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Starting point document
Structural Design NTI "De Vaalt"

Shell EPCM NLxxxx
NTI SE + STD + LNG "De Vaalt" in Echteld, Nederland

Shell Station “De Vaalt”
Medelsestraat 3
4054 NH Echteld

Shell Nederland Verkoopmaatschappij B.V.
"PERMIT PHASE"

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1. General

1.1 Introduction

This report contains the structural design of the canopy of the Shell petrol station NTI Medel located in Echteld. This document shall be part of the WABO permit application (building permit). This should be seen as structural explanation in addition to the building permit application drawings. The starting points mentioned in this report should serve as a guide for the elaboration of the structures. If there are any deviations from these principles at a later stage, this will be presented in the further elaboration of the design.

Note:

This isn't a structural calculation!

Load, stability and strength calculation and drawings of all structures shall be elaborated at a later stage. These documents shall submit for approval to the authorities at least 3 weeks before the start of the specific construction work

1.2 Project scope of work

As part of the EPCM program Shell Verkoopmaatschappij BV is intending to build a new canopy for their new petrol station NTI Medel located on the Medelsestraat at Echteld. The canopy is approximately 22x16 meter with a height of around 9,0 meters. Foundation slab for the LNG equipment has a footprint of approximately 16.5x21.0 meters.

The building is not part of the petrol station and shall not part of this report. On the design it seems visually that the roof structure flows over from canopy to building. This shall be structurally separated with a dilatation.

