

DESIGN CRITERIA AND STANDARDS

Civil DCS

Civil and Structural Design and Construction

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**HEIDELBERG
TECHNOLOGY CENTER**
HEIDELBERGCEMENT Group

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1 Introduction

The requirements in the Particular Design Criteria and Standards overrule the general requirements of the Design Criteria and Standards, in case of discrepancies.

Contractor shall present any conflicts between the local codes and standards and the Employers criteria to the Employer in writing requesting clarification.

2 Definitions

The following words and expressions shall have the meanings hereby assigned to them:

Term	Explanation
Contractor	Means the entity named as Contractor in the main contract.
Employer	Means the entity named as employer in the main contract.
DCS	Or “ Design Criteria and Standards ” means the documents as referred to in Annex 5 or the Employer requirements hereof, and including any specifications and other Employer requirements in respect of the Works to be carried out by the Contractor, if any, and any Variation to such document.
PDCS	Or “ Particular Design Criteria and Standards ” means the documents as referred to in Annex 4 or the Employer requirements hereof, and including any specifications and other Employer requirements in respect of the Works to be carried out by the Contractor, if any, and any Variation to such document.
Site	Means the location as identified in the main contract where the Permanent Works are to be delivered or executed.
Works	Means all the work and design to be performed by the Contractor including temporary work and any Variation as specified in the Contract and the Employers Requirements.

3 Codes and Standards

The design, manufacturing, provisions, installation and construction of all works, shall conform to the local and national codes, standards and safety requirements of the country of the Works and shall conform to the codes and standards mentioned in the DCS.

The design and construction of the Works shall be carried out in accordance with the regulations and requirements of all relevant legal authorities.

4 Work, Material and Conditions

Building materials, working methods, site equipment, etc., shall be applicable for the conditions at Site, additionally:

- a) All materials and manufactured items included in the project shall be new and unused.
- b) All Works shall be executed in a safe and clean way and be of high quality workmanship.
- c) A method statement shall be prepared by the Contractor and approved by the Employer before start of Work.
- d) Errors during execution require approval of Employer before correction can occur.

5 Design

5.1 General

Buildings and other structures shall be designed and constructed with adequate strength and stiffness to provide structural stability, protect nonstructural components and systems from unacceptable damage, and meet the serviceability requirements, additionally:

- a) Design Briefs and Design Calculations shall be prepared in an orderly manner and submitted to the Employer for peer review and submitted to the local authorities if necessary
- b) Calculations shall be signed and sealed by a professional engineer, with a copy provided to the Employer for his records.
- c) The design calculation shall be done only with software that has been previously agreed upon by the Employer.
- d) All designs for walkways, platforms and stairs shall respect the local clearance requirements especially as it relates to rescue routes.
- e) Platforms and stairs above roads and public walkways shall be enclosed to prevent material falling.
- f) All main frame connections shall be bolted.

5.2 Design Life

The design life of the structure shall be at least 50 years unless otherwise approved by the Employer in writing.

5.3 Loads

The design loads listed are the minimum requirements of the Employer. If the applicable loads and load combinations or local standards are higher, the more stringent requirements shall be used for the calculation and design.

The static and dynamic loads of the process equipment and machinery including liners and/or insulation shall be respected and taken into account in the design and anchorage detailing.

Floor and roof live loads and dead loads shall be shown on the drawings or included in the general notes.

5.3.1 Dead Loads

These loads consist on the weight of all construction materials incorporated into the building, fixed machinery and equipment.

a) Weight of materials:

- | | |
|---------------------------------|------------------------|
| 1. Concrete self-weight | 25.0 kN/m ³ |
| 2. Structural steel self-weight | 78.5 kN/m ³ |

5.3.2 Roof Live Loads

These loads are produced during maintenance by workers, equipment, materials and during the life of the structure by movable objects that are not occupancy related.

a) The following roof live loads shall be used:

- | | |
|--|-----------------------|
| 1. Live Load for inaccessible roofs | 1.0 kN/m ² |
| 2. Live load for accessible inclined ($\geq 10^\circ$) roofs | 2.0 kN/m ² |
| 3. Live load for accessible flat ($< 10^\circ$) roofs | 3.0 kN/m ² |
| 4. Dust Load | 0.5 kN/m ² |
| 5. Utility loads as required | |

5.3.3 Floor Live Loads

These loads are produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, or dead load.

a) Floor live loads shall be based on probable area loading in addition to equipment loads, irrespective of flooring material (concrete, grating, checkered plate)

b) The following floor live loads shall be used:

- | | |
|---|------------------------|
| 1. Conveyor walkways | 1.5 kN/m ² |
| 2. Operating & maintenance floors | 2.5 kN/m ² |
| 3. Access platforms & walkways | 2.5 kN/m ² |
| 4. Stairways | 2.5 kN/m ² |
| 5. Operating & maintenance floors (where spillage may accumulate) | 5.0 kN/m ² |
| 6. Preheater main floors | 5.0 kN/m ² |
| 7. Preheater secondary platforms | 2.5 kN/m ² |
| 8. Dust Load | 0.5 kN/m ² |
| 9. All areas for transport and storing refractory * | 15.0 kN/m ² |
| 10. Slab on grade (reference item e) below) | 17.5 kN/m ² |

* Reduce minimum floor live load due to refractory and storage to 10.0 kN/m² for building columns and foundation systems, if allowed according to country codes and PDCS. Clogging load case shall be analyzed separately.

- c) All walkways and platform beams shall support a moving load of 5.0 kN (this is used for checking single member size.)
- d) The uniform and concentrated loads described above are not to be applied simultaneously. The 5.0 kN concentrated load shall be applied over an area of 750 mm x 750 mm.
- e) Loads associated with trucks, forklifts and other vehicles shall be considered, if applicable.

5.3.4 Wind Loads and Snow Loads

The wind and snow loads shall be according to country codes and PDCS.

5.3.5 Seismic Loads

The seismic loads shall be according to country codes and the PDCS.

