for structural steel) or other relevant standards if approved by Owner.

The maximum deflection of crane girders shall be:

a) Vertical and Lateral is L/600 or in line with the crane manufacturers recommendations. The more stringent of the two shall be applied (Class A, B).

L is equal to the span or to double the value of the cantilever length.

Differential horizontal deflection between parallel crane girders shall be limited to the maximum of 20 mm (to be checked with the crane specifications).

Continuous crane girders shall be used whenever possible.

Where more than one crane occupies the same runway, two fully loaded cranes shall be assumed in the same runway but only one of the two with impact, for the computation of stresses caused by vertical loads. For continuous girders, check for negative moments, when cranes are in adjacent bays.

Splices in continuous crane girders shall be made not closer to a column than 1/10 the span. Splices shall be made for the maximum bending moment and shear at the section, but not for less than one-half the resistance of the girder. Field splices of girders shall be made with high-strength bolts or welds.

Design of crane stoppers at both ends shall include dynamic loads from operation as well as from environmental impacts (e.g. wind, seismic).

Length of crane girders will be set in the field based on available material and also on shipping restrictions.

Application of crane lateral forces:

a) Determine the column moments caused by the lateral crane force and the necessary reaction to be supplied by the roof structure.

b) Crane girder lateral strength shall be calculated by using that portion of the member above the neutral axis.

c) For continuous crane girders, the unsupported length of the bottom flange shall be the governing factor.

d) Crane bumpers shall be designed to stop the impact of a loaded crane at 1/2 the rated bridge speed and to allow plunger travel as specified by manufacturer but not less than 50 mm.

2.3.7 Vibrating Load

2.3.7.1 Equipment Framing

Isolate vibrating machines, which will set up excessive building vibrations from the main structural framing, where possible. Where it is not possible to isolate such Equipment, the supporting members and their columns shall be checked for adequacy from the standpoints of their natural frequency of vibration in relation to the frequency of the vibrating Equipment. Tension bracing and stair stringers shall also be designed as compression struts, and channel stair stringers shall be braced on the underside to provide a lateral truss. Horizontal vibrations in members shall be prevented by the use of lateral bracing.

2.3.7.2 Equipment on Isolated Foundation Blocks

Small machinery foundations for reciprocating or centrifugal machinery shall be sized to weigh at least 3.0 times as much as the machine.

Large machinery foundations shall be designed on the basis of a frequency comparison: machine operating frequency compared with the natural frequency of the combined machine and its foundation considering the ground condition.

The Engineer shall prove that the system's own frequency (machine, foundation and ground) is away at least 20% from the machine frequencies (lower and upper ranges) in all possible operation scenarios.

A dynamic insulation membrane shall be used if required.

2.3.8 Lateral Pressure Load

All lateral pressure loads shall be considered, including the ground water pressure, lateral earth pressure, pressure of bulk materials on retaining walls and superimposed loads e.g. through heavy vehicles.

2.3.9 Kiln misalignment

Increased vertical and horizontal loads caused by kiln bending (high temperature condition) shall be considered in the load assumptions, and agreed among Engineer, Equipment Supplier and Owner.

2.4 Environmental Load

2.4.1 Temperature Load

The structural design of buildings and structures shall consider the impact of temperature on the structure that is generated by conduction, convection and radiation and/or the contact with equipment or materials. Special attention shall be given to the assessment of temperature loads in silos and on preheater towers and precalciner structures (considering the close exposure of structural elements to high radiant temperatures from the kiln, cyclones, calciner, ducts and other process Equipment).

Long term or repeating exposure to high temperatures (fatigue effect) to be considered by reduction of permissible stresses.

2.4.2 Wind Load

All structures shall be designed to withstand wind pressure in accordance with the relevant standards and requirements.

In areas of high wind loads, the buildings and structures shall be designed to ensure a normal operation of the plant, i.e. the horizontal displacement of buildings and structures shall be limited in accordance with the connected or installed Equipment.

Special attention shall be put on the way the wind speed is measured to design the structure (3-sec gust, 5-min mean, 10-min mean, 1-hour mean, etc.) in the different local design standards.

2.4.3 Earthquake Load

All structures shall be designed to sustain the seismic load in accordance with the local norms and regulations but are subject to prior approval by the Owner's Representative. Local norms & Eurocode EN 1998 (or IBC) base value for ground acceleration "*a"* shall be represented in % of g; Earthquake with a return period of 475 years with 10% of probability exceedance in 50 years (2% in IBC).

For the base shear force calculation, the effective seismic weight shall consider at least the total dead load, total operating weight of permanent equipment and 25% of the floor live loads.

All structures' behavior response factor and structural system are both subject to prior approval by the Owner's Representative.

2.4.4 Snow Load

All structures shall be designed to bear the snow load pressure according to local norms and regulations but are subject to prior approval by the Owner's Representative. Local norms & Eurocode EN 1991-1-3 (or ASCE 7):

a) Frost depth: where atmospheric ice loads due to freezing rain, snow, and in-cloud icing, the minimum embedment below grade level to provide frost protection shall be determined.

2.5 Extraordinary Loads

2.5.1 Cyclone Clogging

The minimum load value of a clogged cyclone is the dust volume accumulation from the bottom of the cone to the dip tube.

The combination of these extraordinary (accidental) loads shall be done as follows:

a) Local Design: All platforms shall be designed to resist the clogging load. When one or more cyclones are installed at the same platform, the clogging load shall be analyzed for all cyclones but never simultaneously. Combinations shall be made moving the clogging load from one to another cyclone.

b) Global Design: For columns and Foundations, the clogging load shall be analyzed for all cyclones but never simultaneously; combinations shall be made moving the clogging load from one to another cyclone, and from one to another platform, in order to find the most critical location.

c) Floor live and wind loads shall be reduced following the applicable design standard, but seismic loads shall never be included in this load case.

2.6 Load Combinations

The relevant design situations shall be studied and critical load cases identified. For each critical load case, the design values of the effects of actions in combination shall be determined. Rules for the combination of independent actions in design situations shall follow the applicable design standard.

The load combinations shall consider dead load of structure and equipment, material load, live load, wind, earthquake, snow, temperature, dust, extraordinary (accidental) loads, and lateral and vertical earth pressure as applicable.

The seismic load combination shall include at least dead load plus 50% live load and 80% of the material load for the design of silos, bins and hoppers or more as specified in the relevant codes.

2.7 Pile and Foundation Design

2.7.1 General

The pile and foundation design shall be based on the results of the detailed geo-technical soil investigation. Sufficient allowance shall be made to avoid injurious influences of settlement differences on sensitive buildings, structures and Equipment, plant operation and neighboring buildings.

Absolute and differential settlements have to be limited in order to avoid an effect on equipment and buildings.

Between preheater kiln piers and cooler, maximum differential settlement shall not exceed 25 mm, or if more stringent, the equipment suppliers' criteria.

The method of settlement calculation applied by the Engineer is subject to Owners approval.

Any change of the groundwater level caused by the Contractors and/or on Engineers request is subject to Owners approval.

The Geotechnical results and respective foundation recommendation shall be properly considered.

2.7.2 Testing of Foundations

Before concrete is placed on the excavation base of foundations, all tests deemed necessary or particularly ordered by the Geotechnical Engineer and/or specified in Standard Inspection and Testing shall be carried out. The tests shall include plate-bearing tests on the base of major foundations, density tests on cohesionless surface soils and undrained shear strength tests of cohesive layers.

2.7.3 Bearing Piles

Where bearing piles are incorporated in the foundation, full details of the proposed piling system, dimensions, reinforced design, bearing capacity, manufacturing, piling and testing methods shall be provided before piling commences. All processes related to piling shall conform to the latest valid standards EN 1997 (geotechnical design), EN 1536 (bored piles) and EN 12699 (displacement piles) or equivalent.

The piles shall be designed to withstand all stresses due to the loads applied including stresses due to handling pitching, driving and any tensile stresses caused by the driving of adjacent piles. Pre-cast sections entirely without reinforcement will not be accepted.

If steel piles are proposed, due consideration shall be given to the long and short-term effects of corrosion and to corrosion protection.

The working drawings shall include pile layout plans with positions, types and numbers complete with the spacing and angles of piles clearly marked on the drawing. The maximum design-working load of each pile and pile group shall be clearly shown and tabulated.

The groundwater level shall be verified and considered in piling method choice (e.g. Bentonite or steel casing) and pile design.

2.7.4 Testing of Piles

a) Pile Load Tests

A static pile load test is recommended to determine the pile capacity and settlement characteristics prior detailed engineering commences.

A minimum number of test piles shall be defined by the Owner based on geotechnical conditions on site, plant layout and local standards, but shall not be less than 2% of the total number of piles.

Pile test load shall be at least 1.2 times the ultimate pile capacity or as per applicable local standard, whichever is more stringent.

Alternatively to the static pile test, dynamic pile load tests can be performed on Owner's approval.

b) Pile Integrity Test

Pile integrity tests shall be carried out on minimum 50% of the piles.

3. CONSTRUCTION MATERIALS

3.1 Concrete

The design of reinforced concrete structures shall comply with the requirements specified in the latest valid Eurocode EN 1992 or equivalent.

Concrete Quality Class (EN 206-1/EN 1992)	Min. Nominal Comp. Strength (N/mm^2)	
	100mm cylinder	150mm cube
C8/10	8	10
C12/15	12	15
C20/25	20	25
C25/30	25	30
C30/37	30	37
C35/45	35	45

Table 1: Required Concrete Strength

Concrete of quality C8/10 and C12/15 shall be used as plain/mass concrete only. Lean mix concrete in blinding layers shall be of quality C12/15.

The quality of reinforced concrete for foundations and structural members shall be C25/30 or higher. The quality of concrete for silo walls and heavy loaded columns shall be C30/37 or higher.

For special applications concrete quality C35/45 shall be used, if required by structural design.

For pre-stressed concrete structures only concrete of quality of C30/37 or higher is accepted.

3.1.1 Concrete Cover for Reinforcing Steel

Structure	Min. Concrete Cover for Reinforcing Steel
Foundations	50 mm*
Concrete exposed to the ground (below G.L.)	40 mm*
Concrete exposed to the weather (above G.L.)	40 mm*
Concrete exposed to sea climate	40 mm*
Concrete indoors (tempered buildings)	20 mm*

* or higher according to the applied standards.

Table 2: Concrete Cover for Reinforcing Steel

3.2 Reinforcing Steel

For all constructions in reinforced concrete quality C25/30 and higher, the following reinforcing steel qualities in accordance with the latest valid Eurocode EN 1992 or equivalent (subject to approval by the Owner's Representative) shall be used:

Following is an example from the Eurocode, other code minimum yield values (e.g. ASTM A615: minimum yield strength = 420 N/mm^2) are subject to Owners approval.

