


**Project het olifantenperk van  
Diergaarde Blijdorp te  
Rotterdam**  
Funderingsadvies, paalfundering

Opdrachtgever                      Stichting koninklijke diergaarde Blijdorp  
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Controle	ing. ■■■■■	



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## 1 INLEIDING

Voor de realisatie van het project het olifantenperk van Diergaarde Blijdorp te Rotterdam heeft Geobest B.V. opdracht ontvangen van Stichting koninklijke diergaarde Blijdorp voor het opstellen van geotechnische adviezen voor de realisatie van de nieuwbouw.

Het project betreft het renoveren en uitbreiden van het olifantenverblijf. De uitbreiding van het olifantenverblijf wordt gerealiseerd op de locatie van het kamelenverblijf. De opdracht bestaat, hoofdzakelijk, uit drie onderdelen. De drie onderdelen betreft een viaduct voor de olifanten (tussen bestaand en nieuw verblijf), olifantenverblijf en een olifantenbassin.

De projectlocatie is weergegeven in Figuur 1.1. In Figuur 1.1 zijn ook de indicatieve locaties en contouren van de nieuwbouw onderdelen geprojecteerd.



**Figuur 1.1: Projectlocatie.**

Bij het project is SWINN betrokken als constructeur.

Dit adviesrapport heeft betrekking op de omschrijving en resultaten van het (door derden) uitgevoerde grondonderzoek en het daarop gebaseerde funderingsadvies, paalfundering, voor de nieuwbouw onderdelen (alle drie de onderdelen).



## 2 UITGANGSPUNTEN

### 2.1 Normen en richtlijnen

Er is gebruikgemaakt van de volgende normen en richtlijnen:

- [1] NEN 9997-1+C2:2017 'Geotechnisch ontwerp van constructies' – Samenstelling van NEN-EN 1997-1, NEN-EN 1997-1/NB Nationale bijlage en NEN 9097-1 Aanvullingsnorm bij NEN-EN 1997-1, november 2017;
- [2] CUR 2003-7 Bepaling geotechnische parameters; 1<sup>e</sup> druk, oktober 2003.

### 2.2 Verstrekte gegevens

Door de constructeur is het volgende document aangeleverd:

- [3] 22-138-010, 'Het olifantenperk van Diergaarde Blijdorp te Rotterdam', 03 juli 2023, SWINN.

Via het internet zijn diverse databanken te raadplegen met relevante informatie aangaande de bodemgesteldheid en de historie van de locatie. Voor het tot op heden uitgevoerde onderzoek is gebruikgemaakt van de volgende openbare bronnen:

- [4] Overzicht van het Actueel Hoogtebestand Nederland (AHN) ([www.ahn.nl](http://www.ahn.nl));
- [5] Grondonderzoek vanuit het DINOloket van NITG-TNO ([www.dinoloket.nl](http://www.dinoloket.nl));
- [6] Grondwatermonitoring vanuit het GisWeb 2.2 ([www.gis.rotterdam.nl](http://www.gis.rotterdam.nl));
- [7] Gegevens vanaf sites van Waterschappen;
- [8] Gegevens vanaf site van Rijkswaterstaat.

### 2.3 Adviesrapporten

Voor het project is eerder het volgende document/ adviesrapport opgesteld:

- [9] Geobest B.V. Notitie, *Project*: het olifantenperk van Diergaarde Blijdorp te Rotterdam, *Onderwerp*: Schetsontwerp, *Opdrachtgever*: Stichting koninklijke diergaarde Blijdorp, *Rapportnummer*: P54467-N001-V1-RBO, *Status*: Concept, *Rapportdatum*: 11 juni 2023.





### 3 GEOTECHNISCHE GEGEVENS

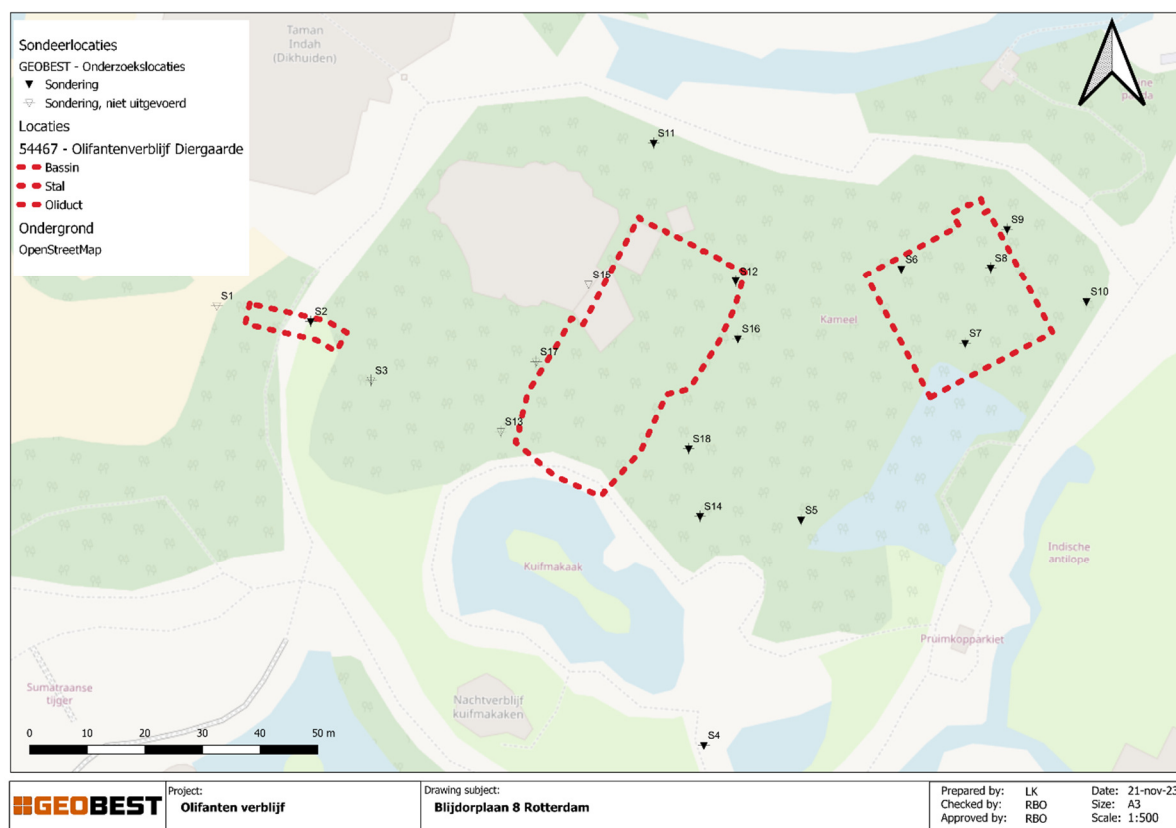
#### 3.1 Grondonderzoek

Door MOS is een grondonderzoek uitgevoerd onder kenmerk 2301002.

Het grondonderzoek omvat het uitvoeren van 18 sonderingen. Vanwege de bereikbaarheid van de locaties zijn diverse sonderingen niet uitgevoerd. Ten tijden van het grondonderzoek waren 13 locaties bereikbaar.

De sonderingen zijn uitgevoerd tot een diepte van circa maaiveld -30 m (maximaal NAP -31,5 m). Naast de conusweerstand ( $q_c$ ) is de plaatselijke wrijving ( $f_s$ ) gemeten. Uit de plaatselijke wrijving en de conusweerstand is het wrijvingsgetal ( $R_f$ ) berekend. Dit getal geeft nader inzicht in de aanwezige grondsoorten.

De sondeerlocaties (uitgevoerd en niet-uitgevoerd) zijn weergegeven in Figuur 3.1.



**Figuur 3.1: Onderzoekslocaties, grondonderzoek.**

De resultaten van het grondonderzoek zijn opgenomen in Bijlage 1.

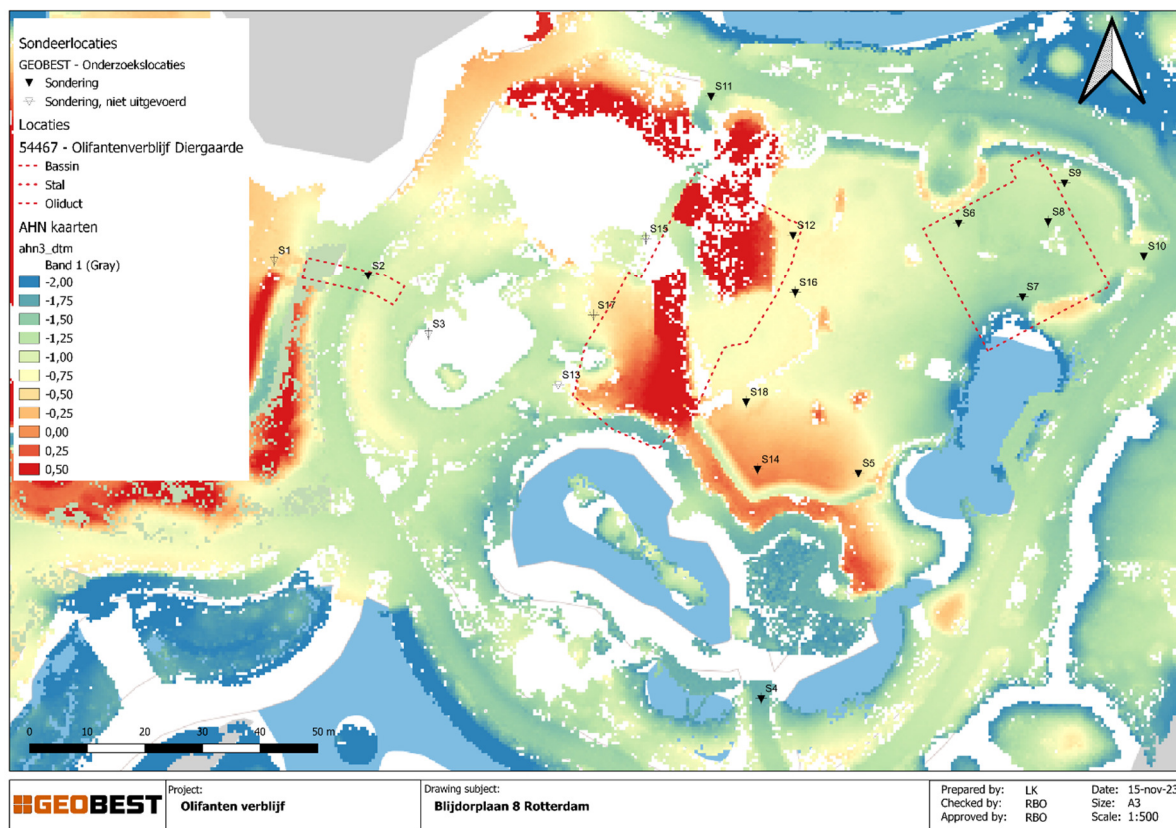
*Geobest staat niet in voor de juistheid en/ of volledigheid van de door derden versterkte informatie en gegevens.*

#### 3.2 Maaiveldniveau

Het maaiveldniveau ter plaatse van de onderzoekslocaties varieert van NAP -1,68 m tot NAP -0.02 m.



Het maaiveldniveau uit het Actueel Hoogtebestand Nederland (afkorting; AHN, [4]) is weergegeven in Figuur 3.2.



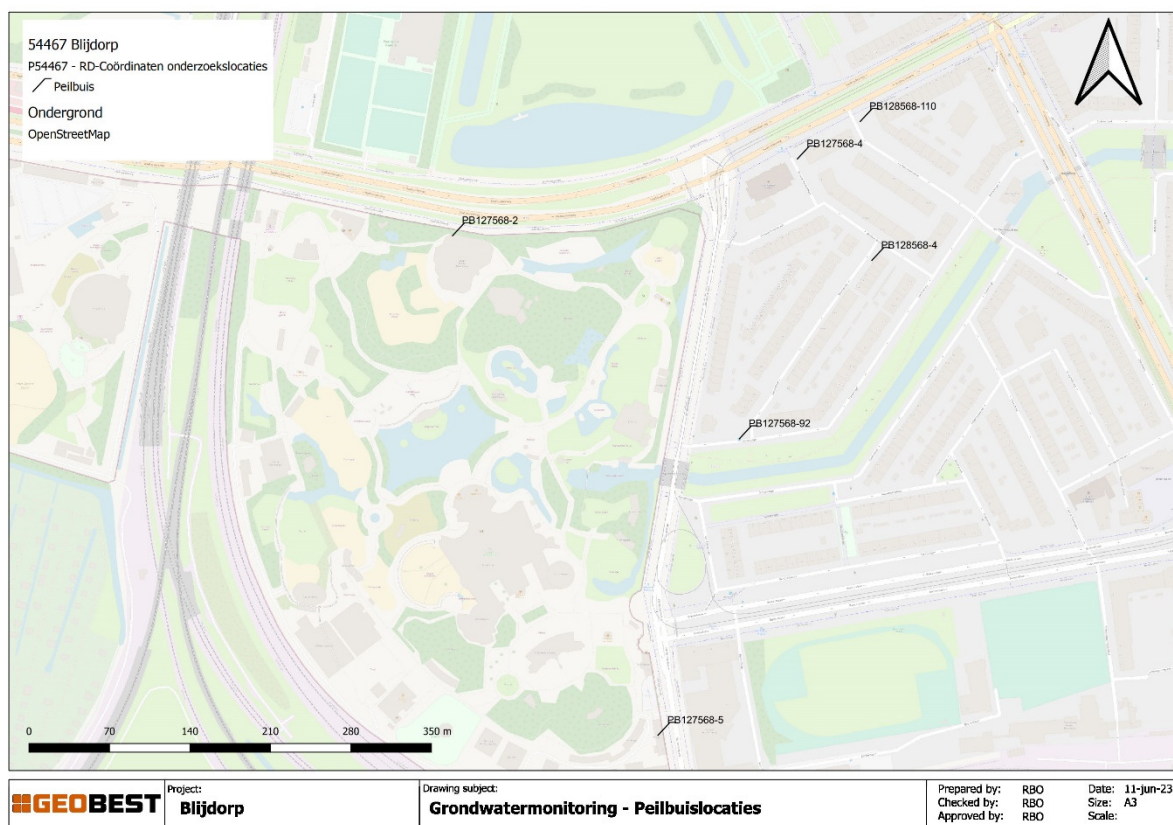
**Figuur 3.2: Maaiveldniveau, AHN.**

Het ingemeten maaiveldniveau van de onderzoek locaties bevestigen het verkregen beeld uit de AHN.

