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Civil and Structural Design basis Project GIGA

ELNG-FLR-ENG-CIV1-DBD-000003

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Please destroy any previous issues

Rev	Description	Date	Made	Checked	Approved
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			[redacted]		

Revision log

Revision	Content of revision
0.1	Issued for Permit

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1. Introduction

1.1. Scope of document

This document contains the basis of design for Civil and Structural engineering. It contains the basic input parameters and data which shall be used for all parts of the project. This document is part of the detailed engineering for Project GIGA of the Gasunie Eems Energy Terminal (EET).

1.2. Project location

The project is located in the Eemshaven in Groningen, the Netherlands.

Figure 1-1; Project location

1.3. Project description

The initial project scope is integrating 2 FSRU's in the Eemshaven and deliver LNG converted to NG to the GTS transport grid.

Nominal capacity for S188 is 400 MMSCFD for Golar Igloo is 500 MMSCFD. Total production capacity is limited by outgoing pipeline which has a limit of 1.3 Mln Nm3/hour.

The initial project scope is completed by January 2023. Then Project MEGA Heat added 10 modules of 10.5 MW natural gas fired heaters to increase available shore heat for FSRU Igloo for enabling stable operation with 2nd regasification skid with 2,6°C lower seawater temperatures from the harbor.

The Project GIGA is adding additional heat with 8 modules of 10.5 MW & 2 modules of 13.5MW natural gas fired heaters to gain independence from RWE.

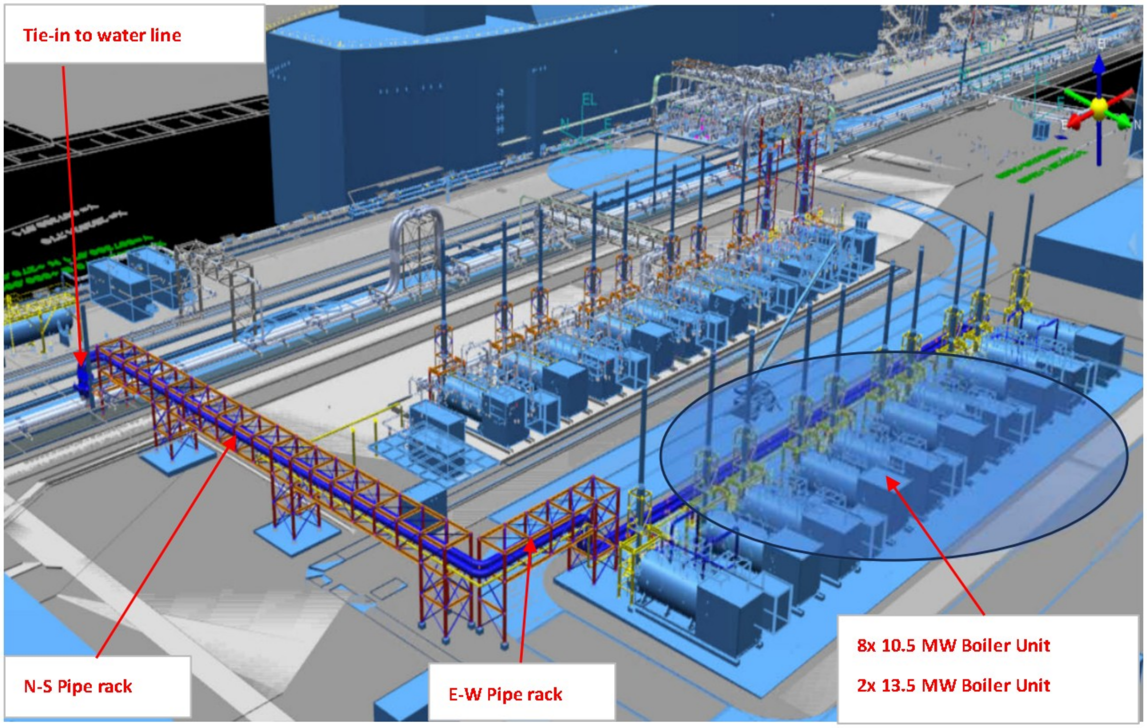


Figure 1-2: Capture of the integrated design model with Project GIGA scope.

2. Basic Engineering data

2.1. Units

The Metric SI system shall be used (Conversion factor 1 kg =10N).

