REPORT

Wind Farm Maasvlakte 2 - Crane Hardstands for Wind Turbines along the Hard Sea Barrier

Preliminary Geotechnical Foundation Design

Client: Eneco Wind B.V.

Reference: BG8375-RHD-ZZ-XX-RP-G-0004

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Classification
Project related

Disclaimer

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1 Introduction

Rijkswaterstaat (RWS) has commissioned Eneco to develop the Maasvlakte 2 wind farm with a capacity of more than 100 MW. The wind farm is located along the western and northern sea barrier, see Figure 1-1. Royal HaskoningDHV is partner of Eneco and provides the design of the wind turbine foundations and the associating civil works, such as the crane hardstands, the cable routing, the construction roads and the transformer station.

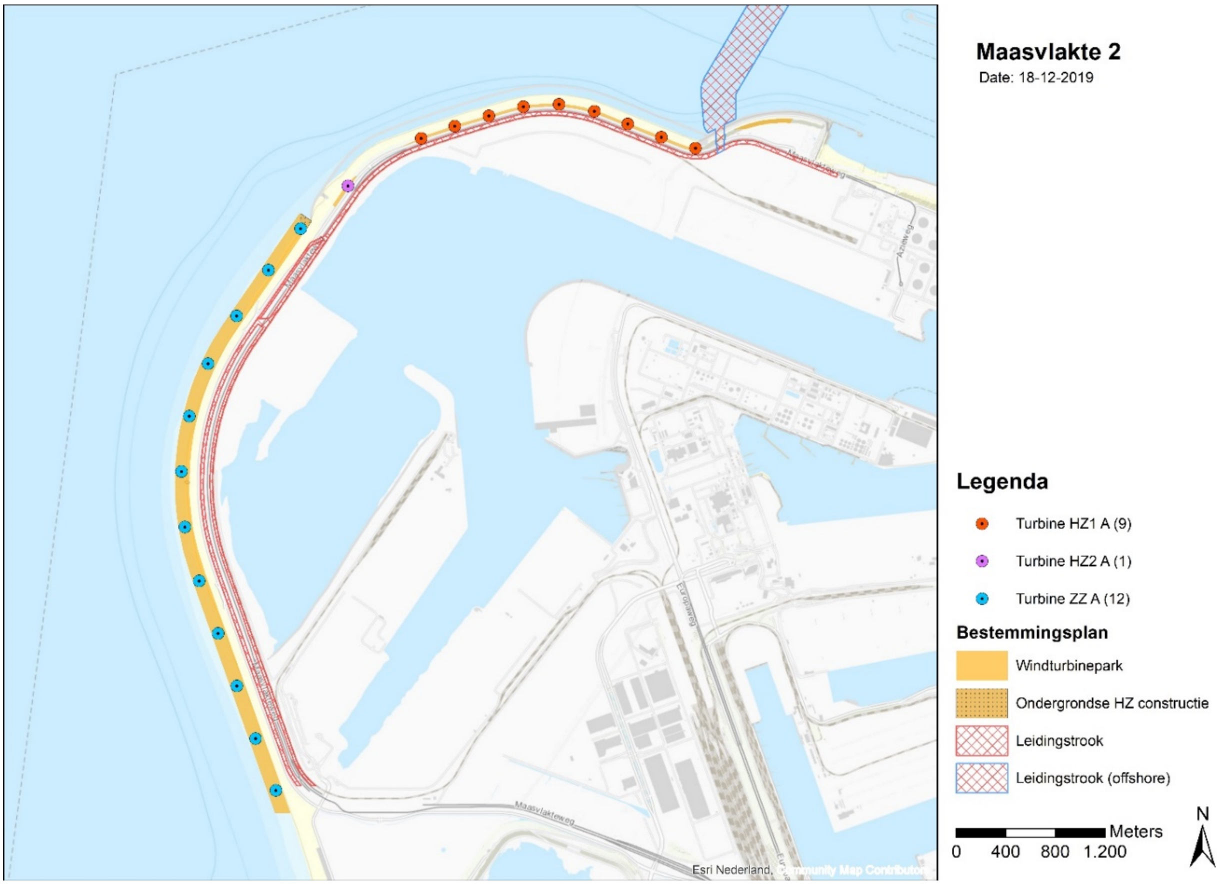


Figure 1-1: Location Wind Farm Maasvlakte 2

This report describes the preliminary geotechnical foundation design for the crane hardstands for the ten (10) wind turbines near the ‘hard sea barrier’ (turbine locations ‘HZ’ in Figure 1-1). The wind turbines are located on the inner slope of the sea barrier.

At this stage of the project no selection has been made yet of the turbine supplier. Consequently, the crane type is not known yet. The crane hardstands are therefore designed to be suitable for both mobile cranes as well as crawler cranes. In this design, the worst-case (most unfavourable) load conditions are derived based on provided specifications for civil works from the intended wind turbines suppliers.

The stability (bearing capacity) of the crane platform is verified by shear failure calculations. Settlement calculations are performed to avoid exceeding maximum allowable inclination.

2 Reference Documents

2.1 Codes and Guidelines

For this project the following documents are applicable:

[REF1] NEN 9997-1+C2:2017, Geotechnical design of structures - Part 1: General rules.
[REF2] STOWA Publication 2019-02A, Handbook Crane Hardstands for Installation of Wind Turbines., 23 May 2019.
[REF3] NEN-EN 1990/+NB, National Annex to NEN-EN 1990+A1+A1/C2: Eurocode: Basis of structural design.

2.2 Specifications for Civil Works

[REF4] Vestas Wind Systems A/S, Crane Pad, Hardstand and Installation Specifications V105/V112/V117/V126/V136/V150. Document no.: 0083-9772 V00. 2019-03-19
[REF5] Siemens Gamesa, Appendix 3: Site Specific Requirements SGWT DD-130-85mHH. Rev. number 00. 2020-03-04
[REF6] Enercon, Specification Access roads and construction site areas, ENERCON Wind energy converter E-115 EP3 E3. Document nr. PLM-SiteL-SP097-E-115 EP3 E3_67m SRT-Rev002de-en. 2019-09-20

2.3 General Site Data

[REF7] Inpijn Blokpoel, Bodemkundig onderzoek Harde Zeewering. Doc. Nr.: 02P003077-adv-01, 21-06-2013
[REF8] PUMA, Geotechnische beoordeling aanleggebied. Doc nr.: puma-q-lb-onb01, 27-02-2008
[REF9] MOS grondmechanica, Sonderingen Windpark 2e Maasvlakte. Doc. Nr.: 4300038842, 4-11-2019
[REF10] Rijkswaterstaat, Memo watervergunning Zachte Zeewering, 23 april 2019
[REF11] PUMA, Harde Zeewering: Geotechnische stabiliteit van Stenig Duin + Blokkendam; Ontwerpnota. Doc. Nr.: puma-mpo-ono02, 15-02-2011
[REF12] Deltares, Bodemdaling in het kustfundament en de getijdenbekkens. Doc. Nr.: 11200538-008-ZKS-0001, 15-02-2018

2.4 Project related documents

[REF13] Kraanopstelplaats HZ-02. Dwarsprofiel type HZ-01 tm HZ-08. Doc. Nr.: BG8375-RHD-ZZ-XX-DR-C-0001, d.d. 08-05-2020
[REF14] Business Plan Windpark Tweede Maasvlakte, v02. d.d. 09-01-2020

3 General Principles

3.1 Project prerequisites

Regarding the crane hardstand design there are no project specific prerequisites mentioned in the risk management plan ([REF14], Appendix 2.4).

3.2 Safety and Reliability

3.2.1 Consequence Class and Geotechnical Category

For the crane hardstand foundation, the following parameters are used:

- Reliability class: RC2 (according to NEN-EN 1990/+NB table B2)
- Geotechnical Category 3 (according to NEN 9997-1:2017 section 2.1)

3.2.2 Design Approach

In accordance with the Eurocode 7 the Design Approach 3 (DA3) is applied for foundation design. For DA3 the design shall be checked against failure in the soil and in the structure, including partial factors on loads (actions) and material properties. The resistance factor is set to 1.0.

3.2.3 Load Factors

The partial load factors are set to:

- 1.5 for bearing capacity analysis in accordance with [REF1];
- 1.3 for stability analysis. [REF1]

3.2.4 Material factors

The material factors used for soil material are in accordance with the Eurocode 7 (NEN 9997-1:2017) for verification of bearing capacity:

- γ_{ϕ}=1,15 for tanφ;
- $\gamma_{c'}$=1,6;
- γ_{cu}=1,35;
- γ_{γ}=1,1.

3.3 Ultimate Limit State Requirements

In accordance with the Eurocodes the geotechnical foundation design demonstrates that exceeding the following ultimate limit states is sufficiently improbable:

- Bearing capacity of the subsoil according to NEN 9997-1:2017;

3.4 Serviceability Limit State Requirements

For the serviceability limit state design all partial load and material factors are set to 1.0.

In accordance with the specification of Siemens Gamesa [REF5] the maximum total settlement shall not exceed 2cm for the specified maximum loads applied for the period of two weeks on crane hardstands.

3.5 Crane Hardstand Layout

The crane hard stand is located near the inner toe of the sea barrier. Each crane hardstand consists of the following components:

- Crane platform:
- Assembly area;
- Auxiliary crane platform;
- Compound area/logistics area.

The preliminary layout of the crane hardstand is shown the figure below.

