Design Philosophy and Acceptance Criteria for Civil Works

CO_2 Capture Facility

Kårstø, Norway

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1	7 OCT 08	Issued for Approval	RWAS	MZ	BTR	WRE	
0	08 OCT.08	Issued for Comments	RWAS	MZ	BTR	WRE	
Rev.	Date	Reason for Revision	By	Check	App	App	Client

Bechtel Power Corporation

Job No. 25474	
Document No.	Rev.
25474 - 000 - 30Y -C01G - 00001	1
PAGE 1 of 21	

GASSNOVA

Project No. - Originator - Disc Code - Doc Type - Serial No.

10112936 - PB - C - TED - 0002

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Design Philosophy and Acceptance Criteria for Civil Works

1.0 INTRODUCTION

The criteria set forth in this document govern civil works (site work and subsurface structures) designs for the FEED study CO_2 Capture and Compression (CCC) Plant at Kårstø. This criteria was written after the review of Exhibit E6.1 [Ref 2.3.2] of the contract was performed and concluded that no comments needed to be made with regards to that document.

2.0 GOVERNING CODES, REGULATIONS, AND REFERENCE DOCUMENTS

Unless specifically stated otherwise, the site work and subsurface structure design shall be based on the applicable portions of the following codes, regulations, project specifications, and reference documents. The editions of the codes and standards referred to in the design criteria are those in effect at the time of contract award, unless noted otherwise. In accordance to the requirements of Exhibit Appendix E1.2 [Ref 2.3.13] the following precedence is established:

1. Norwegian Law and statutory requirements

2. EC-directives referred to in the Norwegian regulations

3. Project Design Basis and Exhibit E

4. Client Standard and Documents for Kårstø and Interfaces

5. NORSOK Standards

6. Norwegian and European harmonized standards

2.1 CODES

2.1.1 IBC 2006 – International Building Code

2.1.2 NS-EN 1990 – Eurocode – Basis of structural design

2.1.3 NS-EN 1991 – Eurocode 1 – Actions on structures

- Part 1-1: General Actions – Densities, self-weight, and imposed loads for buildings
- Part 1-3: General Actions – Snow loads
- Part 1-4: General Actions – Wind actions
- Part 3: Actions induced by cranes and other machinery

2.1.4 NS-EN 1992 – Eurocode 2 – Design of concrete structures

- Part 1-1: General Rules and rules for buildings

- * Part 1-2: General Rules – Structural fire design
- * Part 3: Concrete foundation

2.1.5 NS-EN 1993 – Eurocode 3 – Design of steel structures

- * Part 1-1: General Rules and rules for buildings
- * Part 1-2: General Rules – Structural fire design

2.1.6 NS-EN 1997 – Eurocode 7 – Geotechnical design

- * Part 1: General Rules

2.1.7 NS-EN 1998 – Eurocode 8 – Design of structures for earthquake resistance

- * Part 1-1: General Rules – Seismic actions and general requirements for structures
- * Part 3: Towers, masts, and chimneys
- * Part 5: Foundations, retaining structures, and geotechnical aspects

2.1.8 NS-EN 752-4 – Drain and sewer systems outside buildings

- * Part 4: Hydraulic design and environmental considerations

2.2 REGULATIONS

2.2.1 H-2036-KD – Internal Control Regulation, 22 March 1991 (Ministry of Municipal Affairs and Labor) – Regulations relating to systematic health, environmental, and safety activities in enterprises

2.2.2 No. 2105, 19.11.1985 – The Norwegian Directorate of Labor – Regulation for excavation and stabilization of trenches (Arbeidstilsynets Grøfteforskriftene)