2.2. Language

All documents shall be prepared in English language.

2.3. Codes & Standards

2.3.1. European Codes

Number	Codes and Specifications
NEN-EN 1990	Eurocode 0: Basis of structural design
NEN-EN 1991	Eurocode 1: Actions on structures
NEN-EN 1992	Eurocode 2: Design of concrete structures
NEN-EN 1993	Eurocode 3: Design of steel structures
NEN-EN 1997	Eurocode 7: Geotechnical design
NEN-EN 1998	Eurocode 8: Design of structures for earthquake resistance
EN 1090-2	Execution of steel structures and aluminum structures
EN 10025	Hot rolled products of structural steels
EN 13670	Execution of concrete structures

2.3.2. Gasunie specifications & standards

Number	Codes and Specifications
GTS CSB-29-N	Bouwkundige en civiele constructies
GTS OSB-01-N	Civiele techniek

2.3.3. Existing specifications & standards

Number	Codes and Specifications
ELNG-FLR-ENG-CIV1-DBD-000001	CIVIL STRUCTURAL DESIGN BASIS

2.4. Materials

2.4.1. Concrete

Item	Standard	Modulus of Elasticity (E) (N/mm^2)	Compressive Strength (F_{ck}) (N/mm^2)
Lean Concrete	C12/15	27000	12
Structural concrete for foundations, baseslabs	C30/37	34000	30

2.4.2. Concrete reinforcement

- Reinforcement quality shall be in accordance with NEN-EN 1992-1-1 & EN 10080

Item	Standard	Modulus of Elasticity (E) (N/mm^2)	Yield Str. (F_y) (N/mm^2)	Tens. Str. (Fu) (N/mm^2)
Reinforcing Bars	BE 500S	210000	500	540

2.4.3. Structural steel

- Structural steel shall be in accordance with EN 10025 hot rolled sections.
- All structural steel shall be hot dip galvanized, unless otherwise specified.
- Both structural steel and non-structural elements like handrailing, ladders, stairs shall be made of grade S235.
- Floors shall have grating with openings and bearing bars at 30x3mm, unless noted otherwise.
- Grating shall be designed for a floor load of 5.0kN/m^2. Maximum panel span as provided by supplier shall not be exceeded. Grating panels shall be cut in such way that they don't enclose penetrating piping.

Item	Standard	Modulus of Elasticity (E) (N/mm2)	Yield Str.(Fy) (N/mm2)	Tens.Str. (Fu) (N/mm2)
Structural steel	S 235 JR (Thickness of member ≤40mm)	210000	235	360
	S 235 J2 (40mm <Thickness of member ≤ 80mm)	210000	215	360
Non-structural members (ladders, handrail, stairs)	S 235 JR (Thickness of member ≤16mm)	210000	235	360

2.4.4. Partial material factors on resistance

Item	Basis	Factor – Normal	Factor - Accidental
Concrete	NEN-EN 1992-1-1 2.4.2.4	$\gamma_C = 1.5$	$\gamma_C = 1.2$
Concrete reinf.	NEN-EN 1992-1-1 2.4.2.4	$\gamma_S = 1.15$	$\gamma_S = 1.0$
Structural steel (1)	NEN-EN 1993-1-1 6.1	$\gamma_M = 1.0$	$\gamma_M = 1.0$

Note1; for structural steel connection calculation different values apply, see EN-1993-1-8

2.5. Structural classification

The structures in this project are classified with Consequence class 2 (CC2) per NEN-EN 1990 Annex B. During operation there is no permanent occupation on the site, only operators accessing when necessary. Structural failure would lead to a significant, but not excessive economic loss. Therefore, CC2 applies.

Although the project in basis is designed for approximately 5 years, the design working life for engineering purposes is taken as the default 50 years.

For calculations on modifications of existing structures, in the basis normal new-built CC2 calculation shall be performed.

Structure	Design Working life	Consequence Class	Design supervision level
New structures on EET Quay site	50 years	CC2	DSL2
Existing structures on EET Quay site	50 years	CC2	DSL2
Modification on existing structures	50 years	CC2	DSL2

Resulting partial load factors for CC2;

Structure	Consequence class	Partial load safety factor for Permanent loads - γ_G	Partial load safety factor for Variable loads - γ_Q
All	CC2	1.35 (unfavorable eq. 6.10a) 1.2 (unfavorable eq. 6.10b) 0.9 (favorable)	1.5

Management of reliability is established by working according to the Eurocodes, compliant with the requirements per NEN-EN1990 Annex B. All calculations will be self-checked by the structural engineer and reviewed by a colleague and released by the lead engineer.