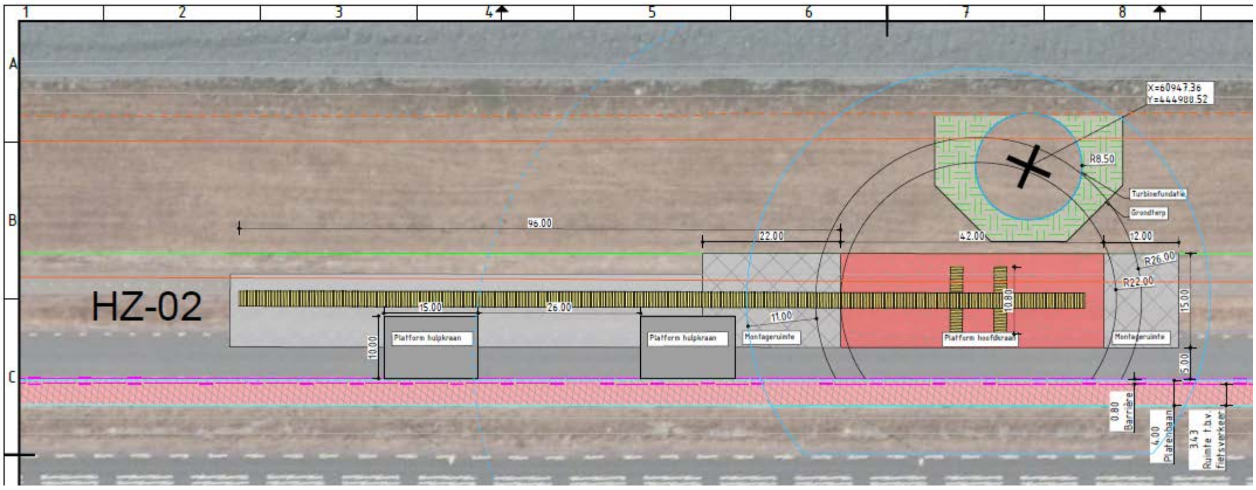


Figure 3-1: layout crane hardstand near location HZ-02 ([REF13])

3.6 Foundation levels

The crane hard stand foundation (reinforced mixed aggregate) will be placed on top of the existing terrain (road) near the toe of the sea barrier. The existing terrain level is approximately NAP +5.5 m.

In selecting the appropriate crane type the approximately 9 m height difference with the top of the foundation shall be taken into account. This height difference is more than the specified maximum level differences (generally +/- 1 to 2.5 m).

3.7 Crane loads and requirement for crane hardstands

The main crane hardstands (MCHS) shall be suitable for both a mobile crane as a crawler crane. Based on the specification for civil works the most unfavourable loads and most stringent criteria are selected.

3.7.1 General Requirements

General requirements with respect to the crane hardstands at the hard sea barrier are as follows:

- It needs to be demonstrated that installation effects do not have negative consequences on the safety of the sea barrier [REF10]. Meaning:
  - o The barrier function needs to be guaranteed during construction;
  - o Vibrations shall not lead to deformation of the block wall in front of the sea barrier;
  - o If vibrations cause settlement of the hard sea barrier, this needs to be repaired before construction is finished.
  - o Vibrations shall not result in soil liquefaction (static and cyclic).

- Pile driving and excavations are only allowed outside the storm season (October 1 – April 1) [REF10].
- No lifting is allowed in case of wind force 6 and higher [REF10];
- No construction works are allowed in case of wind force 7 and higher [REF10];
- Maintenance of the sea barrier shall not be obstructed [REF10];
- The foundations need to be able to be fully removed [REF10];
- An extensive monitoring of the deformations and stability of the sea barrier must be implemented [REF10];
- Convention (proven) foundation methods are preferred [REF10].

3.7.2 Requirements for the Main Crane Hardstand

The requirements for the MCHS are listed in the following table.

Table 3-1: requirements for the MCHS

Parameter	Requirement	Specification
Typical type of crane	LG1750 or LTM11200	[REF4], [REF5]
Outrigger spread	16 m x 16 m	[REF4]
Loaded area (mat dimensions)	Mobile: 4 x (2,4 m x 6,0 m) Mobile: 2 m x 10 m Crawler: 5 m x 10 m	[REF5] [REF6] [REF6]
Length	43 m	[REF5]
Width	20 m	[REF5]
Level to top WTG	Max 2.0 -2.55 m	[REF5], [REF6]
Min. Load bearing cap.	Mobile crane: 200 kPa Crawler crane: 250 kPa	[REF4]
Partial Safety Factor	1.5	[REF4]
Settlement criteria	2cm in 2 weeks	[REF5]
Longitudinal slope	Mobile crane: max. 1% Crawler crane: 0%	[REF4]
Lateral slope	Mobile crane: max. 1% Crawler crane: 0%	[REF4]
Shoulder slope	max. 45˚	[REF4], [REF6]
Compaction criteria lower binder course	$D_{Pr} \geq 100\%$ and $E_{V2}/E_{V1} \leq 2.3$	[REF6]
Compaction criteria upper binder course	$D_{Pr} \geq 103\%$ and $E_{V2}/E_{V1} \leq 2.3$	[REF6]
Minimum layer thickness	0.25 m	[REF6]
Material upper binder course	Aggregate 0/32-0/45mm	[REF6]

3.7.3 Requirements for the Auxiliary Crane Hardstand

The requirements for the ACHS are listed in the following table.

Table 3-2: requirements for the ACHS

Parameter	Requirement	Specification
Typical type of crane	200 to 250t crane	[REF4], [REF5]
Loaded area (mat dimensions)	4 x (2,0 m x 2,0 m)	[REF5]
Length	15,5 m	[REF5]
Width	11 m	[REF5]
Level to top WTG	Max 2.0 -2.55 m	[REF5], [REF6]
Min. Load bearing cap.	Mobile crane: 200 kPa Crawler crane: 250 kPa	[REF4]
Partial Safety Factor	1.5	[REF4]
Settlement criteria	2cm in 2 weeks	[REF5]
Longitudinal slope	max. 1%	[REF4]
Lateral slope	max. 1%	[REF4]
Shoulder slope	max. 45˚	[REF4], [REF6]
Compaction criteria	$D_{Pr} \geq 98\%$	[REF4]

3.7.4 Requirements for the Assembly Area

The requirements for the Assembly Area are listed in the following table.

Table 3-3: requirements for the Assembly Area

Parameter	Requirement	Specification
Typical type of crane	500t to 750t crane	[REF5]
Outrigger spread	12 m x 12 m	[REF4]
Loaded area (mat dimensions)	4 x (2,4 m x 4,0 m) 1 m x 8 m 3 m x 8 m	[REF5] [REF6] [REF6]
Min. Load bearing cap.	200 kPa	[REF4], [REF5]
Partial Safety Factor	1.5	[REF4]
Settlement criteria	2cm in 2 weeks	[REF5]
Longitudinal slope	max. 1%	[REF4]
Lateral slope	max. 1%	[REF4]
Shoulder slope	max. 45˚	[REF4], [REF6]
Compaction criteria	$D_{Pr} \geq 100\%$ and $E_{V2}/E_{V1} \leq 2.3$	[REF6]

3.7.5 Requirements for the Compound Area / Logistics Area

The requirements for the Compound Area and Logistic Area are listed in the following table.

Table 3-4: requirements for the Compound Area and Logistics Area

Parameter	Requirement	Specification
Loaded area (mat dimensions)	2 m x 10 m 5 m x 10 m	[REF6] [REF6]
Length	50 m	[REF5]
Width	30 m	[REF5]
Min. Load bearing cap.	135 kPa	[REF6]
Partial Safety Factor	-	
Settlement criteria	-	
Longitudinal slope	max. 1.5%	[REF5][REF4]
Compaction criteria lower binder course	$D_{Pr} \geq 100\%$ and $E_{V2}/E_{V1} \leq 2.3$	[REF6]
Compaction criteria upper binder course	$D_{Pr} \geq 103\%$ and $E_{V2}/E_{V1} \leq 2.3$	[REF6]
Minimum layer thickness	0.25 m	[REF6]
Material upper binder course	Aggregate 0/32-0/45mm	[REF6]

4 Site and Soil Conditions

4.1 Geotechnical Soil Investigation

During the tender stage of this project, MOS Grondmechanica performed a geotechnical soil investigation on behalf of Rijkswaterstaat [REF9]. In the project area of the hard sea barrier (HZ) four cone penetration tests (CPT's) were carried out to a max. depth of NAP –44,5 m.

In the table below an overview of the soil investigation is presented. The location of these points is given in [REF9].

Table 4-1: Soil investigation CPT locations [REF9]

Name	RD X coordinate [m]	RD Y coordinate [m]	Ground level [m NAP]	End depth [m NAP]
7	58363.390	444527.550	+5.35	-44.48
8	59014.070	444977.310	+5.33	-44.27
9	59734.860	445202.590	+5.19	-37.28
10	60489.520	445152.670	+5.38	-36.14

4.2 Ground Level

The existing ground level at the locations of the crane hardstands is around NAP +5.5 m. A typical cross section of the hard sea barrier is shown in Figure 4-1.