5.3.6 Crane Loads

Crane loads shall be based on the given loads from the original equipment manufacturer and the following loads shall be considered:

- a) Vertical wheel loads
- b) Lateral load
- c) Longitudinal Loads

5.3.7 Equipment Loads

Equipment loads shall be based on the given loads from the original equipment manufacturer and the following loads shall be considered:

- a) Dead loads
- b) Live Loads
- c) Static loads
- d) Dynamic loads

5.3.8 Impact Loads

Impact protection barriers shall be provided for all columns placed near trucks, wheel loaders, fork lifts or other vehicles paths. Alternatively columns shall be designed for horizontal impact loads according to the relevant standards.

5.3.9 Other Loads

The following loads shall be included as required in the civil design:

- a) Process duct and chute loads including coatings, insulation and liners
- b) Thermal expansion and friction loads
- c) Loads due to soil / water pressure
- d) Loading condition due to sequence of construction or maintenance
- e) Dynamic pressure loads (at curves, elbows, etc.)
- f) Loads out of temperature and temperature differences
- g) Loads out of temperature due to radiation

- h) Critical temperature effects
- i) Emergency loads
- j) Load due to moving vehicles near buildings / structures
- k) Or any other loads recommended

5.4 Risk Analysis

A risk analysis shall be done to evaluate the loads from spillage or other accumulations, especially for transfer points, on load combinations, and it shall be submitted to the Employer for approval.

5.5 Allowable Displacements and Deflection Limits

Each structure shall be designed to limit the vertical and horizontal displacements (of foundations, buildings, floors, facades) in accordance with the limits and requirements of the equipment suppliers and the local codes and standards, additionally:

- a) If the equipment is supported at several supports, the supports shall be executed so that detrimental differential settlements are avoided.
- b) Deflections and displacement in structures due to the different loads are not permitted to exceed the specified limits given by the equipment and machinery provider, the PDCS and/or the country codes.
- c) Maximum allowable deflection for all beams is $L/300$.
- d) If masonry walls are on a steel structure, then the deflection is limited to $L/500$.
- e) Beams with large spans shall be cambered. The amount of pre-camber shall be submitted to the Employer for approval.
- f) Maximum allowable deflection to all cantilever beams is $L/200$.
- g) The maximum vertical deflection of Hoist beams shall be $< L/500$ of span.
- h) The maximum vertical deflection of Hand Operated Cranes Bridge beams shall be $< L/600$ of span.
- i) The maximum vertical deflection of motorized industrial cranes bridge beams shall be $< L/800$ of span.
- j) The maximum horizontal deflection of Hoist and Crane beams shall be $< L/600$ of span
- k) Maximum vertical and horizontal deflection of stacker/re-claimer rail supporting members shall be according to the values specified by the equipment supplier.

5.6 Vibrating Equipment

Heavy machinery with impacting or rotating masses requires a support system that can resist dynamic forces and the resulting vibrations.

- a) Structural vibrations shall be minimized according the requirements of the equipment and machinery supplier.
- b) If required the Contractor shall provide vibration frequency calculations and propose measures for the construction for approval by Employer.
- c) Vibrating equipment shall be isolated so as not to pass along the vibration to affect adjacent equipment and offices.

5.7 Silos

Silos shall be designed to resist all applicable actions taking account of the silo structure, the stored solid properties, and the discharge flow patterns that arise during the process of emptying.

- a) Silos shall be water and dust tight.
- b) The maximum allowable surface crack width for concrete silos is 0.2 mm and for applications where stored material is sensitive to water moisture (raw meal, and cement silos) it is 0.1 mm.
- c) The minimum wall thickness for post-tensioned silos is 350 mm with double reinforcement layer.
- d) Asymmetric filling, discharging and eccentric loads shall be considered in the silo design according to EN 1991-4 or ACI 313.
- e) The temperature differences between potentially hot bulk material and cold ambient air shall be considered.
- f) Design temperatures for the structural calculation shall be taken from process and presented to the Employer for approval.
- g) Adequate manholes and access points shall be provided and design requires Employer's approval.
- h) The Contractor shall indicate the net volume, the gross volume and the specific weight of the stored material used for the design for each silo on the drawings.
- i) The thickness of the concrete cover shall be sufficient to address wear on the wall, cones, edges of openings and withdrawal points; or the addition of abrasion resistant plates shall be required.
- j) Bulk density and angle of internal friction for civil design of silos shall be taken from process drawings or in accordance with applicable codes as approved by the Employer.
- k) Silo roof shall have proper slope for the quick drain of rain water.
- l) Steel structure supporting silo roof shall be designed to allow movement due to variation in temperature.

5.8 Special Requirements

5.8.1 ATEX design

Enclosed buildings where coal dust may accumulate shall be designed to prevent coal dust build up. Structural beams wider than 40 mm shall have steep covers and natural cavities shall be avoided where possible.

5.8.2 Daylight design

All buildings shall have a daylight design such that all floors are sufficiently day lighted. The appropriate daylight design shall be in accordance with the relevant industrial standards.

5.8.3 Noise reduction

The building design (i.e. walls, roofs, doors, gates, windows, louvers, etc.) shall consider any noise reduction requirements and take into account the existing and new equipment within the building. Sound calculations shall be submitted to the Employer for approval.

5.8.4 Ventilation systems

Suitable ventilation systems shall be provided where unwanted internal temperatures in buildings occurs.

The maximum wind speed shall be not more than 0.5 m/s inside buildings and 2.0 m/s through louvers.

5.8.5 Sump-pits

Every basement and tunnel shall be provided with a sump-pit at the lowest point for drainage. The sump pit shall have a discharge pipe to the surface to allow pumping of collected water. The volume of the sump pit shall be a minimum of 20 liters, and shall have a metal grated cover.

5.9 Walkways and Platforms

- a) Platforms shall provide adequate access to equipment that requires periodic inspection, lubrication, adjustment, and repair.
- b) Main access walkways shall have a minimum clear width of 1.0 m and clear height of 2.3 m. Secondary access walkways with infrequent usage shall have a minimum clear width of 0.8 m and clear height of 2.3 m.
- c) The clearance all around the mechanical and electrical equipment shall be at least 1.0m or more if required by maintenance.
- d) Walkways shall be provided along conveyor belts as follows:
 1. For belt width < 630 mm an 800 mm wide walkway shall be along one side.
 2. For belt width > 630 mm walkways shall be along both sides; 600 mm wide on one side and 800 mm wide on the other side.
 3. Inclined walkways shall have serrated grating.