Reinforcing Steel Type	Minimum Yield Strength	Ultimate Tensile Strength
Steel B500B (ribbed steel bar)	500 N/mm^2	550 N/mm^2
Steel B500B (welded steel mesh)	500 N/mm^2	550 N/mm^2

Table 3: Reinforcing Steel Grades

Ground slabs, roads and stabilized surfaces can be reinforced with plastic fibers, subject to Owners approval.

3.3 Structural Steel

3.3.1 General

All design of structural steel works and steel flooring shall be in accordance with the latest valid Eurocode EN 1993 or equivalent (subject to approval by the Owner's Representative).

Structural Steel Type	Thickness (mm)			
	t ≤ 40mm		40mm ≤ t ≤ 100mm	
	Minimum Yield Strength	Ultimate Tensile Strength	Minimum Yield Strength	Ultimate Tensile Strength
S235	235 N/mm^2	360 N/mm^2	215 N/mm^2	340 N/mm^2
S275	275 N/mm^2	430 N/mm^2	255 N/mm^2	410 N/mm^2
S355	355 N/mm^2	510 N/mm^2	335 N/mm^2	490 N/mm^2

Table 4: Structural Steel Grades

Equivalent ASTM steel qualities are:

a) ASTM A36: minimum yield strength = 250 N/mm²

b) ASTM A992: minimum yield strength = 345 N/mm²

3.3.2 Connections

Structural steel connections shall be bolted.

All bolt connections shall be made with high tensile strength, galvanized bolts and shall be designed to transmit vertical and/or horizontal loads or reactions.

Minimum connection for beams and diagonals shall be made with two high-strength bolts.

Bolt Class EN 20898-2	Minimum Yield Strength	Ultimate Tensile Strength
10.9	900 N/mm^2	1'000 N/mm^2
8.8	640 N/mm^2	800 N/mm^2
4.8 *	320 N/mm^2	400 N/mm^2

* Allowed for secondary structures only (Purlins, girts and handrails).

Table 5: Bolts Class

Equivalent ASTM steel qualities are:

a) ASTM A490: minimum yield strength = 780 N/mm²

b) ASTM A325: minimum yield strength = 620 N/mm²

c) ASTM A307: minimum yield strength = 310 N/mm²

If welded connections are required, they shall be designed and executed according to the latest valid standard EN 1090-2, or equivalent.

Anchor bolts shall be designed for all conditions of tensions and shear. Provide shear keys if the anchor bolts are inadequate to take the shear at the column base.

Large column base plates shall be provided with holes for proper grouting. For anchor bolts greater than or equal to 20 mm diameter a sole plate is preferred or alternatively the use of a grout sleeve is acceptable.

3.3.3 Steel Purlins and Girts

Vertical or horizontal deflections of purlins and girts shall not be more than L/250 for unreduced Live Loads.

For purlins or girts supporting corrugated roofing or similar construction, the unsupported length shall be the distance between the sag rods.

Purlins, which serve also as the chords of a lateral truss, shall be designed as bracing members in compression.

Position of the purlins shall be to avoid dust accumulation.

3.3.4 Sag Rods

Sag rods shall terminate in a member of adequate stiffness or framing provided to resist tension in the rod. Minimum 12 mm diameter to be used.

3.3.5 Bracings

Building bracings with light loads may be designed as tension cross bracings, provided that the connections do not become excessively large.

Compression bracing is recommended where bracing loads are large.

Roof bracing shall be typically fastened to the underside of purlins in order to prevent sagging.

Continuous longitudinal members, when used exclusively to brace the bottom chords of roof trusses between sway frames, shall be designed as tension members only. Should a line of these members terminate in a sway frame at one end only, such members shall be designed as struts.

Vertical bracings which carry tension only and consist of single-angle diagonals that are connected at their intersection shall have the following minimum ratio (L is length in meters and r is radius of gyration in meters):

L/r /of 300 (about the vertical axis – L = total length between extremities)

L/r /of 300 (about any axis – L = length between one end and the intersection point).

3.3.6 Built-Up members

Built-Up members shall be avoided if possible.

Commercial rolled steel beams of adequate size are preferred over Built-up members in construction of steel structures. If Built-up members are used, consisting of splicing a series of plates or welding cover plates to the flanges, the welds shall be designed and proportioned to resist the bending and shear stresses in the flanges. The welds shall not be discontinuous in the load's areas, shall comply with the design documentation, and shall be made in workshops by qualified welders and all inspected visually and with NDT.

For best practice in the design and usage of Built-up members of all types, refer to the recommendations of American Institute for Steel Construction, Specifications for Structural Steel Buildings 360.

3.3.7 Gratings and Checkered Plates

Gratings and checkered plates shall be designed according to the specified live loads and shall not be considered as a beam stiffener.

Gratings shall be hot galvanized. The supporting grid of the gratings shall have a minimum depth of 30 mm and a minimum thickness of 2 mm. For safety reasons, the mesh shall have a gap of maximum 19 mm on the short side to avoid pieces falling.

The checkered plate thickness shall be min. 5/7 mm. The surface of checkered plates shall have effective non-slippery properties. The span between supports for both gratings and checkered plates shall be less than 1.20m.

-Bearing bar shall have minimum thickness of 5mm

-Bottom portion of checkered plate shall be painted with a protecting coating in case the plate is not galvanized

Grating shall be mechanically secured to support member's fasteners to be approved by Owner.

Checkered plates shall be plugged and seal welded unless otherwise approved by Owner.

The necessary supporting structures (corner steel, grooves, and angles under checkered plates) and their fastening shall be shown in the drawings and they must have at least 25mm of transversal supporting length.

In areas where the checkered plates need to be removed periodically for inspection or maintenance, the individual plates shall not exceed 50 kg in weight, and 1'200 mm in length.

Checkered plate flooring shall not be used as horizontal bracing in the design of buildings and structures.

3.4 Roofing and Cladding

The design of fixing, overlapping and sealing is subject to the Owner's written approval.

3.4.1 Profiled Metal Sheets

Profiled metal sheets for roofing and cladding of buildings and structures shall be watertight and weatherproof and shall offer adequate resistance to local climatic conditions. Special fittings have to match with the sheets. Color needs to be uniform and color choice shall be approved by the Owner.

3.4.2 Design Requirements

a) Minimum steel quality shall conform to the latest valid standard Eurocode EN 10025 or equivalent (min. tensile strength of 360 N/mm2 for S235JRG2 and of 510 N/mm² for S355J2G3).

b) Location and extent of metal cladding on steel structures is project specific and needs to be agreed with the Owner.

c) Steel core thickness min. 0.50 mm for roof and walls.

d) Overall wave height:

- Min. 40 mm for corrugated sheets ("big-wave" type), translucent panel profiles to match wall panels.
- Min. 30 mm for trapezoidal sheets.

e) Rust preventing treatment:

- Galvanization of all surfaces to min. Z-275 (total 275 gram zinc per m^2) or equivalent AZ150.
- Additional PVC coating or stoving enamel (on the weathered side), weather-proof and UV-resistant. According to location, suitability and protection level shall be defined in agreement with the Owner.

f) Minimum roof slope shall be 10%.

g) The deflection of roof and wall sheeting shall not exceed 1/200 of the span.

h) Connections, edgings, closures and other special fittings shall be provided by the sheet manufacturer and shall match the wall color. All metal parts (self-cutting screws, hook bolts) have to be galvanized.

i) Profiled metal sheets have to be fastened to the purlins and rafters of the supporting structure.

j) Self-cutting screws, hook bolts shall be designed for the maximum expected local loads. Roof applications need to have a rubber washer provided to guarantee water tightness.

k) To reduce heat accumulation in cladded buildings, natural ventilation louvers shall be provided.

l) Thermal insulation to be provided depending on the requirements of the specific building.

m) All end laps shall have a minimum width of 150 mm and be located over a purlin or rail.

n) Roofing and cladding shall always be watertight.

o) Alumina sheets are acceptable subject to proven design specifications and Owners approval.

3.4.3 Translucent Sheets

The installation of these translucent sheets (Polycarbonate) is limited to the facades (siding) and shall not be installed in roofs.

Translucent Sheets if utilized to benefit environmental goals (at a premium installation cost), shall be watertight, weatherproof, UV- and heat-resistant and stable against deformations.

Their shape and profile shall go well together with the normal cladding sheets they meet and replace. Refer to paragraph 4.10 (Daylight Design).

3.4.4 Insulation

Wall insulation shall have sufficient resistance against mechanical and fire attack and fulfill the following requirements:

a)	Relative density	approx. 30 kg/m3
b)	Thermal conductivity	approx. 0.035 W/mK
c)	Steam conductivity	approx. 0.68 mg/m h mbar

Where cladded faces or roofs shall have thermal insulation, such insulation shall be designed and fastened according to the building conditions and the involved supporting structure.

The design shall provide for appropriate natural ventilation of cladded hollows to avoid undesirable heating by solar radiation.

Roof insulation shall have not less than 50 mm thickness and with sufficient strength. It shall be placed upon the supporting purlins, below the sheeting and shall be fastened to the purlins together with the sheeting.

The type and layer thickness of insulating material for Equipment and ductwork is specified in the Mechanical Equipment StDC.

3.5 Masonry

3.5.1 General

The design of masonry brickwork and concrete blockwork shall be in accordance with the latest valid Eurocode EN 1996 or equivalent.

All walls and panels in brick or blockwork shall be of sufficient strength and thickness to withstand live loads, dead loads and wind pressures. All walls and wall panels shall be adequately secured to all structural columns and beams by adequate means allowing for the movements due to temperature. Where metal lugs or anchors are provided, they shall be of non-corrosive metal. All expansion joints have to be adequately sealed and protected. For wall heights of 4.5 m and over, the blockwork shall be framed by reinforced concrete into panels of not more than 20 m^2.

Walls thickness of less than 15 cm will be accepted only as non-bearing walls and if less than 3.00 m in height. In seismic areas specific constraints shall be considered.

3.5.2 Concrete Blockwork

The minimum compressive strength of all blocks shall be as follows:

a)	For bearing walls	12 N/mm2
b)	For non-bearing walls	6 N/mm2

The latest valid Eurocode EN 1996 shall be used as a guideline.

3.5.3 Brickwork

For the design of ancillary buildings and for internal masonry walls of production buildings, clay brickwork walls may be used.

The minimum compressive strength of all bricks shall be 12 N/mm^2 for bearing walls and 6 N/mm^2 for non-bearing walls. For the design of brick walls, the latest valid Eurocode EN 1996 shall be used as a guideline.