2.2.3 The Planning and Building Act No. 77 of 14th June 1985, with amendments in force 1st April 2005

2.2.4 Normalreglementet for sanitæranlegg, tekniske bestemmelser, 4th Edition

2.2.5 Våtromsnorment of 2000

2.3 STANDARDS AND SPECIFICATIONS

2.3.1 Exhibit E0 – Design Basis (Doc. No.10112936-FI-B-CON-0051)

2.3.2 Exhibit E6.1 – General Requirements Civil, Structural & Architectural (Doc. No. 10112936-FI-B-CON-0120)

2.3.3 Exhibit E6.2 – Geotechnical Investigation (Doc. No. 10112936-FI-B-CON-0121)

2.3.4 Exhibit E8.1 – HSE Requirements (Doc. No. 10112936-FI-B-CON-0140)

2.3.5 Exhibit E9 – Battery Limits (Doc. No. 10112936-FI-B-CON-0150)

2.3.6 Exhibit Appendix E1.2 – Design Codes and Standards (Doc. No. 10112936-FI-B-CON-0242)

2.3.7 TR1055 – Performance standards for safety system and barriers

2.3.8 TR1303 – Kårstø Design Data Document

2.3.9 TR1319 – Structural Steel and Aluminium Requirements for Kårstø Process Plant

2.3.10 TR1329 – Civil Specification for Kårstø Plant

2.3.11 TR1793 – Security Fences

2.3.12 TR 2080 – Metocean Design Basis

2.3.13 NORSOK Standard N-003 Edition 2, Sept 2007, Norwegian Oil Industry Association

2.4 REFERENCE DOCUMENTS

2.4.1 Drawing NOR140-UC07-UZ-610202 – Appendix E2.17 Civil Drawings Stack Area (Doc. No. 10112936-FI-B-CON-0267-REV01)

2.5 MATERIALS

2.5.1 BS-EN 1722-10 – Specification for anti-intruder fences in chain link and welded mesh

2.5.2 BS EN 1916 – Concrete pipes and fittings, unreinforced, steel fibre, and reinforced

2.5.3 BS EN 1917 – Concrete manholes and inspection chambers

2.5.4 NS-EN 10025 – Hot rolled products of structural steels

2.5.5 NS3576-3 – Steels for reinforcement of concrete, Part 3: Ribbed bars B500C

2.5.6 NS3576-4 – Steels for reinforcement of concrete, Part 4: Welded fabric

2.5.7 EN ISO 1461 – Hot-dip galvanized coatings on fabricated iron and steel articles

2.5.8 EN ISO 4032 – Hexagon nuts, style 1: Product grades A and B

2.5.9 EN ISO 4014 – Hexagon head bolts: Product grades A and B

3.0 SITE INFORMATION

3.1 LOCATION

The Site is located at Kårstø in the municipality of Tysvær on the southwest coast of Norway. Battery limits for the CCC plant extend 221 meters by 100 meters, with the southwest corner of the plot located at N4900 and E20552 on the Kårstø site local coordinate system [Ref. 2.3.1].

3.2 DATUM

The terrain at the Kårstø Process Plant is that of a fully leveled industrialized plant, consisting of leveled crushed rock with variable depth to bedrock. The existing site elevation shall be prepared to an elevation of +6 meters above mean sea level (MSL) by Gassnova [Ref. 2.3.5]. The base elevation of the CCC plant Site, or the finished ground/grade elevation, is set at an average of +7 meters. The reference level at Kårstø is 2.29 meters over the MSL [Ref.2.3.5]. Elevations listed in Drawing NOR140-UC07-UZ-610202 may used as reference.

3.3 PRECIPITATION

The Site has a marine atmosphere with salt spray. For a 12-hour period there is a 10% probability of exceeding 43mm in any given year. The maximum recorded precipitation for a 12-hour period is 50.7mm. The design rainfall is 22mm in 1 hour [Table 2.38, Ref. 2.3.12]. See Section 5.4 of this document for the design basis for site drainage.

3.4 GROUNDWATER TABLE

Based on the provided information for geotechnical and geophysical conditions [Ref. 2.3.3], groundwater is not a consideration in the design of structures and their foundations. The elevation of the groundwater table is taken to be approximately at sea level, per Section 6.4 of this document.

3.5 AIR TEMPERATURES

Air temperature values are as follows:

- Maximum 32.5 °C [Table 2.22, Ref. 2.3.12]
- Minimum -17 °C [Ref. 2.3.1]

3.6 WIND

All structures shall be designed in accordance with EN 1991-1-4. Basic wind velocity is 43 meters/second, based on a 3-second gust speed taken at 10 meters above final grade with a 2% probability of exceedance in a given year [Table 2.17, Ref. 2.3.12]. This value is higher than the 33.7 meters/second value given in TR1303 [Section 5.7.6, Ref. 2.3.8]. See Section 6.0 of this document for information on determining loading due to wind.

3.7 SEISMOLOGY

All structures shall be designed in accordance with IBC 2006. The Peak Ground Acceleration Values given in Table 5-5 of the Kårstø Design Data Document [Ref. 2.3.8] are treated as short-period spectral response accelerations, Ss, used in the IBC. See Section 6.7 of this document for information on determining seismic loading.