5.10 Stairways

- a) Stair treads shall be steel grids with non-slip nosing.
- b) The stair landings shall have welded grating with reinforced edges.
- c) Stair steps shall be welded grates with reinforced tread rods with an anti-slip, perforated stepping surface.
- d) The base of stairways resting on concrete floors shall have base plates and secured with mounting anchors.
- e) The proposed stairway design shall be submitted for approval to the Employer.
- f) Stairways shall be provided for access to platforms and floors where the operation and maintenance personnel shall have access on frequent basis.
- g) The minimum width and height clearance for each stair section is 0.8 m and 2.3 m.
- h) Secondary stairways with infrequent use the minimum width shall be 0.6 m.
- i) Stairways shall not project into open walking areas or be reduced in width at any point.
- j) The maximum riser height shall be 200 mm and the minimum tread width 230 mm.
- k) The step dimensioning formula of riser (r) and tread (t) shall be $2r + t = 630$ mm, but not less than 600 mm and not more than 650 mm.
- l) Stairway angles shall not be more than 41° (without Employer approval) nor less than 30° when measured against the horizontal plane.
- m) The slope within one flight of stairs shall be constant.

- n) One flight of stairs shall not exceed 3 m in height. In case of only one single flight of stairs the height can be maximum 4 m, but only with the approval of the Employer.
- o) The number of steps shall be limited to 15 steps in one flight of stairs.
- p) The width of the landing between 2 flights of stairs shall be a minimum of the width of the stair, but not less than 800 mm.
- q) Stairways shall comply with the norm ISO 14122.

5.11 Stair-Ladders and Ladders

- a) Stair-ladders and ladders shall be securely anchored and braced.
- b) Suitable railings shall be provided for stair-ladders.
- c) A spring loaded safety swing gate is required at top of the stair- ladder and ladders (not chains).
- d) A safety cage shall be provided for ladders higher than 3.00 m.
- e) The Contractor shall submit the proposed ladder design and ladder locations for approval by the Employer.
- f) Stair-ladders and ladders shall be provided where regular maintenance is not necessary and only occasional access is required.
- g) For stair-ladders the maximum riser height shall be maximum 250 mm and the minimum tread shall be 80 mm. The minimum width and height clearance is 0.6 m and 2.3 m. The slope within one flight of stairs shall be constant.
- h) One flight of stairs shall not exceed 3 m in height.
- i) Ladders shall be a minimum of 400 mm wide with horizontal solid rod rungs at 300 mm distance.
- j) The maximum height for a single ladder without platform is 6.0 m. measured between top of walking surfaces.
- k) Alternatives to the above specified stairway or stair ladder design and construction shall only be permitted after written approval by the Employer.
- l) Stair-Ladders and Ladders shall comply with the norm ISO 14122.

5.12 Hand Rails

- a) Hand railings shall be provided around all open floors, stairs, walkways, platforms and service landings.
- b) The minimum height of handrails above floors and walkways shall be 1100 mm.
- c) The minimum height of handrails for stairs shall be 900 mm measured vertically from the top of the stair tread.
- d) The free spaces between the top rail the intermediate rail and the toe guard shall not exceed 500 mm.
- e) The maximum distance between the posts is 1500 mm.
- f) The distance of two posts of separate handrails shall not less than 75 mm, but not more than 120mm.
- g) Hand railings shall be galvanized or protected with specific painting coat system. In addition hand railings shall be painted safety yellow.
- h) All railing and post intersections shall be fully seal welded.
- i) The top rail of handrails shall be installed at a reasonable distance from all components so that there is no risk of trapped or injured fingers.

- j) Rail corners shall be curved. Railing posts are anchored to the supporting structure with at least 2 screws. Welding of handrail and posts shall be done as neatly as possible. All corners shall be rounded and smooth.
- k) Areas where handrails are to be removable to facilitate maintenance access shall be defined and approval by the Employer.
- l) Handrails shall be delivered to the construction site in pre- assembled sections.
- m) Self-locking fasteners shall be sufficiently included for the final on- site assembling.
- n) On- site welding shall be avoided.
- o) Contractor proposed hand railing design shall be submitted for approval to the Employer.
- p) Hand rails shall comply with the norm ISO 14122.

5.13 Base Boards

- a) All landings, walkways, floor openings and platforms shall be provided with guard plates on all exposed edges.
- b) Guard plates shall not be less than 6 mm thick and shall extend at least 100 mm above top of flooring.
- c) The vertical gap between the top of floor and bottom of the guard plate shall not exceed 6 mm.
- d) The horizontal gap between the edge of the floor and the guard plate shall not exceed 6 mm.
- e) Contractor proposed toe guard design shall be submitted for approval to the Employer.
- f) The Base Boards shall comply with the norm ISO 14122.

5.14 Steel Grid Flooring (Grating)

- a) All steel grid flooring shall be “non-slip” type, hot galvanized with bearing bars 30 mm minimum depth and 3 mm minimum thickness.
- b) Grid floor covering shall consist of welded gratings with bearing bars spaced approximately 20 mm.
- c) If there are openings or cut outs in the grating, the edges of all such sections shall be comprise by welding of steel strips of the same size and thickness as the main carrier.
- d) The maximum span shall not exceed 1200 mm for 30 mm thick grating.
- e) The maximum allowable deflection is $L/300$.
- f) The grating shall be secured against lateral movement and lifting by means of locking bolts with screwed-on plates. The substructure shall be configured in such a way that this type of attachment is possible.
- g) Grates shall be fixed or anchored using at least 4 galvanized fasteners.
- h) Contractor proposed area with steel grid flooring shall be submitted for approval to the Employer.
- i) Steel Grid Flooring shall comply with the norm ISO 14122.

5.15 Checkered Plate Flooring

- a) The minimum thickness shall be 6 mm (not including the raised pattern) and appropriately stiffened as required.
- b) Countersunk head screws or suitable devices shall be used to be secured against horizontal displacement.