3.6 Concrete Slabs on Grade

3.6.1 General

In general, all slabs on grade shall be at least 150 mm thick (based on traffic loads and soil conditions) and shall be reinforced with welded steel wire mesh, reinforcing steel bars or plastic fibers.

The maximum spacing for joints shall be:

a) For contraction joints (saw cuts are required): 5.00 m

b) For construction joints: 30.00 m

On heavy loaded slabs (vehicles with axle load of more than 2 tons) transmission of shear forces in the construction joints shall be ensured with shear dowels to avoid differential settlement. For contraction joints, the slab shall be sectioned during the first 24 hours after the casting.

All slabs on grade shall be supported with a sub-base layer consisting of well-graded natural sands, gravels or rock or mixtures thereof shall be laid and compacted in accordance with the Owner's Specifications.

Alternatively, plastic fiber concrete may be used, subject to Owners approval.

Optimum proctor test shall be made to identify soil feature and highlight optimum humidity for compaction. Minimum proctor value for sub-base compaction shall be 95%.

3.6.2 Non-Slippery Finish

Concrete slabs, landings, access steps, access ramps and other critical areas for pedestrians are to be given non-slippery properties by including carborundum or other wear resistant grit into the surfaces prior to finishing.

4. BUILDINGS AND STRUCTURES

4.1 Lines and Levels

The ground floor level of all buildings shall be at least 200 mm above finished site level. Where necessary, appropriate adaptations such as steps and ramps shall be provided.

The levels of all floors and platforms shall be preferably a multiple of 0.20 m.

4.2 Expansion Joints

A sufficient number of joints of proper disposition and dimension shall be provided in order to prevent damages due to:

a) Different stiffness of neighboring buildings or other structures

b) Different settlements

c) Machine-operation (vibration)

d) Influences of temperature

e) Different constructions or construction materials

f) Sufficient gap shall be provided to avoid potential movement of adjacent buildings in opposite directions (i.e. wind, seismic etc.)

To prevent damages by vibration, individual heavy items of machinery are to be provided with their own, well-separated foundations, as to be determined by special calculation.

The joints are to be designed such as to guarantee good function or durability of the joint. Sealing compound and other filling materials shall be of proper climate (i.e. tropical, cold) quality (as applicable at the place of installation) and be able to sustain the local working conditions during construction and operation of the plant. Joints shall be protected; filling product is subject to Owner's approval.

Bearing and sliding joints, when possible, must be designed such that allows inspection and maintenance and provide protection against dust accumulation, contact with water and/or other agent that could compromise the durability and good function of their flexible properties.

4.3 Walkways, Stairs and Platforms

Where specified, platform arrangements shall be provided with stairs (inclination 35 to 40 degrees, length to be limited to match a stair flight of 3 m height) and landings with handrailing. Refer to Paragraph 4.4 (Handrailing).

The minimum clearance for unobstructed passage on all main platforms, walkways and stairways shall be min. H/W = 2.1/0.8[1] m, measured perpendicular to the object. Secondary walkways and stairs for access to Equipment shall be designed with min. H/W = 2.1/0.6 m at least. Spiral stairs shall be avoided.

Step height shall not exceed 200 mm and the sum of two times step height plus the step depth shall be in between 600 and 660 mm (600 mm ≤ 2H + D ≤ 660 mm).

All platforms and walkways shall be designed to the following rules. In locations with the risk of ice formation an agreement with the Owner shall be made:

a) Less than 10% inclination: no special requirements

b) 10% to 20% inclination (in addition to the above rules):
   - Grating: no special requirements
   - Checkered plates: anti slippery features

[1] If not otherwise requested by local Standards

c) 20% to 25% inclination (in addition to the above rules):

- Horizontal platforms are recommended every 10 to 15 m
- Non slippery grating to be used

d) More than 25% inclination (in addition to the above rules):

- Steps with a step height of 0.20 m shall be required.
- Non slippery grating to be used

4.3.1 Attachment of Flooring

Floor decks shall be fixed according to manufacturers' recommendation but the attachment shall be done in a manner where it is impossible to remove a panel from any area unless the panels are specifically designated for removal and equipped with appropriate signage and fall restraint systems.

Grating shall be fixed in a way to not slip out of the floor, safety pins welded (minimum two in diagonal) on the structure or similar (bolted clips).

Any means used to fix the flooring shall not extend above 10 mm to the floor level.

4.3.2 Floor Openings

Floor openings in platforms shall be avoided. If openings are absolutely necessary, sufficient protection against personnel fall shall be provided.

Maintenance floor openings shall be enclosed with handrails and equipped with kick plates.

Inspection openings and manholes passing through floors shall be flash with floor elevation or surface.

4.3.3 Preheater Floors, Platforms and Stairways

The main platforms shall be made of checkered plates or concrete to prevent possible outflow of hot raw meal.

A steel grating platform shall be provided at a min of 200 mm above the roof of the cyclone for enabling access to measurement points over the cyclone roof during kiln operation.

All access platforms for the clean-out holes shall be made of steel grating, to remain clear of material at all times. Clean-out holes shall be provided below the platform level; to avoid accidental spillage can reach the platform and endanger the operators.

Outflow of hot raw meal might be subject to wind and is carried in shifting directions. Hence, in front of a clean-out door, the platforms shall be wide enough with door opening space plus 1 m. Sufficient lighting shall be provided near the clean-out holes.

The door design shall allow opening by one person, without use of hoisting equipment.

The platforms shall be configured such that there are always two paths of egress away from the poke hole location.

Stair tower and access to platforms shall be preferably located outside. If not possible, the exit and access way shall be clearly identified (on the ground and/or structure).

4.3.4 Loading Platforms

All elevated loading platforms (used by forklifts or similar) in the buildings shall be equipped with security doors to allow loading objects and move them on the platform. Handrail systems shall be designed in such a way that the handrail can be temporarily removed for equipment lifting. If handrails need to be removed frequently, a gate shall be installed.

4.4 Handrailing

Handrailing shall be designed for the following locations:

a) Around all platforms, stairways, landings and walkways

b) Around the edges of all elevated floors

c) Alongside the elevated walkways

d) Around the perimeter of all pits and sumps of more than 1.00 m

Handrailing shall include the necessary fastening. It shall consist of min. dia. 48.3 mm x 3.6 mm steel tubes for the handrail and for vertical stanchions (other profiles of equivalent strength are allowed on Owner's approval), which shall be spaced at a maximum distance of 1.50 m.

The height of the handrail above floor shall be 1.10 m for stairs, walkways and platforms on a level up to + 20 m above ground. Above 20 m the height of the handrail shall be 1.30 m.

Handrails with a height of 1.1 m shall be provided with one secondary horizontal rod of min. dia. 32 mm x 2.6 mm steel tube and handrails with a height of 1.3 m shall be provided with two secondary rods.

Handrails shall be delivered to the construction site in pre-assembled sections. Self-locking screw fasteners shall be supplied in sufficient quantity for the final on-site assembly and fixation. On-site welding shall be limited to an absolute minimum.

4.4.1 Removable handrails

In case of removable handrails, anchoring points for working at height PPE shall be provided in the area where the handrail is removed temporarily.

Removable handrails and handrail gates shall be lockable.

4.4.2 Kick Plates (Plinths or Toe Board)

Safety kick plates have to be provided for:

a) The periphery of all elevated floors, walkways and platforms

b) The periphery of all floor openings

c) And everywhere, where an object can be kicked off the floor

The kick plates shall consist of steel sheets of 6 mm thickness and 100 mm height. The bottom of the kick plate above the finished floor level (grating, checkered plate, concrete slab) shall be maximum 10 mm unless otherwise specified.

4.5 Ladders

Ladders may be provided at places where no regular maintenance is necessary and only occasional access is required.

Ladders shall be min. 450 mm wide with horizontal solid rod rungs at 300 mm distance. Suitable railing shall be provided.

For ladders of more than 2.50 m height, solid safety cages shall be provided. The maximum distance for a single ladder without platforms is 6.00 m.

Ladder arrival at every floor shall be equipped with a self-closing gate. All other means such as chains, falling bars, etc. shall be approved by owner.

If the horizontal distance from a fixed ladder, to the guard-rail less than 1.5 m, the guard-rail shall be fitted with an extension.

The ladder cage must extend at least 1 m above an access level or landing platform.

If the gap between the ladder and the arrival platform is more than 30 cm, then a transition platform shall be provided.

In a distance of 2.5 m around the ladder, obstacles shall be avoided.

4.6 Access Doors

All occupied buildings, including electrical substations, shall be designed with at least two emergency exits. The emergency exit doors must have a panic bar opening system.

For bag process bag filters penthouse, hydraulic rooms a second door shall be provided as emergency exit in case of fire.

All exits designated as a means of egress shall have permanently illuminated “EXIT” signs identifying them. These signs shall be powered by battery or emergency generator supply.

Where applicable, doors and door frames shall satisfy the required fire resistance class.

Door-frames and their fixation shall be of strong and rigid design. Door leaves shall have a min. of three hinges.

All enclosed areas shall have adequate doors, giving access to stairways and platforms and all other areas as necessary for efficient operation of the facility and meet applicable Codes, Standards and Laws.

Unless otherwise specified, the doors and frames shall be of mild steel and shall be dimensioned so as to allow the passage of plant and machinery or personnel as appropriate to their particular location.

It shall be possible to obtain clear access for the extraction of the largest indivisible component of the Equipment housed in any building. Doors for electrical rooms and transformer cells shall enable unhindered escape, open towards the outside and shall be in accordance with the relevant regulations.

Doors have to be supplied as complete units of doorframe and door leaf. The design shall conform to the specific local requirements. Filling of doors for insulation shall be in rock ware or equivalent approved by the owner.

The joint between the door or unit frame and the wall or steel structure shall be properly filled with mineral wool and sealed.

All door handles have to be of solid type for industrial use.

All doors for electrical and A/C rooms have to be dustproof. Fire doors shall be fireproof to the required degree of fire resistance. Main access doors for electrical rooms shall be via double door installation. Emergency exit or equipment handling doors may be single door design. Refer also to Paragraph 4.25.1 (General Health and Safety Aspects) and EN 1634).

Big doors higher than 3 m shall be horizontally separated or equipped with a normal sized door for daily use and an overhead removable transom.

The door design shall respect the following requirements:

4.6.1 Steel Doors

The space between the two sheets shall be filled with appropriate and fireproof insulating material. The overall door thickness shall not be less than 55 mm.

All doors for industrial buildings and the outside doors of ancillary buildings (if not otherwise specified in the detail descriptions and/or drawings) shall be made of two steel sheets, each min. 1.5 mm thick.

4.7 Access for Maintenance

Provision and access for maintenance and housekeeping works shall be made, by arranging such elements as stairs, ladders, and galleries. Generally, stairs shall be provided where possible.