3.8 SUBSURFACE CONDITIONS

Geotechnical recommendations are made based information provided within the Geotechnical Investigation provided by Gassnova [Ref. 2.3.3].

3.9 FROST LINE

The depth of frost penetration for the site is 0.9 meter below grade for gravel and 1.2 meter for crushed rock [Ref. 2.3.1]. Subsurface structures resting on rock as indicated within the Civil Specification [Section 4.5.1, Ref. 2.3.10] are not subject to frost heave as long as adequate drainage is provided.

4.0 SUBSURFACE STRUCTURES WITHIN THE CCC BATTERY LIMIT

4.1 GENERAL EQUIPMENT FOUNDATIONS

4.1.1 General

Various smaller pieces of equipment will need to be supported throughout the CCC plant process area. These will not exceed the uniform live load described in Section 6.2 of this document. The necessary support shall be provided by an equipment pad resting on concrete paving.

4.1.2 Design Methodology

Design for the supporting concrete equipment pad shall be per EN 1992-1-1. Therefore, the equipment pad is treated as a structural slab. The design shall be sufficient to transfer the load from the equipment to the pad to the paving and then into the ground. Paving to support the equipment pad is considered heavy duty and falls under the guidelines set forth in Section 5.2.4 of this document.

4.2 ABSORBER TOWER AND CO_2 STRIPPER FOUNDATIONS

4.2.1 General

Each structure will be support by a single concrete pier resting on a concrete mat. The bottom of concrete for the mat shall be at a depth below the frost line indicated in Section 3.9 of this document. The top of the pier shall have a concrete curb with an embedded waterstop formed around the perimeter. This will function as containment against oily water or accidental anime spills. To avoid corroding the bottom of the vessel, the top of concrete for the pier is elevated 200mm above the finished grade surface.

4.2.2 Design Methodology

For the foundation concrete design, an analytical model of the foundation shall be constructed as rigid mat. Rigidity is based on a maximum differential deflection of less than 15% of the total deflection of the mat. Analysis of the mat shall be based on operating loads, lateral shear, and overturning moments at the base of each vessel. These are provided by the respective vessel suppliers and are based on the conditions listed in Section 6.0 of this document. In addition, the loading caused by an accidental explosion, detailed in Section 6.9 of this document, shall be a part of the load combinations for the analysis. The overall foundation shall be designed to satisfy the criteria of EN 1992-1-1 and EN 1997-1. The foundation mat shall be capable of resisting uplift and overturning reactions with an applied factor of safety (Section 7.2 of this document). Sliding of the foundation mat will also be checked but is not considered a concern due to the nature of the rock fill material the mat will be bearing on. Refer to Section 7.0 of this document for further discussion on the design basis of foundations.

4.3 DUCTWORK FOUNDATION

4.3.1 General

The Site's ductwork is supported by an unmanned steel structure. Foundations for the structure supporting the ductwork shall be rectangular spread footings resting on firm a stratum that provides negligible differential settlement between each bent and other facilities attached to the structural steel.

4.3.2 Design Methodology

The foundation concrete design shall be based on methods prescribed in EN 1992-1-1 and EN 1997-1. Reactions at the base of the superstructure shall be transferred directly to the supporting foundations. In order to withstand horizontal loads on the superstructure due to an accident (thermal, impact, explosion), connections at the base of the superstructure shall be fixed. The foundation shall be designed to resist the moment that develops at the base of the superstructure.

4.4 PIPE RACK FOUNDATION

4.4.1 General

The Site's pipe rack is an unmanned steel structure. Foundations for the structure supporting the pipe rack shall be considered as rectangular continuous footings running parallel to the direction of the rack. Each footing shall rest on a firm stratum that provides negligible differential settlement between each bent and other facilities attached to the rack. The ground between the footings may be used for buried utilities as long as it does not encroach within a 300mm envelope surrounding the footing.

4.4.2 Design Methodology

The foundation concrete design shall be based on methods prescribed in EN 1992-1-1 and EN 1997-1. Braced bays shall transfer all longitudinal horizontal loads from wind, temperature, pipe anchors, etc., to the foundations. Extra capacity shall be provided by fixed supports, thus keeping a reserve for unforeseen (accidental)/future longitudinal horizontal loads, similar to those described in Section 4.3.2.