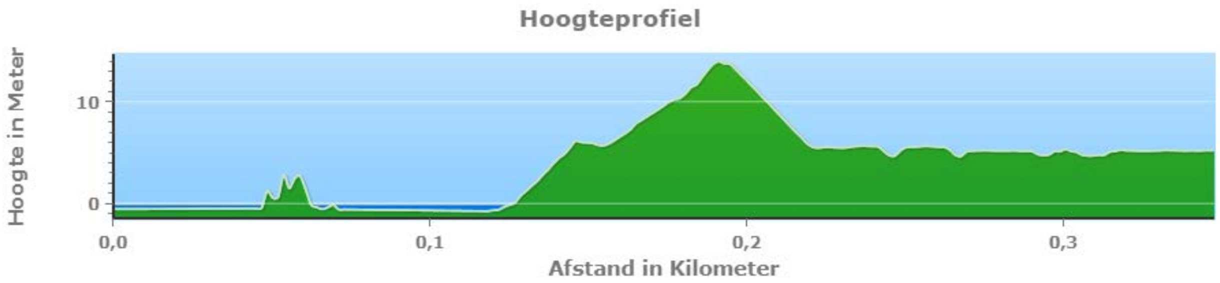
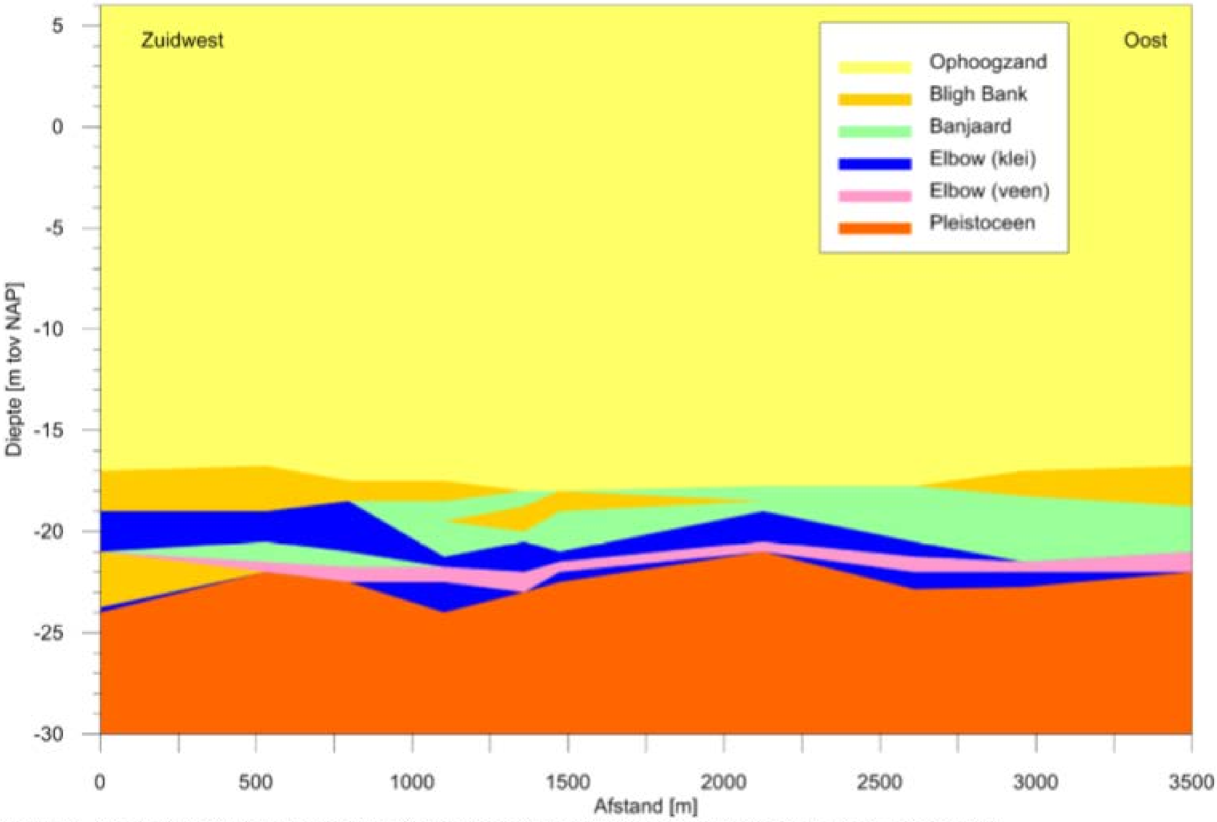


Figure 4-1: Typical elevation profile of the hard sea barrier. Source: AHN

4.3 Soil Profile

From available ground investigations [REF7][REF9] it has become clear that the subsurface below the hard sea barrier mainly consists of sand. Directly below ground level up to a depth of around NAP -17 to -21 m a thick layer of sand fill is present. The sand texture varies from fine to very course. Its consistency varies from moderately to densely packed (cone resistance of up to 50 MPa).

Below the sand fill the naturally sedimented soil is present. At the hard sea barrier down to NAP -22 to -24 this soil profile comprises of sandy clay, clayey sand and peat (geological Elbow Formation). From around NAP -22 to -24 m dense Pleistocene sand is encountered with cone resistances of up to 70 MPa. In this sand locally and at alternating depths reductions in cone resistance are observed, probably caused by loose packing or course gradation. In the figure below a geological cross-section located at the hard sea barrier (HZ) is displayed.



Figuur 5. Geologisch (zuidwest-oost) profiel ter hoogte van harde zeewering (bron: puima-q-lb-onb01).

Figure 4-2: geological profile hard sea barrier (Inpijn-Blokpoel, 2013, [REF7])

4.4 Soil Parameters

Based on the results of the soil investigation, the representative geotechnical soil profiles have been schematized for the crane hardstands. The soil parameters were determined based on table 2.b of NEN 9997-1+C2:2017 [REF1] and correlations with CPT using the cone resistance q_c.

The characteristic values for the shear strength properties and compression properties are given in the following tables.

Table 4-1: Soil stratigraphy and characteristic values for the soil shear strength parameters

Top soil layer [m NAP]	**Description soil layer**	**Bulk unit weight γ_{dry} /γ_{sat}** [kN/m³]	**Effective angle of internal friction φ** [°]	**Effective cohesion c'** [kPa]	**Shear stress C_u** [kPa]
+5.33	Sand, dense	19.0/21.0	35.0	0	N.A.
+3.0	Sand, loose	17.0/19.0	30.0	0	N.A.
1.8	Sand, dense	19.0/21.0	35.0	0	N.A.

Top soil layer [m NAP]	Description soil layer	Bulk unit weight γ_{dry} /γ_{sat} [kN/m^3]	Effective angle of internal friction φ [º]	Effective cohesion c' [kPa]	Shear stress C_u [kPa]
-0.2	Sand, moderate	18.0/20.0	32.5	0	N.A.
-3.8	Sand, moderate	17.5/19.5	30.0	0	N.A.
-8.8	Sand, dense	19.0/21.0	35.0	0	N.A.
-12.2	Sand, moderate	18.0/20.0	32.5	0	N.A.
-15.0	Sand, moderate to dense	18.5/20.5	33.5	0	N.A.
-16	Sand, loose	17.0/19.0	30.0	0	N.A.
-16.4	Sand, moderate	18.0/20.0	32.5	0	N.A.
-17.9	Sand, very clayey	18.0/20.0	25.0	0	N.A.
-20.3	Clay, stiff	19.0/19.0	17.5	13.0	13.0
-22.3	Peat, moderate	12.0/12.0	15.0	2.5	20.0
-23.1	Sand, moderate	18.0/20.0	32.5	0	N.A.

Table 4-2: Soil stratigraphy and characteristic values for the soil compression parameters

Top soil layer [m NAP]	Description soil layer	Bulk unit weight γ_{dry} /γ_{sat} [kN/m^3]	CR [-]	RR [-]	Ca [-]	c_v [m^2/s]
+5.33	Sand, dense	19.0/21.0	0.0031	0.0011	0	drained
+3.0	Sand, loose	17.0/18.0	0.0115	0.0038	0	drained
1.8	Sand, dense	19.0/21.0	0.0031	0.0011	0	drained
-0.2	Sand, moderate	18.0/20.0	0.0031	0.0011	0	drained
-3.8	Sand, moderate	18.0/20.0	0.0031	0.0011	0	drained
-8.8	Sand, dense	19.0/21.0	0.0031	0.0011	0	drained
-12.2	Sand, moderate	18.0/20.0	0.0031	0.0011	0	drained
-15.0	Sand, moderate to dense	18.5/20.5	0.0038	0.0013	0	drained
-16.0	End of model					

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4.5 Ground Water Conditions

4.5.1 Phreatic groundwater level

At this moment at the project location no standpipes are present to deduce an accurate ground water level from. The ground water level will be influenced by the height of the sea level and precipitation. Based on historic standpipe data (Figure 4-3) it's estimated that the average groundwater level varies between NAP +0.5 m and +2.0 m.

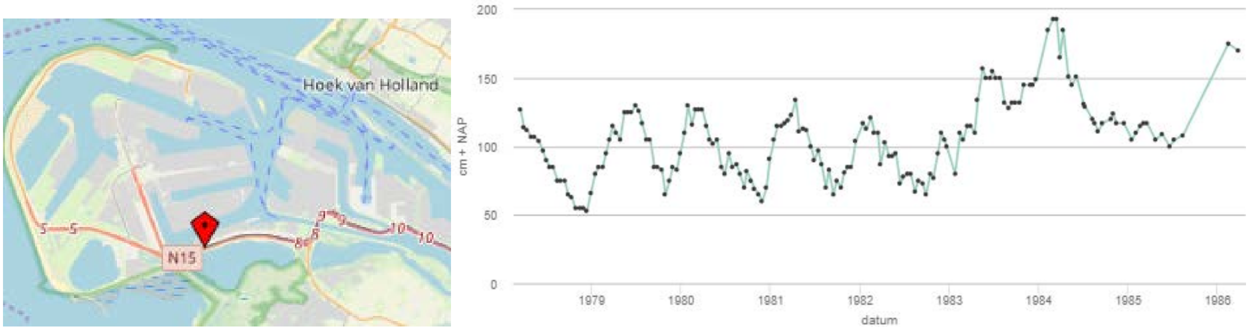


Figure 4-3: historic standpipe B37A0113 displaying shallow groundwater level at the Maasvlakte (www.grondwatertools.nl)

The following ground water levels are used for preliminary design:

- NAP +4.5 m (1 m below ground level) for bearing capacity analysis;
- NAP +2.0 m for settlement analysis.

4.5.2 Hydraulic head 1st aquifer

At this~~e~~ moment at the project location no standpipes are available to estimate the hydraulic head of the Pleistocene sand. In [REF7] a hydraulic head of NAP +0,5 m is assumed. This matches historic standpipe data at Maasvlakte 2, see Figure 4-5.

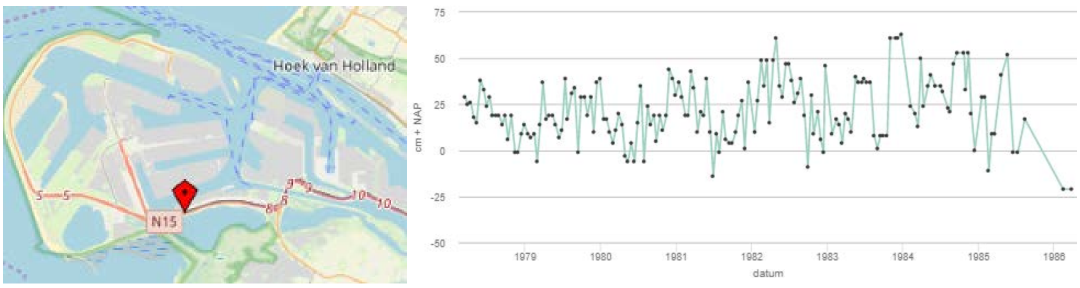


Figure 4-4: historic standpipe B37A0113 with hydraulic head measurements on the Maasvlakte (www.grondwatertools.nl)

5 Foundation Concept

The sandy subsoil is by nature strong and stiff. For construction of the crane hardstands a fill with well compacted sand and/or mixed unbound aggregate is considered enough to provide resistance to the crane loading. The thickness of the unbound mixed aggregate base can be limited by using a geogrid reinforcement. A benefit of using one or more horizontal layers of a geogrid is that loads are spread more even.