[redacted]m the engineering phase of the original quay wall.
Existing geotechnical data:

Doc number		Document title
ELNG-GSP-PER-GDZ-REP-000001	28-May-2021	Geotechnical investigation Wilhelminahaven Noord
OD-W31-E000-ONT-0005-B	Dec-2009	Grondopbouw en grondparameters
VN-41313M	13-Mar-2009	Ergebnisse der erganzenden Bodenuntersuchung

New soil investigation done at GIGA plot.

Doc number		Document title
CEP.35147 rapport Eemshaven fase 4	22-Mar-2024	Geotechnisch bodemonderzoek Synergieweg te Eemshaven, fase 4

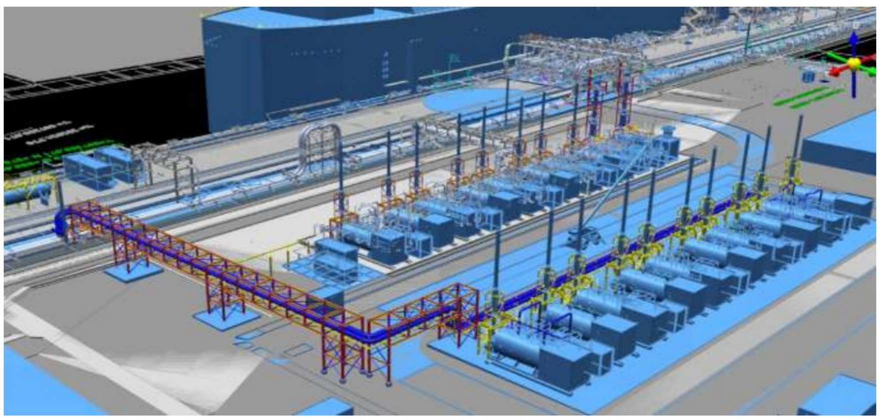
2.7. Coordinate systems

A dedicated local site coordinate system is used. All coordinates are indicated in this reference coordinate system. Local +0.0 elevation is taken equal to the elevation of the top of the concrete quay wall (NAP +5.50m).

A link to the Rijksdriehoek (RD) system is provided on the technical drawings.

2.8. Fire protection concept

The need for fireproofing on EET is defined by the Fluor fire protection specialist and based on fire protection study. On EET, fireproofing requirement was risk based and was provided to structures that were located within the radiation heat contour (Varies from 2.1m to 6.8m). Due to fact that the project GIGA plot is far away from the radiation heat contour, no fire protection is required on the structures.



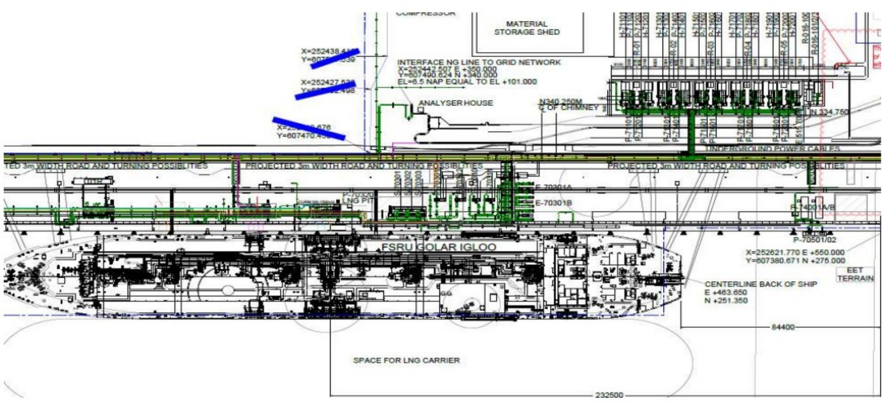


Figure 2-1: Distance of project GIGA plot to the radiation heat contour

2.9. Drainage

The drainage philosophy for the initial phase is described in ELNG-FLR-ENG-CIV1-DBD-000001_Rev1.0.