4.5 BUILDING FOUNDATIONS

4.5.1 General

Support for the buildings housing equipment such as the compressor, storage drums, or pumps will consist of a single foundation mat. Typically, the mat thickness will remain consistent with exception at the perimeter, which may be thicker to avoid the frost depth. Were support for equipment exceeds the design of the mat, such as the compressor itself, the supporting foundation will be an isolated equipment pad within the building.

4.5.2 Design Methodology

Requirements stated in the general requirements for civil, structural and architectural shall be met. Following that basis, the foundation concrete design shall be based on methods prescribed in EN 1992-1-1 and EN 1997-1. Subsequently, a non-factored envelope combination will also be used to present a worst-case scenario for loads transferring into the foundation mat. The general format for load combinations used for the ultimate and serviceability limit states is determined using Section 6 of EN 1990. Isolated equipment pads shall be designed not to transfer load to the building mat.

4.6 FLUE-GAS BLOWER FOUNDATION

4.6.1 General

Each flue-gas blower foundation support shall be an elevated (minimum 200mm above finish grade) structural slab.

4.6.2 Design Methodology

The supporting concrete slab design shall be per EN 1992-1-1 and EN 1997-1. The slab shall rest on firm strata so that differential settlement is avoided or within permissible limits. The premise for this design is that of a shallow foundation. Refer to Section 7.0 of this document for further discussion on the design basis of foundations.

4.7 CONCRETE SUMPS FOR DRAINAGE SYSTEM

4.7.1 General

Contaminated water and oily water shall each drain into a concrete sump as part of the drainage system. Concrete sumps shall fulfill the requirements for concrete culverts listed in Section 5.5.1 of this document.

4.7.2 Design Methodology

The design of the walls and base slab for each sump shall be in accordance with the procedures and guidelines set forth in EN 1992-1-1 and EN 1992-4. An additional check shall be performed against potential uplift due to the head of liquid at sump capacity of the sump shall be performed.

5.0 SITE WORK

5.1 EARTHWORK

Site preparation will be executed by Gassnova [Ref. 2.3.5]. Additional excavation and rough grading are to comply with the requirements in the Civil Specification for Kårstø Plant [Ref. 2.3.10]. Erosion control and sediment control are considered minimal due to the rock fill material used in finished grading; however, sediment control is considered in the development of drainage swales.

5.2 ROADS AND PAVED AREAS

5.2.1 Definitions

Main Plant Access Road – Main plant access roads shall serve as through roads as specified by the plant layout.

Main Service Road – Main service roads shall provide primary access to the process areas, buildings, and equipment.

Module Road – module roads provide transport for modules and other heavy equipment.

Service Road – Service roads shall provide secondary access to the process areas, buildings, and equipment.

Walkways – walkways provide access, by foot, along all main plant access roads and between plant facilities.

5.2.2 General Design Data

All designs and materials shall comply with the applicable codes, standards, and national highway regulations and this document.

The cross-section(s), materials, and compaction requirements shall comply with recommendations contained in the Civil Specification for Kårstø Plant [Ref. 2.3.10].

All roads and parking areas shall be arranged and designed for adequate drainage.

For module roads, a horizontal clearance of 20 meters shall be maintained [Ref. 2.3.10]. This clearance shall be maintained for the full required vertical clearance established per the road classification.

Walkways are a minimum of 1 meter in width and shall follow the design requirements of light-duty pavement described in section 5.2.4.

5.2.3 Detailed Design Data for Roads

As a minimum, roads shall be designed for the requirements given in Table 5-1, unless physically restricted by the site arrangement. Road types (i.e., concrete, asphalt paved, or gravel surfaced) shall be in accordance with the Civil Specification for Kårstø Plant [Ref. 2.3.10].

Design loading conditions are according to the Civil Specification for Kårstø Plant [Ref. 2.3.10] for construction and permanent traffic areas. Specifically, use 100 kN/m^2 for module roads [Ref. 2.3.10]. Use 10 tonnes/axle for other roads [Ref. 2.3.10]

Table 5-1 Road Criteria [Ref. 2.3.2 & 2.3.10]

Criteria	Main Plant Access Road	Main Service Road	Service Road
Maximum Grade, Longitudinal (%)	5	5	5
Maximum Grade, Transverse (%)	2.5	2.5	2.5
Minimum Vertical Radius, meters	150	150	150
Minimum Horizontal Curvature Radius, meters	30.0	30.0	30.0
Minimum Road Width, meters	6.0	5.0	3.0
Required Horizontal Clearance per Shoulder, meters	1.0	1.0	0.25
Required Vertical Clearance, meters	6.0	6.0	4.5

5.2.4 Detailed Design Data for Concrete Paving

Paved areas subject to chemical spillage shall have retention curbs, and the height of such curbs shall be shown on the drawings. Ramps shall be specified where access for mobile equipment is required [Ref. 2.3.10].