### 3.3 Waterstanden

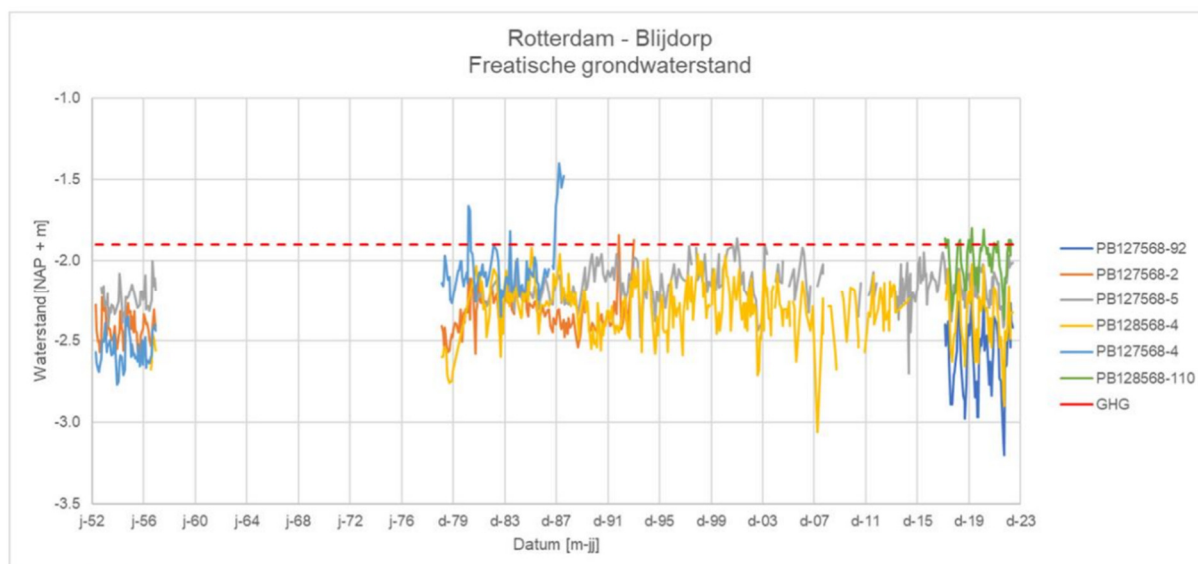
Het uitgevoerde grondonderzoek geeft geen informatie over de grondwaterstand. De grondwaterstand is afgeleid op basis van gegevens uit het GisWeb van de gemeente Rotterdam, [6].

De locaties van de peilbuizen zijn weergegeven in Figuur 3.3.



**Figuur 3.3: Peilbuislocaties.**

Alle peilbuizen (zie Figuur 3.3) zijn ondiepe peilbuizen. De metingen hebben uitsluitend betrekking op de ondiepe, freatische, grondwaterstand. De resultaten van de grondwatermonitoring is weergegeven in Figuur 3.4.



**Figuur 3.4: Grondwatermonitoring.**

In Figuur 3.4 is ook de verwachte Gemiddeld Hoog Grondwater lijn weergegeven.



## 4 PAALFUNDERING

### 4.1 Algemeen

Gelet op de projectgegevens en de opbouw en samenstelling van de ondergrond, kunnen wij vanuit geotechnisch oogpunt instemmen met de keuze voor een fundering op geheide geprefabriceerde betonpalen, mits enige heitrillingen en geluidshinder in de (directe) omgeving toelaatbaar zijn of inwendig geheide stalen buispalen.

De berekeningen van de rekenwaarden van de maximale verticale paaldruk- en -trekweerstand zijn uitgevoerd voor geprefabriceerde betonpalen en inwendig geheide stalen buispalen en zijn voor de paaldrukweerstand en de paaltrekweerstand gebaseerd op de geotechnische norm NEN 9997-1+C2:2017 'Geotechnisch ontwerp van constructies'.

### 4.2 Dimensionering

Volgens opgave van de constructeur zijn de maximale paalbelastingen als aangegeven in Tabel 4-1. De in de tabel aangegeven belastingen betreffende de maatgevende belastingen per paal.

**Tabel 4-1: Paalbelastingen**

Object [-]	Belasting [-]	Maximale paaldrukbelasting [kN]	Maximale paaltrekbelasting [kN]
Viaduct (Oliduct)	UGT	400	-
Olifantenstal	UGT	1000	-
Olifantenbassin	UGT	1000	270 <sup>1)</sup>

<sup>1)</sup> de trekkracht is afgeleid op basis van de aanname dat de trekpalen in een stramien van 2,50 m worden geplaatst. In dat geval bedraagt de waterkolom maximaal 4,0 m (NAP -1,90 m tot NAP -5,90 m) op een oppervlakte van 6,25 m<sup>2</sup>.

Voor de berekening van de rekenwaarde van de maximale draagkracht en toetsing van de UGT type B volgens paragraaf 7.6 van NEN 9997-1+C2:2017 zijn de volgende uitgangspunten aangehouden:

- het project zijn geplaatst in betrouwbaarheidsklasse 2 (RC2);
- de fundatie wordt opgevat als een niet-stijf funderingselement;
- voor het viaduct (Oliduct) zijn de volgende uitgangspunten aangehouden:
  - nieuwbouw wordt gefundeerd op inwendig geheide stalenbuispalen;
  - de draagkracht is berekend op basis van één sondering, S2;
  - het paalkopniveau is aangehouden gelijk aan het maaiveldniveau;
  - bij het berekenen van de draagkracht is geen rekening gehouden met het ontgraven van het maaiveldniveau;
  - bij het berekenen van de draagkracht is geen rekening gehouden met het ophogen van het maaiveldniveau. Hierbij is aangenomen dat het verhoogde maaiveldniveau voor het viaduct onderdeel is van de paalbelasting;
- voor de olifantenstal zijn de volgende uitgangspunten aangehouden:
  - nieuwbouw wordt gefundeerd op geprefabriceerde betonpalen;
  - het paalkopniveau is aangehouden gelijk aan het maaiveldniveau;
  - bij het berekenen van de draagkracht is geen rekening gehouden met het ontgraven of ophogen van het maaiveldniveau;
- voor de olifantenbassin zijn de volgende uitgangspunten aangehouden:
  - nieuwbouw wordt gefundeerd op geprefabriceerde betonpalen;
  - het paalkopniveau is aangehouden gelijk aan de onderzijde van de constructie;
  - bij het berekenen van de draagkracht is rekening gehouden met het ontgraven van het maaiveldniveau tot NAP -5,90 m;
  - bij het berekenen van de draagkracht is geen rekening gehouden met het ophogen van het maaiveldniveau;





- de berekeningen zijn uitgevoerd met een  $\xi_3$  en  $\xi_4$  waarden conform tabel A.10a (niet-stijfbouwwerk). De toegepast  $\xi$ -waarden zijn afhankelijk van de berekende variatiecoëfficiënt alsmede het aantal beschouwde sonderingen;
- de volgende paalklassefactoren zijn gehanteerd:
  - geprefabriceerde betonpaal
$$\begin{aligned}\alpha_p &= 0,70 \\ \alpha_s &= 0,010 \\ \alpha_t &= 0,007 \\ \beta &= 1,00 \\ s &= 1,00\end{aligned}$$
  - inwendig geheide stalen buispaal
$$\begin{aligned}\alpha_p &= 0,70 \\ \alpha_s &= 0,010 \\ \alpha_t &= 0,007 \\ \beta &\approx 0,89 \\ s &= 1,00\end{aligned}$$
- voor de draagkrachtberekeningen op *druk* is de freatische grondwaterstand toegepast vanaf NAP -3,00 m;
- voor de draagkrachtberekeningen op *trek* is de freatische grondwaterstand toegepast vanaf NAP -1,90 m;
- voor de draagkrachtberekeningen op druk is rekening gehouden met het optreden van negatieve kleef langs de paalschacht, vanaf paalkopniveau tot NAP -12,90 m à NAP -17,40 m;
- de partiële materiaalfactor voor de draagkracht van een paal, berekend aan de hand van sonderingen bedraagt voor de negatieve kleef  $\gamma_{f,nk} = 1,00$ ;
- bij het berekenen van de paal*druk*- en *-trek*weerstanden is de positieve schachtwrijving (100%) in rekening gebracht vanaf NAP -12,90 m à NAP -17,40 m tot het paalpuntniveau;
- de partiële materiaalfactor voor de draagkracht van een paal, berekend aan de hand van sonderingen bedraagt voor op druk belaste palen  $\gamma_t = 1,20$ ;
- de partiële materiaalfactor voor de draagkracht van een paal, berekend aan de hand van sonderingen bedraagt voor op trek belaste palen  $\gamma_{s,t} = 1,35$ ;
- de partiële materiaalfactor voor de draagkracht van een paal, berekend aan de hand van sonderingen bedraagt voor de invloed van het wisselen van belastingen  $\gamma_{m,var;q_c} = 1,50$ ;
- voor de draagkrachtberekeningen op *trek* is rekening gehouden met een reductie voor een paal in een paalgroep, uitgaande van plaatsing in een rechthoekig stramien van  $x_1 = 2,50$  m en  $y_1 = 2,50$  m;
- bij de funderingspalen voor het olifantenbassin is in de berekeningen, in verband met de ontgraving(en), rekening gehouden met een reductie van de (vooraf) gemeten conusweerstanden. het reduceren van de conusweerstanden is uitgevoerd door middel van de wortel-reductie conform 7.6.2.3 (k) van NEN 9997-1+C2:2017;
- de voorwaarde bij de wortel-reductie is dat de geprefabriceerde beton palen worden geïnstalleerd voorafgaand aan de ontgraving;

### 4.3 Verticaal paal draagvermogen

#### 4.3.1 Paal*druk*weerstanden

Gelet op de projectgegevens, paalbelasting, opbouw en samenstelling van de ondergrond en het gewenste paalsysteem zijn diverse paalpuntniveaus beschouwd.

De berekeningen zijn uitgevoerd met het programma D-Foundations (Model Bearing Piles (EC7-NL) v 23.1) van Deltares Geosystems. Voor de grondclassificatie is gebruik gemaakt van de CUR regel.

Het berekeningsresultaat is per onderdeel samengevat in Tabel 4-2, Tabel 4-3 en Tabel 4-4.



**Tabel 4-2: Rekenwaarden voor de netto paaldrukweerstand, viaduct.**

Paalpunt-niveau [NAP + m]	$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 219/ 235 [mm/ mm]		$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 273/ 290 [mm/ mm]		$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 324/ 340 [mm/ mm]		$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 356/ 370 [mm/ mm]	
	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]
-16,00	-	151	-	224	-	304	-	353
-16,50	-	203	-	294	-	392	-	455
-17,00	-	247	-	346	-	442	-	494
-17,50	-	259	-	341	-	433	-	496
-18,00	-	252	-	358	-	472	-	543
-18,50	-	270	-	377	-	492	-	567
-19,00	-	329	-	465	-	612	-	709
-19,50	-	373	-	519	-	675	-	777
-20,00	-	400	-	549	-	707	-	809
-20,50	-	471	-	647	-	835	-	958
-21,00	-	525	-	712	-	898	-	1022
-21,50	-	546	-	746	-	955	-	1054
-22,00	-	575	-	692	-	682	-	702
-22,50	-	421	-	539	-	657	-	731
-23,00	-	431	-	550	-	666	-	740

Op basis van de berekende draagkrachten respectievelijk de afname in draagkracht wordt geadviseerd om het paalpuntniveau niet dieper dan NAP -21,00 m toe te passen. Van NAP -21,50 m naar NAP -22,00 m is een sterke afname in draagkracht berekend, met een uitvoeringtolerantie van enkele decimeters bedraagt het maximale paalpuntniveau NAP -21,00 m.

**Tabel 4-3: Rekenwaarden voor de netto paaldrukweerstand, olifantenbassin.**

Paalpunt-niveau [NAP + m]	Vierkant 250 [mm]		Vierkant 290 [mm]		Vierkant 320 [mm]		Vierkant 350 [mm]	
	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]	Variatie. [%]	$R_{c, \text{netto}, d}$ [kN]
-21,50	13,8%	198	14,1%	257	14,4%	308	14,5%	363
-22,00	8,8%	442	8,8%	574	9,3%	678	9,2%	792
-22,50	14,4%	416	14,0%	530	12,2%	630	12,0%	734
-23,00	11,5%	543	11,7%	687	11,8%	808	11,9%	938
-23,50	11,0%	577	11,0%	730	10,6%	853	9,8%	980
-24,00	10,6%	623	9,0%	773	9,0%	905	9,0%	1047
-24,50	7,3%	720	7,4%	898	7,4%	1032	7,7%	1185
-25,00	4,8%	765	3,8%	945	3,6%	1087	3,6%	1240
-25,50	3,8%	781	3,9%	968	4,0%	1122	4,2%	1287
-26,00	4,7%	830	4,6%	1029	4,5%	1193	4,4%	1366
-26,50	6,0%	883	5,8%	1091	5,8%	1261	5,8%	1440
-27,00	2,9%	967	3,1%	1195	3,1%	1378	3,0%	1571
-27,50	4,3%	1010	4,5%	1248	4,7%	1441	4,9%	1644
-28,00	5,7%	1111	4,9%	1361	4,8%	1565	4,8%	1783





Paalpunt-niveau	Vierkant 250 [mm]		Vierkant 290 [mm]		Vierkant 320 [mm]		Vierkant 350 [mm]	
	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$
[NAP + m]	[%]	[kN]	[%]	[kN]	[%]	[kN]	[%]	[kN]
-28,50	3,2%	1167	2,8%	1444	2,4%	1669	2,1%	1906

**Tabel 4-4: Rekenwaarden voor de netto paaldrukweerstand, olifantenstal.**

Paalpunt-niveau	Vierkant 250 [mm]		Vierkant 290 [mm]		Vierkant 320 [mm]		Vierkant 350 [mm]	
	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$	Variatie.	$R_{c,netto,d}$
[NAP + m]	[%]	[kN]	[%]	[kN]	[%]	[kN]	[%]	[kN]
-20,50	12,5%	226	14,4%	289	16,6%	289	16,8%	333
-21,00	15,3%	200	16,0%	255	16,5%	302	16,9%	353
-21,50	14,7%	213	13,1%	268	13,3%	313	13,7%	362
-22,00	12,5%	237	13,1%	298	13,5%	346	14,0%	400
-22,50	8,9%	406	9,1%	514	9,2%	603	9,4%	699
-23,00	10,0%	448	10,6%	568	11,1%	667	13,5%	573
-23,50	15,6%	379	16,0%	475	13,9%	556	13,0%	632
-24,00	13,0%	404	13,5%	503	13,9%	576	14,3%	651
-24,50	12,1%	444	12,2%	553	12,3%	637	12,3%	729
-25,00	8,4%	655	7,8%	809	7,6%	934	7,2%	1064
-25,50	6,2%	747	6,7%	921	6,9%	1063	7,3%	1210
-26,00	5,6%	798	6,3%	978	7,0%	1123	7,5%	1278
-26,50	6,9%	857	7,8%	1045	8,2%	1199	8,5%	1362
-27,00	10,0%	927	10,5%	1139	11,0%	1306	11,5%	1483
-27,50	12,2%	774	13,1%	950	13,4%	1092	13,7%	1233

De vermelde rekenwaarden van de netto paaldrukweerstand ( $R_{c,net,d}$ ) betreffen de rekenwaarden van de maximale paaldrukweerstand die door de paal op paalkopniveau aan de funderingsgrondslag kan worden ontleend.

Bij de combinaties van paalpuntniveaus en paalafmetingen met een variatiecoëfficiënt hoger dan 12% is de rekenwaarde van de netto draagkracht ( $R_{c,net,d}$ ) berekend met een  $\xi$ -factor van 1,30.

De constructieve sterkte moet separaat worden beoordeeld door de constructeur. Een berekeningsvoorbeeld, paaldrukweerstand, is opgenomen onder Bijlage 2, Bijlage 3 en Bijlage 4.

#### 4.3.2 Paaltrekweerstand

Gelet op de projectgegevens, paalbelasting, opbouw en samenstelling van de ondergrond en het gewenste paalsysteem zijn diverse paalpuntniveaus beschouwd.