As confirmed by the boiler supplier, no extra measures taken for the boilers.

New concrete surfaces shall have a slope to avoid standing water.

2.10. Engineering approach

2.10.1. Structural engineering approach

The steel superstructure is modelled and calculated in SCIA Engineer. Following calculation approach is used.

- Slender bracing out of L-sections is modelled as tension only members.
- First-order analysis is used for this calculation. Non-linear calculation is only performed to include effect of tension-only members, not to include the imperfections or second order effects.
- Second order effects are included by sway/non-sway indication and buckling lengths.

2.10.2. Software

Structural calculations; SCIA Engineer Version 20.0.5007

3. Basic load cases and load combinations

3.1. Permanent loads (G)

As per the NEN-EN 1990, permanent action is likely to act throughout a given reference period and for which the variation in magnitude with time is negligible, or for which the variation is always in the same direction until the action attains a certain limit value

3.1.1. Self-weight (GSw)

The structure dead load is the weight of materials forming the structure, foundation, soil above the foundation and all permanently attached items.

Note;

- Self-weight of modelled members is automatically included in SCIA Engineer. Self-weight for any other items shall be manually added, in the report it shall be indicated for what members added loads are included (for instance grating, small support beams).

Item	Description	Self-weight	Unit
Concrete	Unreinforced	24	kN/m³
	Reinforced, Hardened	25	kN/m³
	Reinforced, Unhardened	26	kN/m³
Steel work	Plain steel	78.5	kN/m³
	Grating only	0.35	kN/m²
	Grating, incl. small support beams spaced 1100mm	1.0	kN/m²

3.1.2. Ground water buoyancy (GGw)

Where the bottom of a structure or equipment extends below water level, either temporary or long term, buoyancy and hydrostatic pressures shall be accounted for in the design.

3.1.3. Equipment empty, operating and test load (GEq_{Empty}, GEq_{Oper}, GEq_{Test})

As provided by the vendor.

If no information is available, use Fluor estimated values. These assumptions shall be validated when final data is available.

3.1.4. Piping empty, operating and test load (GP_{Empty}, GP_{Oper}, GP_{Test})

As provided by the Fluor piping department.

If no information is available, use estimated values based on line size. These assumptions shall be validated when final data is available.

3.1.5. Piping and equipment thermal load (GTh)

As provided by the Fluor piping department and vendor.

If no information is available, use estimated values based on line size, or Fluor estimated values. These assumptions shall be validated when final data is available.

For locations without guides or anchor support for piping or equipment, friction loads need to be considered. For structures with multiple pipe supports, these can be considered to be compensated internally, and don't need to be transferred to the foundation.

Surfaces	Friction coefficient	Note
Steel to Steel(not corroded)	0.4	
Steel to Concrete	0.6	
Steel to Grout	0.2	
Proprietary sliding surfaces or coating (e.g. "Teflon")	According to manufacturer's instructions	

3.1.6. Cable tray loads (GEl)

Without more detailed input, a cable tray load of 2.0 kN/m^2 per level of cable tray shall be used.
It covers the weight of the cables and the cable tray itself.

3.2. Variable loads

3.2.1. Floor live load (QLL)

Description	Uniform Load (kN/m^2)	Point Load (kN)
Floors at ground level	10	40
Platforms for operation & maintenance	5	10
Walkways and access platforms	3	10

3.2.2. Snow load (QSL)

Snow load on structures shall be calculated according to NEN EN 1991-1-3.
Snow loads on piperacks or grating floors can be neglected.

s_k = 0.7 kN/m^2

C_e = 1

C_t = 1

3.2.3. Wind load (WL)

Basic wind load input parameters;

Description	Notation	Value	Remarks
Fundamental value wind velocity	$v_{b,0}$	27m/s	Wind region 2
Orography factor	c_o	1	
Directional Factor	c_{dir}	1	
Seasonal Factor	c_{season}	1	
Probability Factor (Return period 50 years)	C_{prob}	1	Buildings, construction & fabricated equipment with height ≤ 25m
Roughness Length	z_o	0.005	For terrain category 0 Coastal area
Air Density	r	1.25 kg/m^3	
Turbulence Factor	K_I	1	

The wind resulting windpressure load $q_p(z)$ is provided in below table.