All access platforms and walkways shall have sufficient space to perform maintenance and areas in front of access doors to dust collectors and cyclones shall be wide enough to ensure totally safe access or retreat.

Special consideration shall be exercised in providing ample access for the unclogging works of dust collector hoppers and cyclones (including preheater stages).

Easy and suitable access for maintenance to all instruments or sensors shall be ensured.

4.8 False Floors and Ceilings

All false floors and ceilings have to be designed in accordance with the local requirements and operation conditions considering the maximum peak and fire loads.

4.8.1 False Floors

For the design of false floors, the following criteria shall apply:

Static loadings

a)	Floor-panels laid directly on supports	13 kN/m2
b)	Supporting system	18 kN/m2

Provision and sufficient allowance shall be made for all cables and other utilities for maintenance, repair and future modification and adaptation work. The necessary free cavity space, ramps, steps, air grilles, plastic skirting, cable cut-outs and lifting devices have to be provided as well as the required fire barriers within the cavity.

The floor panels shall have dimensional stability and resistance against attack by insects and vermin as well as resistance to microorganisms, fungus and mildew considering the prevailing local conditions.

Timber core of panels shall be sound absorbent. Each pedestal shall be capped with PVC or a similar product to prevent chatter and to dampen impact noise.

The floor shall meet the electrostatic requirements of the Equipment manufacturers. It shall be possible to easily replace damaged panels.

4.8.2 False Ceilings

Suspended panel ceilings shall consist of prefabricated metal suspension and sub construction with prefabricated panels. The false ceilings shall have a total weight of approximately 60 to 100 N/m^2. Provision and sufficient space allowance shall be made for all utility lines in the cavity (special ventilation, air conditioning, lighting etc.), for fire prevention and cavity inspection.

All material shall be inflammable as per Eurocode EN 1993-1-2 (class A2) or approved equivalent.

4.9 Roof Design

Roofed buildings shall have water- and dust tight roofs with drainage outlets and discharge pipes or channels projecting outside the building line arranged in such a way that the water run-off is directed away from foundations.

For cladding design requirements refer to Paragraph 3.4 (Roofing and Cladding).

4.10 Daylight Design

Unless otherwise specified, all buildings, which are enclosed with cladding, shall be day lighted by continuous rows of translucent sheets on the appropriate facades of the building, giving a clear opening of at least than 1 m. The number of rows in any particular building shall be such that all floors are adequately day-lit. Refer to Paragraph 3.4.3 (Translucent Sheets).

The appropriate daylight design shall be in accordance with the relevant industrial standards.

Minimum 2% translucent sheet (Polycarbonate) on side cladding to be considered.

4.11 Ventilation

If required, adequate ventilation shall be provided in permanent working places.

4.11.1 Natural Ventilation

Natural ventilation shall be provided only where no fugitive dust can get into the building. In such cases, fixed louvers shall be provided.

4.11.2 Forced Ventilation

Forced ventilation (over pressure units) shall be provided for all enclosed rooms where it is requested without forced cooling units.

The air filters shall be of low velocity and easy to clean. The prefilters at the air inlet shall be of the self-cleaning inertia type, installed outside or inside rooms with direct access to filter cleaning from the outside.

In all rooms with mechanical ventilation, a minimum room temperature of 15°C and a maximum of 35°C shall be maintained, otherwise appropriate heating and cooling shall be provided at least for the permanently occupied rooms or where specifically required by the functionality.

The design rate of hourly air replacement and the capacities shall reduce workers exposure to air borne hazardous substances and shall be in conformity with the respective requirements.

4.12 Heating, Cooling, Air Conditioning

Refer also to the StDC part Electrical Equipment and Systems.

4.12.1 General

Appropriate heating, cooling and air conditioning are required for specified buildings and rooms. The design shall allow for sufficient flexibility (i.e. a spare capacity of 20% shall be provided above nominal heat dissipation) to follow the prevailing variations of the ambient conditions as described in the Local Conditions documents.

Refrigerants used for heating/air conditioning purposes shall have a Global Warming Potential < 1000.

Room temperature requirements for occupied non-electrical rooms:

a) Heating up to 25°C

b) Cooling down to 18°C

For room temperature requirements of electrical rooms refer to paragraph 4.25 (Electrical Rooms and Facilities).

The building construction shall consider the thermal insulation quality and cool storage capacity of the buildings and take advantage of the temperature drop during the nights (min. 15 to 20°C). Latest energy saving technology for Heating and Cooling shall be adopted pending the Project Owners review and approval.

Furthermore, the design shall provide for appropriate and efficient sound insulation and fire prevention for the central plant units, the supply rooms, the connecting supply system (pipes, ducts, etc.) and the Equipment. The sound level shall not exceed 60 dB in any room.

Airflow requirements:

c) Fresh air flow rate:
   - Offices, control rooms and other rooms where persons may stay: 60 m^3/h per person

d) CO2 content not exceeding 0.15% of volume

e) Air replacement for particular rooms:
   - Wardrobe, dressing rooms 10 to 12 per hour
   - Shower, toilets 20 per hour

The air filters shall be of the low velocity type and easy to clean. The prefilters at the air inlet shall be of the self-cleaning inertia type, installed outside or in rooms with direct access for filter cleaning from the outside.

f) Maximum air velocities

- In heated, cooled and air-conditioned rooms between 0.5 and 2.0 m above floor 0.25 m/s
- Through coils of the air handling units 2.8 m/s
- Through filters 2.5 m/s
- Through grilles (louvers) 2.0-2.5 m/s
- In main ducts 5.0-7.0 m/s
- In secondary ducts 3.0-4.0 m/s

The necessary electrical power requirements for all heating, cooling and air conditioning requirements shall be listed in order to design the electrical supply system accordingly.

The heat generated by electrical Equipment installed in the rooms, shall be specified by the electrical Equipment manufacturer and shall be provided for in the design of the air conditioning systems.

4.12.2 Heating and Cooling Systems

Heating and cooling shall generally be provided by means of split system units. For specified ancillary buildings, a central heating and cooling system shall be provided.

4.12.3 Air Conditioning Systems

Where humidity control is required, units shall be provided and combined to be able to keep the relative humidity at 60% with the respective cooling systems where necessary.

4.13 Overhead Cranes

Safe maintenance access to motors and drives shall be provided.

For crane requirements refer to StDC part Mechanical Equipment.

Rails and stops shall be in accordance with the crane manufacturer’s specifications.

Rails shall be laid true to line (maximum tolerances of +/-2.5 mm in gauge and level) and in accordance with the crane manufacturer’s specifications whichever is more stringent. For crane loads refer to Paragraph 2.3.6 Crane Loads.

4.14 Hoists, Monorails

Where hoists or monorails are to be installed, all necessary supporting beams, anchors, and fixing bolts shall be provided.

4.15 Machinery, Equipment, Utilities and Cable Tray Supports

All necessary structural steel supporting structures for machinery, steel silos, hoppers, chutes, utilities and cable trays shall be provided.

4.16 Edge Protection

Edges and arises shall be protected by appropriate edge protecting steel profiles in all places where they may be exposed to nearby traffic, either during the Works or during normal plant operation.

The following minimum requirements for edge protection shall be met:

a) Minimum steel angle section 50 x 50 x 5 mm.

b) Slotted sheet metal anchors, 3 mm thick, welded to the steel angle and embedded by cement mortar or cast-in in the backing structure to be protected.

c) Edge protection height for columns and piers as required by the likely used vehicles, but at least 2 m above finished floor level.

d) All edges of exposed concrete formed elements shall be edge protected by chamfer strips of 20 mm by 45° degree in size, sharp edges shall be avoided.

4.17 Plumbing, Sanitary Installations and Hot Water Supply

Plumbing and sanitary systems shall include supply pipes, sinks, sanitary ware, fittings, waste pipes, gully-traps, and drainage connections to the foul drainage systems.

The selection of the pipes shall consider the subsoil and water analyses, hazardous substances, prevailing climatic conditions at the Site, and shall make appropriate provision for expansion.

Pipes shall be concealed wherever possible, but otherwise painted with three coats of approved paints.

For hot water supply, separate electric boilers are required.

4.17.1 Local Toilet in Production Buildings

Sufficient number of toilets in the production plant buildings shall be provided.

If not otherwise specified, local toilet rooms in the production plants shall contain water closets that are accustomed to the local region water closets with accessories (such as paper roll holder, soap holder, mirror, hand dryer), partitions and doors, wall hung urinals and lavatory basins. Shower to be provided if specified. Toilet and tearoom access areas have to be designed separated from each other.

The water closets shall have a flushing hose, supplied by the flushing water source.

The floor and the walls up to at least 2.00 m of height shall be tiled with shock and wear-resistant tiles.

Sanitary facilities have to be ventilated.

4.17.2 Local Toilet in Ancillary Buildings

If not otherwise specified, local toilet rooms in the ancillary buildings shall contain regional specific water closets with accessories (such as paper roll holder, soap holder, mirror, hand dryer), partitions and doors, wall hung urinals and lavatory basins. Showers to be provided if specified. Toilet and tearoom access areas have to be designed separated from each other.

The water closets shall have a flushing hose, supplied by the flushing water source.

The sanitary Equipment shall be of first-class white sanitary stoneware. Water closets have to be of first-class vitreous material. The floors and the walls up to at least 2.0 m of height shall be tiled with ceramic tiles.

Sanitary facilities have to be ventilated.

4.18 Welfare rooms

Welfare rooms shall be provided in adequate number and size at the elsewhere specified cement plant.

Standard welfare rooms in production buildings shall satisfy the requirements of boiling water and heating up of food, rinsing and cooling.

Welfare rooms have to be ventilated.

4.19 Finishing

4.19.1 Cement mortar floor

Cement mortar shall be mixed with a ratio of 1:2 (1 part of cement, 2 parts of sand) and shall have a minimum thickness of 30 mm. The mortar shall contain 400 kg of Portland cement per m3 of finished volume. Provision (joints, reinforcement) shall be made to avoid damages by shrinkage. Wherever possible, the floor shall be made "wet-on-wet", i.e. applied to the still wet concrete surface.

Surfaces of floors to which cement mortar topping is to be applied later shall be smoothed or slightly grooved. In machine rooms the topping shall be applied after the installation of the machines.

The concrete of floors shall be wetted before applying the cement flooring. A ratio of 1:1 cement/water mixture or approved other bonding agent shall be applied to the floor surface before execution. The finished cement floor shall be duly cured and kept wet for at least one week.

Where the cement floor is the finished floor, it shall receive a final silicate-solution sealing treatment to make a dust-free floor.

Irregularities on the concrete surface shall be compensated.