De berekeningen zijn uitgevoerd aan de hand van een Excel rekensheet en gecontroleerd met het programma D-Foundations (Model Tension Piles (EC7-NL) v 23.1) van Deltares Geosystems. Voor de grondclassificatie is gebruik gemaakt van de CUR regel.

De rekenwaarden van de netto paaltrekweerstand van diverse paalpuntniveaus is voor geprefabriceerde betonpalen samengevat in Tabel 4-5.



**Tabel 4-5: Rekenwaarden voor de netto paaltrekweerstand, olifantenbassin.**

PPN [NAP + m]	Vierkant 250 [mm]			Vierkant 290 [mm]			Vierkant 320 [mm]			Vierkant 350 [mm]		
	$R_{t,net,groep;d}$			$R_{t,net,groep;d}$			$R_{t,net,groep;d}$			$R_{t,net,groep;d}$		
	Hoek paal [kN]	Rand paal [kN]	Mid. paal [kN]	Hoek paal [kN]	Rand paal [kN]	Mid. paal [kN]	Hoek paal [kN]	Rand paal [kN]	Mid. paal [kN]	Hoek paal [kN]	Rand paal [kN]	Mid. paal [kN]
-21,50	101	100	99	119	117	116	132	130	129	146	143	142
-22,00	114	113	112	134	132	131	149	146	145	165	161	160
-22,50	134	131	130	156	153	152	174	170	168	191	186	185
-23,00	151	148	147	176	172	171	195	191	189	215	209	207
-23,50	167	163	162	194	190	188	216	210	208	237	230	228
-24,00	181	178	176	212	206	204	234	228	225	257	250	246
-24,50	196	191	189	228	222	220	252	245	242	277	268	264
-25,00	212	207	205	247	240	237	273	265	261	299	289	285
-25,50	228	223	220	266	258	255	293	284	280	321	310	305
-26,00	244	237	234	283	274	271	312	302	297	342	329	324
-26,50	259	251	248	300	290	286	331	320	315	362	348	342
-27,00	273	265	262	317	306	302	349	337	331	382	367	360
-27,50	288	280	276	334	322	318	368	354	348	403	386	379
-28,00	304	294	291	352	339	334	388	373	366	424	405	398
-28,50	321	311	306	372	358	352	409	392	385	447	427	418

$R_{t,net,groep;d}$  = de rekenwaarde van de netto paaltrekweerstand voor een paal in een paalgroep, inclusief de rekenwaarde van het effectieve gewicht van de paal en een reductie vanwege het groepeffect voor trekpalen, uitgaande van plaatsing in een rechthoekig stramien van 2,50 x 2,50 m.

De constructieve sterkte moet separaat worden beoordeeld door de constructeur. Wij adviseren om alle *trekpalen* over de gehele paallengte te wapenen op de rekenwaarde van de maximale paaltrekbelasting.

Een berekeningsvoorbeeld, paaltrekweerstand, is opgenomen onder Bijlage 5.

#### 4.4 Paalkopzakkingen en -rijzingen

De maximale paalkopzakkingen in de bruikbaarheidsgrenstoestand bedragen (bij de maximale karakteristieke paalbelastingen) circa 15 à 25 mm. Afhankelijk van de opbouw van de ondergrond en de gekozen paalafmetingen bedragen de maximale zettingsverschillen, uitgaande van praktisch gelijke paalbelastingen, 15 mm.

De maximale paalkoprijzingen in de bruikbaarheidsgrenstoestand bedragen (bij de maximale karakteristieke paaltrekbelastingen) circa 5 mm. Afhankelijk van de opbouw van de ondergrond en de belastingsverschillen bedragen de maximale rijzingsverschillen, uitgaande van praktisch gelijke paalbelastingen, circa enkele millimeters.

De werkelijk optredende zettingen en zettingsverschillen (van drukpalen), dan wel rijzingen en rijzingsverschillen (van trekpalen) zijn onder meer afhankelijk van de beschouwde locatie, de toegepaste paalafmetingen en de werkelijk optredende paalbelastingen.



## **5 UITVOERINGSASPECTEN**

Voor de algemene uitvoeringsrichtlijnen van heiwerkzaamheden wordt verwezen naar Bijlage 6.

### **5.1 Heiwerkzaamheden**

Het op diepte heien van de geprefabriceerde betonpalen zal naar verwachting kunnen worden uitgevoerd met bij voorkeur een (traploos regelbaar) hydraulisch heiblok met voldoende slagenergie, een en ander afhankelijk van het paalpuntniveau en de paalafmetingen. De definitieve keuze van het heiblok kan het beste aan de aannemer worden overgelaten.

Aan de hand van de aangetroffen bodemopbouw wordt opgemerkt dat de heiwerkzaamheden met voorzichtigheid moeten worden uitgevoerd. Bij diverse sonderingen is een bodemopbouw aangetroffen waarbij de top laag, niet-cohesieve laag (zand, kleiig), wordt opgevolgd door een cohesieve pakket (klei en veen). Ook op grotere dieptes is dit het geval. Bij het heien in de niet-cohesieve lagen is de weerstand hoger dan bij het heien in de cohesieve lagen. Bij de overgang van hoge naar lage weerstand moet een lage(re) slagenergie worden toegepast. Bij de overgang van hoge naar lage weerstand kunnen significante rekken optreden in het beton, resulterend in scheuren of zelfs paalbreuk. Met het toepassen van een lagere slagenergie bij de overgang(en) wordt de kans hierop verkleind.

De funderingspalen voor het olifantenbassin worden verdiept op diepte geheid door middel van een oplanger. Geadviseerd wordt om de palen maximaal 4,0 m verdiept weg te slaan. De geadviseerde lengte heeft betrekking op de grens aan de uitvoerbaarheid van verdiept palen weg slaan met een oplanger.

### **5.2 Inwendig geheide stalen buispalen**

Het op diepte heien van de geheide stalen buispalen moet worden uitgevoerd met een voldoende zwaar inwendig valblok. Afhankelijk van de beschouwde locatie, de toegepaste paalafmetingen en het paalpuntniveau moet een voldoende zwaar inwendig valblok worden gekozen.

Wij adviseren om het blokgewicht en toe te passen valhoogte vooraf met de (beoogde) paalleverancier af te stemmen, evenals de mogelijkheden voor een probleemloze installatie, waarbij rekening dient te worden gehouden met de lokale omstandigheden (o.a. toegang en werkruimte). Verder dient bij dit paaltype altijd extra aandacht te worden besteed aan een goede kwaliteit van het lassen alsmede de wanddikte van de buizen.



## 6 SLOTOPMERKINGEN

Op basis van de paalbelastingen (Tabel 4-1) en de berekende paaldruk- en trekdraagkrachten (Tabel 4-2 tot en met Tabel 4-5) is het minimale paalpuntniveau afgeleid. Deze zijn samengevat in Tabel 6-1, Tabel 6-2 en Tabel 6-3.

**Tabel 6-1: Samenvatting paalpuntniveau viaduct.**

Minimaal benodigd paalpuntniveau op basis van de maximale paaldrukbelasting				
Maximale paalbelasting [kN]	$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 219/ 235 [mm/ mm] [NAP + m]	$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 273/ 290 [mm/ mm] [NAP + m]	$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 324/ 340 [mm/ mm] [NAP + m]	$\varnothing_{\text{schacht}} / \varnothing_{\text{punt}}$ 356/ 370 [mm/ mm] [NAP + m]
+400	-20,50	-19,00	-17,00	-16,50

**Tabel 6-2: Samenvatting paalpuntniveau olifantenbassin.**

Minimaal benodigd paalpuntniveau op basis van de maximale paaldruk- en trekbelasting				
Maximale paalbelasting [kN]	Vierkant 250 [mm] [NAP + m]	Vierkant 290 [mm] [NAP + m]	Vierkant 320 [mm] [NAP + m]	Vierkant 350 [mm] [NAP + m]
+1.000	-27,50	-26,00	-24,50	-24,00
-270	-27,50	-26,00	-25,50	-25,00

**Tabel 6-3: Samenvatting paalpuntniveau olifantenstal.**

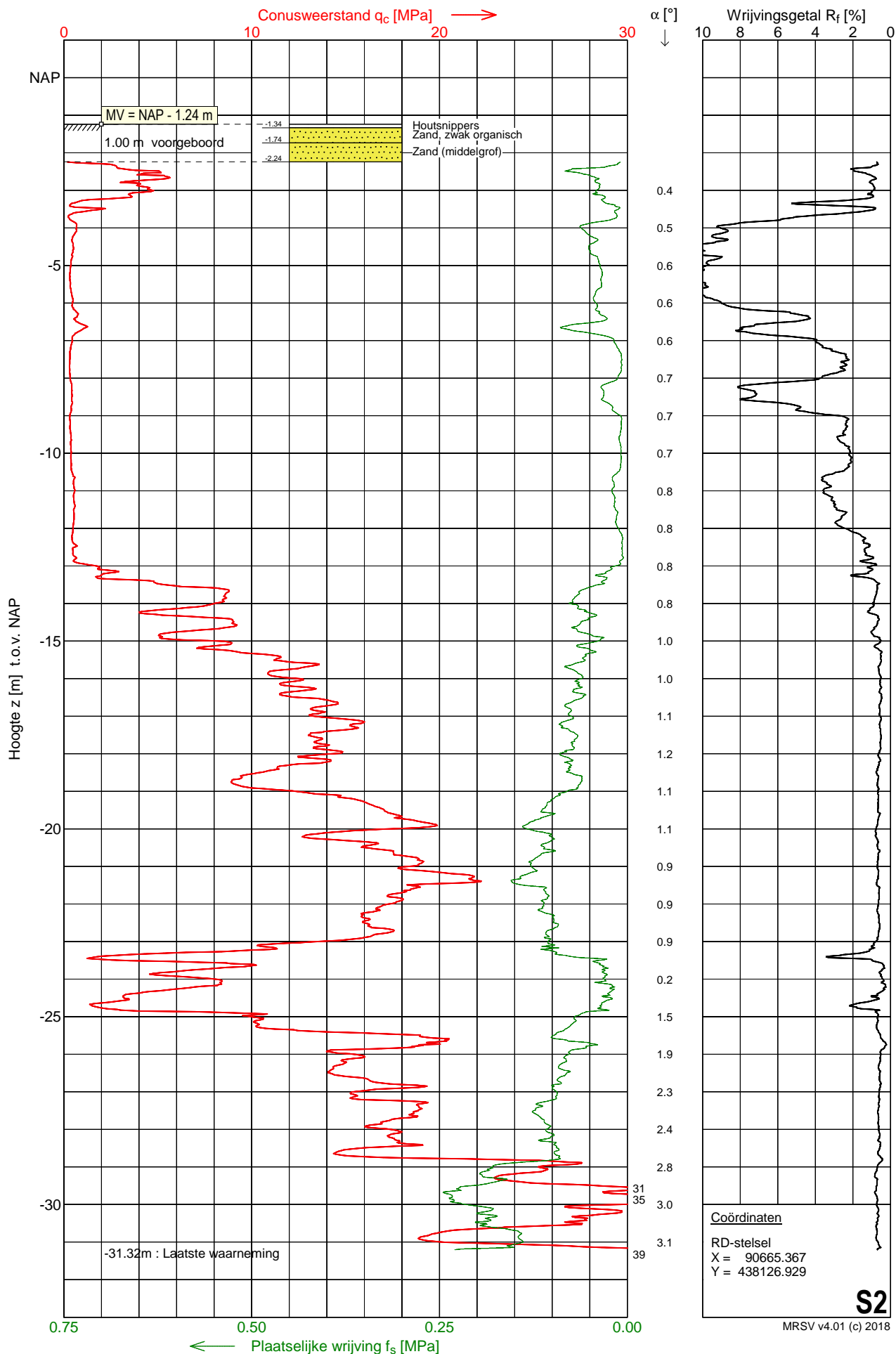
Minimaal benodigd paalpuntniveau op basis van de maximale paaldrukbelasting				
Maximale paalbelasting [kN]	Vierkant 250 [mm] [NAP + m]	Vierkant 290 [mm] [NAP + m]	Vierkant 320 [mm] [NAP + m]	Vierkant 350 [mm] [NAP + m]
+1.000	-	-26,50	-25,50	-25,00

Bijlage 1      Resultaten grondonderzoek

# Sondering S2

Opdracht : 2301002 Conus nummer : S15-CFII.1885  
 Plaats : Rotterdam Soort conus : Elektrisch  
 Datum : 21-06-2023 Opp. conuspunt : 1500 mm<sup>2</sup>  
 Project : Project Diergaarde Blijdorp

NEN-EN-ISO-22476-1  
 Klasse 3, type TE1  
 Sondeerunit : SR16  
 Blad : 1 van 1

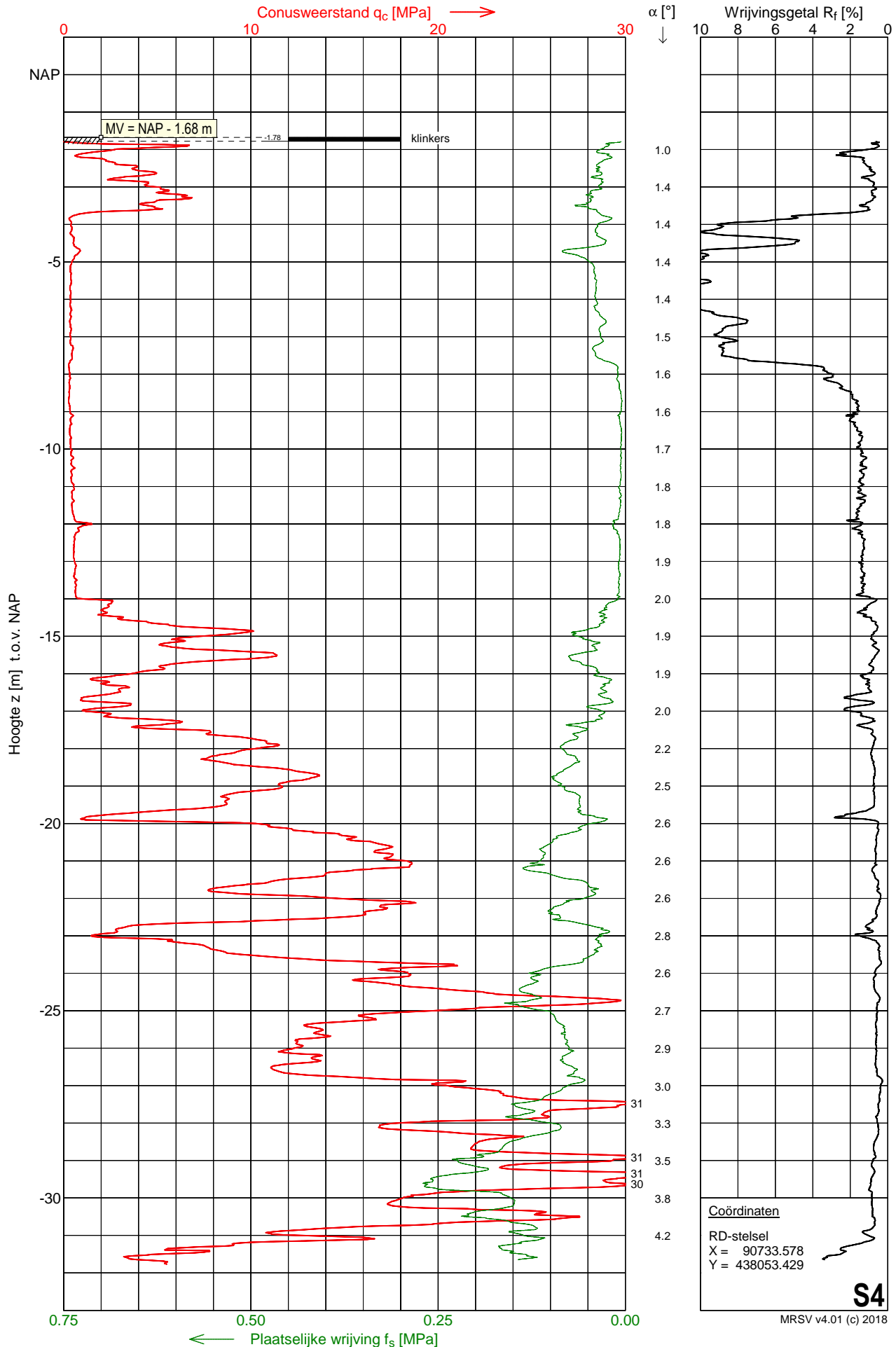




# Sondering S4

Opdracht : 2301002 Conus nummer : S15-CFII.1885  
Plaats : Rotterdam Soort conus : Elektrisch  
Datum : 22-06-2023 Opp. conuspunt : 1500 mm<sup>2</sup>  
Project : Project Diergaarde Blijdorp