- c) The maximum span shall not exceed 1000 mm wide for 6 mm thick checkered plate, unless checkered plate is supplied with attached stiffeners (angles) in which case it can be 1200 mm wide.
- d) Checkered plate floors shall be raised, if necessary, to match other floor levels at the same elevation.
- e) The maximum allowable deflection is $L/300$.
- f) Checkered plate shall be hot galvanized.
- g) Where checkered plate is used for a roof or exposed to weather, the plates shall be watertight and sloped to effectively drain water. All plate penetrations shall have a seal welded toe plate to prevent water egress to levels below.
- h) Contractor proposed area with checkered plate shall be submitted for approval to the Employer.
- i) Flooring shall comply with the norm ISO 14122

5.16 Bolts, Screws, Nuts and Washers

- a) All bolts, screws, nuts and washers shall be hot dip galvanized.
- b) No flame cutting of holes is permitted.
- c) Misaligned holes shall be plugged and re-drilled.
- d) Bolts, screws, and nuts made of special steel shall have marks for proper identification.
- e) Nuts, washers and other parts used on moving and/ or vibrating equipment shall be self-locking or shall be double nutted or secured with a locking device to avoid loosening
- f) Bolted connections shall have a minimum of two bolts.
- g) Burrs resulting from drilling or punching shall be removed.
- h) Holes in hollow sections shall be closed and sealed so as to prevent the ingress of moisture.
- i) Drainage holes shall be arranged in profiles that collect water.
- j) The method of tightening the Friction Grip Bolts shall be approved by the Employer.
- k) Flat washers shall be fitted under all nuts except at conical rolled flanges, where the corresponding tapered washers shall be used.
- l) Connection bolts of different strength grade shall not be used in the same structure.
- m) All field connections shall be bolted unless approved by the Employer.

5.17 Welding

5.17.1 General

- a) Welding procedures and welding materials shall comply with good welding practice.
- b) Welding machine grounding shall be to a dedicated separate ground rod at grade.
- c) Extreme care is required with the placement of the ground lead when welding around installed equipment.
- d) Only certified welders shall perform all welding.
- e) Welders shall demonstrate their good welding practice to the Employer with welding tests under supervision on request.
- f) All welding procedures shall be described in a method statement for approval by the Employer.

- g) Only welding shown in the drawings shall be permitted. Additional joints, which are not shown in the drawing, shall be rejected.
- h) Welding at temperatures below 5°C shall only be executed with suitable preheating and inspection.
- i) Welding shall be executed in closed areas or halls with air drafts below 5 m/sec.
- j) Pre- heating of welding parts shall be considered.
- k) Heat treatment shall be applied to relieve the stresses in highly stressed welded joints.

5.17.2 Inspection

- a) All critical welds shall be subject to inspection in accordance with the inspection specification.
- b) The Contractor shall propose inspection method; ultrasonic, x-ray, or other methods for approval by the Employer.
- c) Welds selected at random and those suspected to be defective shall be inspected by an appointed inspection authority/company.
- d) Each weld shall be inspected visually for:
 - 1. Lack of fusion
 - 2. Excessive surface porosity
 - 3. Cracks
 - 4. Welds not reasonably uniform in appearance
 - 5. Deformation in shape of members due to welding

5.17.3 Repair of Defects

- a) Rejected welds shall be removed by grinding, chipping, arc or flame gouging and welded again.
- b) Cracks that occur during welding shall be removed by grinding, chipping or arc or flame gouging.
- c) Dye-penetrant or magnetic particle inspection shall be used to ensure that the cracks have been completely eliminated prior to resuming welding.
- d) Electrodes contaminated with dirt, oil or other contaminants can be cause for discontinuing welding.
- e) Welds, which were performed with dirty or contaminated electrodes shall be rejected.
- f) Repaired welds are subject to inspection again.

5.18 Galvanizing

- a) The coat thickness shall be not less than 50 microns
- b) Because of the risk of cracks in the steel construction the zinc bath shall have a tin content $\leq 0.3\%$ by weight, lead content of $\leq 0.9\%$ by weight and a bismuth content of $\leq 0.1\%$ by weight.
- c) All damaged galvanizing due to welding repairs shall be cold-galvanized.

5.19 Priming and Painting

5.19.1 Preparation of Surfaces

- a) The cleanliness and roughness of the surface shall be suitable to the intended coating and shall provide good adhesion of the coating.

- b) The surface preparation shall be inspected and approved prior to coating application
- c) Foreign coating materials like mill scale rust or old coatings shall be removed.

5.19.2 Surface Treatment Procedure

- a) The minimum rust removal shall reach Near White Metal - Mill scale, rust and foreign particles are removed to the extent that only traces remain in the form of spots or stripes. The cleaned surface will show varying shades of grey.
- b) The minimum grade of cleanliness shall be SA 2 ½ based on International ISO- norm 8501-1 or comparable standards.

5.19.3 Coating

- a) The necessary thickness and numbers of layers depends on the expected life time of the coating and the environmental corrosion aggressiveness.
- b) The basic protective coat-system shall be an epoxy resin- or polyurethane with the following minimum total coat thickness:
- c) Not less than 120 microns (2-3 layers) for interior structural steel
- d) Not less than 160 microns (3-4 layers) for exterior structural steel.
- e) The first layer shall be a priming coat.
- f) The Employer shall select the final coating system and color.

5.20 Earthing and Lightning Protection and Equipotential Bonding

Refer to Earthing DCS

6 Piling

A method statement shall be prepared and submitted to the Employer for approval of pile test program and piling work.

6.1 Pile Test Program

- a) The pile design shall be based upon a pile test program.
- b) The number of static and dynamic tests of the test program shall be proposed according to Local Laws and regulations by the Contractor and is subject to approval by the Employer.
- c) A dynamic pile test shall be confirmed with a sufficient number of static pile tests.
- d) Piles which failed during the testing program shall be replaced with a suitable number of additional piles. The structural calculation shall be checked and adapted accordingly.

6.2 Drilled Piles

- a) The reinforcement cages for drilled piles shall be rigid.
- b) The measures to ensure sufficient concrete cover are subject to approval by the Employer.
- c) Boring without cased borehole is subject to approval by the Employer.
- d) Pile drilling and concreting record shall be maintained for all piles
- e) Setting out of piles shall be done according to construction drawings and approved by Employer before drilling.

- f) Verticality of the piles shall be kept within allowable limits.