4.19.2 Floor and Wall Tiles

Samples of all floor and wall finishes, such as ceramic, terrazzo, PVC and cement tiles or basaltic plates, shall be submitted for approval before commencement of work.

Tiles shall not be fixed on loose material.

All types of finishes and tiles shall be uniform in size, surface, color and glazing. Damaged and broken plates or tiles shall not be used. The finish shall be smooth, leveled and the joints between plates or tiles neat and filled to the respective finished floor or wall.

4.19.3 Terrazzo Floors

Terrazzo tiles and terrazzo floors shall be manufactured of a mixture of sand, marble chips and cement (650 kg cement per m^3 of sand and marble chips). The maximum size of marble aggregates shall be 15 mm. An appropriate coloring pigment of high resistance to weather and cleaning compound stress shall be added.

Wearing surfaces of min. 15 mm thickness shall be composed of approved 10 to 20 mm grade marble chip aggregate. The mix proportion (by volume) shall be three parts of aggregates to one part of cement. The surface of laid terrazzo floors shall be treated with a polishing grinding machine.

The finished terrazzo flooring shall meet the following criteria:

a) Have an appearance which is uniform and stable in structure and color

b) Allow for:
   - Frequent walkway use
   - Live load up to 10 kN/m2 at any place for terrazzo flooring on ground slab
   - Live load as specified elsewhere or as required for the particular location, but at least 4 kN/m2 at any place for terrazzo flooring

c) Have the required surface qualities such as:
   - Evenness
   - Roughness
   - Non-slip property

d) Be wear-resistant, anti-corrosive, not affected by water and cleaning compound, weatherproof (if outdoors) and able to withstand the specific local conditions.

4.19.4 Wall Tiles

Tiles shall be placed in a workmanlike manner, with continuous joint lines. All joints between wall tiles shall be at most 3 mm wide. Vertical joints shall be maintained plumb, level and even.

Where tiling abuts against wood or metal frames or other tiling at angles and round pipes and so on, it shall be carefully cut and fitted to form close neat joints.

4.19.5 Unglazed Ceramic Tiling

Split ceramic flags of appropriately fine granular crystalline sintered stone have to be weather-resistant and acid-proof.

The following widths of joints are required:

a) Side length up to 150 mm: 2 mm

b) Side length over 150 mm: 2 to max. 8 mm

4.19.6 Marble Tiles

In specified areas of the CCR Building (Central control room, entrance and corridor) and the Administration Building (Manager's offices, entrance and corridor), marble tiles shall be installed for the floors.

4.20 Silos

4.20.1 Silo Capacity

The definition of the life storage capacity of silos is the net volume which can be discharged in regard to the method of filling, position of feeders, outlets and the natural angle of response of the material.

4.20.2 Silo Loading

The silo loading shall comply with the latest valid Eurocode EN 1991-4 (Actions on structures, silos and tanks).

4.20.3 Silo Design

The design, construction and testing of silos shall generally comply with Eurocode EN 1991-4 (Actions on structures, silos and tanks) and EN 1992 (Concrete design), including Annexes.

A finite element analysis of the complete silo shall be done, including but not limited to foundation, walls below cone, inverted cone or slab, silo shell and roof.

The wall design envelope for all loading scenarios shall:

a) Consider that the foundation is supported by vertical springs with upper and lower subgrade values, in order to get vertical positive and negative moments on the wall (inner and outer vertical reinforcement).

b) Consider the restrained condition at the top due to the roof beams.

c) Neglect the potential stiffness provided by the cone to the walls. The wall shall be free for displacement (floating cone).

All conditions have to be taken into account for filling, discharging and refilling of materials as well as the respective dynamic and impact effects. The theory of flow channels by eccentric discharge shall be considered. With this condition, large horizontal bending moments occur which cannot be reflected adequately by overpressure factors.

The loads from superimposed structures, mechanical Equipment, machinery, additional live loads and the soil characteristics and their influence (settlements) shall be introduced into the design.

The minimum wall thickness for a reinforced concrete silo is 200 mm with double layer reinforcement.

For Cement and Raw Meal the lowest μ value shall be used for pressure calculations and the highest value for vertical friction load calculation in the Silo wall. It shall be noted that in all evaluations, the wall friction coefficient μ shall not be taken as greater than Tangent of the angle of internal friction, $\mu < \tan \varphi$.

The horizontal reinforcement in the pressure zone will be designed to take the pressure of the material, temperature and bending effects, and it shall be limited (not more than) to 100 cm²/m, which is rebar diameter 25 mm every 100 mm in both faces. Sufficient horizontal stirrups shall be provided at every reinforcing steel overlap. The lateral pressure produced by the stored material shall be calculated at every m. A graph showing the pressure curves and the contribution of the reinforcement to take those pressures shall be prepared.

Cracks control verifications for the silos have to be submitted together with the structural analyses. The following maximum surface crack widths W_k (for permanent loads and bulk loads) will be allowed:

d) For blending and cement silos:

- Wk = 0.10 mm in the lower 1/3 of bulk height or over the height of aeration
- Wk = 0.15 mm above

e) For other silos:

- Wk = 0.20 mm

The connection between the silo walls or bases and concrete foundations shall be watertight and dust proof.

For Multicell-Silos the developed length of a silo wall between two compartment walls shall not exceed 15.00 m if possible.

For silos with Truck bulk loading, the minimum entrance width shall be 4.00 m, height 4.20 m, and the concrete wall between the openings shall be minimum 2.00 m wide. At the upper 1.50 m of the opening, the width shall be reduced from 4.00 to 3.00 m. The free perpendicular distance between the truck lane and the silo wall shall be at least 2.50 m.

All Silos shall be designed watertight in reinforced concrete; the concrete quality shall be at least C 30/37. If post tensioning shall be used, the respective essential characteristics shall be submitted for approval; the silo construction methodology shall be reviewed and approved by the Owner.

4.20.4 Post Tensioned Silo

The minimum cylindrical wall thickness is 350 mm with double layer reinforcement.

The tendons shall be designed to take a proportion of the lateral pressure; it means the silos will be partially post-tensioned. Tendons shall be designed to take only the hoop tension. The conventional reinforcement shall be designed to take the remaining % of the pressure, the temperature and bending effects as well.

The admissible stress and losses in the tendons shall be calculated jointly with the post-tensioning system supplier. The tendons shall be designed using allowable stresses method or similar according to the codes mentioned above.

If possible, the silo shall be designed with four buttresses (large diameter silos might require six buttresses). The tendons shall be tensioned 180° on both sides simultaneously. In the tensioned sequence, complete circles shall be tensed simultaneously before going to the next level. The pilasters shall be cast monolithically with the Silo wall from the foundation up to the top.

The minimum spacing between the tendons will be 150 mm or 3 times the tendon diameter and shall be increasing gradually from the bottom up to the top following the design pressure curve. In the tendon zone, horizontal ties between the exterior and interior reinforcement shall be placed. The tendons will be used only to the height where normal reinforcement can take the pressures. The tendons shall be discontinued when 25 mm bars at 200 mm can resist the stresses and the pressure. The tendons shall be located inside the outside layer of the vertical wall reinforcement.

The vertical bending produced by the tendon spacing, by the wall thickness change and by the restriction of the bottom slab or the inverted cone ring shall be considered. The bending shall be taken by conventional vertical reinforcement.

The material pressure curve shall be done showing the contribution of the tendons and the conventional reinforcement. When calculating the concrete stress, the areas by the ducts and reinforcement shall be reduced.

The bottom ring of the inverted cone shall be separated from the silo wall and no additional tendons shall be used to take radial loads from the ring.

All essential design data and especially the characteristics of the stored materials, including density, angle of repose and temperature gradient along the silo walls shall be clearly indicated in the calculation sheets and drawings.

The silos shall be designed to ensure complete emptying. Adequate manholes shall be provided (walls, roofs).

Construction Methods and Principles

The cylindrical walls of reinforced concrete silos shall be constructed, if possible, with the slip forming technique. All construction provisions and details for these silos shall be consequently designed, considering the slip forming technique:

a) Complete execution of the shell in a single and continuous operation over its whole height i.e. no cold joints. Contractor shall demonstrate all provisions, in order to avoid cold joints (i.e. batch plant operation, stand-by power supply).

b) Reinforcement steel and post tensioning material disposition for a continuous construction.

c) Inserted and embedded parts to be placed during construction.

d) Appropriate provisions in the shell for intermediate slabs.

Silo inverted cones shall be preferably made with pre-cast concrete elements. Connections and filling with in-situ reinforced concrete after pre-cast elements are placed and fixed.

4.20.5 Inside Wall Surface

If not otherwise specified, the lower third of the inside wall surfaces and the cones of reinforced concrete silos for raw meal and cement shall be troweled smooth preferably during the slip forming.

4.20.6 Silo Roof

The top slab roof shall be made using large steel beams or trusses with steel sheet deck form or precast slabs and waterproof reinforced concrete. The drainage slopes shall be made during the casting of the concrete.

Clinker silo roofs may have a conical, water- and dust-tight cladded steel structure roof.

Special attention shall be given to the connection between silo walls and roof, potential differential expansion due to temperature or dynamic (extraction) loads have to be considered and require an adequately flexible connection.

4.20.7 Steel Silos

The steel silos shall be of weather-resistant steel with quality according to Eurocodes (EN 1993-4-1 steel silo design) or equivalent. Sufficient allowance for corrosion and wear shall be applied to the steel wall design in addition to the statically required steel wall thickness. The connection between the silo shells or bases and the reinforced concrete foundations shall be watertight and dust-proof.

Bolted type steel silos are accepted up to a capacity of 1’000 t. Larger Silos are subject to Owner’s approval.

The roof shall be dust tight, waterproof and shall be provided with sufficient drainage slope.

4.21 Bins and Hoppers

The design shall comply with the following:

a) StDC Part Mechanical Equipment.

b) Weight of material inside of hopper shall be added to the forces acting on the hopper.

c) Minimum material load shall consider the full volume of the bin or hopper and shall not be less than 10 kN/m3 (for light materials)All structural steel members subjected to abrasive action of sliding material shall include 1.5 mm additional steel thickness provision for abrasive wear.

d) Steel plate for hoppers shall be a minimum of 6 mm thickness which includes provision allowance for abrasive wear. For hoppers over 6 m diameter shall be a minimum of 8 mm thickness.

e) No bolts or welds shall project above stored material sliding plane on steel plate.

4.22 Exhaust Chimneys or Stacks

Exhaust chimneys shall be founded on a solid reinforced concrete foundation. For the design criteria of the chimneys please refer to StDC Part Mechanical Equipment.