Concrete paving shall generally have a minimum thickness of 160mm and be reinforced with steel wire mesh or similar, located 50mm from the top of the slab. Underlying soil and rock conditions shall be taken into consideration, and the paving shall conform to the requirements of Statens Vegvesen [Ref. 2.2.4].

Light-duty paving shall be designed for a uniformly distributed load equal to 2.5 kN/m^2. Heavy-duty paving shall be designed in accordance with normal practice as given in the latest edition of the Statens Vegvesen Handbook [Ref. 2.2.4 & 2.3.10].

Expansion and dummy contraction joints shall be designed according to Vegnormalen. Expansion joint dowels shall be used only when required for structural purposes.

Concrete paving shall be separated by a standard expansion joint from all foundation piers projecting above ground [Ref. 2.3.10].

Expansion joints shall be not more than 20 meters apart, and dummy contraction joints shall be not more than 10 meters apart [Ref. 2.3.10].

5.2.5 Detailed Design Data for Parking Areas

A minimum of 12 parking places shall be within the CCC Plant area [Ref. 2.3.2]. Walkways leaving from the parking area shall be a minimum 1 meter in width [Ref. 2.3.2]. Lighting and guardrails shall be provided along the roads and parking areas

[Ref. 2.3.2]. The design of the parking area shall meet the minimum requirements of a module road to function as a staging area for equipment and cranes.

5.3 FENCES

The perimeter of the site will be surrounded by a security fence. The following criteria shall be upheld according to the Statoil technical requirements [Ref. 2.3.11]:

- The fence shall be 2.4 meters high from ground level to the top of the mesh.
- The top of the fence shall be armored with a minimum of three barbed wires.
- The barbed wire holders shall be welded or screwed to the fence pole at a 45-degree angle pointing outward.
- Welded mesh and steel posts shall be galvanized.
- The ground should be of decomposed stone, graded fines, and coarse sand, or equivalent, and the area shall be well drained.
- All personnel gates, evacuation gates, and driving gates shall have the same corresponding standard as the security fence.
- All wire shall comply with EN 1722-10. Welded mesh wire should be 4mm in diameter, and the size of the mesh shall be a maximum of 25mm vertical and 75mm horizontal.
- Posts shall be set in concrete, and a concrete sill should be cast to run the full length of the fencing.
- The gap between the fence and the concrete sill should be less than 100mm.
- The fence should preferably be installed straight, in line, and level.
- On the outside of the security fence there shall be a clear and open zone of at least 5 meters. Inside the fence, there shall be a clear zone of at least 10 meters.

5.4 DRAINAGE SYSTEMS

The design for managing drainage systems shall be in accordance with the applicable codes and local standards. The design shall also be in full compliance with the guidelines established in the Kårstø Design Data [Ref. 2.3.8], Civil Specification [Ref. 2.3.10] and HSE Requirements [Ref. 2.3.4].

5.4.1 Stormwater

Stormwater design for the entire site shall be coordinated with Bechtel's Hydraulics and Hydrology Group.

Post-development discharges off site shall conform to the Owner's existing discharge permits for the site.

Manholes or catch basins shall be provided at all changes of flow direction and at intervals not to exceed 100 meters. Further details on manholes can be found within the Civil Specification for Kårstø Plant [Ref. 2.3.10].

Concrete pipes shall be used. The pipes shall comply with EN 1916. The sewer mains pipe system shall be at least 305mm in nominal diameter. The minimum pipe slope for non-pressurized gravity-flow portions shall generally be 0.50%. Lower slopes will be allowed when minimum head is available.

Rainfall intensity data for the design shall be as specified in Section 3.3 of this document.

5.4.2 Oily Water

The oily water drain system capacity shall fulfill either the requirements for fire water and leak volumes [Ref. 2.3.8] or the calculated capacity for rainwater according to the precipitation data given in Section 3.3 of this document, whichever gives the larger volume. Fire water drainage/leak volumes shall be analyzed and defined by a safety analysis [Ref. 2.3.7].