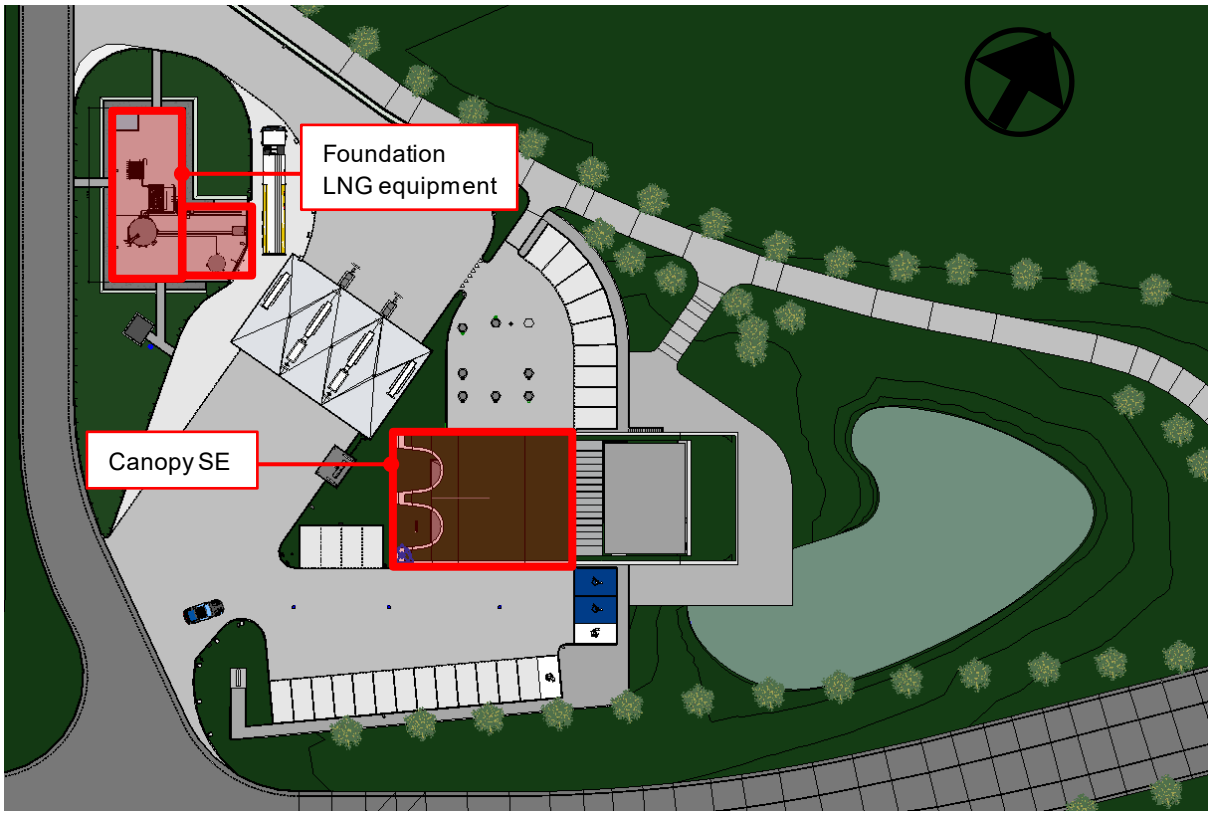


Fig. Site overview of canopy

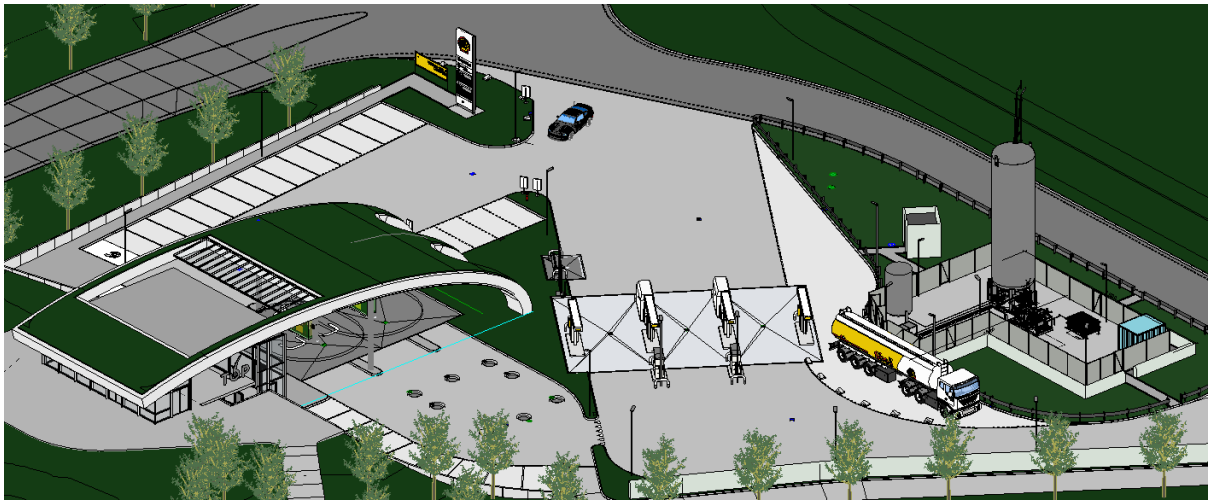


Fig. 3D overview of location

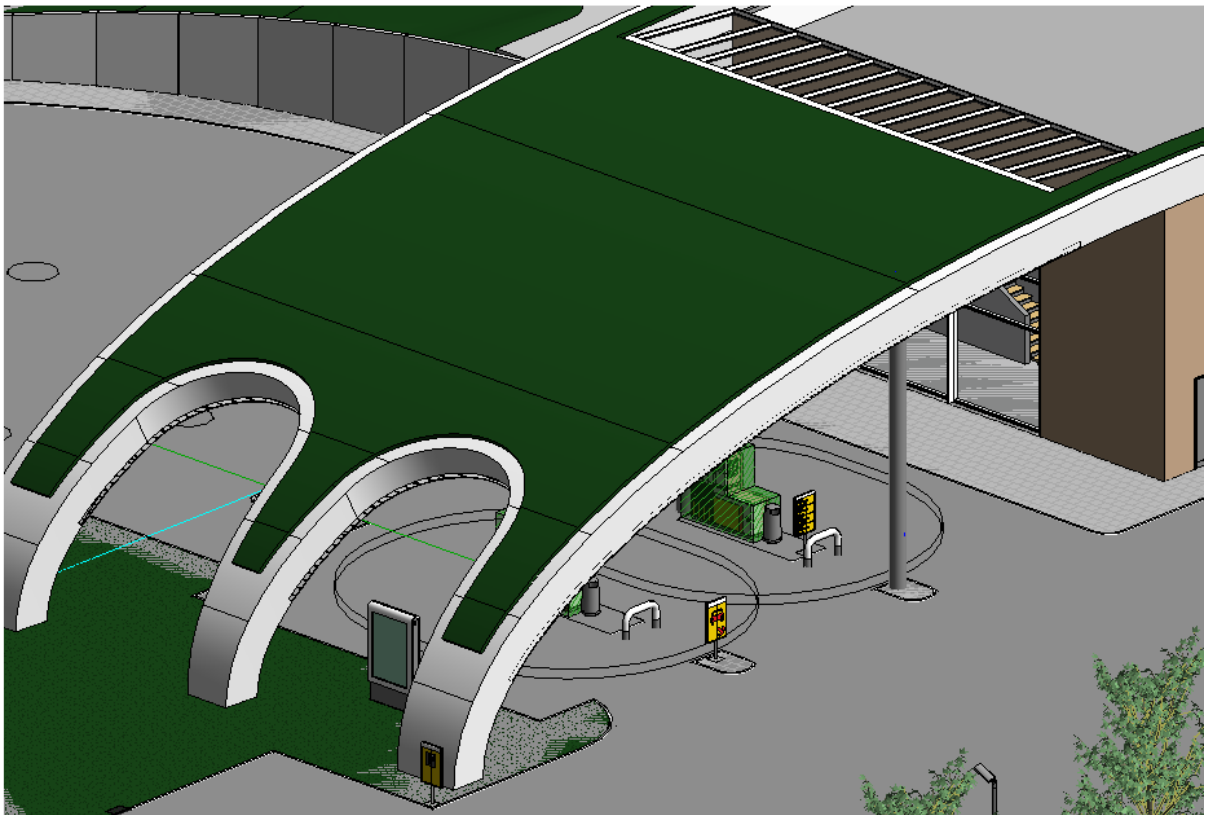


Fig. 3D view of canopy

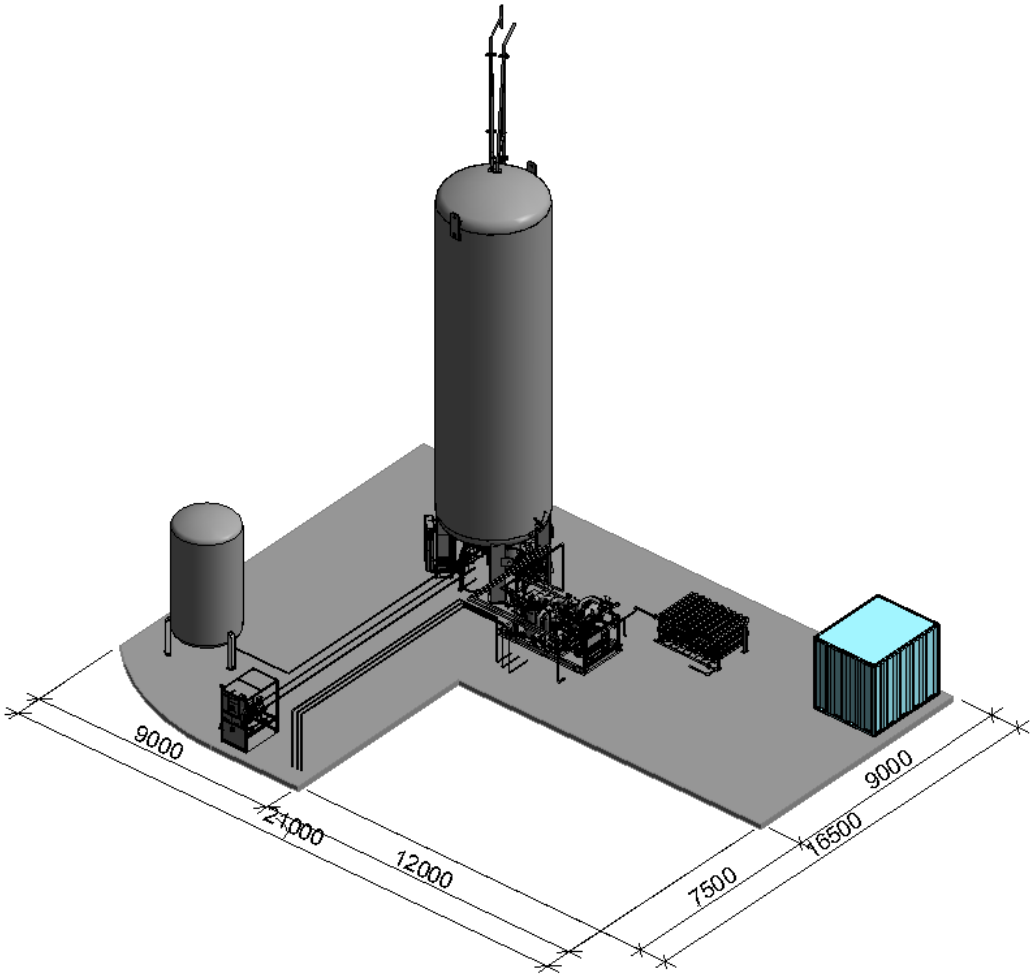


Fig. 3D view of slab foundation

2. Codes & Regulations

This calculation has been based on the last expenditures of the European standards with applicable Dutch National Annexes:

- NEN-EN 1990 & NB Basis of structural design
- NEN-EN 1991 & NB Actions on structures
- NEN-EN 1992 & NB Design of concrete structures
- NEN-EN 1993 & NB Design of steel structures
- NEN-EN 1997 & NB Geotechnical design
- NEN-EN 206-1 Specification, performance, production and conformity
- NEN-EN 10080 Steel for the reinforcement of concrete
- NEN-EN 13670 Execution of concrete structures
- NEN-EN 1090-1 Execution of steel and aluminium structures
  Part 1: Requirements for conformity assessment of structural components
- NEN-EN 1090-2 Execution of steel and aluminium structures
  Part 2: Technical requirements for steel structures
- NEN-EN 10025-2 Hot rolled products of structural steel