Despite the fact that the sandy subsoil imposes low geotechnical risks, key factors for the foundation design are:

- the bearing capacity during crane loading;
- the stiffness and deformation during crane loading.

The stability of the soil and structure (strength) and the degree of deformation are analysed in chapters 6 and 7.

A typical cross section of the selected design option is shown below.

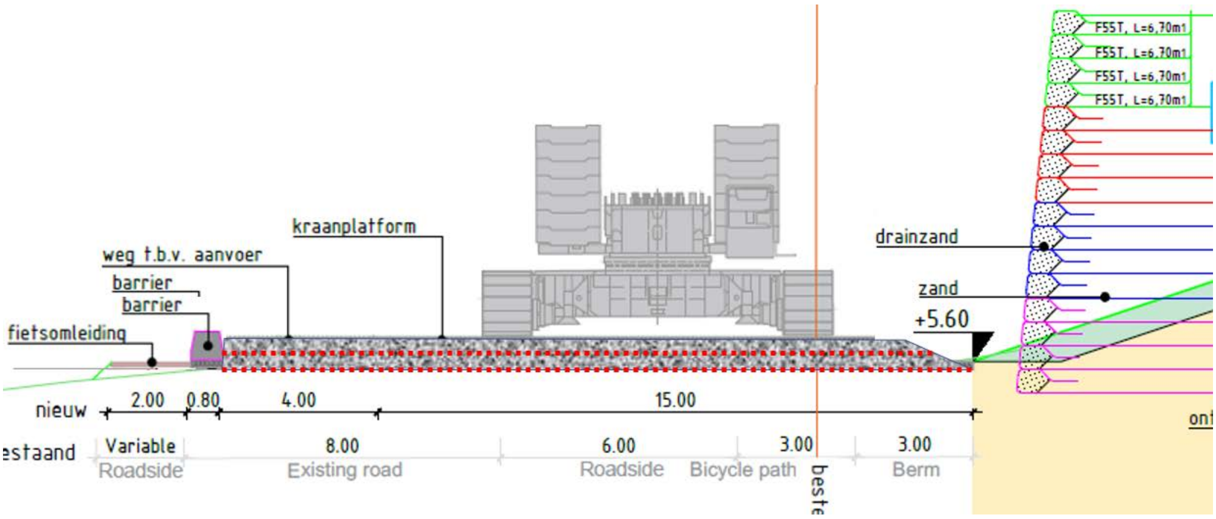


Figure 5-1: foundation concept- for crane hardstands near the hard sea barrier

6 Bearing Capacity Analysis

6.1 Verification Method

The bearing capacity of the subsoil is checked for the drained situation. The undrained situation is not considered as no cohesive layers are present with the influence depth (upper 5 to 10 m).

The verification is performed for loads as specified in chapter 3. Various dimensions of the loaded area are considered. The mobile crane or crawler crane is assumed to be placed on steel plates or wooden mats on top of an embankment. The embankment consists of compacted mixed granulate material in combination with layers of geogrids (at maximum 0.5 m intermediate distance).

The crane load is assumed to spread at an angle of 45º (1:1) within the embankment with mixed granulate and geogrids. The load spreading capacity of the steel plates or wooden mats is not considered in this stage of the design.

The following formula is used to calculate the bearing capacity (Rd) of the subsoil in the drained state (in accordance with NEN 9997-1: 2017):

$$\sigma'_{\text{max;d}} = c'_{\text{gem;d}} \times N_c \times s_c \times b_c \times i_c + \sigma'_{\text{v;z;d}} \times N_q \times s_q \times b_q \times i_q + 0,5 \times \gamma'_{\text{gem;d}} \times b' \times N_{\gamma'} \times s_{\gamma'} \times b_{\gamma} \times i_{\gamma'}$$

$$R_{\text{d}} = \sigma'_{\text{max;d}} \times A'$$

The calculations are based on non-eccentric loaded foundations.

6.2 Verification Bearing Capacity

The bearing capacity is verified for the different components of the crane hardstands. The results are presented in the table below

Table 6-1: Results calculations bearing capacity crane hardstands

Hardstand	Foundation crane hardstand	qk [kPa]	Loaded area	Vd [kN]	Rd [kN]	u.c. (Vd ≤ Rd)
MCHS	0.60 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid	250	2.4 m x 6.0 m	5571	5712	0.98
	0.65 m aggregate (0/320/45mm) with at least 2 layers of geogrid	250	2.0 m x 10.0 m	7767	8121	0.96
	0.35 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid	250	5.0 m x 10.0 m	18985	20373	0.96
ACHS	0.6 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid	250	2.0 m x 2.0 m	1568	1663	0.94
Assembly Area	0.5 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid	200	2.4 m x 4.0 m	2974	3321	0.90
		200	1.0 m x 8.0 m	2499	2787	0.90
		200	3.0 m x 8.0 m	7398	8965	0.83
Compound Area	0.25 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid	135	2.0 m x 10.0 m	4105	4301	0.95
		135	5.0 m x 10.0 m	10249	17980	0.57

7 Settlement Analysis

7.1 Verification Method

According to the requirements the total settlement of the crane hardstand shall not exceed a value of 2 cm within 14 days under a loading of a static concentrated load. The verification of this requirement is performed for the operational crane loads without load factors. The loads due to backfill and the compaction of the backfill material will take place immediately during construction and are therefore not considered.

The calculations are performed with the programme D-Settlement 18.1. The load of the main crane was modelled as a 10m x 5m rectangular load (worst case: largest loaded area).

7.2 Verification of Settlement

The calculation results are listed in Appendix 2 and graphically represented in Figure 7-1. It can be verified that the expected settlements are less than 2cm.

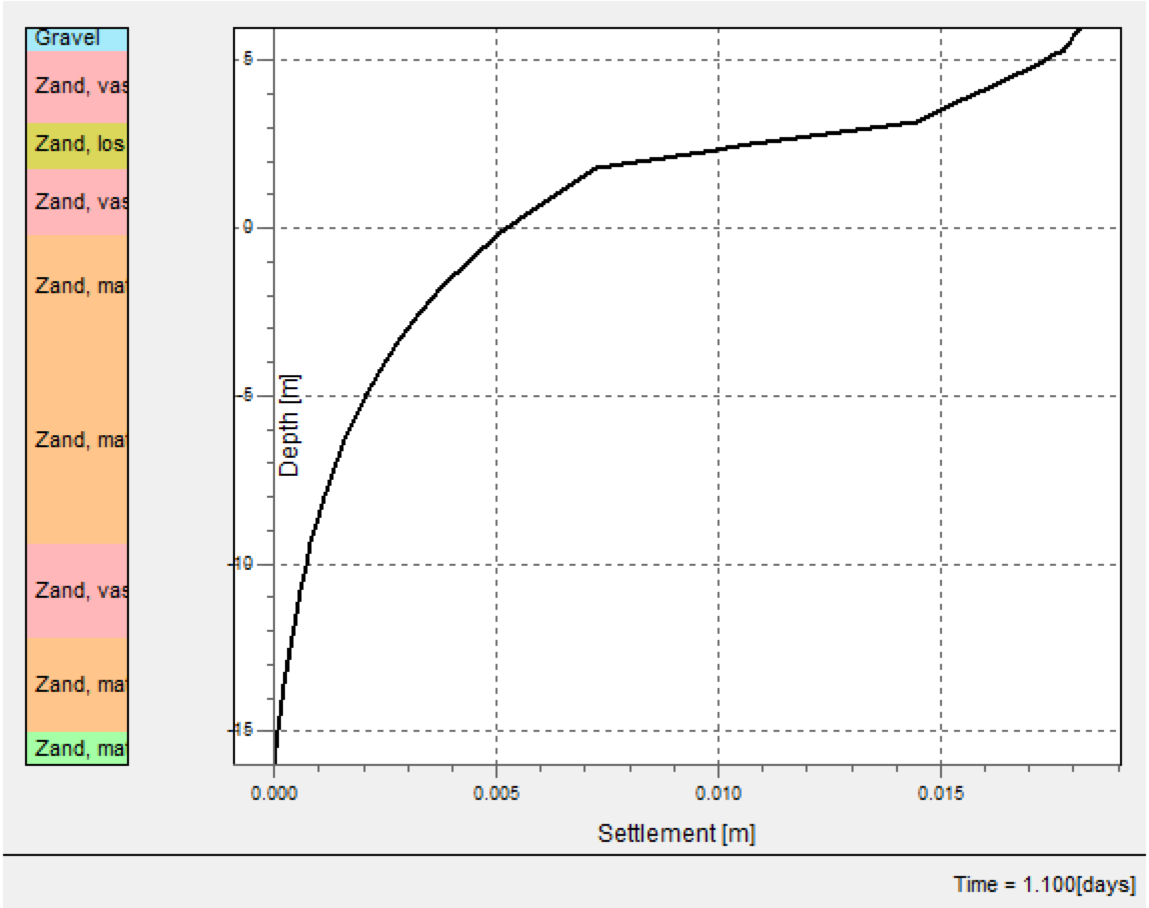


Figure 7-1: Settlement due to MCHS crane loading

8 Conclusions

The following conclusions can be drawn based on the performed geotechnical calculations:

- The site is characterized by a sandy subsoil with high bearing capacity and low compressibility.

- The foundation for the crane hardstands shall be placed on top of the existing terrain (road and bicycle lane). There is no need for ground improvement.