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

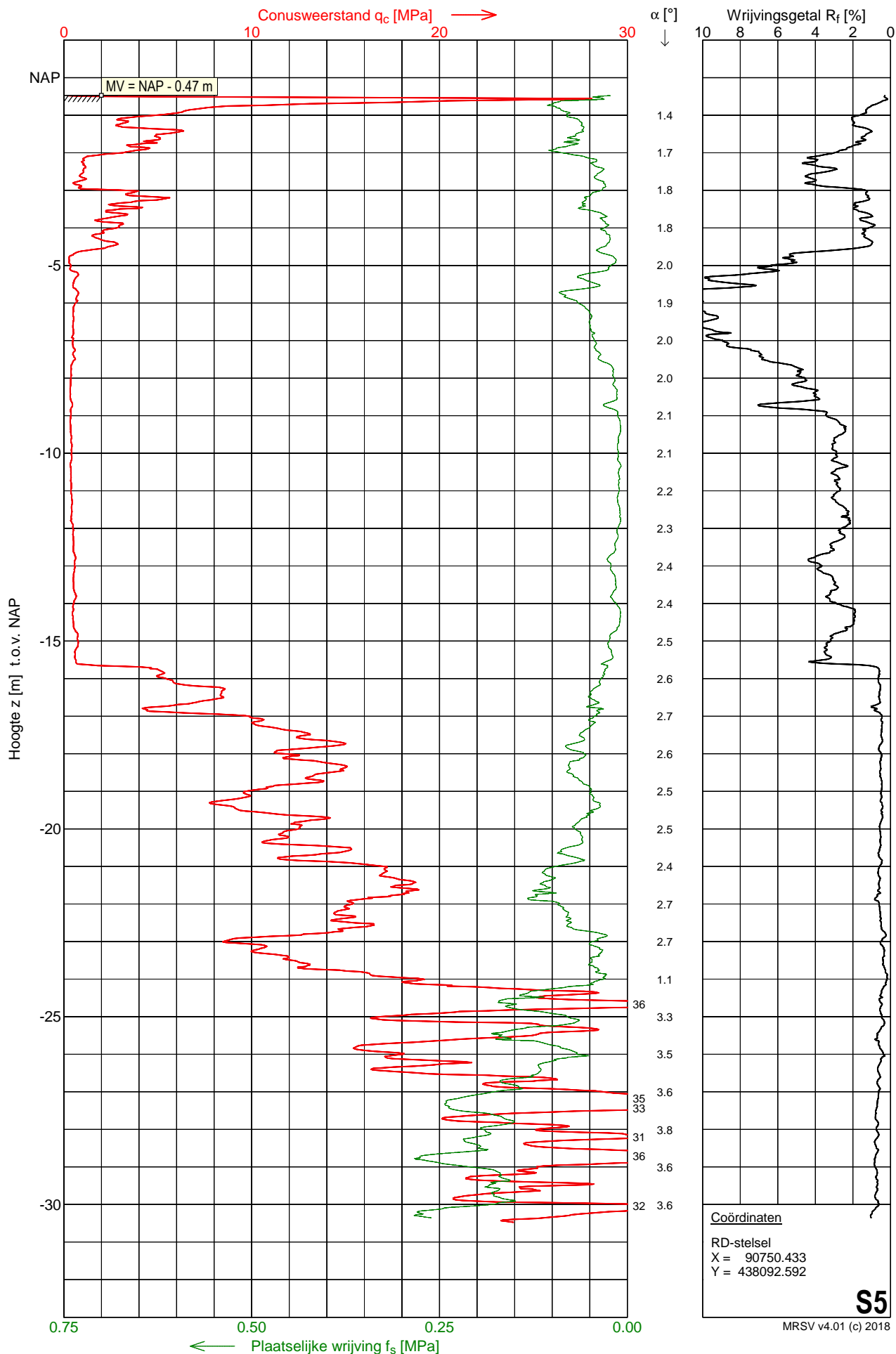


# Sondering S5

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

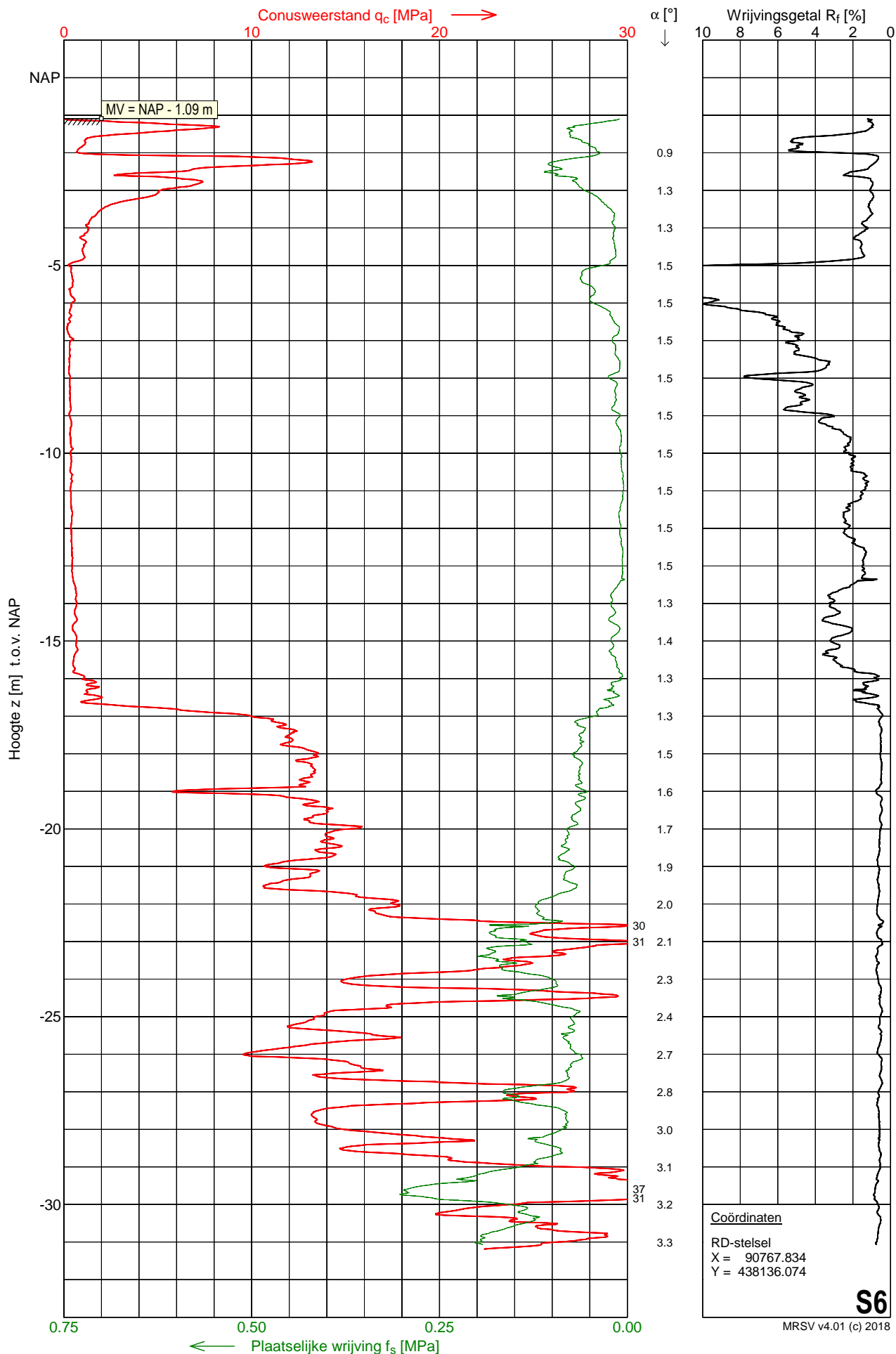


# Sondering S6

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

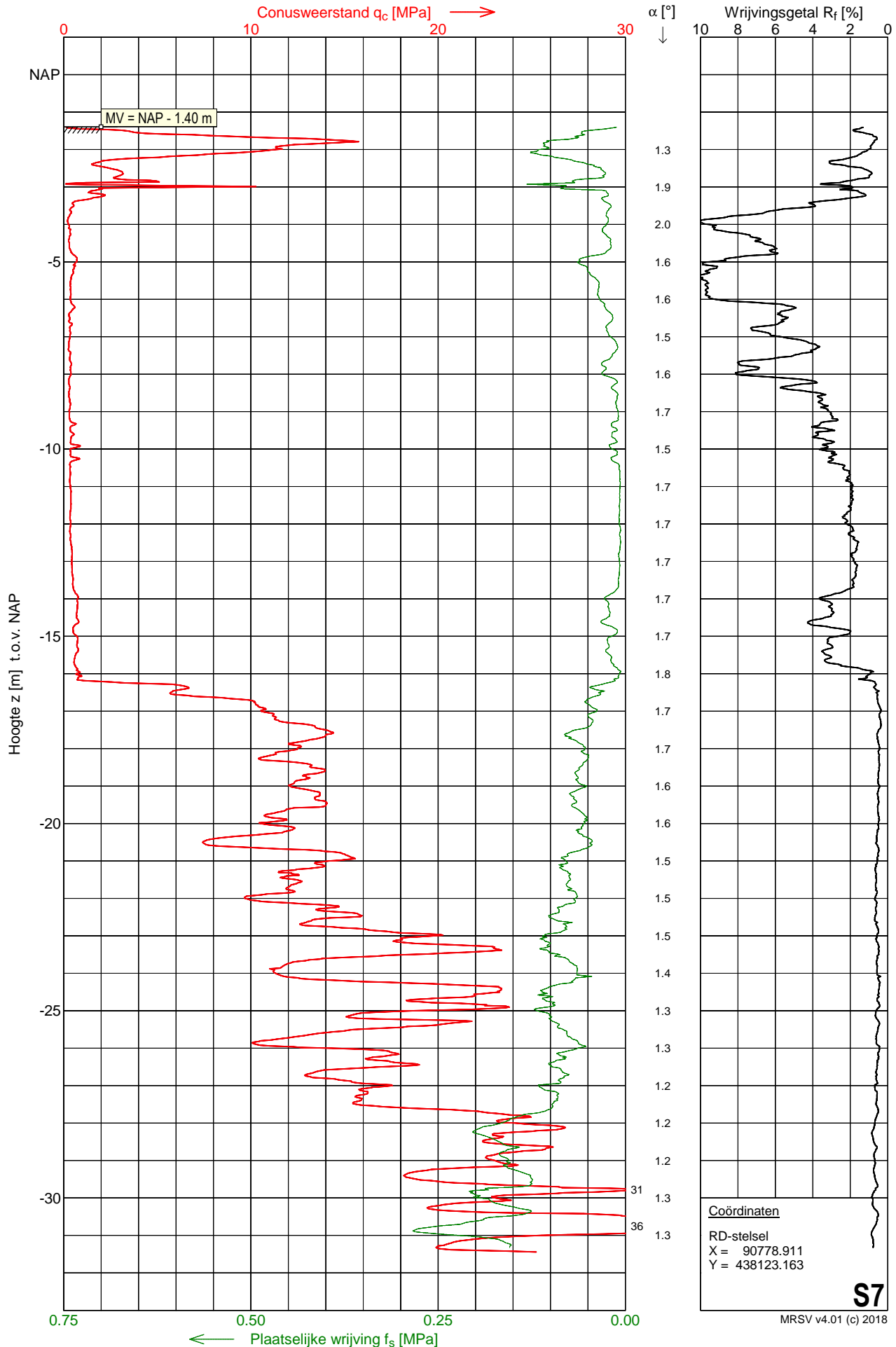
NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1



# Sondering S7

Opdracht : 2301002 Conus nummer : S15-CFII.1885  
 Plaats : Rotterdam Soort conus : Elektrisch  
 Datum : 20-06-2023 Opp. conuspunt : 1500 mm<sup>2</sup>  
 Project : Project Diergaarde Blijdorp