Tabel NB.5 — Extreme stuwdruk in kN/m² als functie van de hoogte

Hoogte	Gebied I			Gebied II			Gebied III	
m	Kust	Onbebouwd	Bebouwd	Kust	Onbebouwd	Bebouwd	Onbebouwd	Bebouwd
1	0,93	0,71	0,69	0,78	0,60	0,58	0,49	0,48
2	1,11	0,71	0,69	0,93	0,60	0,58	0,49	0,48
3	1,22	0,71	0,69	1,02	0,60	0,58	0,49	0,48
4	1,30	0,71	0,69	1,09	0,60	0,58	0,49	0,48
5	1,37	0,78	0,69	1,14	0,66	0,58	0,54	0,48
6	1,42	0,84	0,69	1,19	0,71	0,58	0,58	0,48
7	1,47	0,89	0,69	1,23	0,75	0,58	0,62	0,48
8	1,51	0,94	0,73	1,26	0,79	0,62	0,65	0,51
9	1,55	0,98	0,77	1,29	0,82	0,65	0,68	0,53
10	1,58	1,02	0,81	1,32	0,85	0,68	0,70	0,56
15	1,71	1,16	0,96	1,43	0,98	0,80	0,80	0,66
20	1,80	1,27	1,07	1,51	1,07	0,90	0,88	0,74

The total wind load on equipment support structures may be determined as the sum of the forces of each component in the structure. Components shall include: Equipment and supports (without considering shielding), piping, structural framing, ladders, stairs and other miscellaneous objects attached to the structure. However, the total wind force due to wind for an ordinary structure need not exceed that of an enclosed structure that would completely envelope the structure and attachments.

Wind loads shall be regarded in the main orthogonal directions, but also diagonal wind shall be considered in the engineering calculations.

3.2.4. Maintenance loads (QMaint)

For piperack structures the load from scaffolding shall be included in design. This is only for a temporary load situation.

3.3. Accidental loads

3.3.1. Seismic loads (ASe)

Ground peak acceleration a_g*s is smaller then 0.05g for 475 year return period, therefore according NPR 9998 no seismic loads need to be considered.

3.4. Load combinations

3.4.1. Serviceability limit state (SLS)

Characteristic combinations;

Characteristic SLS load combinations are defined for checking deflections.

			LC Description	GSW_Structure	GSW_Add	G_FP	G_GW	GEq_empty	GEq_oper	GEq_test	GP_empty	GP_oper	GP_test	GTh[Y]	GTh[X]	GEI	QLL	QSL	W[+X]	W[-X]	W[+Y]	W[-Y]	Qmaint
			LC ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
			LC Name	LC1	LC1A	LC1B	LC1C	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC7	LC11	LC12	LC13	LC14	LC15	LC16	LC17
Name	Description	Type																					
SLS F 1A	1.0*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.0*(Q_LL)	SLS	1	1	1	1			1			1		1	1	1	1						
SLS F 1B	1.0*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.0*(Q_LL)	SLS	1	1	1	1			1			1		1	-1	1	1						
SLS F 1C	1.0*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.0*(Q_LL)	SLS	1	1	1	1			1			1		-1	1	1	1						
SLS F 1D	1.0*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.0*(Q_LL)	SLS	1	1	1	1			1			1		-1	-1	1	1						
SLS G 2A	1.0*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[+X])	SLS	1	1	1	1			1			1		1	1	1	0.7		1				
SLS G 2B	1.0*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[+X])	SLS	1	1	1	1			1			1		1	-1	1	0.7		1				
SLS G 2C	1.0*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[-X])	SLS	1	1	1	1			1			1		-1	1	1	0.7			1			
SLS G 2D	1.0*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[-X])	SLS	1	1	1	1			1			1		-1	-1	1	0.7			1			
SLS G 2E	1.0*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[+Y])	SLS	1	1	1	1			1			1		1	1	1	0.7				1		
SLS G 2F	1.0*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[-Y])	SLS	1	1	1	1			1			1		1	-1	1	0.7					1	
SLS G 2G	1.0*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[+Y])	SLS	1	1	1	1			1			1		-1	1	1	0.7				1		
SLS G 2H	1.0*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(W[-Y])	SLS	1	1	1	1			1			1		-1	-1	1	0.7					1	
SLS G 2I	1.0*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(0.71*W[+X] + 0.71*	SLS	1	1	1	1			1			1		1	1	1	0.7		0.71		0.71		
SLS G 2J	1.0*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(0.71*W[+X] + 0.71*	SLS	1	1	1	1			1			1		1	-1	1	0.7		0.71			0.71	
SLS G 2K	1.0*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(0.71*W[-X] + 0.71*	SLS	1	1	1	1			1			1		-1	1	1	0.7			0.71	0.71		
SLS G 2L	1.0*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(0.71*W[-X] + 0.71*W	SLS	1	1	1	1			1			1		-1	-1	1	0.7			0.71		0.71	
SLS H 3A	1.0*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(Q_SL)	SLS	1	1	1	1			1			1		1	1	1	0.7	1					
SLS H 3B	1.0*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(Q_SL)	SLS	1	1	1	1			1			1		1	-1	1	0.7	1					
SLS H 3C	1.0*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 0.7*(Q_LL) + 1.0*(Q_SL)	SLS	1	1	1	1			1			1		-1	1	1	0.7	1					
SLS H 3D	1.0*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 0.7*(Q_LL) + 1.0*(Q_SL)	SLS	1	1	1	1			1			1		-1	-1	1	0.7	1					