- For the various crane hardstands the foundation should consist of:
  - MCHS: 0.65 m aggregate (0/32-0/45mm) with at least 2 layers of geogrid;
  - ACHS: 0.6 m aggregate (0/32-0/45mm) with 2 layers of geogrid;
  - Assembly Area: 0.5 m aggregate (0/32-0/45mm) with 2 layers of geogrid;
  - Compound Area: 0.2 m aggregate (0/32-0/45mm) with 1 layer of geogrid;

- Expected settlement during crane loading are less than 2 cm during 2 weeks, which is in accordance with the requirements.

Appendix 1: Results calculation bearing capacity

Model input

Load and parameter partial factors:

Parameter	Phi	Cohesion	Unit weight	Cu	permanent load	temporary load
Partial factor	1,15	1,6	1,1	1,35	1,5	1,5

Soil profile:

	Layer	Top [m GL]	Top [m NAP]	g_dry [kN/m3]	g_wet [kN/m3]	cohesion [kPa]	phi [deg]	cu [kPa]	phi_design [deg]	cu_design [kPa]	cohesion_design [kPa]	Spread angle
1	Zand, vast	0.00	5.33	19.00	21.00	0.00	35.00	nan	31.34	nan	0.00	8.00
2	Zand, los	-2.13	3.20	17.00	19.00	0.00	30.00	nan	26.66	nan	0.00	8.00
3	Zand, vast	-3.53	1.80	19.00	21.00	0.00	35.00	nan	31.34	nan	0.00	8.00
4	Zand, matig	-5.53	-0.20	18.00	20.00	0.00	32.50	nan	28.99	nan	0.00	8.00
5	zand matig-los	-8.63	-3.30	17.50	19.50	0.00	30.00	nan	26.66	nan	0.00	8.00
6	Zand vast	-14.73	-9.40	19.00	21.00	0.00	35.00	nan	31.34	nan	0.00	8.00
7	Zand matig	-17.53	-12.20	18.00	20.00	0.00	32.50	nan	28.99	nan	0.00	8.00
8	Zand matig vast	-20.33	-15.00	18.50	20.50	0.00	33.50	nan	29.92	nan	0.00	8.00
9	Zand los	-21.33	-16.00	17.00	19.00	0.00	30.00	nan	26.66	nan	0.00	8.00
10	Zand matig	-21.73	-16.40	18.00	20.00	0.00	32.50	nan	28.99	nan	0.00	8.00
11	zand, sterk kleiig	-23.23	-17.90	18.00	20.00	0.00	25.00	nan	22.07	nan	0.00	8.00
12	klei, vast	-25.63	-20.30	19.00	19.00	13.00	17.50	13.00	15.33	9.63	8.12	8.00
13	veen matig	-27.63	-22.30	12.00	12.00	2.50	15.00	20.00	13.12	14.81	1.56	8.00
14	zand matig	-28.43	-23.10	18.00	20.00	0.00	32.50	nan	28.99	nan	0.00	8.00

Ground water level: NAP + 2,32 m

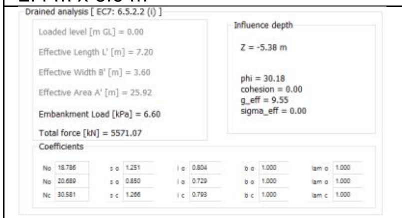
MCHS hard stand

Loads:

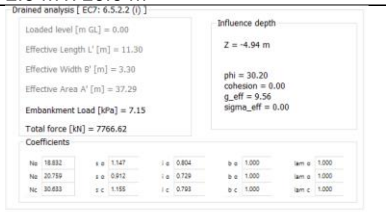
Qmin [kN/m2]	Effective length [m]	Effective width [m]	Rep. Vertical Force [kN]	Rep. Horizontal Force [kN]
250	6,0	2,4	5400	540
250	10,0	2,0	7500	750
250	10,0	5,0	18750	1875

Results:

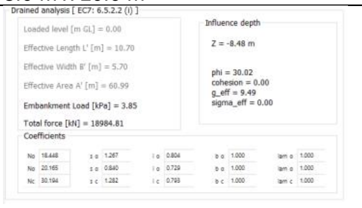
2.4 m x 6.0 m



2.0 m x 10.0 m



5.0 m x 10.0 m



Hardstand	Foundation crane hardstand	qk [kPa]	Loaded area	Vd [kN]	Rd [kN]	u.c. (Vd ≤ Rd)

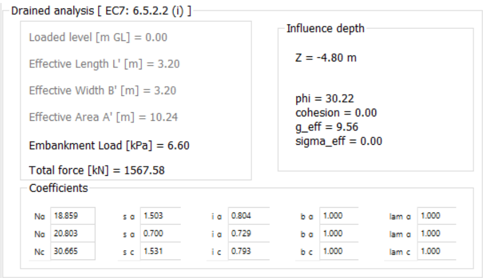
MCHS	0.60 m aggregate (0/32-0/45mm) with 2 layers of geogrid	250	2.4 m x 6.0 m	5571	5712	0.98
	0.65 m aggregate (0/320/45mm) with 2 layers of geogrid	250	2.0 m x 10.0 m	7767	8121	0.96
	0.35 m aggregate (0/32-0/45mm) with 1 layer of geogrid	250	5.0 m x 10.0 m	18985	20373	0.96

ACHS hard stand

Loads:

Qmin [kN/m2]	Effective length [m]	Effective width [m]	Rep. Vertical Force [kN]	Rep. Horizontal Force [kN]
250	2,0	2,0	1500	150

Results:



Hardstand	Foundation crane hardstand	qk [kPa]	Loaded area	Vd [kN]	Rd [kN]	u.c. (Vd ≤ Rd)
ACHS	0.6 m aggregate (0/32-0/45mm) with 2 layers of geogrid	250	2.0 m x 2.0 m	1568	1663	0.94

Assembly area

Loads:

Qmin [kN/m2]	Effective length [m]	Effective width [m]	Rep. Vertical Force [kN]	Rep. Horizontal Force [kN]
200	4,0	2,4	2880	288
200	8,0	1,0	2400	240
200	8,0	3,0	7200	720

Results:

2.4 m x 4.0 m

Drained analysis [EC7: 6.5.2.2 (i)]

Loaded level [m GL] = 0.00
Effective Length L' [m] = 5.00
Effective Width B' [m] = 3.40
Effective Area A' [m] = 17.00
Embankment Load [kPa] = 5.50
Total force [kN] = 2973.50

Influence depth

Z = -5.09 m

phi = 30.19
cohesion = 0.00
g_eff = 9.56
sigma_eff = 0.00

Coefficients

Nα	18.811	s α	1.342	i α	0.804	b α	1.000	lam α	1.000
Nα	20.727	s α	0.796	i α	0.729	b α	1.000	lam α	1.000
Nc	30.609	s c	1.361	i c	0.793	b c	1.000	lam c	1.000

1.0 m x 8.0 m

Drained analysis [EC7: 6.5.2.2 (i)]

Loaded level [m GL] = 0.00
Effective Length L' [m] = 9.00
Effective Width B' [m] = 2.00
Effective Area A' [m] = 18.00
Embankment Load [kPa] = 5.50
Total force [kN] = 2499.00

Influence depth

Z = -3.09 m

phi = 30.89
cohesion = 0.00
g_eff = 9.83
sigma_eff = 0.00

Coefficients

Nα	20.365	s α	1.114	i α	0.804	b α	1.000	lam α	1.000
Nα	23.167	s α	0.933	i α	0.729	b α	1.000	lam α	1.000
Nc	32.372	s c	1.120	i c	0.794	b c	1.000	lam c	1.000

3.0 m x 8.0 m

Drained analysis [EC7: 6.5.2.2 (i)]

Loaded level [m GL] = 0.00
Effective Length L' [m] = 9.00
Effective Width B' [m] = 4.00
Effective Area A' [m] = 36.00
Embankment Load [kPa] = 5.50
Total force [kN] = 7398.00

Influence depth

Z = -5.97 m

phi = 30.17
cohesion = 0.00
g_eff = 9.55
sigma_eff = 0.00

Coefficients

Nα	18.759	s α	1.223	i α	0.804	b α	1.000	lam α	1.000
Nα	20.646	s α	0.867	i α	0.729	b α	1.000	lam α	1.000
Nc	30.550	s c	1.236	i c	0.793	b c	1.000	lam c	1.000

Hardstand	Foundation crane hardstand	qk [kPa]	Loaded area	Vd [kN]	Rd [kN]	u.c. (Vd ≤ Rd)
Assembly Area	0.5 m aggregate (0/32-0/45mm) with 2 layers of geogrid	200	2.4 m x 4.0 m	2974	3321	0.90
		200	1.0 m x 8.0 m	2499	2787	0.90
		200	3.0 m x 8.0 m	7398	8965	0.83

Compound area

Loads:

Qmin [kN/m2]	Effective length [m]	Effective width [m]	Rep. Vertical Force [kN]	Rep. Horizontal Force [kN]
135	10,0	2,0	4050	405
135	10,0	5,0	10125	1012,5

Results:

2.0 m x 10.0 m

Drained analysis [EC7: 6.5.2.2 (i)]

Loaded level [m GL] = 0.00
Effective Length L' [m] = 10.40
Effective Width B' [m] = 2.40
Effective Area A' [m] = 24.96
Embankment Load [kPa] = 2.20
Total force [kN] = 4104.91

Influence depth

Z = -3.66 m

phi = 30.52
cohesion = 0.00
g_eff = 9.68
sigma_eff = 0.00

Coefficients

Nα	19.533	s α	1.117	i α	0.804	b α	1.000	lam α	1.000
Nα	21.855	s α	0.931	i α	0.729	b α	1.000	lam α	1.000
Nc	31.433	s c	1.124	i c	0.794	b c	1.000	lam c	1.000

5.0 m x 10.0 m

Drained analysis [EC7: 6.5.2.2 (i)]

Loaded level [m GL] = 0.00
Effective Length L' [m] = 10.40
Effective Width B' [m] = 5.40
Effective Area A' [m] = 56.16
Embankment Load [kPa] = 2.20
Total force [kN] = 10248.55