NEN-EN-ISO-22476-1  
 Klasse 3, type TE1  
 Sondeerunit : SR16  
 Blad : 1 van 1

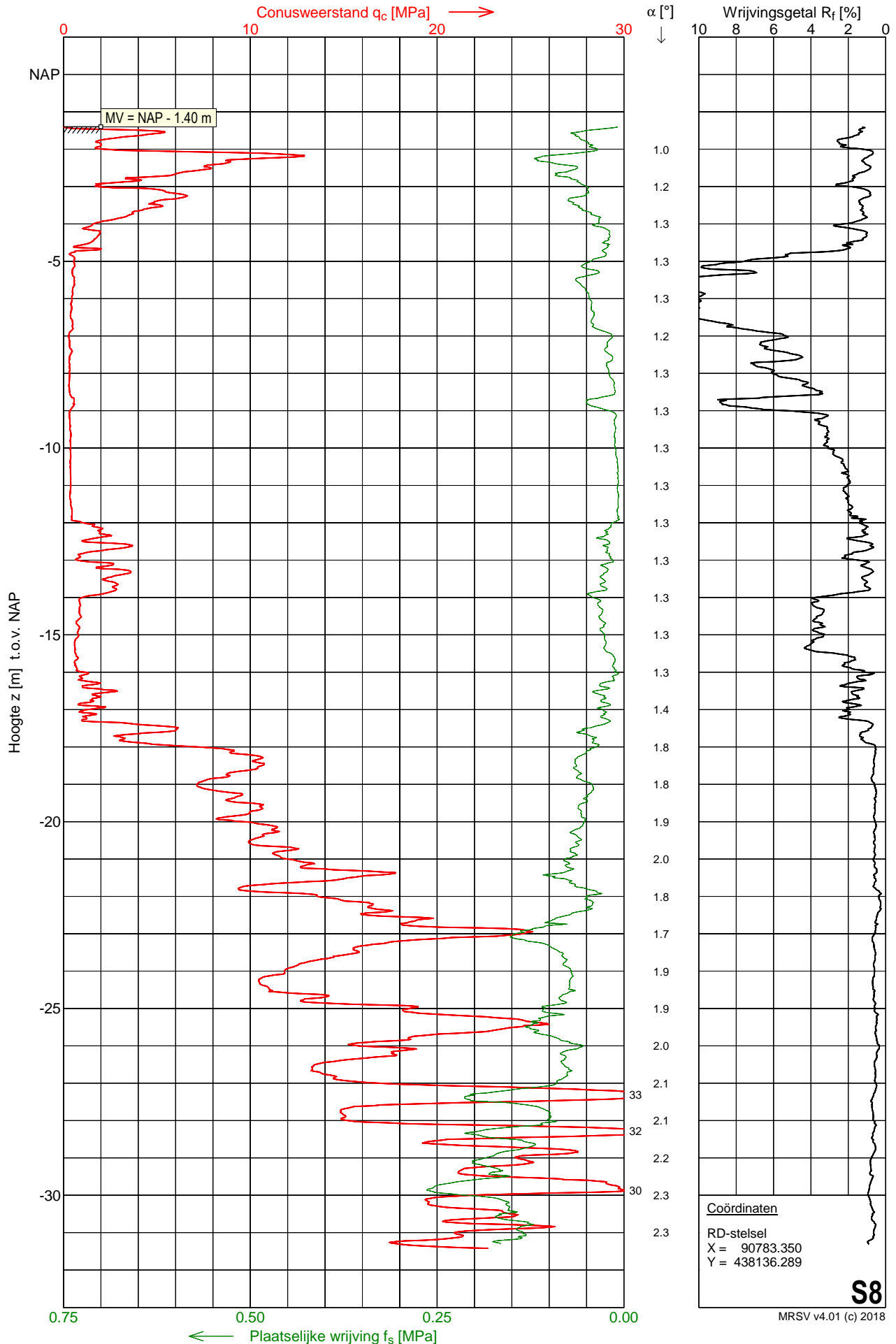


# Sondering S8

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

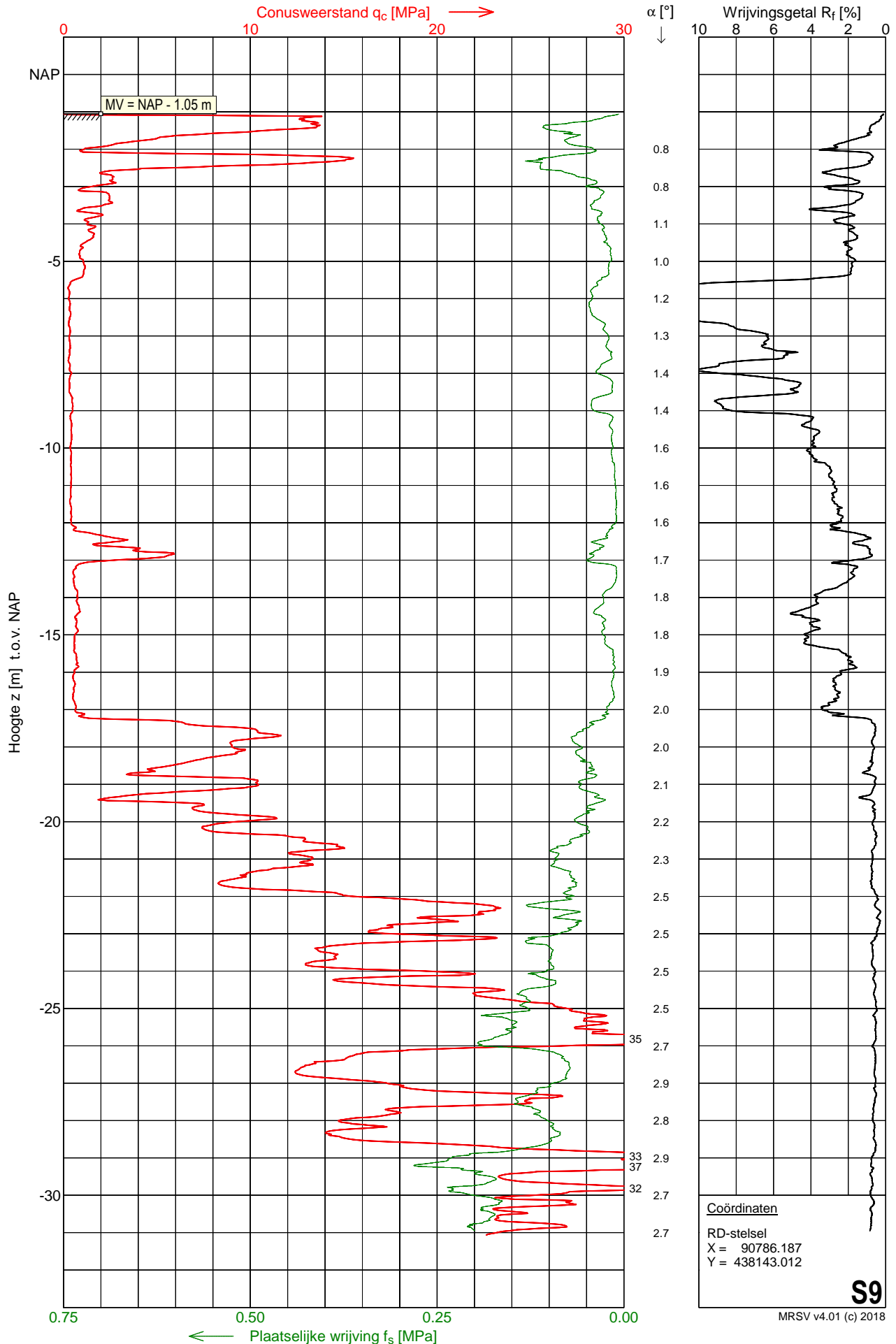


# Sondering S9

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1



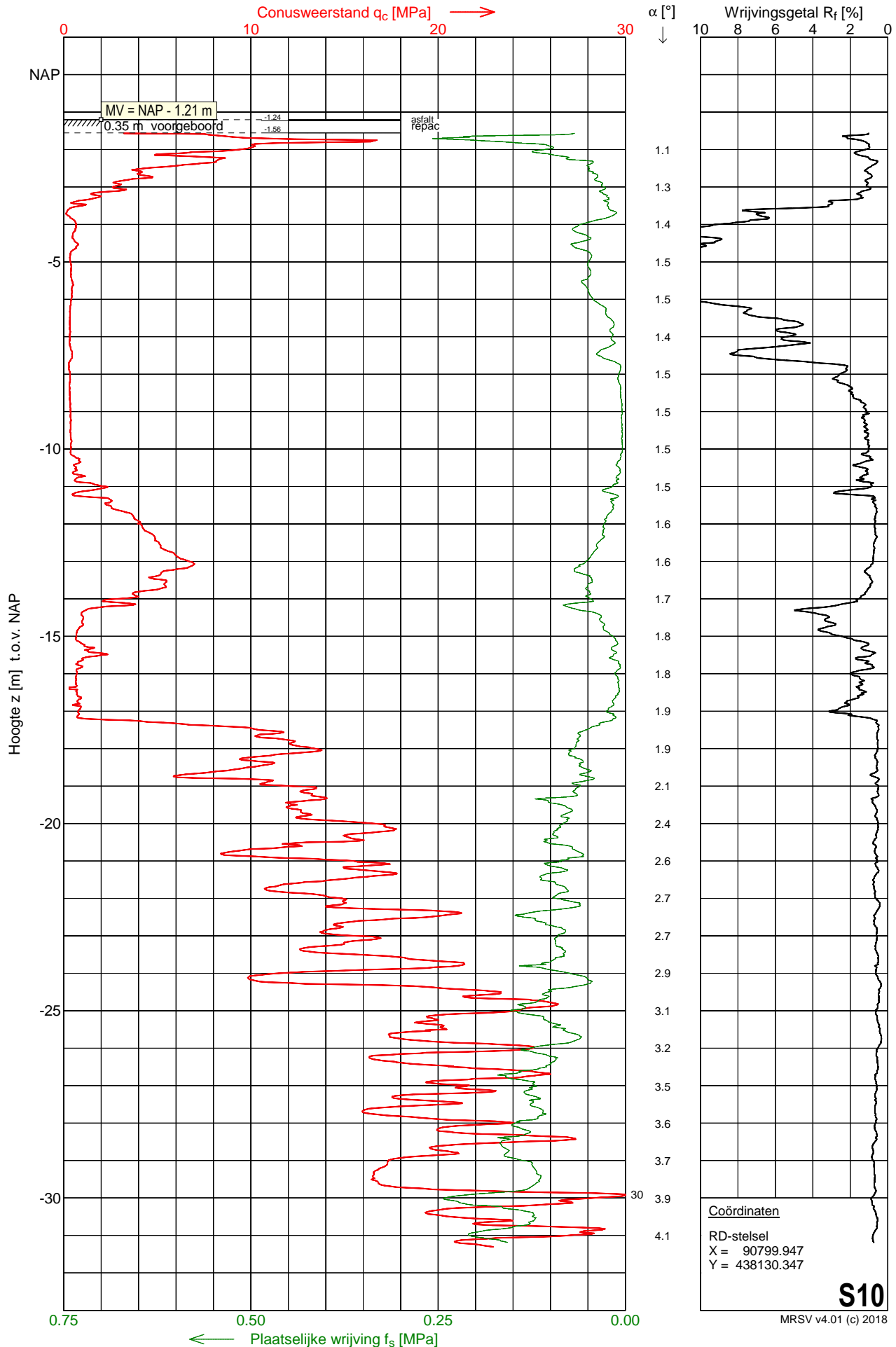


# Sondering S10

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 21-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1



NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

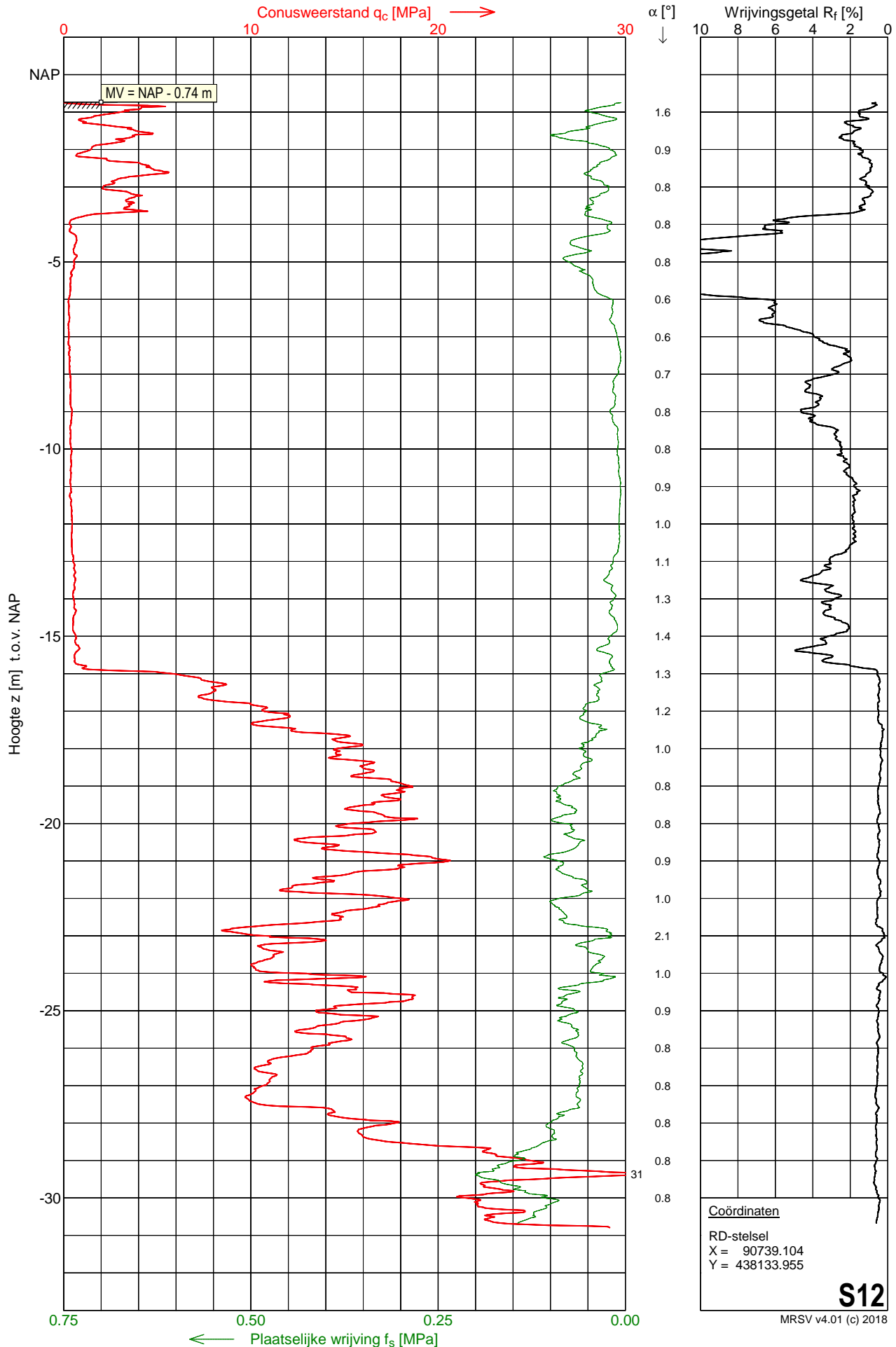


## Sondering S12

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

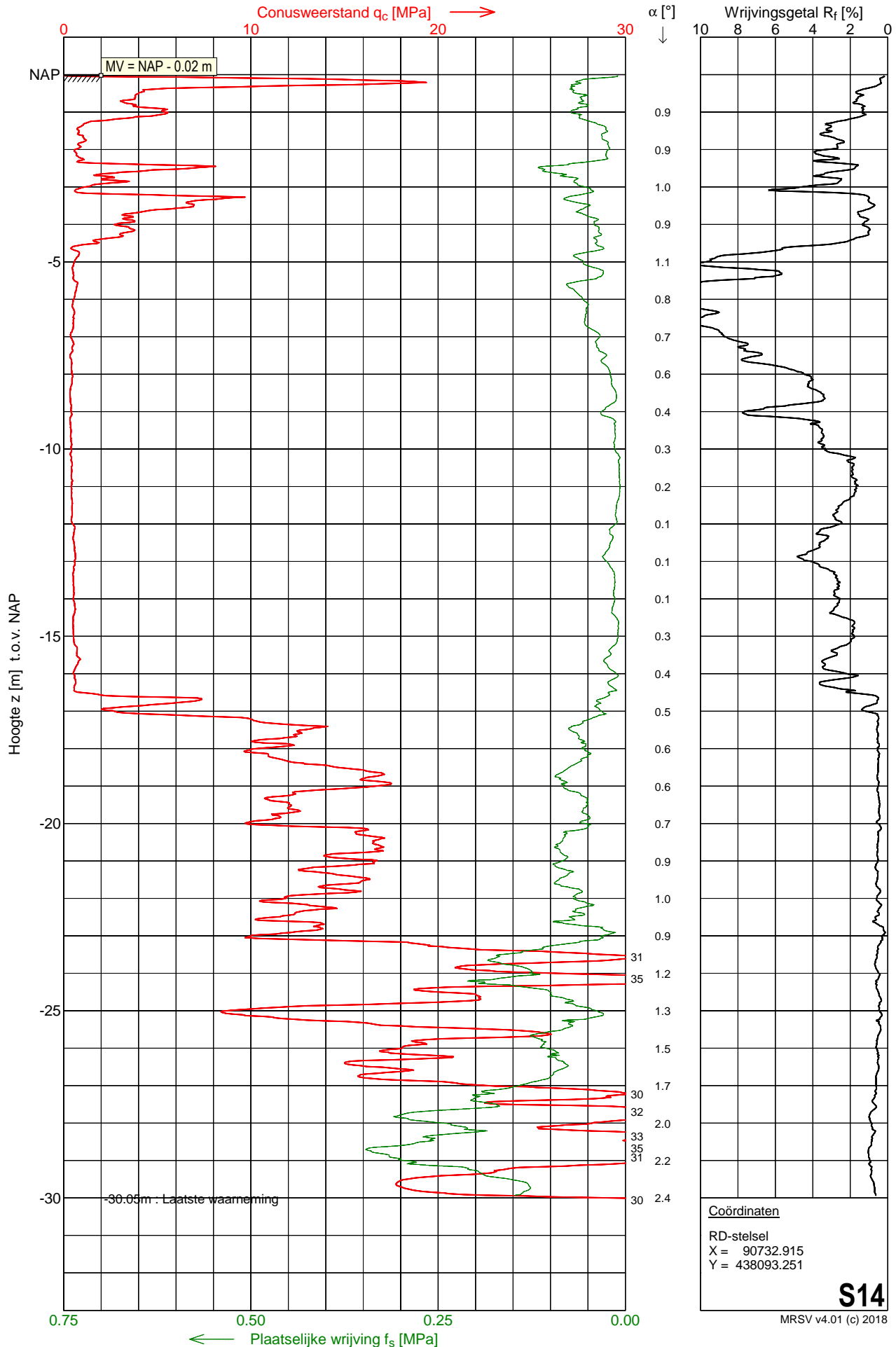


# Sondering S14

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 21-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