6.3 Driven Piles

- a) The piles shall be driven with fixed leads to hold the pile in its position and to ensure the alignment.
- b) A pile driving record document shall be prepared for each pile. This document shall contain the following items:
 1. Construction information,
 2. Location,
 3. Construction company,
 4. Number of pile,
 5. Drawing number,
 6. Installation date with the start and end time,
 7. Length and diameter of pile,
 8. The bottom and top elevations,
 9. Soil type,
 10. Deviations,
 11. Quality of reinforcement,
 12. Quality of concrete,
 13. Condition of pile joints,
 14. Pile driving and final set record,
 15. Remarks.
- c) If any unexpected ground conditions, unexpected change of drive characteristic or misalignment occurs the Contractor shall inform the Employer immediately.
- d) Piles which fail during driving or are misaligned shall be replaced with a suitable number of additional piles. The structural calculation shall be checked and adapted accordingly.

7 Earthworks

7.1 Excavation

- a) The bottom of excavations shall be undisturbed soil or suitably compacted material.
- b) The maximum slopes of the berm and the number of necessary berms shall be respected. All slopes shall be in a stable condition.
- c) Excavations shall be shored or braced to ensure stability.
- d) The excavation shall take into account adequate working space for installing formworks and for the safety of personnel.
- e) Care shall be exercised to prevent damage to existing underground piping and devices during excavation and backfill.
- f) Appropriate safety protection shall be in place for trench excavation.

7.2 Shoring, Sheeting and Bracing

Where necessary excavations shall be suitably shored, sheeted and braced. For all non-standardized shoring and bracing a structural calculation shall be approved by the Employer.

7.3 Drainage

All holes, pits and trenches shall be maintained in a dry condition. Suitable drainage or pumping devices shall be provided. Contractor is responsible for the management of storm water during construction.

7.4 Excavated Materials

The use or disposal of the excavated material requires the approval of the Employer.

7.5 Fence and Warning Lights

All pits and trenches shall be fenced and equipped with warning lights.

7.6 Filling Materials

- a) Filling material shall be homogenous and un-contaminated.
- b) The maximum size of lumps or stones shall be less than 75 mm.
- c) The use of recycled materials requires the approval of the Employer.

7.7 Construction of Fill and Backfill

- a) The filling shall be done in layers of not more than 30 cm thickness.
- b) Fill and backfill shall be compacted to not less than 95% according to modified Proctor Test.
- c) Filling shall not be performed when frost or other conditions prevent proper compaction of the material.

7.8 Site Grading and Surface Drainage

The finished surface shall be graded such that no water accumulation shall occur. Surface drainage shall lead water to collection systems.

8 Concrete

8.1 Concrete Mix

- a) The **water-cement-ratio** shall be **equal or lower than 0.5**.
- b) Trial mix results for each designated mix shall be submitted to the Employer for approval prior to any concrete being placed in the works.

8.2 Aggregates

- a) The maximum size shall be 32 mm. The space between the reinforcement shall be considered for the maximum grain size.
- b) Aggregate shall have sufficient strength, shall be clean, durable, and free of absorbed chemicals and free of coatings and clay as well as other materials in quantities which could affect the hydration of the cement paste.
- c) The usage of **recycling materials is not permitted**.

8.3 Water

Water shall be clear and free of harmful quantities of oil, acid, alkali, salts, organic materials or other hazardous materials.

8.4 Admixtures

All admixtures shall be in line with the local regulations and shall be approved by the Employer.

8.5 Delivery Tickets

- a) Each portion of concrete used for the project site shall be equipped with duplicate delivery tickets.
- b) Delivery tickets shall provide at least the following information:
 1. Contractor
 2. Ready-mixed concrete plant
 3. Country code plate of truck
 4. Date and dispatch time at the mixing plant
 5. Build-in location
 6. Brand name of cement
 7. Classification of cement
 8. Amount of cement per m³
 9. Size and grading curve of aggregates
 10. Water/ cement ratio
 11. Kind and amount of admixtures
 12. Water and/or admixtures added at job
 13. Temperature of concrete

9 Reinforcement

9.1 Reinforcing Bars

- a) All bars shall be bent cold and shall not be straightened or re-bent again.
- b) Bars with kinks or bends not shown on the Contractor's drawings shall not be used.
- c) Heating of bars shall only be permitted with the approval of the Employer.
- d) All reinforcing steel as fabricated shall be free from loose mill scale, rust, oil and grease and from coatings that destroy or reduce the bond to the concrete.
- e) No cutting of reinforcing bars with a torch shall be allowed.
- f) Welding of reinforcing bars shall be permitted only after Employer's approval.
- g) Binding wires for slip form works are recommended to be galvanized.
- h) Bar bending radius and overlapping length shall follow local regulations.

9.2 Pre-Stressing Reinforcement

- a) Pre-stressing reinforcement shall be protected against humidity and water. After inserting the pre-stressing reinforcement into the ducts the post-tensioning of the pre-

stressing reinforcement and the grouting of the ducts shall be executed within 4 weeks or according to the manufactures regulations.

- b) All activities such as inserting the strands, post- tensioning and grouting of the ducts shall be recorded and submitted to the Employer.

9.3 Placing of Reinforcement

- a) The reinforcing steel shall be placed and spaced in accordance with the relevant drawings. Reinforcing steel shall be well secured to prevent displacement during installation and placing of concrete by using suitable measures.
- b) Sufficient number of supports for reinforcing steel shall be used to prevent sagging of bars or mesh.
- c) Reinforcement shall be clean of the ground and protected from mud, oil and other substances, which may adversely affect its use in the works
- d) Employer shall review the reinforcing after installation for approval.

9.4 Cover

- a) The concrete cover shall be in accordance with the soil and environment aggressiveness.
- b) The minimum concrete cover protection for reinforcing steel shall not be less than:
 - 1. Bottoms of footing and other concrete cast against the ground 60 mm
 - 2. Bottoms of footing and other concrete cast against lean concrete 40 mm
 - 3. Surfaces exposed to weather 40 mm
 - 4. Surfaces in contact with the ground after removal of forms 40 mm
 - 5. Slabs and walls not exposed to weather or ground 30 mm
 - 6. Silo walls outside 50 mm
 - 7. Silo walls inside 50 mm
 - 8. Drilled Piles 60 mm

9.5 Cleaning

- a) Before placement of concrete, the reinforcing steel shall be inspected and cleaned.
- b) All materials and waste that may prevent effective bonding or create voids in the concrete shall be removed.
- c) Grout coatings on reinforcing steel from previously placed concrete shall be cleaned off.