- NEN-EN 10210-1 Hot finished structural hollow sections
- NEN-EN 10219-1 Cold formed welded structural hollow sections
- NEN-EN-ISO 898-1 Bolts, screws and studs with specified property classes
- NEN-EN-ISO 898-2 Nuts with specified proof load values

Other standards and regulations:

- NEN 9997-1 Geotechnical design of structures – part 1 – General rules
- Shell Global Innovation & Design Standards

3. Design Criteria

Indicative design working life		*In accordance with Table NB.1 – 2.1 of NEN-EN 1990/NB*
Category 3	50 years	Building structures and other common structures

Consequences classes (CC)	*In accordance with Table NB.20 – B1 of NEN-EN 1990/NB*
CC2	**Medium** consequence for loss of human life, *and/or* economic, social or environmental consequences **considerable**

Reliability classes (RC)		*In accordance with Tables B2 and B3 of NEN-EN 1990*	
RC2	$\beta_{(1\ year)} = 4,7$	$\beta_{(50\ years)} = 3,8$	$K_{FI} = 1,0$

Design supervision levels (DSL)		*In accordance with Table B4 of NEN-EN 1990*
DSL 2 i.r.t. RC2	Normal supervision	Checking by different persons that those originally responsible and in accordance with the procedure of the organization