4.23 Elevator Towers and Shafts

4.23.1 General Design Aspects

High free standing elevator towers and shafts shall be designed to withstand all applicable loads, including dynamic loads from the elevators as well as temperature, wind and earthquake loads. Allowance shall be made for appropriate fixations to neighboring buildings. In order to avoid differential settlement, elevator towers and elevator shafts shall be placed wherever possible on common foundations with the neighboring or surrounding buildings. The design of elevator towers and shafts shall consider and limit the horizontal displacements in accordance with the limits and requirements of the connected or installed Equipment.

4.23.2 Goods and Personnel Elevator Shafts

The shafts for goods and personnel elevators shall be built of reinforced concrete or structural steel with cladding according to the construction of the related building. Doors have to be provided at the required levels and without sill.

All pertinent fixations and rails shall be provided in accordance with the requirements of the elevator supplier.

The machine room shall preferably be located above the top of the shaft. It shall be easily accessible for maintenance and inspection from a deck, platform or gangway over a staircase. The machine room slab shall be designed with anchor rails and lifting provision. The pit at the bottom of the shaft shall be accessible and have a pump sump.

The permitted tolerance of the finished work shall be not more than +/- 20 mm in any case. Building deviations from the exact vertical line shall not be over +/- 20 mm for the total distance inside the elevator shaft from bottom to top.

4.23.3 Bucket Elevator Towers

The design of the bucket elevator towers shall be closely coordinated with the Equipment supplier. The facade of the mid part might be open; under the condition that the elevator casing is designed to withstand the wind loads. The elevator tower structure shall be fixed to neighboring buildings. All fixation and supporting points of the elevator casing and structure shall be designed under consideration of the movements of the Equipment.

4.24 Conveyor gantries and Utility Bridges

Conveyors placed above ground shall be supported by closed or open type bridges of reinforced concrete or structural steel with reinforced concrete foundations. The design shall include adequate safety factors for the Contractor's Equipment loads during construction and additional live load for future belts or pipelines.

Closed conveyor bridges shall be cladded with metal sheets. Sufficient translucent sheets shall be considered to provide adequate daylight.

The conveyor bridge for a single conveyor shall be provided with the following clearance for unobstructed passage and maintenance walkway:

- One accessible maintenance walkway of min. 800 mm on one side and one accessible maintenance walkway of min. 600 mm on the other side of the conveyor for conveyors larger than 800 mm width. For conveyor belts with a width of 800 mm or smaller only one walkway of 800 mm can be accepted upon Owners approval.

The conveyor bridge for multiple conveyors shall be provided with the following clearance for unobstructed passage and maintenance walkway:

- One maintenance walkway between the conveyors of min. 1000 mm and two accessible walkways of min. 600mm on both outer sides of the conveyors. For conveyor belts with a width of 800 mm or smaller only one walkway in-between both conveyors of 1000 mm can be accepted upon Owners approval.

For road or walkway crossings, a full underneath closure shall be installed to prevent spillage of material. The appropriate collection/cleaning of these spillages shall be considered.

The utility bridge with one side cable tray and pipe racks shall be provided with a minimum clearance for unobstructed passage of min. 800 mm.

The utility bridge with two side cable tray and pipe racks shall be provided with a minimum clearance for unobstructed passage of min. 1000 mm.

Platforms which are not enclosed shall be fully guarded with handrailing. If not otherwise specified, the conveyor and utility bridge walkways shall be of grating. Columns or trestles supporting conveyor bridges shall be spaced so as to provide a minimum of 10 m clear access between columns. Where bridges cross access roads or hard stands, a minimum height of 7 m shall be provided from surfaced ground level to the underside of the conveyor bridge. Supporting columns or trestles next to traffic areas shall be protected (concrete, steel or earth, stones etc.) or shall be designed for the maximum impact loads of the trucks used at the operation site.

Bridges carrying conveying pipes shall be designed and dimensioned to carry the number of pipes required for the specified purpose including 20% available spare capacity for future installation.

Bridges carrying cables and utility pipelines shall be designed and dimensioned for the specified purpose including 20% available spare capacity for future installation.

4.25 Electrical Rooms and Facilities

Refer also to the StDC part Electrical Equipment and Systems.

4.25.1 General Health and Safety Aspects

International Codes (EN, IBC or DIN) and the relevant local regulations shall apply for all aspects of emergency and safety in electrical rooms and facilities, including fire protection and evacuation of electrical areas, i.e. fire proof doors, emergency exits, door opening towards the outside, single action unlock of inside door locks and emergency lights.

Sufficient fire protection measures according to international standards shall be taken.

4.25.2 Electrical Rooms

The electrical rooms shall be sufficiently sized and shall provide spare space for future modifications and additions. The distance between the switchgear panel rows shall not be less than 1.8 m between operation fronts, 1.5 m between an operation front and a rear sidewall and 1.0 m off the panel rear side to the wall (if access is required).

All electrical rooms shall be located above surrounding ground level. They shall be designed and constructed watertight and dustproof. Electrical rooms shall have no windows.

All electrical rooms are unmanned and shall be cooled by closed circuit cooling units. Non-condensing room temperature condition shall be maintained. Equipment with excessive heat dissipation shall preferably lead the heat directly to the outside of the room. Electrical rooms shall be equipped with an appropriate heating and cooling system to avoid condensation in the rooms. The design of the air conditioning system shall comply with the specifications as per Paragraph 4.12 (Heating, Cooling, Air Conditioning).

For the finishing and conditions of electrical rooms the respective individual specification shall be applied.

All electrical rooms shall be constructed to prevent the entry of vermin or rodents.

The outer entrance of electrical rooms shall be splash-proof.

4.25.2.1 Cable Installation in Electrical Rooms

For ease of cable installation, all electrical rooms shall be provided with a cable basement, allowing the installation of cable trays. The cable basement shall preferably be located above surrounding ground level. The minimum clear height of this cable basement shall be 2.2 m. Access to the basement shall preferably be provided from the outside, alternatively from the electrical room whereby fire barrier functions of access doors as well as the applied cooling systems require special attention. In general, the cable basement shall extend over the same area as the electrical room and shall be water- and dust-tight.

Alternatively, a design with false floor might be foreseen, provided the approval by the Owner.

4.25.3 Control Rooms, Computer & X-Ray Rooms as part of the technical building

The construction and finishing of control rooms, computer rooms and X-Ray rooms shall be similar to that of electrical rooms.

Control rooms, computer rooms and X-Ray rooms shall be furnished with:

- Air conditioning system with non-visible ducting.
- Windows with sun protecting glass as well as manually adjustable louvers for sun protection.
- Floors shall be furnished with stoneware tiles or equivalent subject to Owner approval.

False floors shall be avoided for new constructions. Cable installation shall preferably be from cable trays installed above false ceilings of the lower rooms.

4.25.4 Battery Rooms

Separate battery rooms as specified below shall be foreseen if required by local legislation.

In such a case, the rooms shall be furnished with a separate ventilation system (no recirculation of exhaust air into common cooling ducts).

The finishing standard of the inside walls, floor and ceiling can be of concrete or masonry without special plastering or paint. Nearby the batteries the presence of possibly aggressive liquids and atmosphere shall be provided for, i.e. acid resistant paint and acid resistant tiles shall be applied if required.

4.25.5 Main and Distribution Transformers

4.25.5.1 Sheltered Installation (Indoor)

Main and distribution transformers shall be installed in individual transformer cells with roofing and fire walls. The transformers shall be cooled by natural air draught. For sheltered transformer cells, the siding shall be of a galvanized steel structure with a wire netting of max. 10 mm mesh size up to the height of approx. 2.00 m above ground.

The upper part shall be closed with masonry or metal cladding for rain protection from the side. The doors of each cell shall be sized for maintenance purposes. Adequate openings for erection and taking out of the transformer for repair or inspection shall be foreseen with doors or removable side sections.

The transformers shall, as far as feasible, be located approx. 0.5 m above surrounding ground level. The roof construction shall consider the required hot air release at the highest point. A pit or oil basin shall be provided below the transformer in case of liquid immersed (oil-cooled) transformer.

4.25.5.2 Outdoor Installation (preferred solution)

Outdoor installed main transformers shall be protected with a solid wire mesh fence with door, allowing for erection and later taking out of the transformers for repair or inspection. The transformers shall be cooled by natural air draught. Fire protection walls to adjacent transformers and rooms are required. The transformers shall, as far as feasible, be located approx. 0.5 m above surrounding ground level in order to allow for good cooling. A pit or oil basin shall be provided below the transformer in case of liquid immersed (oil-cooled) transformer.

4.25.5.3 Transformer Pits/Oil Basins

The transformer pits or oil basins below the transformers shall be watertight and if required by the country, coated with oil resistant epoxy paint. Transformer pit sumps shall have a lockable gravity drain for ease of storm water release.

4.25.6 Cabling

4.25.6.1 Duct Bank or Conduit Bank

Conduit banks with pipes, certified for electrical installations shall be used as per typical drawing in StDC part Electrical Equipment and Systems. For power, control and communication cables the pipes shall have the specified diameter as per cable specification for installation and at least 20% capacity for future installation or at a minimum one spare pipe for each kind of cable shall be installed along each run. The pipes shall be properly positioned and embedded in sand along the entire length and embedded in reinforced concrete in road underpasses prior to the cable installation. The top of the concrete shall be marked and the backfill with a tracer wire for ease of future detection. The pipe joints shall be waterproof. Pipes shall slope to the manholes.

Manholes (cable pull pits) are required for distances of more than 60 meters or where the cable run changes direction. They shall be of a uniform design with 2.0 m clear height and a length and width of 1.5 m. Openings to enter the manhole shall be approximately 0.5 m above ground level and shall be equipped with an access ladder and a cover of rigid design with water tight sealing. A pump sump shall be provided below the opening. The location of these manholes shall be out of the paved areas.

Conduit banks shall not cross open areas where future placement of buildings is planned.

4.25.6.2 Cable Galleries

If applicable, cables might be installed on steel structure galleries as an alternative to cable duct banks. A cover shed shall be installed to protect the cables from sun and dust. Suitable and safe access for installation and maintenance of the cables shall be provided along the galleries.

Cable galleries with installations on both sides shall have a minimum clear cross section of 2.2 m width x 2.2 m height. Cable galleries with installations on one side only shall have a minimum clear cross section of 1.6 m width x 2.2 m height. A minimum walk through width of 0.8 m shall be maintained.

Existing conveyor and utility bridges shall be used for cable installation where applicable.

Escape route, i.e. emergency access or exit at least every 100 m.

4.25.6.3 Cable Tunnels

If walk-through cable tunnels are requested by the Owner, the below criteria shall be followed:

Cable tunnels shall follow roads and not cross open areas where future placement of buildings is possible.