Quasi-permanent combinations;

Quasi-permanent SLS load combinations are defined for checking crack width in concrete.
These are not listed here.

3.4.2. Ultimate limit state (ULS)

CC2 Ultimate limit state combinations are used for verification of structural strength.

		LC Description		GSW_Structure	GSW_Add	G_FP	G_GW	GEq_empty	GEq_oper	GEq_test	GP_empty	GP_oper	GP_test	GTh[Y]	GTh[X]	GEl	QLL	QSL	W[+X]	W[-X]	W[+Y]	W[-Y]	Qmaint
		LC ID		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		LC Name		LC1	LC1A	LC1B	LC1C	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC7	LC11	LC12	LC13	LC14	LC15	LC16	LC17
Name	Description	Type																					
ULS A 1A	1.5*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.05*(Q_LL)	ULS	1	1.35	1.35	1.35			1.35			1.35		1.35	1.35	1.35	1.05						
ULS A 1B	1.5*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.05*(Q_LL)	ULS	1	1.35	1.35	1.35			1.35			1.35		1.35	-1.35	1.35	1.05						
ULS A 1C	1.5*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.05*(Q_LL)	ULS	1	1.35	1.35	1.35			1.35			1.35		-1.35	1.35	1.35	1.05						
ULS A 1D	1.5*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.05*(Q_LL)	ULS	1	1.35	1.35	1.35			1.35			1.35		-1.35	-1.35	1.35	1.05						
ULS B 2A	1.2*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.5*(Q_LL)	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	1.2	1.2	1.5						
ULS B 2B	1.2*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.5*(Q_LL)	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	-1.2	1.2	1.5						
ULS B 2C	1.2*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.5*(Q_LL)	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	1.2	1.2	1.5						
ULS B 2D	1.2*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.5*(Q_LL)	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	-1.2	1.2	1.5						
ULS B 3A	1.2*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[+X])	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	1.2	1.2	1.05		1.5				
ULS B 3B	1.2*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[+X])	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	-1.2	1.2	1.05		1.5				
ULS B 3C	1.2*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[-X])	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	1.2	1.2	1.05			1.5			
ULS B 3D	1.2*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[-X])	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	-1.2	1.2	1.05			1.5			
ULS B 3E	1.2*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[+Y])	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	1.2	1.2	1.05				1.5		
ULS B 3F	1.2*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[-Y])	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	-1.2	1.2	1.05					1.5	
ULS B 3G	1.2*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[+Y])	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	1.2	1.2	1.05				1.5		
ULS B 3H	1.2*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(W[-Y])	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	-1.2	1.2	1.05					1.5	
ULS B 3I	1.2*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(0.71*W[+X] + 0.71	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	1.2	1.2	1.05		1.06		1.06		
ULS B 3J	1.2*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(0.71*W[+X] + 0.71	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	-1.2	1.2	1.05		1.06			1.06	
ULS B 3K	1.2*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(0.71*W[-X] + 0.71*	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	1.2	1.2	1.05			1.06	1.06		
ULS B 3L	1.2*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(0.71*W[-X] + 0.71*	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	-1.2	1.2	1.05			1.06		1.06	
ULS B 4A	1.2*(DL + G_Oper + G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(Q_SN)	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	1.2	1.2	1.05	1.5					
ULS B 4B	1.2*(DL + G_Oper + G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(Q_SN)	ULS	1	1.2	1.2	1.2			1.2			1.2		1.2	-1.2	1.2	1.05	1.5					
ULS B 4C	1.2*(DL + G_Oper - G_Th[X] + G_Th[Y]) + 1.05*(Q_LL) + 1.5*(Q_SN)	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	1.2	1.2	1.05	1.5					