Inspection levels (IL)		*In accordance with Table B5 of NEN-EN 1990*
IL2 i.r.t. RC2	Normal inspection	Inspection in accordance with the procedures of organization

Execution classes (EXC)	*In accordance with material treaties execution standards NEN-EN 13670 and NEN-EN 1090*
EXC2 i.r.t. RC2 and RC1	Office, shopping, domestic and residential areas, industrial structures

Categories of use		*In accordance with Art.6.3 of NEN-EN 1991-1-1/NB*		
		Values of Ψ factors *In accordance with Table NB.2 – A1.1 of NEN-EN 1990/NB*		
E	Industrial use	$\Psi_0 = 1,0$	$\Psi_1 = 0,9$	$\Psi_2 = 0,8$
H	roofs (not accessible)	$\Psi_0 = 0,0$	$\Psi_1 = 0,0$	$\Psi_2 = 0,0$
	Snow loads	$\Psi_0 = 0,0$	$\Psi_1 = 0,2$	$\Psi_2 = 0,0$
	Loads by rainwater	$\Psi_0 = 0,0$	$\Psi_1 = 0,0$	$\Psi_2 = 0,0$
	Wind loads	$\Psi_0 = 0,0$	$\Psi_1 = 0,2$	$\Psi_2 = 0,0$

Vertical deflections and horizontal displacements		*In accordance with Art.A1.4.3 of NEN-EN 1990/NB*
Other roofs	w_{max}	≤ 1/250 × L
	w_2+w_3	≤ 1/250 × L
Cantilever – L_{rep} = 2 x L	w_2+w_3	≤ 1/250 × L