9.6 Spacer

Spacers and any other accessories in contact with formwork shall be non-corrosive and non-organic material. Plastic spacers or concrete spacers are preferred.

10 Concrete Construction

10.1 Formwork

- a) An excavated surface shall not be used in place of forms without approval of the Employer.

- b) The formwork and bracing shall be designed and constructed for the loads, lateral pressures and deflections. Allowable stresses, tolerances and the deflection under load shall be taken into account.
- c) Where deflections are too large the formwork shall be cambered to compensate.
- d) All exposed concrete-edges shall have a 20 to 25 mm chamfer (i.e. using triangular fillets 2.0 cm x 2.0 cm). Excluded are the areas of flush joints between concrete and masonry or attachment of doors and gates
- e) The accuracy of formwork shall be in general +/- 1 cm in all directions, unless stated elsewhere.
- f) Anchor bolts shall have a sole plate that accurately matches the base plate to ensure alignment. Anchor bolt thread shall be secured and maintained and shall allow double nutting.
- g) The joints of the surfaces shall be square and level.
- h) The formwork shall be tight to avoid the run-off of cement grout. The form shall be coated to prevent bond with concrete. The joints of the surfaces shall be square and level.
- i) Slip forms shall be made out of steel with a steel surface.
- j) Slip forms made out of plywood can be used only with the Employer's approval.
- k) The internal slip form shall have a slight conical form; the external none.
- l) The slip form shall be rigid with bracing elements to avoid oval shapes.

10.2 Placing Concrete

10.2.1 Preparation before Placing

- a) The formwork shall be completely installed and braced.
- b) Water, snow, ice, frost, dirt or other foreign materials shall be removed.
- c) The reinforcement and all built-in parts shall be installed. Sleeves, joint materials, anchors and other embedded materials shall be installed and fixed in precise position.
- d) All surfaces of formworks, the embedded materials, reinforcement as well as the conveying equipment, shall be cleaned of concrete and dried mortar previously placed.
- e) The surfaces of all old construction which the concrete is to be placed against shall be free from water, mud and foreign debris.
- f) Concrete shall not be placed on frozen ground, frozen fill material or frozen old construction.

10.2.2 Inspection and Acceptance before Placing

- a) The Contractor shall give the Employer at least 48 hour notice before placing concrete to permit proper inspection of forms and reinforcement by the Employer.
- b) The Contractor, the Employer and if applicable the Electrician, shall sign the pour card prior to any concrete placement. Failure to comply could result in that the Contractor shall remove and replace the Work at his expense.

10.2.3 Strength Requirements and Testing

The Contractor shall take samples of concrete, cure, store and transport for testing in a laboratory approved by the Employer and as required by the country codes. The Contractor shall maintain and provide to the Employer the results without delay.

10.2.4 Concrete Conveying

- a) When pumping concrete, Contractor shall use equipment of suitable capacity.
- b) The discharge shall be controlled so that the concrete can effectively be compacted/vibrated in horizontal layers not more than 300 mm.
- c) The loss of slump shall not exceed 50 mm.
- d) Pipes made of aluminum or aluminum alloy shall not be used to convey concrete.

10.2.5 Placing

- a) Placing of the individual layers shall be kept as short as possible to achieve an effective bond between the layers. The new layer shall be placed before the old one sets.
- b) It shall not be allowed to place concrete on concrete which is in the hardening stage (is no longer plastic) to avoid cold joints.
- c) If a section cannot be placed continuously, construction joints shall be located at points as approved by the Employer.
- d) Concrete contaminated by foreign materials shall not be used.
- e) Concrete shall not be discharged from the truck 90 minutes after water was first mixed with the cement.
- f) Concrete with admixtures for lengthening the workability shall not be discharged from the truck 180 minutes after water was first mixed with the cement. Exceptions are possible with special measures, but only with approval of the Employer.

10.2.6 Segregation

- a) Concrete shall be placed as close as possible in its final position to avoid segregation due to re-handling or flowing.
- b) Concrete shall not be handled by any method which cause segregation.
- c) Vibrators shall not be used to transport concrete within forms.
- d) Concrete shall not free fall more than 1.2m. Where greater drops are required, a tremie or elephant trunk shall be used to control descent.

10.2.7 Consolidation

- a) All concrete shall be consolidated by vibration.
- b) Mechanical vibrators shall have a sufficient minimum frequency and size, and it shall be operated by skilled workmen.
- c) All air on the surface of the formwork, in the concrete and around the reinforcement and embedded items shall be eliminated. Honeycombing or pitting of concrete shall be avoided.
- d) Vibrators shall be inserted and removed at many points with a distance between 500 to 700 mm.
- e) Each application of the vibrator into the concrete shall be approximately 10 sec.
- f) Over vibrating with durations more than 30 sec shall be avoided.
- g) During all concrete placing operations stand-by vibrators shall be on site.

10.3 Weather

10.3.1 Rain or Snow

Concrete shall not be placed during rain or snow without adequate protection and the approval of the Employer. Rainwater or snow shall not be allowed to increase the mixing water or damage the surface finish.

10.3.2 Cold Weather

- a) Concrete shall not be placed against frozen or icy surfaces.
- b) At the time of casting the temperature of concrete shall not be less than 5° C. Placing of concrete to temperatures less than 5° shall be done with special methods and actions, which shall be approved by Employer.
- c) After placing the concrete the temperature shall be maintained between 10°C and 22°C for the next 7 days. Methods of heating materials and protecting the temperature of concrete shall be considered.

10.3.3 Hot Weather

- a) Concrete cast during hot weather shall have a maximum placing temperature of 30°C.
- b) Difficulties like high loss of slump, flash set, or cold joints shall be avoided.
- c) After placing the concrete the temperature shall be maintained between 24°C and 38°C for next 7 days. Methods for cooling the water and aggregates at the batch plant or elsewhere, and protecting the temperature of concrete shall be considered.