5.4.3 Contaminated Water

Hazardous material spills are controlled by an open drain system arrangement including bunds to collect liquid spills. The open drain system provides measures to contain and properly dispose of spilled liquids as well as to handle rainwater and fire water [Ref. 2.3.4].

The drainage system capacity shall be sufficient to handle either the heaviest 1-hour rainfall over a 10-year recurrence period or the full fire water capacity, plus expected liquid spills that can be released from equipment that is not readily isolated, whichever volume is larger [Ref. 2.3.4].

Bunds shall be arranged around all large storage tanks and have the capacity to collect 110% of the inventory of the largest tank within the bund or 25% of the volumes of all the tanks within the bund, whichever is larger. To prevent small spills from exposing more than one tank, bunds around two or more tanks shall be subdivided by spill bunds around each tank that have the capacity to retain 10% of that tank's total volume. The area within a bund should be graded to a level that ensures that any spillage has a preferential flow away from the tank. Piping within a bund area shall be minimized and, where possible, buried. Fittings that may quickly fail when exposed to fire shall be avoided within a bund [Ref. 2.3.4].

5.4.4 Sanitary Water

In sanitary water systems, manholes shall be provided at each bend and at least every 80 meters on straight lines [Ref. 2.3.10].

5.5 BURIED UTILITIES

5.5.1 Cable Culverts

When, electrical and instrument cables are placed in concrete culverts. Sidewalls shall have blockouts for cable inlets and outlets. The number and positions of blockouts shall be specified [Ref. 2.3.10].

In offsite areas, direct-buried cable trenches may be considered [Ref. 2.3.10].

Culvert walls and top covers shall be designed to sustain the pressure from backfilling and imposed loads, if any. Otherwise, they shall have a minimum wall thickness of 150mm and shall be reinforced. The culverts shall be completely filled with sand [Ref. 2.3.10].

Bottom slabs shall have adequate drainage holes to facilitate surface and ground water movement [Ref. 2.3.10].

Top covers shall be supported on the culvert walls. Covers shall have lifting bolts not exceeding the top cover elevation [Ref. 2.3.10]. If a culvert is located within paved area, the grooves around each culvert cover element shall be sealed with oil and frost-resistant sealing compound [Ref. 2.3.10].

Concrete culvert covers in asphalted areas shall be separated from the asphalt by a minimum 400mm-wide strip of reinforced concrete, partly founded on the culvert walls. This 400mm side protection shall be used on both sides of a culvert trace expecting future traffic, to ensure that the culvert covers maintain the designed position. The concrete covers shall be designed to withstand traffic loads specified in the area. In situ cast covers shall be constructed in such a manner that they can be re-used [Ref. 2.3.10].

5.5.2 Piping

Underground piping systems are the scope of Mechanical and Plant Design disciplines. If sleepers are required, the design shall be based on geometry and loads (pressure, thermal, etc.) provided by the discipline designing the piping system. Wind loading is a consideration for the sleeper design only if the bottom of the pipe is more than 1 meter above finished grade. Sleepers shall include an embedded steel profile (hot dip galvanized), as support for the pipes [Ref. 2.3.10].

6.0 DESIGN LOADS

6.1 PERMANENT LOADS (D)

Permanent loads are also called dead loads. They shall consist of the weight of all materials of construction incorporated into each structure, including, but not limited to, floors, stairways, finishes, and other similarly incorporated architectural and structural items, plus piping and fixed equipment loads as per preliminary information.

The design dead load criterion specific for subsurface structures in this facility is:

Equipment Loading	1.5 kN/m^2 minimum

The following concentrated load shall also be used to account for unforeseen construction or operating conditions. This load is applied in the vertical direction:

Concentrated Load on Slab on Grade to be Considered with Dead Load Only	13.30 kN minimum or as required for construction and plant operation

6.2 LIVE LOADS (L AND L_O)

6.2.1 General

Live loads (L) are those loads produced by the use and occupancy of each structure and do not include construction or environmental loads such as wind loads, seismic loads, snow loads, rain loads, flood loads, or dead loads. In the absence of any load, EN 1991-1-1 may be referenced. No reductions in live load shall be considered. In loading combinations including wind or seismic, the live loads shall be limited to those occurring during the plant operation (L_o). The operating live loads shall be established in accordance with the layout and mechanical requirements, applied simultaneously with the wind loads. These loads may vary, depending on the function of the specific area and as per actual vendor/manufacturer drawings.