Cable tunnels with installations on both side walls shall have a clear minimum cross section of 2.2 m width x 2.2 m height. Cable tunnels with installations on one side wall only shall have a clear cross section of 1.6 m width x 2.2 m height.
A minimum clear walk through width of 0.8 m shall be maintained.

Cable tunnels shall be designed and constructed watertight.

All cable tunnels shall be executed with a slope and a gutter along one tunnel wall where the cable trays will be installed. The gutter shall lead into sump holes. Above each sump an emergency exit, preferably combined with an overpressure relief and access opening to install a mobile sump pump, shall be provided.

Cable tunnel intersections and tee-offs shall be executed with a walk-through underpass to avoid a total blockage of access once the cable trays, cables and pipes are installed. Cable radius requirements for plastic pipes shall be accounted for in the design of the tee-offs.

Forced ventilation shall be provided where required duly considering fire barrier sections and requirements.

Cable tunnels may also be used for non-fire and non-heat hazardous piping installation shall be installed between main power distribution buildings and the different electrical rooms and major buildings.

Escape route, i.e. emergency access or exit at least at every 50 m.

4.25.6.4 Outdoor Lighting

Cables for outdoor lighting may be buried in sand and marked with suitable markings. The mast foundation shall be constructed with reinforced concrete, for protection of the mast from traffic.

4.26 Lighting

Lighting design, supply and installation for buildings, structures, facilities, roads and stabilized surfaces shall follow the guidelines as specified in StDC Part Electrical Equipment and Systems.

4.27 Grounding and Lightning Protection

The grounding system shall be uniform and coordinated for all buildings and structures. It shall fully consider the electrical requirements and the local codes.

For the plant grounding, the system "foundation grounding" with emphasis on potential equalization shall be foreseen.

A copper or galvanized steel tape shall be laid as a ring type grounding conductor on the ground of every building. The conductors shall be fixed with clamps onto reinforcement bars and be extended with the required leads to the tapping points above ground. Refer to typical drawing in StDC Part Electrical Equipment and Systems. Welding onto reinforcement bars shall be strictly prohibited.

An appropriate lightning protection system shall be installed.

Close coordination of the design and erection between the foundation grounding, the electrical grounding and the lightning protection shall be provided.

4.28 Cathode Protection

Cathode protection of underground steel structures and installations shall be installed if soil properties and/or relevant conditions (e.g. marine environment) or standards ask for.

4.29 Tanks

All tanks storing liquids, which are:

a) Flammable

b) A danger to the environment

c) A danger to personnel

d) Leakage could create risks

shall be installed in a containment basin or provided with double wall isolation and alarm system for leakages.

Uplift load case (empty condition) to be considered for all tanks located below or partly below ground level.

4.29.1 Containment

Such containment basins shall be governed by the applicable regulation.

No open drains or permanently installed automatic pumps shall be incorporated into these containment basins.

The containment basins shall have a manual valve to ensure that they do not fill with rainwater or snow.

If secondary containment may have to be connected to the storm water network: in such case, an isolating valve shall be provided to enable the retention of any spillage within the secondary containment or to drain clean rain water as required.

De-oiling pit shall be provided for secondary containments of any oily product tank.

The secondary containment shall be watertight (if in concrete, special design shall be considered to ensure this water tightness requirement, including inner surfaces painted with epoxy sealant) and fulfill the requirement of the local regulation.

For oily product unloading facilities, specific arrangement is required to collect all rain water from the unloading platform to a specific de-oiling facility. No oily spillage to the storm water is allowed.

4.29.2 Capacity

The secondary containment system shall provide storage of at least 110% of the tank or lubricant/hydraulic systems maximum capacity. If more than one container is stored, the system shall be capable of storing 110% of the biggest container's capacity or 25% of their total capacity, whichever is the largest.

A room or vault can provide appropriate secondary containment. The walls and floor shall be sufficiently waterproof to contain spilled oil. If such containment has any drains or other openings, that dray or opening shall be provided with a valve to prevent release of product outside the containment area.

This document does not describe requirements for tanks that are ancillary to equipment such as transformers and hydraulic oil tanks.

National regulation shall be followed for the storage tanks and its handling system, based on the size and use of the tank.

4.29.3 Additional safety requirement

In addition, the below minimum safety requirements need to be considered for their installation:

a) Minimum Distance from Property Lines/Buildings.

b) Fuel tanks shall be at least 6m from a building or property line.

c) The vent pipe shall be located at a minimum distance of 5m from any electrical equipment, sparkling potential emission or hot temperature source.

d) Fuel tanks shall clearly indicate type and properties of fuel they are designed for.

4.30 Waterproofing

Waterproofing design shall comply with best practices design such as:

a) Accessible areas (e.g. roofs) shall be protected against potential damaging.

b) Light metallic roofs with less than 10% slope shall prove the non-accumulation of water by additional deflection.

c) Only certified waterproofing material and products (by EN or US institutions) should be accepted and are subject to Owners approval.

d) For tanks where no waterproofing material is placed:

- Structural design of walls shall fulfil both concepts: hinged and fixed base
- Design shall follow the latest EN 1992 Part 3 "Liquid retaining and containment structures". The classification of tightness shall be tightness class 2 or more stringent
- Stresses and strains in concrete elements imposed by deformations shall be determined as per Annex L of EN 1992-3
- Crack width calculation shall follow Annex M of EN 1992-3

5. INFRASTRUCTURE

5.1 Fire Prevention and Fire Fighting

5.1.1 General

A comprehensive fire prevention and firefighting system according to applicable standards (could be local or international standards imposed by the authorities or insurer) including all protective building arrangements and required firefighting facilities shall be provided. They shall cover all plant sections with potential fire hazard such as but not limited to:

a) Electrical rooms, transformer cells and cable basements

b) Installation tunnels and installation shafts

c) Control and computer rooms

d) Air conditioning rooms

e) Elevator control rooms

f) Workshop, parts and bag storage, burner platform and all other areas of the plant with potential fire hazard

g) Lube Oil storages

h) Fuel storage and tanks

i) Fuel transport and pump areas

j) Fuel filling stations

k) False floors and false ceilings in above named rooms and buildings

The envisaged fire prevention system shall cover the civil and structural aspects and consists mainly of fire barriers.

For information on "Fire Detection Equipment" refer to StDC part Electrical Equipment and Systems.

5.1.2 Fire Barriers

All fire barriers and fire barrier doors shall be of the fire resistance class F90 or T30 respectively according to Eurocode EN ISO 1182, or equivalent.

All fire hazardous areas, electrical rooms, cable and installation openings towards outside or adjacent rooms shall be closed by fire barriers.

Exits of cable basements shall be closed by fire barriers with fire barrier doors.

Cable tunnels shall include fire barriers at reasonable intervals. The aeration of the tunnels shall not be reduced due to the installed fire barriers.

Cable trays/ladders have to be interrupted at fire barriers.

Building sections shall be provided with overpressure releases and emergency exits.

The sealing material used shall be suitable for easy installation of additional cables and provide a simple method of repairs after such Works.

Fire barriers shall be closed as soon as all cables have been pulled and fixed, but latest prior to commissioning.

5.1.3 Fire Fighting

5.1.3.1 Permanent Installations

The firefighting water system shall be distributed in order to cover all production buildings, ancillary buildings, service buildings and facilities. The firefighting water-pressurizing system shall be furnished with adequately sized reservoir, diesel engine driven emergency pumps, as required by the code or insurance. The installation shall consist of as a minimum:

a) Piping network with pipelines, valves, pumps

b) Adequate number of fire hydrants with hoses and hose cabinets

5.1.3.2 Mobile Installations

All electrical rooms as well as any other potential fire hazard areas shall be equipped with adequate firefighting Equipment. It shall allow for easy accessibility and handling, shall be marked with signage and shall consist of:

a) Adequate number of mobile fire extinguishers of appropriate size and type depending on the potential fire Class

5.2 Water Supply and Treatment

The design shall allow for reduced water consumption. Where feasible and indicated provisions for adequate wastewater recycling shall be taken.

5.2.1 Potable Water Supply and Treatment

All main process and occupied buildings shall be provided with potable water as required by the number of personnel.

A pipeline system and pumps shall transport the potable water from the source to the plant. The design shall allow for sufficient quantity and pressure from the well/source to the supply-points.

The water treatment plant for potable water shall meet the local standards and code for drinking water. Sufficient water storage basins or tanks shall be provided.

5.2.2 Process Water Supply and Treatment

The design quantities, qualities and pressures have to meet the requirements of the manufacturer of the Mechanical Equipment.

The water supply system shall include:

a) Water intake building and facilities for installation of intake pumps, filters and other intake Equipment, if required.

b) Pump station, filters, pumps, valves and pipelines for intake and transportation of the required quantity of water from the source to the supply-points, including heat trace and insulation where required. Branches to be fit with valves for isolation.

c) Water treatment plant and facilities for mechanical and chemical treatment, clarification, flocculation and sedimentation as required.

d) Water basins for storage of raw water, treated water, cold water and warm water.

e) The slurry of the process water, if environmentally harmless, may be drained with storm water, if compliant with the site permit and if conform to the local standards and regulations.

Emergency situations on the cooling water system shall not create overflows or flooding to Equipment and process buildings.

5.2.3 Evaporative Cooling Systems

Emergency situations on the cooling water system shall not create overflows or dangerous situations to Equipment and process.

Evaporative cooling systems should be designed and constructed to facilitate safe operation and maintenance, help cleaning and disinfection and control the release of water droplets. The following requirements shall be fulfilled:

a) Cooling towers and evaporative condensers shall be made of corrosion-resistant materials that are easy to clean and disinfect.

b) Towers should be located so that there is an unimpeded supply of ambient air and no obstruction to the exhaust stream from the tower. Ideally, towers shall not be located near to any air conditioning or ventilation inlets not close to open windows. There shall be adequate space around the tower for routine maintenance and inspection and around gantries or platforms, access doors and hatches, so that all parts of the equipment that require inspection and maintenance can be safely accessed.

c) Drift eliminators shall be installed in all towers that have fans and shall reduce the drift loss to less than 0.01% of the water flow through the tower.

d) The base tank or pond of cooling towers shall be fully enclosed to prevent direct sunlight onto the water. The bottom of the tank or pond should be sloped, or otherwise designed, to facilitate draining with a suitably sized drain connection at the lowest point.

e) The tower shall be made of materials that do not support microbial growth and can be readily disinfected.

5.2.4 Fire Fighting Water Supply and Treatment

The firefighting water supply and treatment system shall be designed in combination with the supply and treatment system for the process water. The distribution system shall be independent from the process and potable water systems and shall include all process and ancillary buildings. The piping system shall allow opening and closing of independent circuits and lines via valves. In case of fire, firefighting water shall be retained in a fire fighting water containment basin or similar.