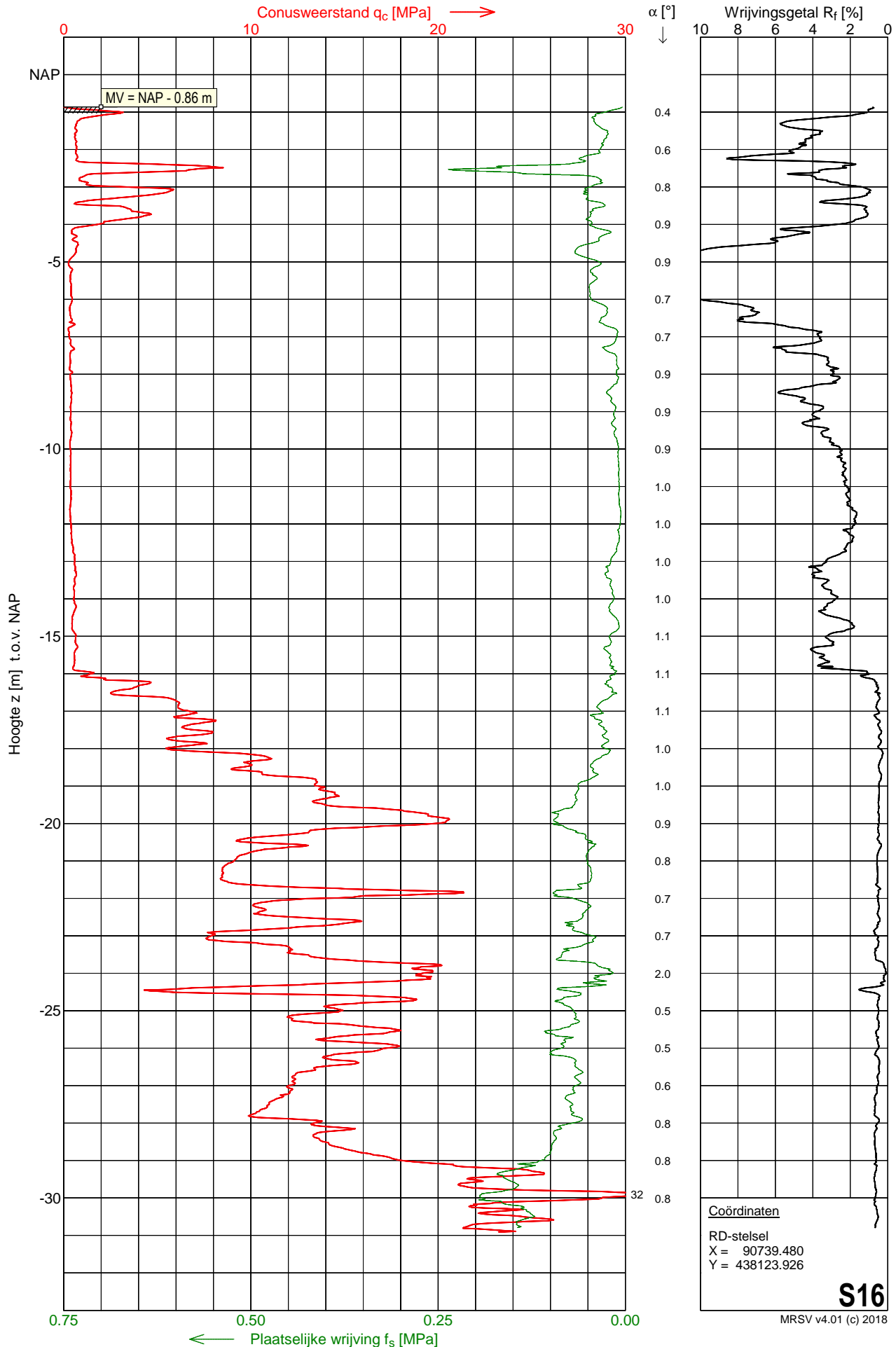


# Sondering S16

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 20-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1

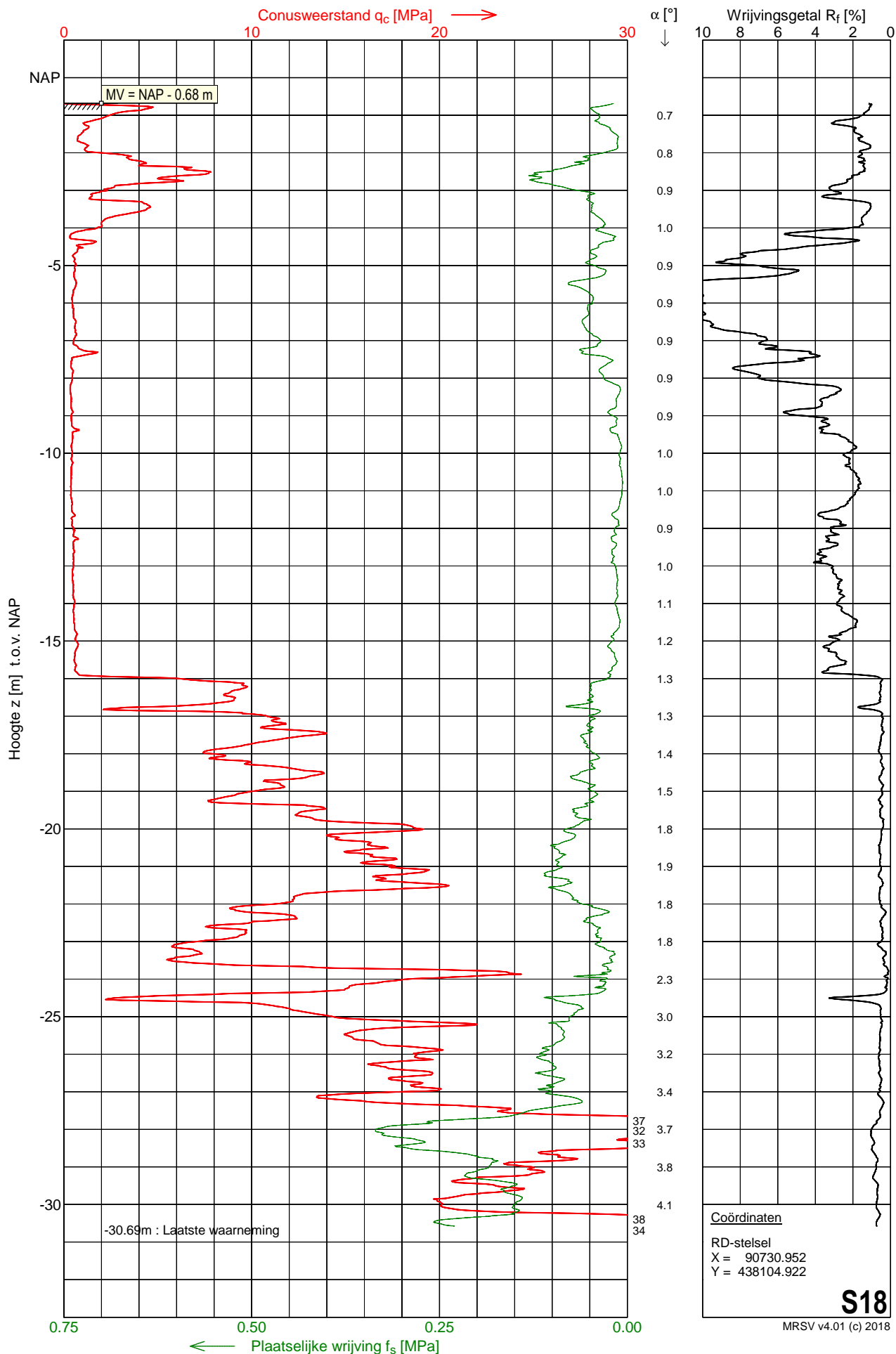


# Sondering S18

Opdracht : 2301002  
Plaats : Rotterdam  
Datum : 21-06-2023  
Project : Project Diergaarde Blijdorp

Conus nummer : S15-CFII.1885  
Soort conus : Elektrisch  
Opp. conuspunt : 1500 mm<sup>2</sup>

NEN-EN-ISO-22476-1  
Klasse 3, type TE1  
Sondeerunit : SR16  
Blad : 1 van 1



Opdracht : 2301002  
Plaats : Rotterdam  
Project : Project Diergaarde Blijdorp

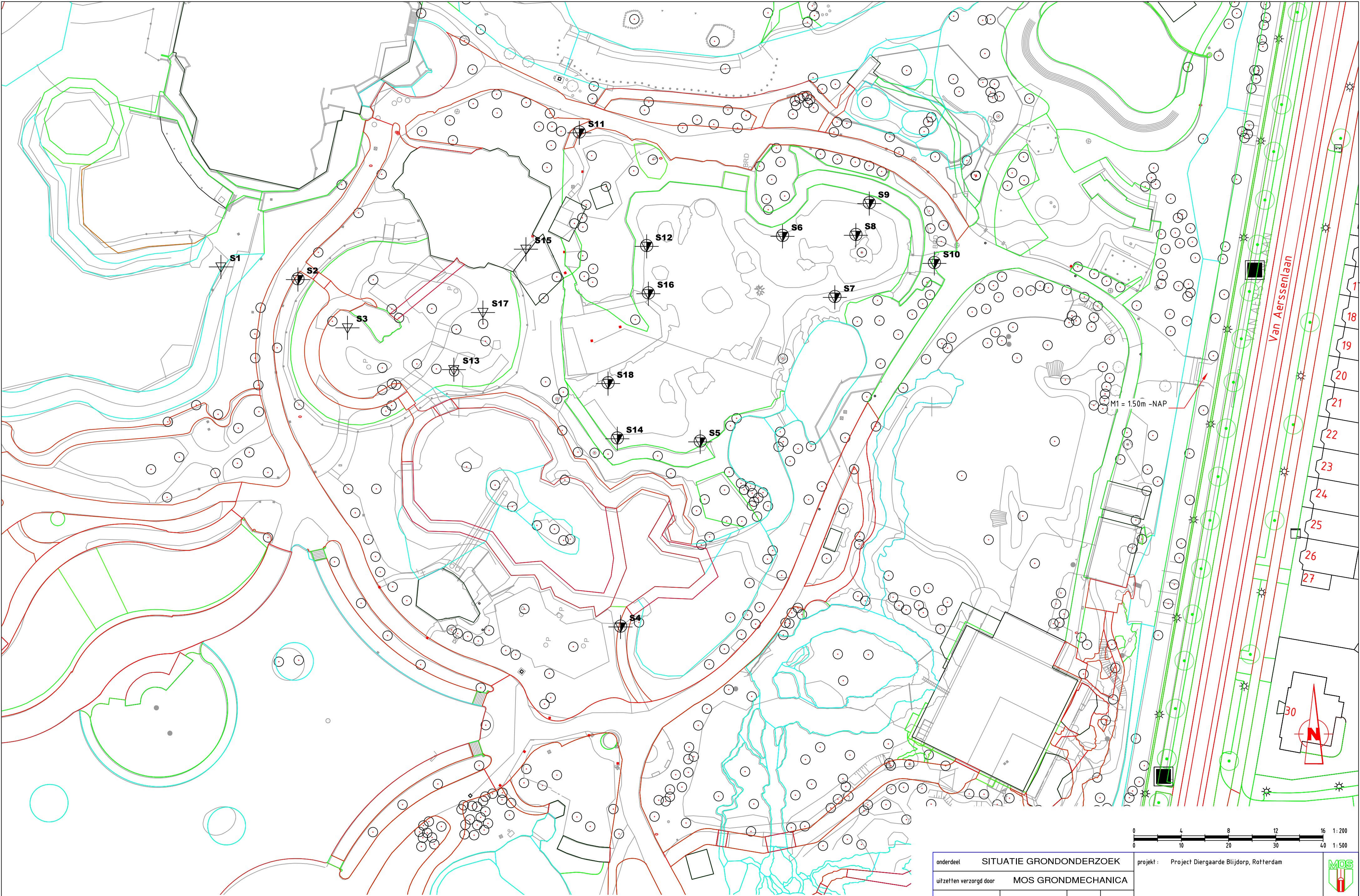
## COÖRDINATEN EN HOOGTEMATEN

Inmeetdatum : 22-06-2023  
Ingemeten door : ar  
Coördinatenstelsel : RD  
Metingen uitgevoerd met RTK GPS systeem

SONDERINGEN						
Sondeernummer	X[m] opgegeven	Y[m] opgegeven	X[m] ingemeten	Y[m] ingemeten	Z[m] t.o.v. NAP	Verplaatsing [m]
S1	90649.09	438129.60	-	-	-	-
S2	90665.01	438128.58	90665.37	438126.93	-1.24	1.69
S3	90675.85	438116.72	-	-	-	-
S4	90708.59	438068.14	90733.58	438053.43	-1.68	29.00
S5	90750.02	438089.57	90750.43	438092.59	-0.47	3.05
S6	90768.15	438138.40	90767.83	438136.07	-1.09	2.35
S7	90778.17	438122.47	90778.91	438123.16	-1.40	1.01
S8	90782.98	438134.56	90783.35	438136.29	-1.40	1.77
S9	90787.11	438143.35	90786.19	438143.01	-1.05	0.98
S10	90799.53	438130.35	90799.95	438130.35	-1.21	0.42
S11	90729.44	438160.28	90724.87	438157.96	-1.41	5.12
S12	90737.35	438137.34	90739.10	438133.96	-0.74	3.81
S13	90698.34	438107.88	-	-	-	-
S14	90714.45	438101.12	90732.92	438093.25	-0.02	20.07
S15	90713.58	438133.35	-	-	-	-
S16	90733.26	438122.74	90739.48	438123.93	-0.86	6.33
S17	90704.49	438119.96	-	-	-	-
S18	90726.52	438110.49	90730.95	438104.92	-0.68	7.12