6.2.2 Minimum Live Loads for Design

In general, subsurface structure design shall be based on the given reactions transferred from the structure being supported. In the absence of those values, the design live load criterion specific for subsurface structures in this facility is:

General Floor Slabs on Grade	12 kN/m^2

6.3 EARTH PRESSURES

Active or passive pressures will not be considered in the design of foundations.

6.4 GROUNDWATER PRESSURES

For structural and buoyancy calculations, the high groundwater shall be assumed at elevation 0 meters (mean sea level).

6.5 VEHICLE SURCHARGE

Surcharge loads from vehicles shall be considered in the design of all foundations and structures where such loading may exist, e.g., forklift traffic on floor slabs, operation/maintenance and/or delivery vehicles imposing wheel surcharge loads on slabs, below grade walls, etc., by either driving directly on them, or adjacent to them.

Any foundation or structure accessible to vehicle surcharge loading shall be designed for either 12 kN/m^2 or the vehicle surcharge loads noted in Section 6.3.2 of EN 1991-1-1. Alternatively, the design can implement the use of guardrails and/or bollards to prevent or control such loading effects.

6.6 WIND LOADS

All structures and equipment mountings shall be designed for wind loading using the following parameters from EN 1991-1-4:

- Basic Wind Speed: V_b= 43 meters/second
- Terrain Category: Type 0

The pipe rack and equipment supporting structure shall be designed for 20% extra wind forces to allow for future extensions. Fatigue loading shall be considered for equipment and structures subject to vortex-shedding excited vibrations [Ref. 2.3.8].

6.7 SEISMIC LOADS

The design seismic load criteria are as follows:

• Design Code/Standard Reference	IBC 2006-Section 1613
• Occupancy Category	II
• Mapped maximum considered earthquake – spectral response acceleration at short period (475 years), Ss	0.07g [Ref. 2.3.8]
• Site Class	B
• Seismic Design Category	A

6.8 SNOW LOADS

Structures shall be designed for a snow load of 2.0 kN/m^2 [Section 2.10, Ref. 2.3.12].

6.9 ACCIDENTAL LOADS

Accidental loads are loads caused by abnormal operation or technical failure [Section 5.7.13, Ref. 2.3.8]. Accidental loads can be applied to subsurface structures or foundations on the basis that the results from those loading conditions are transferred through the surface structure into the supporting subsurface structure (refer to the structural design philosophy for actual loading requirement).

7.0 DESIGN BASIS

7.1 GENERAL

Reinforced concrete structures shall designed using ultimate limit states in conjunction with the partial factor method described in EN 1990 and EN 1992-1-1.

Soil bearing pressures resulting from actual service design dead and live loads shall not exceed the allowable bearing capacities of the supporting soil, as recommended in the Geotechnical Investigation [Ref. 2.3.3].

7.2 LOAD COMBINATIONS AND LIMIT STATES

Concrete structure designs shall be in accordance with the general rules given in EN 1990. EN 1992 deems these requirements satisfied when the following are applied together:

- Limit-state design in conjunction with partial factor method in accordance with EN 1990
- Loads in accordance with EN 1991
- Combination of loads in accordance with EN 1990
- Resistance, durability, and serviceability in accordance with EN 1992

The following limit states shall be considered per EN 1997-1:

- Loss of overall stability
- Bearing resistance failure, punching failure, squeezing
- Failure by sliding
- Excessive settlements
- Unacceptable vibrations

7.3 FOUNDATIONS

7.3.1 Shallow Foundations

The allowable bearing pressure is:

190 kN/m^2 – Bottom of concrete slabs supported on structural fill

Materials used to support footings shall be compacted to a minimum of 95% of the modified Proctor (NS-EN 1997-1) maximum dry density. The bottoms of all foundations supporting major equipment or piping, as described in Section 4.0 of this document, shall be a minimum of 0.9 meter below finished grade.

7.3.2 Foundations on Rock

The allowable bearing pressure is:

380 kN/m^2 – Bottom of concrete slabs supported on rock

7.3.3 Supplemental Check

The stability ratios for all concrete footing foundation designs shall not exceed the following values:

- Overturning: 1.50 (wind actions)
1.20 (blast actions)
- Uplift: 1.50 (wind actions)

Sliding: 1.50 (wind actions)
1.10 (seismic actions)

8.0 CONSTRUCTION MATERIALS

8.1 CONCRETE AND GROUT

The minimum compressive cylinder strength (f_{ck}) of structural concrete, as measured at 28 days, shall be 35 MPa, unless approved otherwise [Ref. 2.1.4].