10.4 Finishing of Slabs and Foundations

- a) Coarse aggregate shall not be on the surface.
- b) The surface shall be treated with a smoothing tool such as a steel trowel or a screed board for slabs.
- c) All exposed concrete shall be rubbed smooth so there is a consistent color and texture with all tie rod holes patched.
- d) If a non-skid surface is required on a slab a light broom finish shall be used.
- e) Slabs inside production buildings or storage halls finishing with a troweling machine shall be used.
- f) Floor cover shall meet the functionality of the building. It shall be easy to clean, adequate visually, meet safety requirements (not slippery when wet).
- g) In areas where base plates or base frames from equipment are to be installed, a rough surface shall be produced in two directions.
- h) Horizontal surfaces exposed to weather shall have an inclination to prevent puddles.
- i) Any finished concrete floor areas that hold ponded water shall be removed and replaced. The repair shall be approved by the Employer and all costs shall be to the Contractor's account.

10.5 Concrete Curing

- a) All concrete shall be cured by membrane curing or water curing.
- b) Membrane curing: The water-retaining sealing compound shall be applied direct after top finishing of the concrete surface. The certification and the manual for application from the manufacturer shall be respected.

- c) Water curing is not the preferred after treatment measure and shall be approved by the Employer. Water shall be clear and free of harmful quantities of oil, acid, alkali, salts, organic materials or other hazardous materials.
- d) During water curing the water application shall start after top finishing of the surface and shall continue at least 10 days. The surfaces shall be wet continuously by an approved method.
- e) In case of mass concrete work (more than one meter thickness), temperature of concrete shall be continuously monitored by installing thermocouples and a method for cooling the concrete shall be considered.

10.6 Protection of Concrete and Removal of Formwork

- a) During hardening and curing the concrete shall be protected from hot or cold temperatures, premature drying and rain and running water.
- b) Due to the heat of hydration and/or the heat from the sun the formworks shall be kept wet during the curing period.
- c) After removal of the formwork during the curing time, the curing of the exposed concrete surface shall be executed immediately.
- d) Stress and shocks out of mechanical or other accidents, heavy vibrations, shocks and load stresses shall be avoided. Suitable measures shall be taken.
- e) Formwork shall be removed after the concrete has gained required strength. Minimum stripping period shall be two days for non-load bearing parts of formwork and ten days for the direct load-bearing formwork

10.7 Masonry

- a) The design of masonry shall be in accordance with the country codes.
- b) Masonry stones shall be handled carefully to prevent spalling and cracking.
- c) Masonry stones shall be stored dry to prevent damages caused by weather, traffic or other causes.
- d) The building bricks and blocks shall be frost-resistant for areas, where temperatures below 0°C can occur.
- e) All masonry shall be from the same production run and shall be uniform in color.
- f) Anchors and ties shall be galvanized. The use of different types is only permitted with the approval of the Employer.
- g) All masonry laid shall be uniform, level and plumb, if there is no other specification.
- h) Brickwork which is not intended to plaster shall have a uniform joint, without visible grout or mortar stains.
- i) All necessary cuts of the masonry shall be accurate and precise to have a uniform joint width. All openings and cut outs shall be proper executed.
- j) All masonry walls shall be of sufficient strength and thickness to withstand all applicable loads.
- k) Masonry stones shall not be set when the temperature of outside is lower than 5° C, unless suitable means are provided to heat the masonry material to protect the finished work from freezing.
- l) All equipment for mixing and transporting mortar and masonry shall be clean and free of the set mortar, dirt or other foreign substances.

- m) On the exterior side of the masonry, a layer in clear and water repellent silicone shall be applied.

10.8 Grouting Works

- a) The base plates of the machines and the construction shall be temporarily supported on steel wedges and shims and properly aligned before grouting.
- b) All pockets and the entire area of the base plate shall be cleaned out.
- c) The surface under the base plate shall be roughened by chipping, sandblasting or using other mechanical means in order to have a good bond of grout to concrete. Any oil and/or grease soaked concrete and loose, damaged or cracked concrete shall be removed until solid and sound concrete is reached and well visible.
- d) Just before grouting all water shall be removed.
- e) For the grouting a suitable none-shrink mortar shall be used.
- f) Additional holes shall be foreseen in base plates to ensure that no air pockets are left after grouting
- g) Grout thickness shall not be less than 25 mm nor greater than 50 mm. For greater thickness, additional fine aggregates shall be mixed with the grouting mortar according to the Supplier's instructions.
- h) The instructions of the Supplier for grouting material shall be followed.

11 Roads and Drainage

11.1 Paved and Compacted Roads

- a) The sub grade layer shall be compacted to 95% according to a modified Proctor Test.
- b) Above base coarse it is necessary to reach a bearing capacity of $E_{v2} = 120 \text{ MN/m}^2$ and $E_{v2}/E_{v1} < 2.2$, (E_v = strain modulus).
- c) The reinforced concrete slab shall be a minimum of 220 mm thickness. Expansion joints shall be considered and indicated in the drawings.
- d) All materials and the total construction shall reach a frost resistant level in countries and areas where temperatures below 0° C are possible.

11.2 Drainage

- a) Drains shall be designed based on rainfall data, catchment area and the ground condition.
- b) The drainage design shall be submitted to the Employer for approval.
- c) Oil separator shall be provided before water drainage discharge.

12 Steel Structure

12.1 Steel Fabrication

- a) All steel work shall be new free from defects impairing strength, durability, appearance and possessing structural properties to withstand safely the stresses to which these shall be subjected.

- b) All material shall be kept free from dirt, grease and other foreign matter and shall be protected from corrosion.
- c) Mill certificates covering chemical and physical properties of all steel material shall be submitted by the Contractor for Employer approval prior to fabrication.
- d) High strength bolts shall be used for all main bearing type and moment connections. Main connections shall include main beam to beam, main beam to column, column splices, main bracing, crane brackets and all beams carrying equipment load.
- e) Bolt holes shall be cut, drilled, or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes shall be clean cut without torn or ragged edges.
- f) Vertical bracing shall be connected to both beam and column at the intersection of column, beam and bracing.
- g) Testing of welded joints for built up sections, plate girders and columns shall be conducted by Contractor.