ULS B 4D	1.2*(DL + G_Oper - G_Th[X] - G_Th[Y]) + 1.05*(Q_LL) + 1.5*(Q_SN)	ULS	1	1.2	1.2	1.2			1.2			1.2		-1.2	-1.2	1.2	1.05	1.5					
ULS C 5A	0.9*(DL + G_Empty) + 1.5*(W[+X])	ULS	1	0.9	0.9		1.2	0.9											1.5				
ULS C 5B	0.9*(DL + G_Empty) + 1.5*(W[-X])	ULS	1	0.9	0.9		1.2	0.9												1.5			
ULS C 5C	0.9*(DL + G_Empty) + 1.5*(W[+Y])	ULS	1	0.9	0.9		1.2	0.9													1.5		
ULS C 5D	0.9*(DL + G_Empty) + 1.5*(W[-Y])	ULS	1	0.9	0.9		1.2	0.9														1.5	
ULS C 5E	0.9*(DL + G_Empty) + 1.5*(0.71*W[+X] + 0.71*W[+Y])	ULS	1	0.9	0.9		1.2	0.9											1.06		1.06		
ULS C 5F	0.9*(DL + G_Empty) + 1.5*(0.71*W[+X] + 0.71*W[-Y])	ULS	1	0.9	0.9		1.2	0.9											1.06			1.06	
ULS C 5G	0.9*(DL + G_Empty) + 1.5*(0.71*W[-X] + 0.71*W[+Y])	ULS	1	0.9	0.9		1.2	0.9												1.06	1.06		
ULS C 5H	0.9*(DL + G_Empty) + 1.5*(0.71*W[-X] + 0.71*W[-Y])	ULS	1	0.9	0.9		1.2	0.9												1.06		1.06	
ULS C 6A	0.9*(DL + G_Oper) + 1.2*(G_Th[X] + G_Th[Y]) + 1.5*(W[+X])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	1.2	0.9			1.5				
ULS C 6B	0.9*(DL + G_Oper) + 1.2*(G_Th[X] - G_Th[Y]) + 1.5*(W[+X])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	-1.2	0.9			1.5				
ULS C 6C	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] + G_Th[Y]) + 1.5*(W[-X])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	1.2	0.9				1.5			
ULS C 6D	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] - G_Th[Y]) + 1.5*(W[-X])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	-1.2	0.9				1.5			
ULS C 6E	0.9*(DL + G_Oper) + 1.2*(G_Th[X] + G_Th[Y]) + 1.5*(W[+Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	1.2	0.9					1.5		
ULS C 6F	0.9*(DL + G_Oper) + 1.2*(G_Th[X] - G_Th[Y]) + 1.5*(W[-Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	-1.2	0.9						1.5	
ULS C 6G	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] + G_Th[Y]) + 1.5*(W[+Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	1.2	0.9					1.5		
ULS C 6H	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] - G_Th[Y]) + 1.5*(W[-Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	-1.2	0.9						1.5	
ULS C 6I	0.9*(DL + G_Oper) + 1.2*(G_Th[X] + G_Th[Y]) + 1.5*(0.71*W[+X] + 0.71*W[+Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	1.2	0.9			1.06		1.06		
ULS C 6J	0.9*(DL + G_Oper) + 1.2*(G_Th[X] - G_Th[Y]) + 1.5*(0.71*W[+X] + 0.71*W[-Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		1.2	-1.2	0.9			1.06			1.06	
ULS C 6K	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] + G_Th[Y]) + 1.5*(0.71*W[-X] + 0.71*W[+Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	1.2	0.9				1.06	1.06		
ULS C 6L	0.9*(DL + G_Oper) + 1.2*(-G_Th[X] - G_Th[Y]) + 1.5*(0.71*W[-X] + 0.71*W[-Y])	ULS	1	0.9	0.9		1.2		0.9			0.9		-1.2	-1.2	0.9				1.06		1.06	
ULS D 7	1.35*(DL + G_Test) + 1.05*(Q_LL + Q_Maint)	ULS	1	1.35	1.35	1.35				1.35			1.35			1.35	1.05						1.05
ULS D 8A	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(W[+X])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05		0.75				1.05
ULS D 8B	1.2*(DL + G_Test) + 1.05* (Q_LL + Q_Maint) + 0.75*(W[-X])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05		0.75				1.05
ULS D 8C	1.2*(DL + G_Test) + 1.05*(Q_LL) + 0.75*(W[+Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05			0.75			1.05
ULS D 8D	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(W[-Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05			0.75			1.05
ULS D 8E	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(0.71*W[+X] + 0.71*W[+Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05		0.53		0.53		1.05
ULS D 8F	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(0.71*W[+X] + 0.71*W[-Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05		0.53			0.53	1.05
ULS D 8G	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(0.71*W[-X] + 0.71*W[+Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05			0.53	0.53		1.05
ULS D 8H	1.2*(DL + G_Test) + 1.05*(Q_LL + Q_Maint) + 0.75*(0.71*W[-X] + 0.71*W[-Y])	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.05			0.53		0.53	1.05
ULS D 9	1.2*(DL + G_Test) + 1.5*(Q_LL + Q_Maint)	ULS	1	1.2	1.2	1.2				1.2			1.2			1.2	1.5						1.5