Horizontal deflections		*In accordance with Art.A1.4.3 of NEN-EN 1990/NB*
Walls or other structures (one or the more levels) and industrial structures (more than one level) (NEN-EN 1993-1-3/NB)	w_{max}	≤ 1/200 × L
horizontal deflection at the location of height difference	w_{max}	≤ 20 mm

Horizontal displacements		*In accordance with Art.A1.4.3 of NEN-EN 1990/NB*
Other structures (one level)	u_{tot}	≤ 1/300 × H

4. Material

4.1 Steel

4.1.1 Quality

Steel sections quality

Hot rolled products of structural steel	S235	$f_y = 235$ N/mm^2	$f_u = 360$ N/mm^2	*NEN-EN 10025-2*
Hot finished structural hollow sections	S275 H	$f_y = 275$ N/mm^2	$f_u = 430$ N/mm^2	*NEN-EN 10210-1*

Fasteners quality

Bolts, screws and studs with specified property classes	4.6	$f_{yb} = 240$ N/mm^2	$f_{ub} = 400$ N/mm^2	*NEN-EN-ISO 898-1*
	8.8	$f_{yb} = 640$ N/mm^2	$f_{ub} = 800$ N/mm^2	
Nuts with specified proof load values	4	corresponding bolt	4.6; 4.8	*NEN-EN-ISO 898-2*
	8	corresponding bolt	8.8	

4.1.2 Partial factors

Partial factors of resistance in de sections *In accordance with Art.6.1 of NEN-EN 1993-1-1/NB*

$\gamma_{M0} = 1,0$ $\gamma_{M1} = 1,0$ $\gamma_{M2} = 1,25$

Partial factors of resistance of joints *In accordance with Art.2.2 of NEN-EN 1993-1-8/NB*

$\gamma_{M2} = 1,25$ $\gamma_{M3} = 1,25$ $\gamma_{M3;ser} = 1,1$ $\gamma_{M4} = 1,0$ $\gamma_{M5} = 1,0$ $\gamma_{M6;ser} = 1,0$ $\gamma_{M7} = 1,1$

4.2 Concrete

4.2.1 Quality

Concrete quality *In accordance with Table 3.1 of NEN-EN 1992-1-1/NB*

Blinding layer	C12/15	$f_{ck} = 12$ N/mm^2	$f_{ck;cube} = 15$ N/mm^2
In situ concrete	C30/37	$f_{ck} = 30$ N/mm^2	$f_{ck;cube} = 37$ N/mm^2

Quality of the reinforcement steel *In accordance with Annex C of NEN-EN 1992-1-1/NB and NEN-EN 10080*

	B500B	$f_{yk} = 500$ N/mm^2	with dented or ribbed surface

4.2.2 Partial factors

Partial factors for materials *In accordance with Art.2.4.2.4 of NEN-EN 1992-1-1/NB*

Design situation	**γ_C for concrete**	**γ_S for reinforcing steel**
Persistent & Transient	1,5	1,15
Accidental	1,2	1,0
Fatigue	1,35	1,15
Serviceability	1,0	1,0

Partial factors for materials for foundation *In accordance with Art 2.4.2.5 of NEN-EN 1992-1-1/NB*

$k_f = 1,1$

5. Actions

5.1 Permanent actions

Dead loads of structural structures	*In accordance with Table A1 t/m A12 of NEN-EN 1991-1-1*
Steel structures	78,5 kN/m^3
Concrete structures	25,0 kN/m^3

Dead loads of non-structural structures	*In accordance with Table A1 t/m A12 of NEN-EN 1991-1-1*
Roof	
- Biodiverse green roof	1,40 kN/m^2
- Roof structure (corrugated steel plate)	0,40 kN/m^2
- Installation hanging in canopy (lighting, drains)	0,10 kN/m^2
- Suspended ceiling	0,10 kN/m^2

5.2 Imposed loads

Imposed loads for floors and roofs		*In accordance with Table NB.1 – 6.2 to NB.5 of NEN-EN 1991-1-1/NB*
Floors for industrial use	Category E2	5,00 kN/m^2
Roofs (not accessible), only maintenance	Category H	1,00 kN/m^2

Imposed loads for equipment		*In accordance with supplier specifications*
LNG Tank "LNG T"	Ø4,0m, h=12,0m	Q_k = 605,0 kN
LIN Tank "LIN T"	Ø1,5m, h=3,0m	Q_k = 60,0 kN
Pomp with satnow skid	3,4 x 1,8m, h=2,2m	Q_k = 15,0 kN
Saturation Vaporizer "SV"	2,5 x 1,6m, h=1,2m	Q_k = 3,0 kN
Offload skid	1,5 x 1,0m, h= 2,2m	Q_k = 2,0 kN

5.3 Snow loads

Snow load on roof	*In accordance with Art.5 of NEN-EN 1991-1-3 & NB*
Flat roof	0,56 kN/m^2

5.4 Loads by rainwater

Loads by rainwater *In accordance with Art.7 of NEN-EN 1991-1-3/NB*

Accumulating height is not exceeding snow load. Sufficient slope, down spouts and emergency overflow are part of the design