Influence depth

Z = -8.04 m

phi = 30.05
cohesion = 0.00
g_eff = 9.50
sigma_eff = 0.00

Coefficients

Nα	18.508	s α	1.260	i α	0.804	b α	1.000	lam α	1.000
Nα	20.259	s α	0.844	i α	0.729	b α	1.000	lam α	1.000
Nc	30.263	s c	1.275	i c	0.793	b c	1.000	lam c	1.000

Hardstand	Foundation crane hardstand	qk [kPa]	Loaded area	Vd [kN]	Rd [kN]	u.c. (Vd ≤ Rd)
Compound Area	0.20 m aggregate (0/32-0/45mm) with 1 layer of geogrid	135	2.0 m x 10.0 m	4105	4301	0.95
		135	5.0 m x 10.0 m	10249	17980	0.57

Appendix 2: D-Settlement results

Report for D-Settlement 18.2

Settlement Calculations
Developed by Deltares

Company:	Royal HaskoningDHV
Date of report:	4/20/2020
Time of report:	9:27:17 AM
Report with version:	18.2.1.20481
Date of calculation:	16-4-2020
Time of calculation:	14:36:04
Calculated with version:	18.2.1.20481
File name:	C:\..\D-Settlement\WPMV2_kraanopstelplaatsen_HZ_zettingen_20200416

1 Table of Contents

2 Echo of the Input

2.1 Layer Boundaries

Boundary number	Co-ordinates [m]				
9 - X -	0.000	34.000	35.000	65.000	66.000
9 - Y -	5.330	5.330	5.980	5.980	5.330
9 - X -	100.000				
9 - Y -	5.330				
8 - X -	0.000	34.000	66.000	100.000	
8 - Y -	5.330	5.330	5.330	5.330	
7 - X -	0.000	100.000			
7 - Y -	3.200	3.200			
6 - X -	0.000	100.000			
6 - Y -	1.800	1.800			
5 - X -	0.000	100.000			
5 - Y -	-0.200	-0.200			
4 - X -	0.000	100.000			
4 - Y -	-3.300	-3.300			
3 - X -	0.000	100.000			
3 - Y -	-9.400	-9.400			
2 - X -	0.000	100.000			
2 - Y -	-12.200	-12.200			
1 - X -	0.000	100.000			
1 - Y -	-15.000	-15.000			
0 - X -	0.000	100.000			
0 - Y -	-16.000	-16.000			

2.2 Pl-lines

PI-line number	Co-ordinates [m]				
1 - X -	0.000	100.000			
1 - Y -	2.300	2.300			

2.3 General Data

Soil model:	NEN Bjerrum
Consolidation model:	Darcy
Strain model:	Linear
Groundwater level:	Initial determined by PI-line number 1
Unit weight of water:	9.81 [kN/m³]
Stress distribution	
- Soil:	Buisman
- Loads:	None
End of consolidation:	10000.00 [days]
No maintain profile	
Pc (initial):	Variable parallel to the initial effective stress
Pc (per step):	Automatic increased to the final effective stresses
Creep rate reference time:	1.000 [days]
No imaginary surface	
With submerging	
(only for non uniform loads)	
- Iteration stop criterium :	0.10 [m]
Load column width	
- Non-Uniform Loads :	1.00 [m]
- Trapeziform Loads :	1.00 [m]

2.4 Soil Profiles

Layer number	Material name	Pl-line top	Pl-line bottom
9	Gravel	1	1
8	Zand, vast	1	1
7	Zand, los	1	1
6	Zand, vast	1	1
5	Zand, matig	1	1
4	Zand, matig	1	1
3	Zand, vast	1	1
2	Zand, matig	1	1
1	Zand, matig vast	1	1

2.5 Soil Properties

Layer number	Drained	Unit weight	
		Unsaturated [kN/m³]	Saturated [kN/m³]
9	Yes	19.00	21.00
8	Yes	19.00	21.00
7	Yes	17.00	18.00
6	Yes	19.00	21.00
5	Yes	18.00	20.00
4	Yes	18.00	20.00
3	Yes	19.00	21.00
2	Yes	18.00	20.00
1	Yes	18.50	20.50

Layer number	Storage type	Vert. consolid. coefficient Cv [m²/s]	Vertical permeability [m/s]	Permeability strain mod. [-]	Initial vertical permeability [m/s]
9	Vert. cons.	-	-	-	-
8	Vert. cons.	-	-	-	-
7	Vert. cons.	-	-	-	-
6	Vert. cons.	-	-	-	-
5	Vert. cons.	-	-	-	-
4	Vert. cons.	-	-	-	-
3	Vert. cons.	-	-	-	-
2	Vert. cons.	-	-	-	-
1	Vert. cons.	-	-	-	-

Layer number	POP [kN/m²]	OCR [-]	Equiv. age [days]
9	-	1.00	-
8	-	1.00	-
7	0.00	-	-
6	-	1.00	-
5	-	1.00	-
4	-	1.00	-
3	-	1.00	-
2	-	1.00	-
1	-	1.00	-

Layer number	Secondary swelling type	Secondary swelling factor[-]	Unloading stress ratio[-]
9	Full	-	-
8	Full	-	-
7	Full	-	-
6	Full	-	-

Layer number	Secondary swelling type	Secondary swelling factor[-]	Unloading stress ratio[-]
5	Full	-	-
4	Full	-	-
3	Full	-	-
2	Full	-	-
1	Full	-	-

Layer number	Reloading/ swelling ratio RR [-]	Compression ratio CR [-]	Coeff. of sec. compression Ca [-]	Reloading/ swelling index Cr [-]	Compression index Cc [-]	Initial void ratio (e0) [-]
9	0.0006000	0.0019000	0.0000000	-	-	-
8	0.0011000	0.0031000	0.0000000	-	-	-
7	0.0038000	0.0115000	0.0000000	-	-	-
6	0.0011000	0.0031000	0.0000000	-	-	-
5	0.0011000	0.0031000	0.0000000	-	-	-
4	0.0011000	0.0031000	0.0000000	-	-	-
3	0.0011000	0.0031000	0.0000000	-	-	-
2	0.0011000	0.0031000	0.0000000	-	-	-
1	0.0013000	0.0038000	0.0000000	-	-	-

2.6 Rectangular Loads

Load number	Time	Magnitude	Dimension		Center			Shape factor
			Width(x)	Width(z)	X	Y	Z	
	[days]	[kN/m²]	[m]	[m]	[m]	[m]	[m]	[-]
1	1	250.00	10.00	5.00	50.00	5.98	0.00	0.00

2.7 Verticals

Vertical number	X co-ordinates [m]				
1 - 5	0.000	34.000	35.000	45.000	49.728
6 - 9	55.000	65.000	66.000	100.000	

Discretisation = 20

3 Results per Vertical

3.1 Results for Vertical 1 (X = 0.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.330	0.001	5.330	0.000	0.000
5.230	1.900	5.230	0.000	0.000
5.130	3.800	5.130	0.000	0.000
5.030	5.700	5.030	0.000	0.000
4.930	7.600	4.930	0.000	0.000
4.830	9.500	4.830	0.000	0.000
4.730	11.400	4.730	0.000	0.000
4.630	13.300	4.630	0.000	0.000
4.530	15.200	4.530	0.000	0.000
4.430	17.100	4.430	0.000	0.000
4.330	19.000	4.330	0.000	0.000
4.265	20.235	4.265	0.000	0.000
3.700	30.970	3.700	0.000	0.000
3.200	40.470	3.200	0.000	0.000
3.200	40.470	3.200	0.000	0.000
2.500	52.370	2.500	0.000	0.000
2.300	55.770	2.300	0.000	0.000
1.800	59.865	2.300	0.000	0.000
1.800	59.865	2.300	0.000	0.000
0.800	71.055	2.300	0.000	0.000
-0.200	82.246	2.300	0.001	0.000
-0.200	82.246	2.300	0.001	0.000
-0.950	89.889	2.300	0.001	0.000
-1.750	98.041	2.300	0.002	0.000
-2.500	105.685	2.300	0.003	0.000
-3.300	113.838	2.300	0.004	0.000
-3.300	113.838	2.300	0.004	0.000
-3.950	120.462	2.300	0.005	0.000
-4.950	130.654	2.300	0.007	0.000
-5.950	140.847	2.300	0.009	0.000
-6.350	144.924	2.300	0.011	0.000
-7.000	151.550	2.300	0.013	0.000
-8.000	161.744	2.300	0.017	0.000
-9.000	171.938	2.300	0.021	0.000
-9.400	176.016	2.300	0.023	0.000
-9.400	176.016	2.300	0.023	0.000
-10.100	183.853	2.300	0.027	0.000
-10.800	191.690	2.300	0.031	0.000
-11.500	199.528	2.300	0.036	0.000
-12.200	207.366	2.300	0.041	0.000
-12.200	207.366	2.300	0.041	0.000
-12.900	214.504	2.300	0.046	0.000
-13.600	221.643	2.300	0.052	0.000
-15.000	235.921	2.300	0.064	0.000
-15.000	235.921	2.300	0.064	0.000
-15.500	241.271	2.300	0.069	0.000
-16.000	246.621	2.300	0.074	0.000