12.2 Delivery, Storage and Handling

- a) Steel components and packaged materials shall be protected from corrosion, mud and damage
- b) All the fabricated frames shall be suitably braced and packed to prevent distortion during transit.
- c) Steel components shall be supported above the ground using pallets, platforms or other supports and individual member marking shall be visible when members are stacked.
- d) Bolts and screw sets shall be kept in dry storage.
- e) Steel shall be handled in such a way to avoid any damage to any existing structure, services or stored items.

12.3 Steel Erection

- a) All steel pieces shall have unique identification markings to facilitate assembly and inspection.
- b) The Contractor shall provide a plan for lifting operations during assembling with a method statement to the Employer for approval.
- c) Specifications and instructions for the steel erection shall be kept on the site.
- d) Scaffolds, ladders and safety appliances shall be erected so, that the Employer can safely inspect any or all of the work. Inspection will be made as required by the Employer and co-operation in assisting and permitting access is mandatory.
- e) The bases of steel columns shall be temporarily set to the correct level and positioned using narrow steel packs, steel wedges and the holding down bolts prior to grouting in accordance with the design.
- f) The entire main structure (columns and main link beams) shall be plumb and levelled prior to grouting of the columns.
- g) A report documenting the correctness of the structure shall be submitted to and approved by the Employer prior to grouting.

12.4 Remedial Works

- a) Alignment of holes shall be such that bolts may be inserted by hand with no more than light tapping with a hammer. No out of line bolts shall be permitted.

- b) Site welding, burning, cutting, slotting and other remedial measures are forbidden without the express consent and approval of the Employer.
- c) Touch-up paint shall be applied where painted surfaces have been damaged.
- d) Surfaces to be touch-up painted shall be properly prepared prior to painting.

12.5 Inspections, Tests and Approvals

Materials and fabrication procedures in the workshop and field service are subject to inspection and tests conducted by or requested by the Employer. Materials or components, which do not comply with the specified requirements shall be promptly removed and replaced.

12.6 Dimensions and Tolerances

The maximum acceptable dimensional deviation shall be in accordance with the country codes and the Particular DCS.

13 Roofing and Cladding

13.1 General Design Requirements

- a) The materials selected shall meet the local weather conditions.
- b) The materials shall be waterproof and weatherproof.
- c) A vapor barrier shall be considered to prevent moisture in the insulation.
- d) The design and construction shall take into consideration that pedestrians sometimes walk on the roof for maintenance reasons.
- e) Protective roof coating over concrete roofs shall be applied
- f) Siding sheets for existing building modifications shall match existing sheets in configurations, size and finish.
- g) Panel lengths shall be as long as practical to provide a minimum laps. Panels shall have the length required to cover at least two spans.
- h) The Employer shall approve the profile and the color.
- i) The minimum thickness of fiberglass roofing sheet lighting board shall be 1.6 mm.

13.2 Metal Roofing

- a) The minimum inclination according to the type of material shall be respected.
- b) Thickness of roofing with corrugated steel sheets shall not be less than 0.85 mm.
- c) Ridge caps, flashing, fasteners and similar items in connection with roofing shall be fabricated of the same material and color as the roofing sheets.
- d) Roofs shall be fastened with stainless steel screws and neoprene washers.

13.3 Metal Siding

- a) Thickness of siding with corrugated steel sheets shall be not less than 0.6 mm.
- b) Accessories such as metal flashing, fasteners and similar items in connection with metal siding shall be fabricated of the same material and color as the siding sheets.
- c) Siding shall be fastened with stainless steel screws and neoprene washers.

- d) Metal siding shall be installed with all necessary waterproof flashing, fasteners, sealants, etc. as for a complete installation.

14 Personnel and Service Doors

14.1 General Design Requirements

- a) All doors for industrial buildings and the outside doors of ancillary buildings shall be made of two seamless steel sheets, each min. 1.2 mm thick with a metal door steel frame.
- b) The space between the two sheets shall be filled with appropriate and fireproof insulating material. The overall door thickness shall be not less than 45 mm.
- c) Door sizes shall be standardized and be indicated on the drawings.
- d) Door sizes and door types and related accessories shall be approved by the Employer.
- e) The outside doors for insulated buildings shall be sufficient insulated and made by a reputable manufacturer.
- f) Door frames for all exterior service doors shall be structural steel frames with removable steel doorstops.
- g) All exterior doors shall be weather and rain proof.
- h) All exterior doors shall have thresholds or floor elevations designed so that ponded storm water cannot enter the room.
- i) Doors shall have clear-wired glass vision panels where required.
- j) Acoustic insulation and/ or thermal insulation shall be provided if required.
- k) Service doors shall be large enough to allow removal of the largest piece of equipment contained within the room. Service doors shall have removable overhead transoms or shall be provided with suitable cut outs to accommodate hoist beam extensions, and flashed with rubber or similar materials.
- l) A linkage device shall be provided for service doors with difficult access to assist in opening and closing the doors safely from inside of the building.
- m) Safety chains or other suitable devices shall be provided where elevated doors and gates open above the ground.
- n) Exterior doors shall always open outward for escape reasons.
- o) The Employer shall approve the color for doors.

14.2 Hinged Type Doors

Hinged type doors shall be the standard product of a reputable manufacturer regularly engaged in the manufacture of this type of product. Hinges shall be heavy duty, ball bearing type in sufficient number and spacing for resistance to prolonged wear.

14.3 Roll-up Doors

- a) Roll-up doors shall be the standard product of a reputable manufacturer regularly engaged in the manufacture of this type of product.
- b) Roll-up doors shall be weather proof.
- c) The curtain shall be formed of galvanized interlocking steel slats.
- d) Roll-up doors shall be motorized, unless approved by Employer.

14.4 Hardware Doors

Door furniture, closers, stops, holders, hinges, thresholds, weather-stripping, push and pull plates, kick plates, etc., shall be provided for each door and its intended use. Hardware in general shall be specified as heavy-duty type. All doors shall be equipped for master key system.

14.5 Glass and Glazing

Glass in general shall be clear double strength quality sheet glass. Where required, “sandwich type” safety glass shall be used, for accident prevention.