The minimum compressive cube strength ($f_{ck,cube}$) of grout, as measured at 28 days, shall be 45 MPa, unless approved otherwise [Ref. 2.1.4].

If not otherwise specified, the minimum concrete mix grades shall be in accordance with Table 8-1 [Ref. 2.3.10].

Table 8-1 Concrete Materials

Min. Grade	Usage	Durability Class	Chloride Class
B30	Blinding layers underneath foundations	M60	C1 1.0
B35	Concrete structures	M45	C1 0.1

8.2 REINFORCING STEEL

Reinforcing steel shall be deformed bars of billet steel, conforming to NS 3576-3/ B500C [Ref. 2.3.10] with minimum yield strength of 500 N/mm^2. All reinforcing and accessories shall be in accordance with the requirements established in the Civil Specification for Kårstø Plant [Ref. 2.3.10].

8.3 ANCHOR BOLTS AND EMBEDMENTS

8.3.1 Anchor Bolts

The following criteria shall be upheld for the design of anchor bolts [Section 3.2.3, Ref. 2.3.10]:

- Anchor bolts shall be cast-in-place.
- Anchor bolts shall conform to NS-ISO4014, Grade 8.8.
- Anchor bolts shall be mechanically galvanized in accordance with NS-EN ISO1461, after fabrication, along with nuts and washers.
- Square washers for carbon steel anchor bolts shall be per NS 5277.
- Nuts for carbon steel anchor bolts shall be per NS-ISO4032, Grade 10.
- The bolt assembly shall include a square anchor plate fixed with bolt, square washer, and two nuts.

In addition, anchor bolts shall be set true and plumb within the following tolerances, unless otherwise specified by equipment manufacturer [Section 3.3, Ref. 2.3.10]:

- Side deviation complete bolt group, Δ1 ±3mm

- Side deviation between bolts in a bolt group, Δ2 ±3mm
- Side deviation single bolt, Δ2* ±3mm
- Height deviation, Δ3 +15mm to -2mm
- Side deviation top bolt, Δs Maximum (bolt height/250, 2mm)

* Note: The plate length/width gives the number of lines where slope deviation and deviation from plane are to be documented:

L = 0–500mm	2 places (both edges)
L = 500–1500mm	3 places (edges plus centerline)
L ≥ 1500mm	4 places (edges plus 2 lines on plate)

8.3.2 Embedments

The following criteria shall be upheld for the design of embedment plates [Section 3.2.4, Ref. 2.3.10]:

- Embedments shall be cast-in-place.
- Embedments shall conform to NS-EN 10025-2-S235J0+N.
- Embedded steel plates where welding will occur after installation shall be cleaned/blasted to SA 2,5 and given one coat of two-pack inorganic zinc-silicate weldable primer with a minimum dry film thickness of 25μ.

In addition, embedded steel plate shall comply with the following tolerances [Section 3.3, Ref. 2.3.10]:

- Side deviation, Δx, Δy ±10mm
- Height deviation, Δz 0mm to -6mm
- Slope deviation* ±3%
- Deviation from plane (curvature), Δ* maximum (L/1000, 3mm)

* Note: The plate length/width gives the number of lines where slope deviation and deviation from plane are to be documented:

L = 0–500mm	2 places (both edges)
L = 500–1500mm	3 places (edges plus centerline)
L ≥ 1500mm	4 places (edges plus 2 lines on plate)

9.0 CONSTRUCTION CONSIDERATIONS

Prior to issuing any design documents, verify that all materials required for the installation of the design have been specified on the particular drawing by listing associated reference specifications and/or drawing notes.

Concrete neat line dimensions shall be shown in meters and specified to the nearest 6mm, to the maximum extent possible.

Reinforcing steel spacing shall be shown in millimeters. The clear distance (horizontal and vertical) between individual parallel bars or horizontal layers of parallel bars should be not less than the maximum of the bar diameter, 5 mm + maximum size of aggregate, or 20 mm [Section 8.2, Ref. 2.1.4].

All outer corners shall be chamfered to a depth and width of 25mm [Section 4.5.1, Ref. 2.3.10].