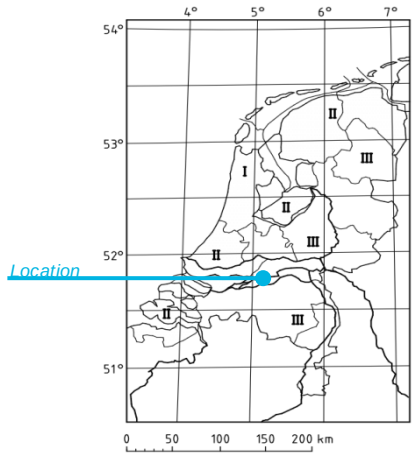
5.5 Wind load

Wind pressure $q_p(z)$

In accordance with Table NB.5 of NEN-EN 1991-1-4/NB

Wind category	III

Fig. NB.1 - Classification of the Netherlands in wind categories



Area	Without obstacles	
Reference height z_e	9,0 meters	15,0 meters

Extreme wind pressure $q_p(z)$

Table NB.5 - Wind velocity pressure in kN/m² in relation with the height

Height	Category I			Category II			Category III	
m	coastal	without obstacles	with buildings	coastal	without obstacles	with buildings	without obstacles	with buildings
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	1,19	0,96	1,43	0,98	0,80	0,80	0,66

Structural factor c_sc_e

In accordance with Art.6 of NEN-EN 1991-1-4 & NB

Building height ≤ 15 m (c_sc_d = 1,0)	*in accordance with Art.6.2(1)a*
Walls and roof elements with natural frequency > 5 Hz (c_sc_d = 1,0)	*in accordance with Art.6.2(1)b*
Building with framework and stability walls H < 100m en H < 4 * building depth (c_sc_d = 1,0)	*in accordance with Art.6.2(1)c*

Pressure, friction and force coefficients

In accordance with Art.7 of NEN-EN 1991-1-4 & NB

Vertical walls of rectangular plan buildings, (c_{pe}) in accordance with Art.7.2.2

NOTE: A reduction factor of 0,85 can be applied as lack of correlation between windward and leeward faces in accordance with Art. 7.2.2(3).

Table NB.6 – 7.1 – External pressure coefficients for vertical wall of rectangular plan buildings

Zone	A		B		C		D		E	
h/d	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5	–1,2	–1,4	–0,8	–1,1	–0,5		+0,8	+1,0	–0,7	
≤ 1	–1,2	–1,4	–0,8	–1,1	–0,5		+0,8	+1,0	–0,5	

	Windward	c_{pe} = +0,8	
	Leeward	c_{pe} = -0,5	
Canopy roofs, (c_{pe}) in accordance with Tables 7.6d 7.8, with roof slope of -5° and +5°	Downwards	c_f = +0,3	
	Upwards	c_f = -1,3	
Vaulted roofs with rectangular base, (c_{pe}) in accordance with Fig. 7.11	Downwards	C_{pe} = +0,8	
	Upwards	C_{pe} = -1,2	
Friction coefficients (c_{fr}) in accordance with Table 7.10	Smooth	c_{fr} = 0,01	(e.g. steel, smooth concrete)
	Rough	c_{fr} = 0,02	(e.g. rough concrete, tar-boards)
	Very rough	c_{fr} = 0,04	(i.e. ripples, ribs, folds)
Structural elements with rectangular sections, (c_f) in accordance with Art.7.		c_f = 2,1	
Force coefficient $c_{f,0}$ for regular polygonal sections (c_{fe}) in accordance with Art.7.	Dodecagon surface smooth	c_{fe} = 0,9	

5.6 Accidental actions

Impact

In accordance with art 4.3 of NEN-EN 1991-7/NB

Accidental actions caused by road vehicles shall not be taken into account. Where traffic is passing or parking along the structure provisions are taken into the design of the terrain to avoid impact on the structures.

Explosion

In accordance with NEN-EN 1991-7/NB

Accidental actions caused by gas explosion shall not be considered in the design of structures.

6. Combinations of actions

6.1 ULS – Ultimate Limit States

Table NB.4 – A1.2 (B) – Design values of actions (STR/GEO) (Set B) in accordance with NEN-EN 1990/NB

Persistent and transient design situations	Permanent actions		Leading variable action	Accompanying variable actions	
	Unfavourable	Favourable		Main (if any)	Others
(Eq. 6.10a)	1,35 $G_{kj,sup}$	0,9 $G_{kj,inf}$		1,5 $\psi_{0,1}Q_{k,1}$	1,5 $\psi_{0,i}Q_{k,i}$ i > 1
(Eq. 6.10b)	1,2 $G_{kj,sup}$ ζ = 0,89 is included	0,9 $G_{kj,inf}$	1,5 $Q_{k,1}$		1,5 $\psi_{0,i}Q_{k,i}$ i > 1

6.2 SLS – Serviceability Limit States

Table A1.4 – Design values of actions for use in the combination of actions In accordance with NEN-EN 1990

Combination	Permanent action G_d		Variable actions G_d	
	Unfavourable	Favourable	Leading	Others
Characteristic	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $Q_{k,1}$	1,0 $\psi_{0,i}Q_{k,i}$
Frequent	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $\Psi_{1,1}Q_{k,1}$	1,0 $\Psi_{2,i}Q_{k,i}$
Quasi-permanent	1,0 $G_{kj,sup}$	1,0 $G_{kj,inf}$	1,0 $\Psi_{2,1}Q_{k,1}$	1,0 $\Psi_{2,i}Q_{k,i}$

7. Schematic overview

7.1 Structural overview canopy

7.1.1 Steel structure

Below the schematic overview of the steel structure. Profiling still has to be determined. The design possibly may still deviate once the strength calculation of the steel structure has been carried out.