OVERIGE LOCATIES						
Naam meetpunt	X[m] opgegeven	Y[m] opgegeven	X[m] ingemeten	Y[m] ingemeten	Z[m] t.o.v. NAP	Verplaatsing [m]
M1 / asweg	-	-	90857.66	438107.12	-1.50	-





Sonderring



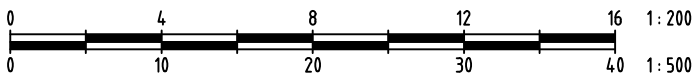
Sonderring met pl.wrijving



Boring



Peilbuis



onderdeel <b>SITUATIE GRONDONDERZOEK</b>			
uitzetten verzorgd door <b>MOS GRONDMECHANICA</b>			
schaal   1:   500	maten in meters	get.   c.s.	
datum   28-06-23	opdr.nr.:   2301002		
wijz.	Formaat :   A2		

project :   Project Diergaarde Blijdorp, Rotterdam



**MOS GRONDMECHANICA**  
Albert Plesmanweg 47, 3088 GB Rotterdam - Telefoon (088) 5130200



Bijlage 2      Berekeningsvoorbeeld paal*druk*weerstanden viaduct

## Report for D-Foundations 23.1

Design and Verification according to Eurocode 7 of Bearing/Tension Piles and Shallow Foundations  
Developed by Deltares



Company:	Geobest B.V.
Date of report:	4-12-2023
Time of report:	15:24:34
Report with version:	23.1.1.40340
Date of calculation:	4-12-2023
Time of calculation:	15:23:26
Calculated with version:	23.1.1.40340
File name:	P54467_Druk Normaal_v0.00
Project identification:	Olifantenverblijf Diergaarde Oliduct, stal, bassin D-Foundations P54467_Druk Normaal_v0.00

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## 2 Input Data

### 2.1 General Input Data

Model Bearing Piles (EC7-NL)

### 2.2 General Report Data

Geotechnical consultant : RBO  
 Design engineer superstructure :  
 Principal :  
 Title 1 : Olifantenverblijf Diergaarde  
 Title 2 : Oliduct, stal, bassin  
 Title 3 : D-Foundations P54467\_Druk Normaal\_v0.00  
 Number of project : P54437  
 Location of project : Blijdorplaan 8 Rotterdam

### 2.3 Application Area Model Bearing Piles

The verifications performed by the model BEARING PILES of D-FOUNDATIONS concern pile foundations on which axial static or quasi-static loads cause pressures in the piles. The calculations of pile forces and pile displacements are based on Cone Penetration Tests. Possible rise of (tension-)piles and horizontal displacements of piles and/or pile groups are not taken into account.

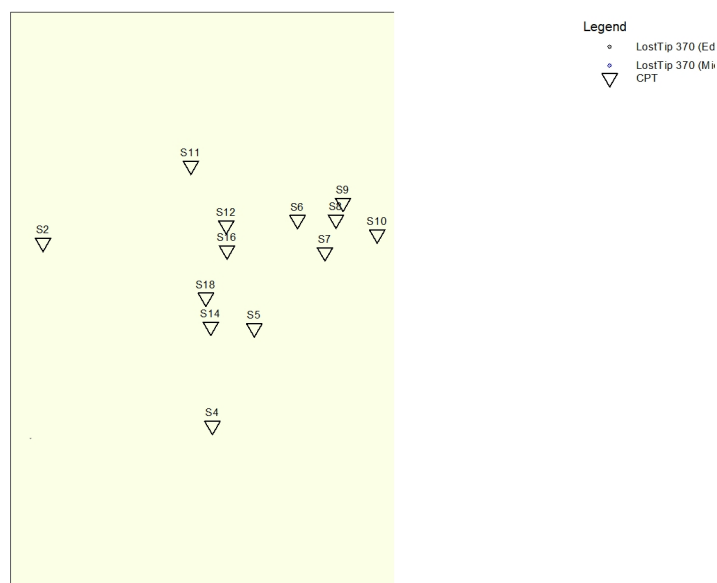
### 2.4 Superstructure

Rigidity of the superstructure : Non-Rigid

### 2.5 General CPT Data

Number of CPT's : 1  
 Timing of CPT's : CPT - Excavation - Install

#### 2.5.1 View of CPT's in Foundation Plan



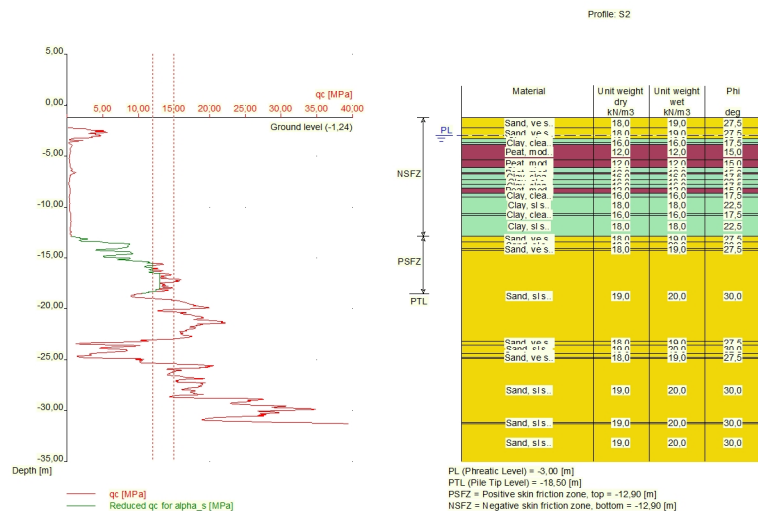
Name CPT	Pile tip level [m R.L.]	Top of pos. friction zone [m R.L.]	Bottom of neg. friction zone [m R.L.]	X-coor- dinate [m]	Y-coor- dinate [m]
S2	-18,50	-12,90	-12,90	90665,37	438126,93

## 2.6 Soil Data

Number of soil profiles (= number of CPT's) : 1

### 2.6.1 Soil Profile S2

Belonging to CPT	S2
Surface level in [m. reference level] :	-1,24
Phreatic level in [m. reference level] :	-3,00
Pile tip level in [m. reference level] :	-18,50
Top of positive skin friction zone in [m. reference level] :	-12,90
Bottom of negative skin friction zone in [m. reference level] :	-12,90
OCR-value foundation layer :	1,00
Expected groundlevel settlement in [m] :	0,11
Number of layers in profile :	27



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,240	18,00	19,00	27,50	Sand	0,200
2	-2,250	18,00	19,00	27,50	Sand	0,200
3	-3,300	18,00	18,00	22,50	Clay	--
4	-3,650	16,00	16,00	17,50	Clay	--
5	-3,850	12,00	12,00	15,00	Peat	--
6	-5,350	12,00	12,00	15,00	Peat	--
7	-6,150	16,00	16,00	17,50	Clay	--
8	-6,650	12,00	12,00	15,00	Peat	--
9	-6,750	16,00	16,00	17,50	Clay	--
10	-7,350	18,00	18,00	22,50	Clay	--
11	-7,750	16,00	16,00	17,50	Clay	--
12	-8 150	12 00	12 00	15 00	Peat	--

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
13	-8,650	16,00	16,00	17,50	Clay	--
14	-9,050	18,00	18,00	22,50	Clay	--
15	-10,650	16,00	16,00	17,50	Clay	--
16	-10,850	18,00	18,00	22,50	Clay	--
17	-12,900	18,00	19,00	27,50	Sand	0,200
18	-13,469	19,00	20,00	30,00	Sand	0,200
19	-14,069	18,00	19,00	27,50	Sand	0,200
20	-14,269	19,00	20,00	30,00	Sand	0,200
21	-23,170	18,00	19,00	27,50	Sand	0,200
22	-23,570	19,00	20,00	30,00	Sand	0,200
23	-24,370	18,00	19,00	27,50	Sand	0,200
24	-24,770	18,00	19,00	27,50	Sand	0,200
25	-24,870	19,00	20,00	30,00	Sand	0,200
26	-31,170	19,00	20,00	30,00	Sand	0,200
27	-31,270	19,00	20,00	30,00	Sand	0,200

## 2.7 Pile Types

### 2.7.1 Pile type : Rect 320x320

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,320

Largest side pile tip [m] : 0,320

### 2.7.2 Pile type : Rect 250x250

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,250

Largest side pile tip [m] : 0,250

### 2.7.3 Pile type : Rect 290x290

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,290

Largest side pile tip [m] : 0,290

**2.7.4 Pile type : Rect 350x350**

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.	
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.	
Pile dimensions :	
Smallest side pile tip [m] :	0,350
Largest side pile tip [m] :	0,350

**2.7.5 Pile type : Rect 400x400**

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.	
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.	
Pile dimensions :	
Smallest side pile tip [m] :	0,400
Largest side pile tip [m] :	0,400

**2.7.6 Pile type : LostTip 235**

Pile type :	User defined (vibrating)
Note: This user defined pile type is considered not to be of a in place formed type.	
Hence the characteristic value of the friction angle at the pile shaft (delta) will be taken as $0.75 \cdot \phi$ .	

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves :	1
Materialtype for pile :	Steel
Slip layer :	None
Pile shape :	Round pile with lost tip
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.	
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.	
Pile dimensions :	
Diameter at tip [m] :	0,235
Diameter shaft [m] :	0,219
Effective height enlarged base [m] :	0,000

**2.7.7 Pile type : LostTip 290**

Pile type :	User defined (vibrating)
Note: This user defined pile type is considered not to be of a in place formed type.	
Hence the characteristic value of the friction angle at the pile shaft (delta) will be taken as $0.75 \cdot \phi$ .	



Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Diameter at tip [m] : 0,290  
Diameter shaft [m] : 0,273  
Effective height enlarged base [m] : 0,000

#### 2.7.8 Pile type : LostTip 340

Pile type : User defined (vibrating)  
Note: This user defined pile type is considered not to be of a in place formed type.  
Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Diameter at tip [m] : 0,340  
Diameter shaft [m] : 0,324  
Effective height enlarged base [m] : 0,000

#### 2.7.9 Pile type : LostTip 370

Pile type : User defined (vibrating)  
Note: This user defined pile type is considered not to be of a in place formed type.  
Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

Materialtype for pile :

Slip layer :

Pile shape :

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Diameter at tip [m] :

Diameter shaft [m] :

Effective heigth enlarged base [m] :

1

Steel

None

Round pile with lost tip

0,370

0,356

0,000

## 2.8 Foundation Plan

Number of piles :

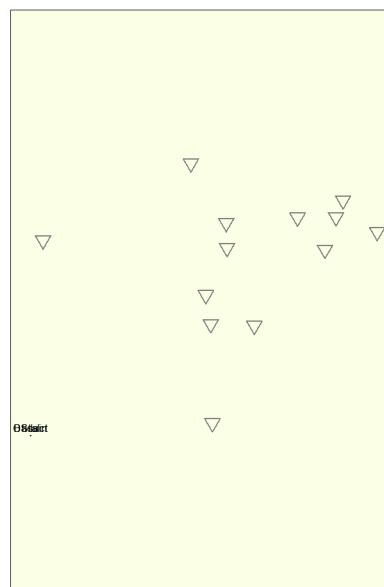
3

Number of collaborating piles\* :

1

\* : 0 = not defined, 1 = non rigid superstructure, >1 = rigid superstructure

### 2.8.1 View of Foundation Plan



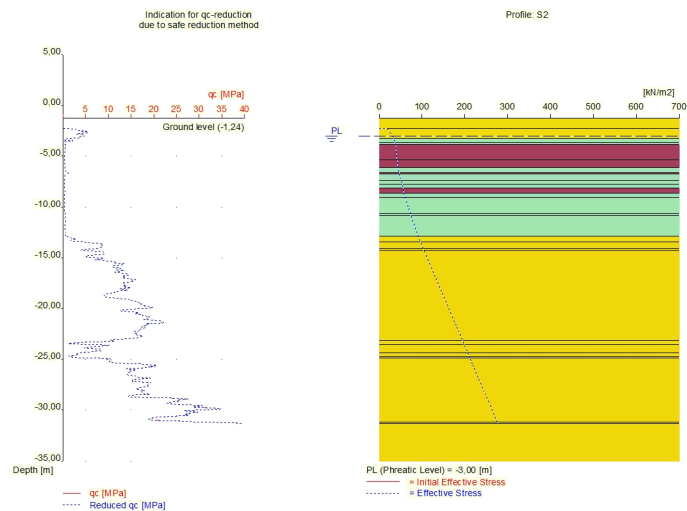
Legend  
 • LostTip 370 (Ed)  
 • LostTip 370 (Mi)  
 ▽ CPT

Pile nr/name	X-coordinate [m]	Y-coordinate [m]	Fc;d (EQU/STR/GEO) [kN]	Fc;d (SLS) [kN]	P0 [kN/m2]	Pile head level [m R.L.]
1: Oliduct	90660,37	438048,43	0,00	0,00	0,00	-0,80
2: Bassin	90660,37	438048,43	0,00	0,00	0,00	-0,80
3: Stal	90660,37	438048,43	0,00	0,00	0,00	-0,80

## 2.9 Excavation Data

Excavation level in [m. reference level] :  
Reduction model :

0,00  
Safe (NEN)



## 2.10 Overruled Parameters

User defined Factor xi3 [-] : 1,39  
User defined Factor xi4 [-] : 1,39  
User defined gamma;b [-] : 1,20  
User defined gamma;s [-] : 1,20  
User defined gamma;f;nk [-] : 1,00

## 2.11 Model Options

Use pilegroup for negative skin friction (standard)  
Do not create intermediate results file  
Use reduction for continuous flight auger piles (standard)  
Use the influence of excavations (standard).

## 2.12 Model Options

Selected pile types :

- LostTip 370
- LostTip 340
- LostTip 290
- LostTip 235

Selected profiles :

- S2

Trajectory

-begin [m] : -13,00  
-end [m] : -23,00  
-interval [m] : 0,50

## 3 Bearing Piles (EC7-NL): Results Preliminary Design, Indication Bearing Capacity

### 3.1 Errors and Warnings

Warning : The factor  $\xi_3$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\xi_4$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{b,b}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{s,s}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{f,nk}$  (NEN 9997-1+C2:2017 art. 7.3.2.2) is user defined. Evidence to support this from the NEN deviating value has to be provided.

### 3.2 Remarks

When checking the survey and testing of soil according to NEN 9997-1+C2:2017 art. 3.2.3 section (e), the program uses the provided CPT test level. It does NOT take into account possible different pile tip levels. When different pile tip levels are used in this calculation, the user itself must check for possibly required additional survey and testing of soil.

Note : The calculations performed are based on a single pile for limit state EQU/STR/GEO (= ultimate limit state). Due to the nature of preliminary design, a single pile is always assumed. A possible pileplan is disregarded when using the preliminary design option. Hence a non rigid superstructure is assumed and pile group effects are not considered.