4. Design requirements

4.1. Concrete foundation design

In the basis, all foundation works will be concrete slabs on soil, without piling.

On the EET quay site the existing subsoil has been properly compacted and pre-loaded, so sufficient bearing capacity should be available. Existing paving will be removed and foundation slab placed on soil.

Remarks on concrete design;

- Exposure Class related to environmental conditions in accordance with EN 206-1 & NEN-EN 1992-1-1 ch. 4.
- Maximum Crack width as per NEN-EN 1992-1-1 chapter 7.
- Minimum cover shall be provided to ensure safe transmission of forces and protection of steel against corrosion (durability).
- Thickness of blinding concrete shall be 50mm.
- Chamfer strips 25mm shall be used on the exterior angles of concrete elements to provide clean, straight chamfers on all exposed corners.
- Partial material safety factors according NEN-EN 1992-1-1;

Item	Symbol	Value – Normal	Value - Accidental
Concrete	γ_c	$\gamma_C = 1.5$	$\gamma_C = 1.2$
Concrete reinf.	γ_s	$\gamma_S = 1.15$	$\gamma_S = 1.0$

4.2. Steel design

Steel design shall be standalone structures as much as possible, with minimum (horizontal) load transfer to the foundations.

Remarks on Structural steel design;

- Limit the variation in steel sections used. Apply commonly available sections to maximum extend, e.g. HEA400, HEA300, HEA240, HEA200, HEA140, L80x8, UNP200.
- Limit the amount of moment fixed connections to maximum extend.
- Structures shall be designed, detailed and erected such that the joints and all surfaces are accessible for proper inspection, cleaning and painting. Pockets or depressions that could hold water shall have drain holes.
- Strength and stability of steel structure shall be designed in accordance with NEN-EN 1993-1-1 and execution with EN1090-2.
- Strength of steel connections shall comply with NEN-EN 1993-1-8 and execution with EN1090-2.
- Partial safety factor for steel resistance in accordance with NEN-EN 1993-1-1, as shown below;

Situation	Symbol	Value
For resistance of cross section whatever the class is	γ_{M0}	1.00
For resistance of members to instability assessed by member checks	γ_{M1}	1.00
For resistance of cross section in tension to fracture	γ_{M2}	1.25

4.3. Deformation and deflection criteria

4.3.1. Horizontal drift criteria

Description	Maximum Deflection
Pipe racks	H/200
Other Structures	H/200
Hoist beam between two support points (Relative deformation)	L/600
Cantilever hoist beam	L/300
Difference between horizontal displacement of adjacent frames or columns (supporting crane beams or hoist beam)	H/600

4.3.2. Beam deflection criteria

Description	Maximum Deflection
Pipe racks	L/300
Floor beams	L/300
Cantilevers	L/150
Floor beams for supporting equipment	L/400
Hoist beams	L/600

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