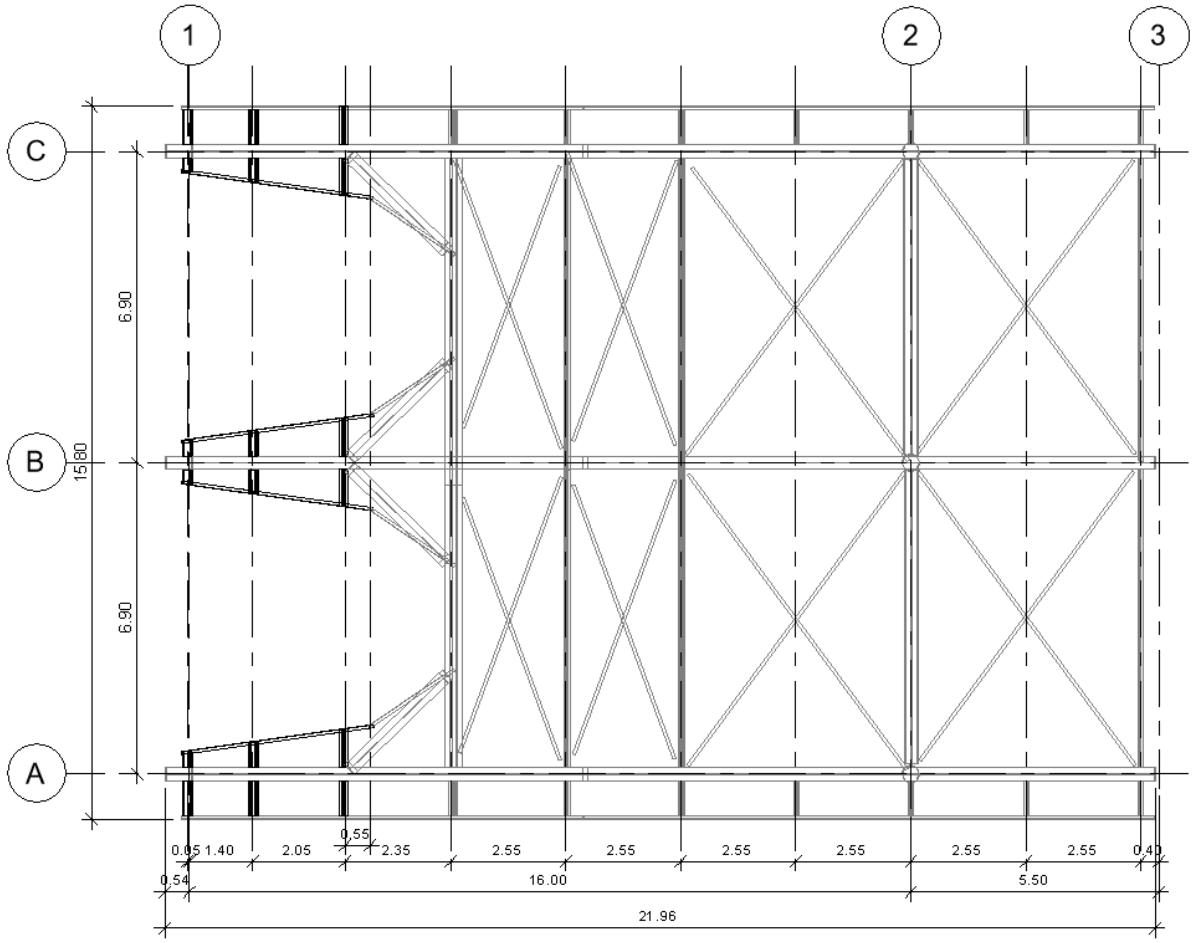


Fig. Overview steel structure canopy

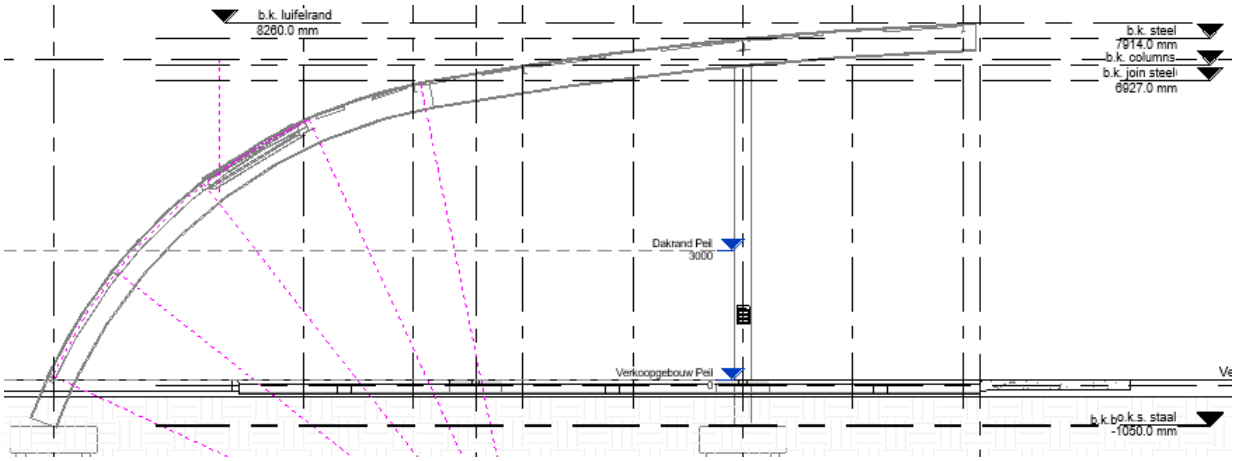
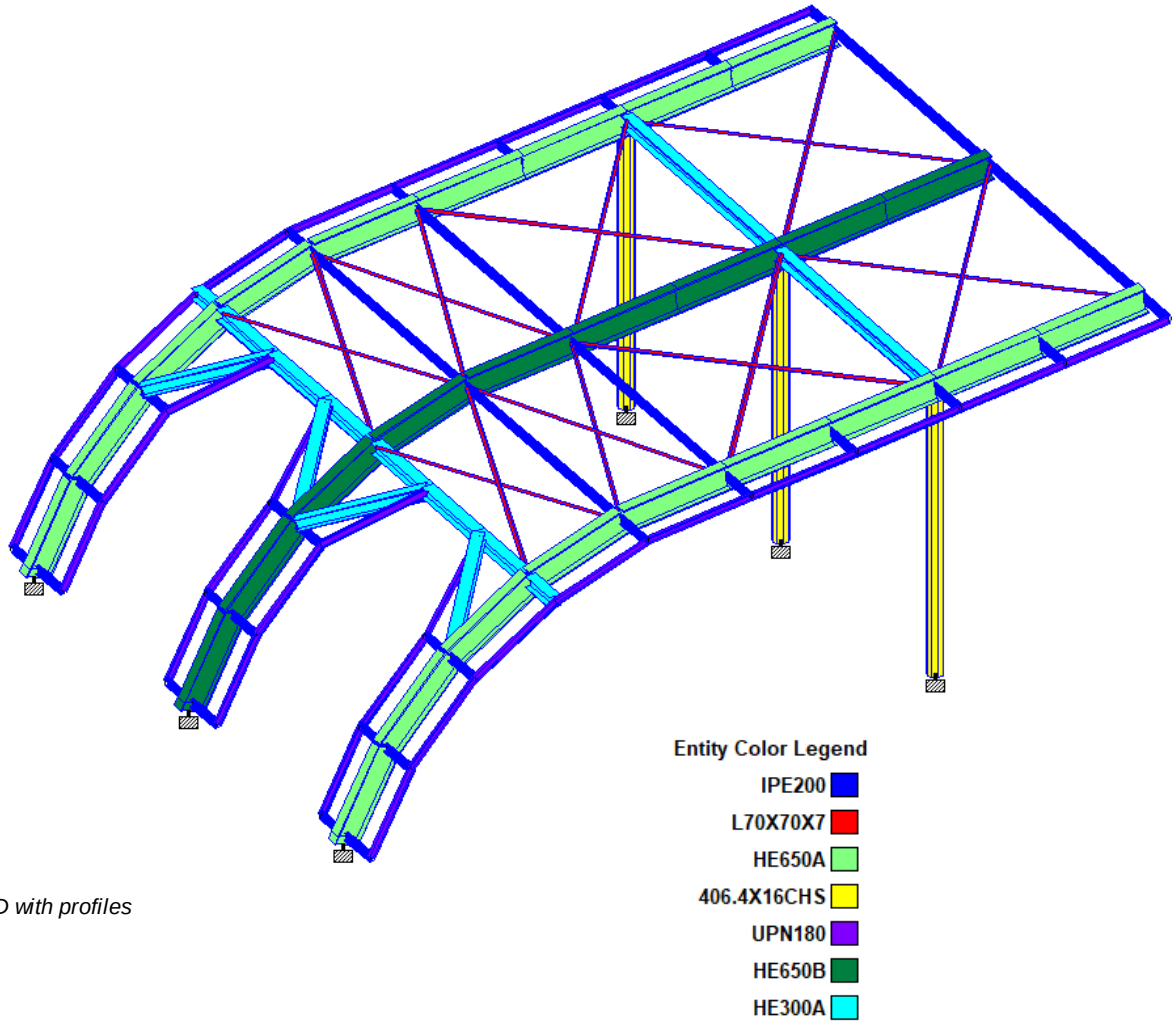


Fig. Side view steel structure canopy



3D with profiles

7.1.2 Foundation

Below the schematic overview of the foundation. Based on the soil condition in this area it is expected that the foundation shall be carried out on piling. A geotechnical investigation still must be prepared to determine the exact configuration.