3.2 Results for Vertical 2 (X = 34.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.330	0.001	5.330	0.000	0.000
5.230	1.900	5.230	0.000	0.000
5.130	3.801	5.130	0.001	0.000
5.030	5.701	5.030	0.001	0.000
4.930	7.601	4.930	0.001	0.000
4.830	9.502	4.830	0.002	0.000
4.730	11.402	4.730	0.002	0.000
4.630	13.303	4.630	0.003	0.000
4.530	15.204	4.530	0.004	0.000
4.430	17.106	4.430	0.006	0.000
4.330	19.007	4.330	0.007	0.000
4.265	20.243	4.265	0.008	0.000
3.700	30.995	3.700	0.025	0.000
3.200	40.524	3.200	0.054	0.000
3.200	40.524	3.200	0.054	0.000
2.500	52.492	2.500	0.122	0.000
2.300	55.915	2.300	0.145	0.000
1.800	60.093	2.300	0.228	0.000
1.800	60.093	2.300	0.228	0.000
0.800	71.521	2.300	0.466	0.000
-0.200	83.043	2.300	0.798	0.000
-0.200	83.043	2.300	0.798	0.000
-0.950	90.985	2.300	1.098	0.000
-1.750	99.493	2.300	1.453	0.000
-2.500	107.489	2.300	1.807	0.000
-3.300	116.024	2.300	2.190	0.000
-3.300	116.025	2.300	2.190	0.000
-3.950	122.956	2.300	2.499	0.000
-4.950	133.600	2.300	2.953	0.000
-5.950	144.206	2.300	3.368	0.000
-6.350	148.435	2.300	3.521	0.000
-7.000	155.289	2.300	3.752	0.000
-8.000	165.789	2.300	4.062	0.000
-9.000	176.234	2.300	4.317	0.000
-9.400	180.398	2.300	4.405	0.000
-9.400	180.398	2.300	4.405	0.000
-10.100	188.363	2.300	4.537	0.000
-10.800	196.305	2.300	4.646	0.000
-11.500	204.225	2.300	4.733	0.000
-12.200	212.124	2.300	4.799	0.000
-12.200	212.124	2.300	4.799	0.000
-12.900	219.304	2.300	4.846	0.000
-13.600	226.467	2.300	4.876	0.000
-15.000	240.749	2.300	4.892	0.000
-15.000	240.749	2.300	4.892	0.000
-15.500	246.087	2.300	4.885	0.000
-16.000	251.419	2.300	4.872	0.000

3.3 Results for Vertical 3 (X = 35.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.980	0.001	5.980	0.000	0.001
5.880	1.900	5.880	0.000	0.001
5.780	3.800	5.780	0.000	0.001
5.680	5.700	5.680	0.000	0.001
5.655	6.175	5.655	0.000	0.001
5.580	7.600	5.580	0.000	0.001
5.480	9.500	5.480	0.000	0.001
5.380	11.400	5.380	0.000	0.001
5.330	12.350	5.330	0.000	0.001
5.330	12.350	5.330	0.000	0.001
5.280	13.300	5.280	0.000	0.001
5.180	15.201	5.180	0.001	0.001
5.080	17.101	5.080	0.001	0.001
4.980	19.002	4.980	0.002	0.001
4.265	32.599	4.265	0.014	0.001
3.700	43.361	3.700	0.041	0.001
3.200	52.905	3.200	0.085	0.001
3.200	52.905	3.200	0.085	0.001
2.500	64.911	2.500	0.191	0.001
2.300	68.347	2.300	0.227	0.001
1.800	72.567	2.300	0.352	0.001
1.800	72.567	2.300	0.352	0.001
0.800	84.106	2.300	0.701	0.001
-0.200	95.763	2.300	1.168	0.001
-0.200	95.763	2.300	1.168	0.001
-0.950	103.812	2.300	1.575	0.001
-1.750	112.430	2.300	2.041	0.000
-2.500	120.521	2.300	2.489	0.000
-3.300	129.143	2.300	2.959	0.000
-3.300	129.143	2.300	2.959	0.000
-3.950	136.133	2.300	3.325	0.000
-4.950	146.843	2.300	3.845	0.000
-5.950	157.487	2.300	4.300	0.000
-6.350	161.725	2.300	4.461	0.000
-7.000	168.586	2.300	4.699	0.000
-8.000	179.082	2.300	5.005	0.000
-9.000	189.507	2.300	5.240	0.000
-9.400	193.660	2.300	5.317	0.000
-9.400	193.660	2.300	5.317	0.000
-10.100	201.603	2.300	5.427	0.000
-10.800	209.518	2.300	5.509	0.000
-11.500	217.409	2.300	5.567	0.000
-12.200	225.277	2.300	5.602	0.000
-12.200	225.277	2.300	5.602	0.000
-12.900	232.425	2.300	5.617	0.000
-13.600	239.555	2.300	5.614	0.000
-15.000	253.771	2.300	5.564	0.000
-15.000	253.771	2.300	5.564	0.000
-15.500	259.086	2.300	5.534	0.000
-16.000	264.396	2.300	5.499	0.000

3.4 Results for Vertical 4 (X = 45.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.980	125.001	5.980	125.000	0.019
5.880	124.624	5.880	122.724	0.018
5.780	124.691	5.780	120.891	0.018
5.680	125.181	5.680	119.481	0.018
5.655	125.366	5.655	119.191	0.018
5.580	126.063	5.580	118.463	0.017
5.480	127.297	5.480	117.797	0.017
5.380	128.835	5.380	117.435	0.017
5.330	129.702	5.330	117.352	0.017
5.330	129.702	5.330	117.352	0.017
5.280	130.624	5.280	117.324	0.017
5.180	132.610	5.180	117.410	0.016
5.080	134.738	5.080	117.638	0.016
4.980	136.956	4.980	117.956	0.016
4.265	151.966	4.265	119.381	0.014
3.700	159.825	3.700	116.505	0.013
3.200	163.967	3.200	111.147	0.012
3.200	163.967	3.200	111.147	0.012
2.500	166.103	2.500	101.383	0.009
2.300	166.476	2.300	98.356	0.008
1.800	163.268	2.300	91.053	0.006
1.800	163.268	2.300	91.053	0.006
0.800	161.110	2.300	77.705	0.005
-0.200	161.249	2.300	66.654	0.004
-0.200	161.249	2.300	66.654	0.004
-0.950	162.013	2.300	59.776	0.003
-1.750	163.934	2.300	53.544	0.003
-2.500	166.582	2.300	48.550	0.003
-3.300	170.141	2.300	43.957	0.002
-3.300	170.141	2.300	43.957	0.002
-3.950	173.491	2.300	40.683	0.002
-4.950	179.300	2.300	36.302	0.002
-5.950	185.756	2.300	32.568	0.001
-6.350	188.490	2.300	31.227	0.001
-7.000	193.094	2.300	29.207	0.001
-8.000	200.517	2.300	26.440	0.001
-9.000	208.292	2.300	24.025	0.001
-9.400	211.488	2.300	23.145	0.001
-9.400	211.488	2.300	23.145	0.001
-10.100	217.885	2.300	21.709	0.001
-10.800	224.402	2.300	20.393	0.001
-11.500	231.028	2.300	19.186	0.000
-12.200	237.751	2.300	18.076	0.000
-12.200	237.751	2.300	18.076	0.000
-12.900	243.861	2.300	17.053	0.000
-13.600	250.050	2.300	16.109	0.000
-15.000	262.637	2.300	14.430	0.000
-15.000	262.637	2.300	14.430	0.000
-15.500	267.442	2.300	13.890	0.000
-16.000	272.275	2.300	13.378	0.000

3.5 Results for Vertical 5 (X = 49.73 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.980	0.741	5.980	0.740	0.018
5.880	3.089	5.880	1.189	0.018
5.780	6.324	5.780	2.524	0.018
5.680	10.409	5.680	4.709	0.018
5.655	11.556	5.655	5.381	0.018
5.580	15.286	5.580	7.686	0.018
5.480	20.881	5.480	11.381	0.018
5.380	27.103	5.380	15.703	0.018
5.330	30.418	5.330	18.068	0.018
5.330	30.419	5.330	18.068	0.018
5.280	33.852	5.280	20.552	0.018
5.180	41.022	5.180	25.822	0.018
5.080	48.506	5.080	31.406	0.017
4.980	56.201	4.980	37.201	0.017
4.265	109.926	4.265	77.341	0.016
3.700	143.090	3.700	99.770	0.015
3.200	164.089	3.200	111.269	0.014
3.200	164.089	3.200	111.269	0.014
2.500	181.853	2.500	117.133	0.011
2.300	185.252	2.300	117.132	0.010
1.800	187.476	2.300	115.261	0.007
1.800	187.476	2.300	115.261	0.007
0.800	189.504	2.300	106.099	0.006
-0.200	188.819	2.300	94.224	0.005
-0.200	188.818	2.300	94.223	0.005
-0.950	187.479	2.300	85.241	0.004
-1.750	186.638	2.300	76.249	0.004
-2.500	186.621	2.300	68.589	0.003
-3.300	187.483	2.300	61.299	0.003
-3.300	187.483	2.300	61.298	0.003
-3.950	188.831	2.300	56.024	0.002
-4.950	191.944	2.300	48.946	0.002
-5.950	196.156	2.300	42.969	0.002
-6.350	198.110	2.300	40.847	0.002
-7.000	201.574	2.300	37.687	0.001
-8.000	207.518	2.300	33.441	0.001
-9.000	214.094	2.300	29.827	0.001
-9.400	216.876	2.300	28.533	0.001
-9.400	216.876	2.300	28.533	0.001
-10.100	222.627	2.300	26.451	0.001
-10.800	228.586	2.300	24.577	0.001
-11.500	234.728	2.300	22.886	0.000
-12.200	241.031	2.300	21.356	0.000
-12.200	241.031	2.300	21.356	0.000
-12.900	246.776	2.300	19.968	0.000
-13.600	252.648	2.300	18.707	0.000
-15.000	264.713	2.300	16.506	0.000
-15.000	264.714	2.300	16.506	0.000
-15.500	269.363	2.300	15.811	0.000
-16.000	274.055	2.300	15.158	0.000