5.2.5 Non-Potable Water

The non-potable water system shall include the wash down services, utility services and garden services.

Provided there is sufficient supply from the source, the non-potable service water may be taken from the potable water system.

5.2.6 Water Distribution

The water distribution system shall be divided into independent streams for process water, potable water and firefighting.

Sufficient number of valves shall be installed for network maintenance purposes, in order to open and close independent circuits and lines.

5.2.7 Materials and Workmanship

Water supply piping shall be designed according to the latest valid Eurocodes standards or equivalent and shall consist of outside and inside corrosion protected pipes.

The whole water supply shall be designed and installed in such a manner, that it will be protected and proof against mechanical, electrical, and chemical attack and shall be tested for 1 1/2 times operating pressure before all lines are backfilled if underground.

5.3 Sewerage System and Sewage Treatment

The sewerage system shall include the collection and treatment of sewage water, as well as lead away of treated water. The sewage treatment shall include water from all sanitary facilities, toilets, and kitchens, wash down water and waste water from laboratories. The treatment of sewage water and final disposal of the treated water shall be in accordance with the local statutory regulations. The BOD (Biological Oxygen Demand) of the treated water shall be not greater than 20 PPM. Oil separating systems shall be installed where required.

If not otherwise specified, the treated water shall be guided into the lead away drainage system.

Manholes (cable pull pits) are required for distances of more than 100 meters or where the pipe changes direction. They shall be of a uniform design with variable height and a length and width of 1.5 m. Openings to enter the manhole shall be approximately 0.20 m above ground level and shall be equipped with an access ladder and a cover of rigid design with water tight sealing. A pump sump shall be provided below the opening. The location of these manholes shall be out of the pavement areas.

5.4 Storm water Drainage System

The storm water drainage system shall include the collection, drainage and lead away of surface water, including collection and drainage of surface water coming from adjoining properties in accordance with the local authorities and codes.

Generally, the storm water drainage system shall be conducted by the road surface and connected to open channels. Open drainage channels shall include measures to protect personnel and mobile equipment. In the areas of production, ancillary and service buildings, the channels shall be constructed with reinforced concrete bottom and walls and covered with pre-cast concrete elements for over-passing, where required.

For the drainage system, a rain scenario with 10 years return period shall be considered. Applicable rain duration shall be determined based on local climatic conditions and run-off regime.

The surface run-off coefficient C for drainage calculations depends on the ground or roof type and its purpose. Typical surface coefficient C values in industrial areas are:

Ground or Roof Type	Surface coefficient C
Inclined roofs	1.00
Asphalt or concrete road	0.80 to 0.90
Non-paved roads	0.50 to 0.70
Impermeable ground with lawns	0.20 to 0.35
Permeable ground with vegetation	0.10 to 0.20

Table 6: Surface coefficient C

5.5 Roads and stabilized surfaces

5.5.1 General

Roads and surfacing shall be designed in accordance with the relevant technical specifications and codes of practice of either European or American standards.

Roads shall be designed for the maximum imposed loads and of such width to suit all vehicles used at the Plant Site, but at least in accordance with Eurocode EN 1991-2.

The road design shall consider the actual and future vehicle loads, the traffic frequencies and the sub-ground conditions of all plant roads.

All drains, pipes, sewers, channels and conduit banks as well as crossing of existing installations shall be completed before the construction of the roads.

Avoid placing of manholes and underground utilities including electrical duct banks under paved surfaces.

5.5.1.1 Road slope

The maximum sustained grade for roads and ramps is 10%; up to 15% is acceptable for short distances (i.e.: truck off-loading areas, entrance of storages).

5.5.1.2 Road Width

The width of the roads within the plant shall be appropriate for the type of vehicles and amount of traffic using that particular road. In any case the design of the roads shall be suitable for access by emergency vehicles such as fire trucks or ambulances.

Roads where there is a risk of falling over an embankment shall be protected with suitable guard rails or berms. Height of the berm should be min. half of the wheel diameter of the biggest vehicle operating in that area.

To define properly the size and the type of the road, a risk assessment needs to be conducted to determine adequate road width.

5.5.2 Materials for roads and stabilized surfaces

Roads and stabilized surfaces shall consist of crushed stone of the minimum size of 75 to 100 mm. It shall be free from dust, waste, metal, vegetation or any other foreign material.

Sub-base shall consist of crushed hard rock or gravel of approved sizes.

The wearing courses shall be suitable for the temperature and rainfalls that are recorded in the area.

5.5.3 Preparation of Formation

The formation shall be compacted to an even and uniform surface, which shall be parallel to the finished surface of the road or path. Rolling shall be carried out with heavy rollers, adequately adapted to the nature and condition of the soil. After compaction or stabilization (if required) the formation shall yield a California Bearing Ratio of 15%.

The formation surface design shall allow for effective and permanent drainage during the Works.

5.5.4 Sub-Base

After the formation has been adequately constructed and compacted, a sub-base consisting of well-graded natural sands, gravels or rock or mixtures thereof shall be laid and compacted to a finished thickness of at least:

a) 300 mm (one or two layers) for concrete, asphalt or gravel roads with proctor 95% or more

b) Or in accordance with the local conditions, subject to Owner's request

5.5.5 Concrete Surfacing

A sand layer, 80 mm thick (max. grain size 16 mm), covered with a PE foil of min. 0.1 mm thick, shall be placed between sub-base and concrete slab. The slab shall be made of concrete C25/30. One layer of reinforcement steel or welded mesh or plastic fibers shall be used in order to avoid shrinkage.

The required slab thickness for roads and stabilized surfaces shall be at least 180 mm.

The design shall also include provisions for all joints. The following maximum distances shall be ensured:

a)	For contraction joints (saw cuts)	5 m
b)	For expansion joints	30 m
c)	For longitudinal joints	5 m

After finishing operations and surface broom sweeping have been completed the exposed surfaces shall be cured by covering the concrete for 24 hours with wet burlap or other approved material, applied as soon as the concrete has hardened and followed by a 7-day curing period of ponding, spraying with an approved curing compound or covering with wet earth, straw, burlap or cotton mats which shall be kept saturated with water for 7 days. Instead of this wet curing procedure, an approved impervious membrane may be applied immediately after finishing the concrete surface.

5.5.6 Bituminous Surfacing

The bituminous pavement shall be placed in two layers:

a) Base course, min. 80 mm thick

b) Wearing course shall not exceed a final compacted thickness of max. 40 mm

A prime coat of 1.5 to 2 kg/m^2 of liquid bitumen shall be sprayed on the first layer.

5.5.7 Gravel Roads

Roads and stabilized surfaces which are neither concrete nor asphalt shall be prepared with compacted gravel/crushed limestone and optionally sprayed with bitumen or similar.

5.5.8 Tolerances

Tolerances on the finished layers, regardless of the form of construction shall not exceed the following values (based on the measurement with a 4 m long lath):

a)	Formation (sub-grade)	+/- 40 mm
b)	Sub-base	+/- 25 mm
c)	Surfacing	+/- 10 mm

The road surface shall be min. 200 mm above ground level and consider special requirements for traffic ability under i.e. flooding conditions.

5.5.9 Road Marking and Signposts

Road marking and building, direction and traffic control signposts in local language (and English language) shall be provided as per permit, local regulations and standards.

5.5.10 Quarry Roads

Haul road rolling surface width shall be 3.5 times the width of the widest vehicle for two-way traffic and 2.5 times for one-way traffic; the space needed for road ditches and berms shall be added. At bends and corners the road rolling surface shall be increased to 4 times the width of the widest vehicle.

Edge protection and safety berms shall be at the minimum height of 1.5 meters, or at the radius height of the biggest tire of equipment operating in that area, whichever is the greatest. The safety berms shall be continuous and built with compacted fine materials and not with large blocks. In any case, it shall be enough to avoid the mobile equipment crossing the berm.

Reversing areas shall be designed with adequate space and edge protection.

Blind curves shall be avoided.

Sufficient drainage in haulage roads is required.

The inclination of a haul road for off-road dump trucks shall not exceed 8%. Inclinations of 10% shall only be accepted for stretches no longer than 150m in a total of 400m.

For temporary or short ramps, e.g. between two benches, a maximum inclination of 12% can only be accepted for a maximum of 100m.

Collision or center berms: Haul roads with long or high grade shall be provided of central collision berms as means of physical mitigation in case of runaway or break failure of mobile equipment. Collision berms should be 50m long and separated by 30m gaps.

Runaway or escape lanes: Where zigzag haul roads are used, the escape lanes shall be placed at the beginning of each sharp curve (seen from the top). The escape lane should preferably have a reverse grade (up to 20%/11°). Emergency lanes shall have the following min dimensions: 10–12 m wide and 30–60 m long, depending on individual mobile equipment and inclination. Their location has to be marked with signs.

A risk assessment shall be conducted to determine the need for emergency stoppage lanes (or escape way) in case of brake failures on heavy equipment when driving a ramp. A risk assessment shall be done for roads with grade between 10 and 15%. The emergency road design shall be completed with the assistance of the technical authorities. As for the other roads in the quarry, the berms shall be built with compacted "earth" or granulated materials and not with blocks.

5.6 Fencing and Gates

Boundary fencing if required by the traffic plan with doors and gates shall be installed for the plant area. If not otherwise specified, the boundary fencing shall consist of a 2.40 m high perimeter fence with galvanized steel posts on a reinforced concrete pedestal, with galvanized chain wire fencing and 3 lines of barbed wire at the top. Sufficient number of vehicle gates and personnel doors shall be installed according to the traffic plan.

The main gate shall be motorized and of solid galvanized steel. Individual, motorized boom barriers shall be installed for incoming and for outgoing traffic at the main gate.

An automated access control system shall be provided.

5.7 Masterkey System

An overall plant master key system covering all plant doors, sub dividing them into functional or organizational sectors as required, shall be installed.

A master key sub-system, as integral part of the overall plant key system shall cover all electrical room doors and the respective building access doors as follows:

a) Only one specific common key for all low voltage and control room doors

b) Only one specific common key for all medium and high voltage and transformer room doors

c) One semi-master key for these two categories of rooms

5.8 Jetty Structure

The jetty and access bridge shall be designed for the local weather conditions, sub-soil conditions, present- and future river/sea water behavior as well as for on- and off-going barges and for various other loads and stresses of installed and mobile Equipment for the requirement of the project. Proper protection along the jetty and access bridge for landing barges shall be provided.

The design of the jetty shall be verified by mathematical model testing in a laboratory, if required, and the test results shall be provided for the design.

Rescue devices and means shall be provided for works performed near water, as per international standards.

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