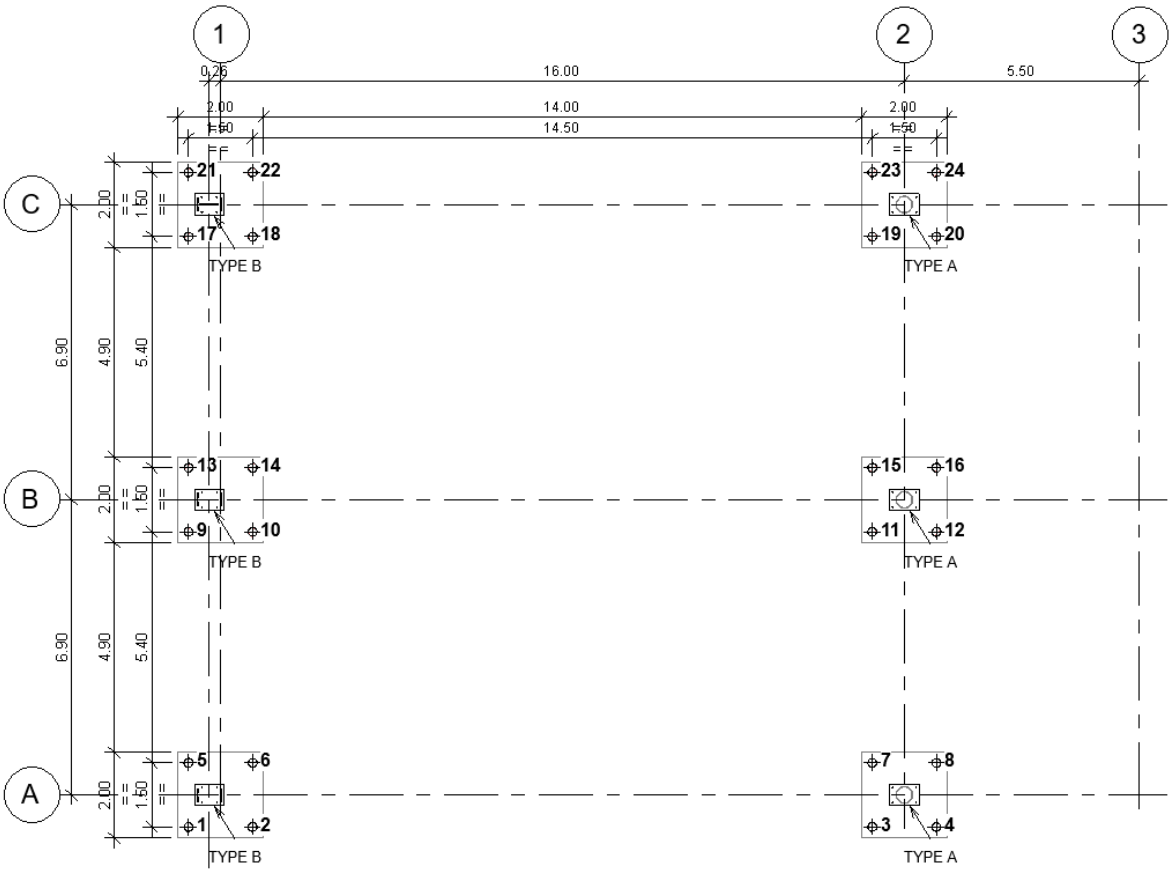


Fig. Overview foundation canopy

7.2 Structural overview LNG equipment

7.2.1 Foundation

Below the schematic overview of the foundation. The equipment shall be positioned on top a concrete slab. Based on the soil condition in this area it is expected that the foundation shall be carried out on piling. A geotechnical investigation still must be prepared to determine the exact configuration.

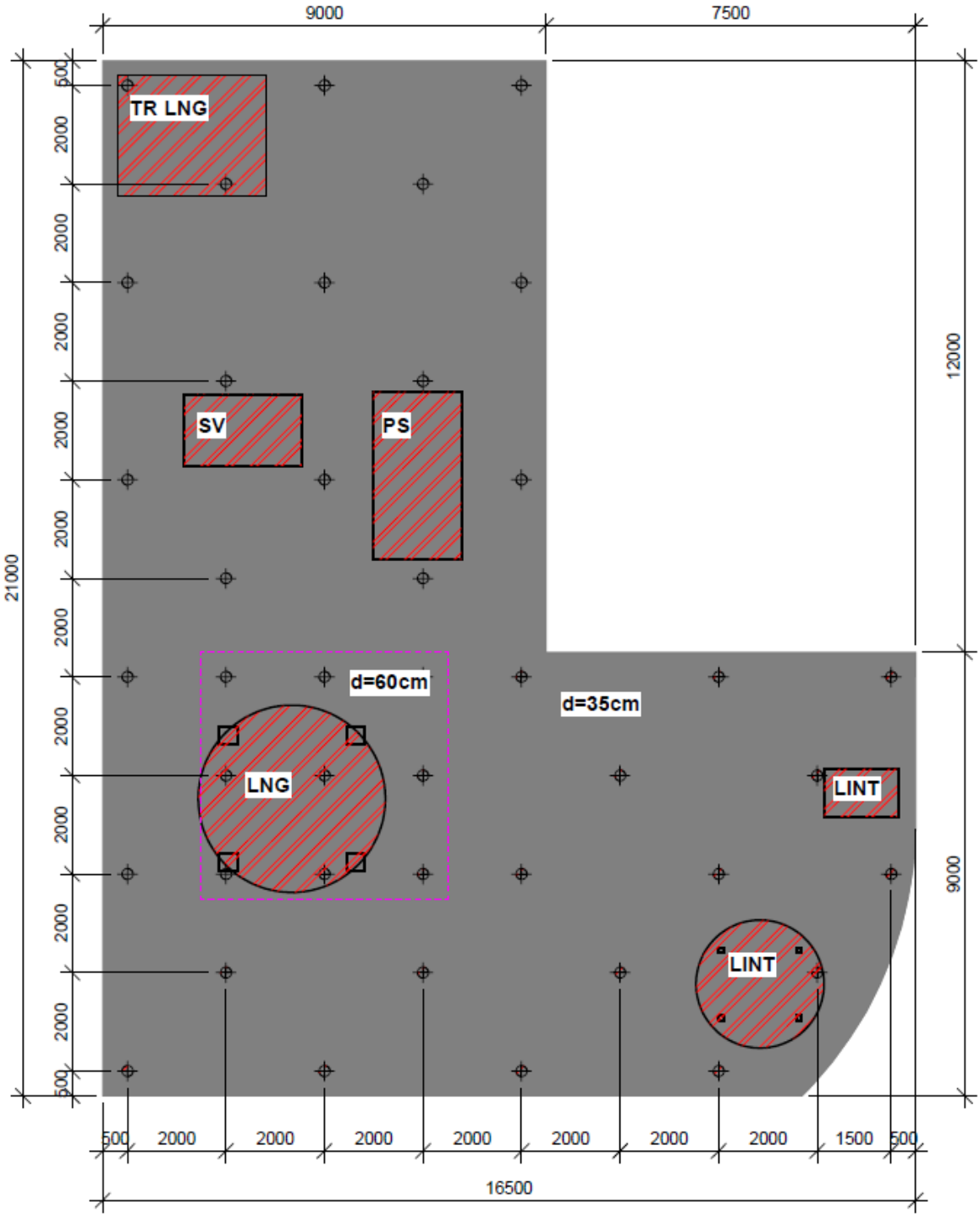


Fig. Overview slab foundation

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