3.6 Results for Vertical 6 (X = 55.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.980	125.001	5.980	125.000	0.019
5.880	124.624	5.880	122.724	0.018
5.780	124.691	5.780	120.891	0.018
5.680	125.181	5.680	119.481	0.018
5.655	125.366	5.655	119.191	0.018
5.580	126.063	5.580	118.463	0.017
5.480	127.297	5.480	117.797	0.017
5.380	128.835	5.380	117.435	0.017
5.330	129.702	5.330	117.352	0.017
5.330	129.702	5.330	117.352	0.017
5.280	130.624	5.280	117.324	0.017
5.180	132.610	5.180	117.410	0.016
5.080	134.738	5.080	117.638	0.016
4.980	136.956	4.980	117.956	0.016
4.265	151.966	4.265	119.381	0.014
3.700	159.825	3.700	116.505	0.013
3.200	163.967	3.200	111.147	0.012
3.200	163.967	3.200	111.147	0.012
2.500	166.103	2.500	101.383	0.009
2.300	166.476	2.300	98.356	0.008
1.800	163.268	2.300	91.053	0.006
1.800	163.268	2.300	91.053	0.006
0.800	161.110	2.300	77.705	0.005
-0.200	161.249	2.300	66.654	0.004
-0.200	161.249	2.300	66.654	0.004
-0.950	162.013	2.300	59.776	0.003
-1.750	163.934	2.300	53.544	0.003
-2.500	166.582	2.300	48.550	0.003
-3.300	170.141	2.300	43.957	0.002
-3.300	170.141	2.300	43.957	0.002
-3.950	173.491	2.300	40.683	0.002
-4.950	179.300	2.300	36.302	0.002
-5.950	185.756	2.300	32.568	0.001
-6.350	188.490	2.300	31.227	0.001
-7.000	193.094	2.300	29.207	0.001
-8.000	200.517	2.300	26.440	0.001
-9.000	208.292	2.300	24.025	0.001
-9.400	211.488	2.300	23.145	0.001
-9.400	211.488	2.300	23.145	0.001
-10.100	217.885	2.300	21.709	0.001
-10.800	224.402	2.300	20.393	0.001
-11.500	231.028	2.300	19.186	0.000
-12.200	237.751	2.300	18.076	0.000
-12.200	237.751	2.300	18.076	0.000
-12.900	243.861	2.300	17.053	0.000
-13.600	250.050	2.300	16.109	0.000
-15.000	262.637	2.300	14.430	0.000
-15.000	262.637	2.300	14.430	0.000
-15.500	267.442	2.300	13.890	0.000
-16.000	272.275	2.300	13.378	0.000

3.7 Results for Vertical 7 (X = 65.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.980	0.001	5.980	0.000	0.001
5.880	1.900	5.880	0.000	0.001
5.780	3.800	5.780	0.000	0.001
5.680	5.700	5.680	0.000	0.001
5.655	6.175	5.655	0.000	0.001
5.580	7.600	5.580	0.000	0.001
5.480	9.500	5.480	0.000	0.001
5.380	11.400	5.380	0.000	0.001
5.330	12.350	5.330	0.000	0.001
5.330	12.350	5.330	0.000	0.001
5.280	13.300	5.280	0.000	0.001
5.180	15.201	5.180	0.001	0.001
5.080	17.101	5.080	0.001	0.001
4.980	19.002	4.980	0.002	0.001
4.265	32.599	4.265	0.014	0.001
3.700	43.361	3.700	0.041	0.001
3.200	52.905	3.200	0.085	0.001
3.200	52.905	3.200	0.085	0.001
2.500	64.911	2.500	0.191	0.001
2.300	68.347	2.300	0.227	0.001
1.800	72.567	2.300	0.352	0.001
1.800	72.567	2.300	0.352	0.001
0.800	84.106	2.300	0.701	0.001
-0.200	95.763	2.300	1.168	0.001
-0.200	95.763	2.300	1.168	0.001
-0.950	103.812	2.300	1.575	0.001
-1.750	112.430	2.300	2.041	0.000
-2.500	120.521	2.300	2.489	0.000
-3.300	129.143	2.300	2.959	0.000
-3.300	129.143	2.300	2.959	0.000
-3.950	136.133	2.300	3.325	0.000
-4.950	146.843	2.300	3.845	0.000
-5.950	157.487	2.300	4.300	0.000
-6.350	161.725	2.300	4.461	0.000
-7.000	168.586	2.300	4.699	0.000
-8.000	179.082	2.300	5.005	0.000
-9.000	189.507	2.300	5.240	0.000
-9.400	193.660	2.300	5.317	0.000
-9.400	193.660	2.300	5.317	0.000
-10.100	201.603	2.300	5.427	0.000
-10.800	209.518	2.300	5.509	0.000
-11.500	217.409	2.300	5.567	0.000
-12.200	225.277	2.300	5.602	0.000
-12.200	225.277	2.300	5.602	0.000
-12.900	232.425	2.300	5.617	0.000
-13.600	239.555	2.300	5.614	0.000
-15.000	253.771	2.300	5.564	0.000
-15.000	253.771	2.300	5.564	0.000
-15.500	259.086	2.300	5.534	0.000
-16.000	264.396	2.300	5.499	0.000

3.8 Results for Vertical 8 (X = 66.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.330	0.001	5.330	0.000	0.000
5.230	1.900	5.230	0.000	0.000
5.130	3.801	5.130	0.001	0.000
5.030	5.701	5.030	0.001	0.000
4.930	7.601	4.930	0.001	0.000
4.830	9.502	4.830	0.002	0.000
4.730	11.402	4.730	0.002	0.000
4.630	13.303	4.630	0.003	0.000
4.530	15.204	4.530	0.004	0.000
4.430	17.106	4.430	0.006	0.000
4.330	19.007	4.330	0.007	0.000
4.265	20.243	4.265	0.008	0.000
3.700	30.995	3.700	0.025	0.000
3.200	40.524	3.200	0.054	0.000
3.200	40.524	3.200	0.054	0.000
2.500	52.492	2.500	0.122	0.000
2.300	55.915	2.300	0.145	0.000
1.800	60.093	2.300	0.228	0.000
1.800	60.093	2.300	0.228	0.000
0.800	71.521	2.300	0.466	0.000
-0.200	83.043	2.300	0.798	0.000
-0.200	83.043	2.300	0.798	0.000
-0.950	90.985	2.300	1.098	0.000
-1.750	99.493	2.300	1.453	0.000
-2.500	107.489	2.300	1.807	0.000
-3.300	116.024	2.300	2.190	0.000
-3.300	116.025	2.300	2.190	0.000
-3.950	122.956	2.300	2.499	0.000
-4.950	133.600	2.300	2.953	0.000
-5.950	144.206	2.300	3.368	0.000
-6.350	148.435	2.300	3.521	0.000
-7.000	155.289	2.300	3.752	0.000
-8.000	165.789	2.300	4.062	0.000
-9.000	176.234	2.300	4.317	0.000
-9.400	180.398	2.300	4.405	0.000
-9.400	180.398	2.300	4.405	0.000
-10.100	188.363	2.300	4.537	0.000
-10.800	196.305	2.300	4.646	0.000
-11.500	204.225	2.300	4.733	0.000
-12.200	212.124	2.300	4.799	0.000
-12.200	212.124	2.300	4.799	0.000
-12.900	219.304	2.300	4.846	0.000
-13.600	226.467	2.300	4.876	0.000
-15.000	240.749	2.300	4.892	0.000
-15.000	240.749	2.300	4.892	0.000
-15.500	246.087	2.300	4.885	0.000
-16.000	251.419	2.300	4.872	0.000

3.9 Results for Vertical 9 (X = 100.00 m; Z = 0.00 m)

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.330	0.001	5.330	0.000	0.000
5.230	1.900	5.230	0.000	0.000
5.130	3.800	5.130	0.000	0.000

Depth [m]	Effective Stress [kPa]	Hydraulic head [m]	Loading [kPa]	Settlement [m]
5.030	5.700	5.030	0.000	0.000
4.930	7.600	4.930	0.000	0.000
4.830	9.500	4.830	0.000	0.000
4.730	11.400	4.730	0.000	0.000
4.630	13.300	4.630	0.000	0.000
4.530	15.200	4.530	0.000	0.000
4.430	17.100	4.430	0.000	0.000
4.330	19.000	4.330	0.000	0.000
4.265	20.235	4.265	0.000	0.000
3.700	30.970	3.700	0.000	0.000
3.200	40.470	3.200	0.000	0.000
3.200	40.470	3.200	0.000	0.000
2.500	52.370	2.500	0.000	0.000
2.300	55.770	2.300	0.000	0.000
1.800	59.865	2.300	0.000	0.000
1.800	59.865	2.300	0.000	0.000
0.800	71.055	2.300	0.000	0.000
-0.200	82.246	2.300	0.001	0.000
-0.200	82.246	2.300	0.001	0.000
-0.950	89.889	2.300	0.001	0.000
-1.750	98.041	2.300	0.002	0.000
-2.500	105.685	2.300	0.003	0.000
-3.300	113.838	2.300	0.004	0.000
-3.300	113.838	2.300	0.004	0.000
-3.950	120.462	2.300	0.005	0.000
-4.950	130.654	2.300	0.007	0.000
-5.950	140.847	2.300	0.009	0.000
-6.350	144.924	2.300	0.011	0.000
-7.000	151.550	2.300	0.013	0.000
-8.000	161.744	2.300	0.017	0.000
-9.000	171.938	2.300	0.021	0.000
-9.400	176.016	2.300	0.023	0.000
-9.400	176.016	2.300	0.023	0.000
-10.100	183.853	2.300	0.027	0.000
-10.800	191.690	2.300	0.031	0.000
-11.500	199.528	2.300	0.036	0.000
-12.200	207.366	2.300	0.041	0.000
-12.200	207.366	2.300	0.041	0.000
-12.900	214.504	2.300	0.046	0.000
-13.600	221.643	2.300	0.052	0.000
-15.000	235.921	2.300	0.064	0.000
-15.000	235.921	2.300	0.064	0.000
-15.500	241.271	2.300	0.069	0.000
-16.000	246.621	2.300	0.074	0.000

4 Settlements

4.1 Settlements

Vertical number	X co-ordinate [m]	Z co-ordinate [m]	Surface level [m]	Settlement [m]
1	0.00	0.00	5.33	0.000
2	34.00	0.00	5.33	0.000
3	35.00	0.00	5.98	0.001
4	45.00	0.00	5.98	0.019
5	49.73	0.00	5.98	0.018
6	55.00	0.00	5.98	0.019
7	65.00	0.00	5.98	0.001
8	66.00	0.00	5.33	0.000
9	100.00	0.00	5.33	0.000

4.2 Residual Times

Vertical number	Time [days]	Settlement [m]	Part of final settlement [%]	Residual settlements [m]
1	14	0.000	100.000	0.000
2	14	0.000	100.000	0.000
3	14	0.001	100.000	0.000
4	14	0.019	100.000	0.000
5	14	0.018	100.000	0.000
6	14	0.019	100.000	0.000
7	14	0.001	100.000	0.000
8	14	0.000	100.000	0.000
9	14	0.000	100.000	0.000

End of Report