### 3.3 Calculation Parameters

#### 3.3.1 Pile Factors

$\gamma_{b,b}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\gamma_{s,s}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\xi_3$ (user defined) :	1,39
$\xi_4$ (user defined) :	1,39

#### 3.3.2 Pile type : LostTip 370

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves :	1
Materialtype for pile :	Steel
Slip layer :	None
Pile shape :	Round pile with lost tip
$\beta$ (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	0,90
$s$ (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crossection of the pile base) :	1,00

Pile dimensions :

Diameter at tip [m] :	0,370
Diameter shaft [m] :	0,356
Effective height enlarged base [m] :	0,000

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
1:S2	0,0100	--	0,7000

### 3.3.3 Pile type : LostTip 340

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

1

Materialtype for pile :

Steel

Slip layer :

None

Pile shape :

Round pile with lost tip

beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017

art. 7.6.2.3(g) : Pile tip) :

0,90

s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for

the influence of the shape of the crosssection of the pile base) :

1,00

Pile dimensions :

Diameter at tip [m] :	0,340
Diameter shaft [m] :	0,324
Effective height enlarged base [m] :	0,000

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
1:S2	0,0100	--	0,7000

### 3.3.4 Pile type : LostTip 290

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) : 0,89  
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) : 1,00

Pile dimensions :  
Diameter at tip [m] : 0,290  
Diameter shaft [m] : 0,273  
Effective heigth enlarged base [m] : 0,000

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
1:S2	0,0100	--	0,7000

### 3.3.5 Pile type : LostTip 235

Pile type : User defined (vibrating)  
Note: This user defined pile type is considered not to be of a in place formed type.  
Hence the characteristic value of the friction angle at the pile shaft (delta) will be taken as 0.75 \* phi.

Pile type for determination of execution factor alpha\_s in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor alpha\_s in clay/loam/peat:  
alpha\_s clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note : alpha\_s depends on the soiltype and relative depth.

Pile type for determination of pile class factor alpha\_p :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) : 0,89  
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) : 1,00

Pile dimensions :  
Diameter at tip [m] : 0,235  
Diameter shaft [m] : 0,219  
Effective heigth enlarged base [m] : 0,000

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
1:S2	0,0100	--	0,7000

### 3.4 Results Bearing Forces for Pile type : LostTip 370

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-13.00	80	1	81	49	164	164	-115
1:S2	-13.50	219	17	236	141	164	164	-23
1:S2	-14.00	215	63	278	167	164	164	3
1:S2	-14.50	275	100	375	225	164	164	61
1:S2	-15.00	361	139	500	300	164	164	136

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-15.50	533	192	725	435	164	164	271
1:S2	-16.00	606	257	863	517	164	164	353
1:S2	-16.50	709	323	1032	619	164	164	455
1:S2	-17.00	701	396	1097	658	164	164	494
1:S2	-17.50	633	468	1101	660	164	164	496
1:S2	-18.00	638	541	1179	707	164	164	543
1:S2	-18.50	611	609	1220	731	164	164	567
1:S2	-19.00	793	663	1456	873	164	164	709
1:S2	-19.50	827	742	1569	941	164	164	777
1:S2	-20.00	802	821	1623	973	164	164	809
1:S2	-20.50	970	901	1871	1122	164	164	958
1:S2	-21.00	995	984	1979	1186	164	164	1022
1:S2	-21.50	964	1068	2032	1218	164	164	1054
1:S2	-22.00	292	1152	1444	866	164	164	702
1:S2	-22.50	257	1236	1493	895	164	164	731
1:S2	-23.00	188	1320	1508	904	164	164	740

\* Rc;net;d = Rc;d - Fnsf;d

### 3.5 Results Bearing Forces for Pile type : LostTip 340

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-13.00	68	1	69	41	149	149	-108
1:S2	-13.50	186	16	202	121	149	149	-28
1:S2	-14.00	184	57	241	144	149	149	-5
1:S2	-14.50	237	91	328	197	149	149	48
1:S2	-15.00	309	127	436	261	149	149	112
1:S2	-15.50	459	175	634	380	149	149	231
1:S2	-16.00	523	233	756	453	149	149	304
1:S2	-16.50	608	294	902	541	149	149	392
1:S2	-17.00	625	360	985	591	149	149	442
1:S2	-17.50	544	426	970	582	149	149	433
1:S2	-18.00	542	493	1035	621	149	149	472
1:S2	-18.50	516	554	1070	641	149	149	492
1:S2	-19.00	667	603	1270	761	149	149	612
1:S2	-19.50	700	675	1375	824	149	149	675
1:S2	-20.00	680	747	1427	856	149	149	707
1:S2	-20.50	822	820	1642	984	149	149	835
1:S2	-21.00	851	896	1747	1047	149	149	898
1:S2	-21.50	869	972	1841	1104	149	149	955
1:S2	-22.00	337	1049	1386	831	149	149	682
1:S2	-22.50	219	1125	1344	806	149	149	657
1:S2	-23.00	159	1201	1360	815	149	149	666

\* Rc;net;d = Rc;d - Fnsf;d

### 3.6 Results Bearing Forces for Pile type : LostTip 290

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-13.00	49	1	50	30	125	125	-95
1:S2	-13.50	135	13	148	89	125	125	-36
1:S2	-14.00	136	48	184	110	125	125	-15
1:S2	-14.50	177	77	254	152	125	125	27
1:S2	-15.00	231	107	338	203	125	125	78
1:S2	-15.50	343	147	490	294	125	125	169
1:S2	-16.00	385	197	582	349	125	125	224
1:S2	-16.50	451	248	699	419	125	125	294
1:S2	-17.00	483	303	786	471	125	125	346
1:S2	-17.50	419	359	778	466	125	125	341
1:S2	-18.00	390	415	805	483	125	125	358
1:S2	-18.50	371	467	838	502	125	125	377
1:S2	-19.00	476	508	984	590	125	125	465

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-19.50	506	569	1075	644	125	125	519
1:S2	-20.00	495	630	1125	674	125	125	549
1:S2	-20.50	597	691	1288	772	125	125	647
1:S2	-21.00	641	755	1396	837	125	125	712
1:S2	-21.50	634	819	1453	871	125	125	746
1:S2	-22.00	479	884	1363	817	125	125	692
1:S2	-22.50	159	948	1107	664	125	125	539
1:S2	-23.00	114	1012	1126	675	125	125	550

\* Rc;net;d = Rc;d - Fnsf;d

### 3.7 Results Bearing Forces for Pile type : LostTip 235

Number/Name CPT	Level [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]	Rc;net;d [kN]
1:S2	-13.00	32	1	33	20	101	101	-81
1:S2	-13.50	90	11	101	61	101	101	-40
1:S2	-14.00	93	39	132	79	101	101	-22
1:S2	-14.50	123	62	185	111	101	101	10
1:S2	-15.00	160	86	246	147	101	101	46
1:S2	-15.50	232	118	350	210	101	101	109
1:S2	-16.00	262	158	420	252	101	101	151
1:S2	-16.50	308	199	507	304	101	101	203
1:S2	-17.00	338	243	581	348	101	101	247
1:S2	-17.50	313	288	601	360	101	101	259
1:S2	-18.00	256	333	589	353	101	101	252
1:S2	-18.50	244	374	618	371	101	101	270
1:S2	-19.00	309	408	717	430	101	101	329
1:S2	-19.50	335	456	791	474	101	101	373
1:S2	-20.00	330	505	835	501	101	101	400
1:S2	-20.50	400	554	954	572	101	101	471
1:S2	-21.00	439	606	1045	626	101	101	525
1:S2	-21.50	423	657	1080	647	101	101	546
1:S2	-22.00	418	709	1127	676	101	101	575
1:S2	-22.50	111	760	871	522	101	101	421
1:S2	-23.00	75	812	887	532	101	101	431

\* Rc;net;d = Rc;d - Fnsf;d

### 3.8 Summary Net Bearing Capacity in kN

Number/Name CPT	Groundlevel [m R.L.]	Level [m R.L.]	LostTip 370 Rc;net;d [kN]	LostTip 340 Rc;net;d [kN]	LostTip 290 Rc;net;d [kN]	LostTip 235 Rc;net;d [kN]
1:S2	-1,24	-13,00	-115,00	-108,00	-95,00	-81,00
1:S2	-1,24	-13,50	-23,00	-28,00	-36,00	-40,00
1:S2	-1,24	-14,00	3,00	-5,00	-15,00	-22,00
1:S2	-1,24	-14,50	61,00	48,00	27,00	10,00
1:S2	-1,24	-15,00	136,00	112,00	78,00	46,00
1:S2	-1,24	-15,50	271,00	231,00	169,00	109,00
1:S2	-1,24	-16,00	353,00	304,00	224,00	151,00
1:S2	-1,24	-16,50	455,00	392,00	294,00	203,00
1:S2	-1,24	-17,00	494,00	442,00	346,00	247,00
1:S2	-1,24	-17,50	496,00	433,00	341,00	259,00
1:S2	-1,24	-18,00	543,00	472,00	358,00	252,00
1:S2	-1,24	-18,50	567,00	492,00	377,00	270,00
1:S2	-1,24	-19,00	709,00	612,00	465,00	329,00
1:S2	-1,24	-19,50	777,00	675,00	519,00	373,00
1:S2	-1,24	-20,00	809,00	707,00	549,00	400,00
1:S2	-1,24	-20,50	958,00	835,00	647,00	471,00
1:S2	-1,24	-21,00	1022,00	898,00	712,00	525,00
1:S2	-1,24	-21,50	1054,00	955,00	746,00	546,00
1:S2	-1,24	-22,00	702,00	682,00	692,00	575,00
1:S2	-1,24	-22,50	731,00	657,00	539,00	421,00



Number/Name CPT	Groundlevel [m R.L.]	Level [m R.L.]	LostTip 370 Rc;net;d [kN]	LostTip 340 Rc;net;d [kN]	LostTip 290 Rc;net;d [kN]	LostTip 235 Rc;net;d [kN]
1:S2	-1,24	-23,00	740,00	666,00	550,00	431,00

**End of Report**

Bijlage 3      Berekeningsvoorbeeld paal*druk*weerstanden olifantenstal

## Report for D-Foundations 23.1

Design and Verification according to Eurocode 7 of Bearing/Tension Piles and Shallow Foundations  
Developed by Deltares



Company:	Geobest B.V.
Date of report:	5-12-2023
Time of report:	12:23:28
Report with version:	23.1.1.40340
Date of calculation:	5-12-2023
Time of calculation:	12:23:10
Calculated with version:	23.1.1.40340
File name:	P54467_Druk Normaal_v0.00
Project identification:	Olifantenverblijf Diergaarde Oliduct, stal, bassin D-Foundations P54467_Druk Normaal_v0.00

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## 2 Input Data

### 2.1 General Input Data

Model Bearing Piles (EC7-NL)

### 2.2 General Report Data

Geotechnical consultant : RBO  
 Design engineer superstructure :  
 Principal :  
 Title 1 : Olifantenverblijf Diergaarde  
 Title 2 : Oliduct, stal, bassin  
 Title 3 : D-Foundations P54467\_Druk Normaal\_v0.00  
 Number of project : P54437  
 Location of project : Blijdorplaan 8 Rotterdam

### 2.3 Application Area Model Bearing Piles

The verifications performed by the model BEARING PILES of D-FOUNDATIONS concern pile foundations on which axial static or quasi-static loads cause pressures in the piles. The calculations of pile forces and pile displacements are based on Cone Penetration Tests. Possible rise of (tension-)piles and horizontal displacements of piles and/or pile groups are not taken into account.

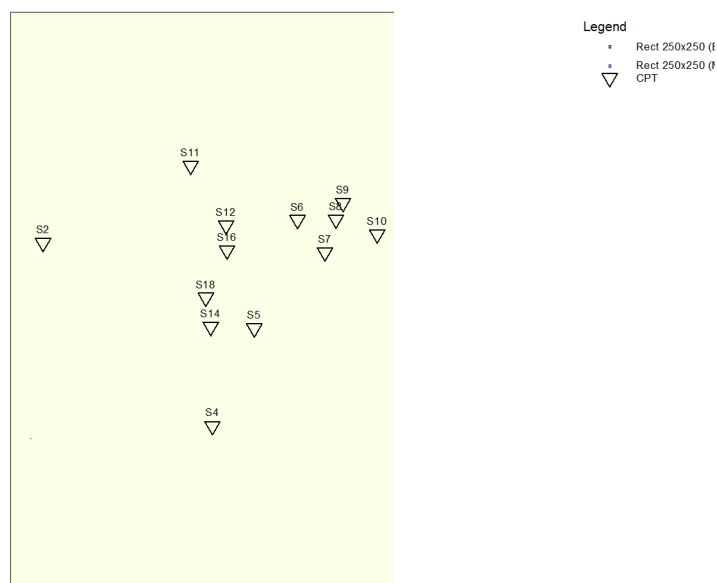
### 2.4 Superstructure

Rigidity of the superstructure : Non-Rigid

### 2.5 General CPT Data

Number of CPT's : 5  
 Timing of CPT's : CPT - Excavation - Install

#### 2.5.1 View of CPT's in Foundation Plan



Name CPT	Pile tip level [m R.L.]	Top of pos. friction zone [m R.L.]	Bottom of neg. friction zone [m R.L.]	X-coor- dinate [m]	Y-coor- dinate [m]
S11	-18,50	-16,10	-16,10	90724,87	438157,96
S12	-18,50	-15,91	-15,91	90739,10	438133,96
S14	-18,50	-16,50	-16,50	90732,92	438093,25
S16	-18,50	-16,17	-16,17	90739,48	438123,93
S18	-18,50	-15,91	-15,91	90730,95	438104,92

## 2.6 Soil Data

Number of soil profiles (= number of CPT's) : 5

### 2.6.1 Soil Profile S11

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Pile tip level in [m. reference level] :

Top of positive skin friction zone in [m. reference level] :

Bottom of negative skin friction zone in [m. reference level] :

OCR-value foundation layer :

Expected groundlevel settlement in [m] :

Number of layers in profile :

S11

-0,50

-3,00

-18,50

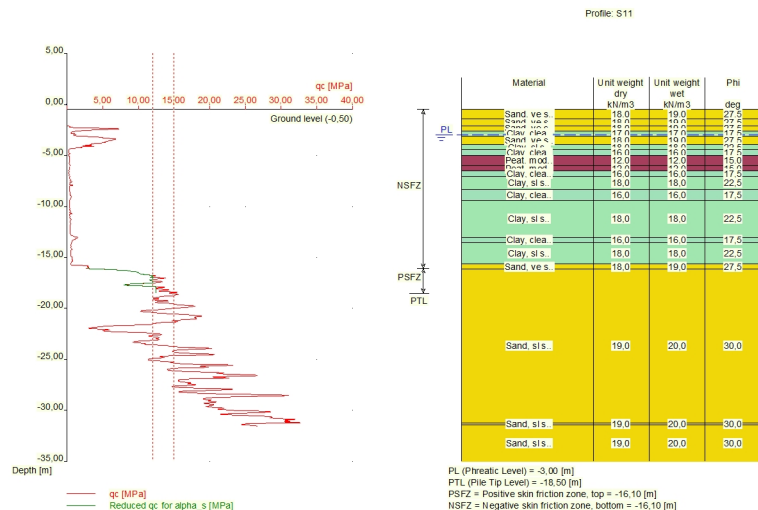
-16,10

-16,10

1,00

0,11

19



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma:sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-0,500	18,00	19,00	27,50	Sand	0,200
2	-1,410	18,00	19,00	27,50	Sand	0,200
3	-2,120	18,00	19,00	27,50	Sand	0,200
4	-2,580	17,00	17,00	17,50	Clay	--
5	-3,130	18,00	19,00	27,50	Sand	0,200
6	-3,939	18,00	18,00	22,50	Clay	--
7	-4,459	16,00	16,00	17,50	Clay	--
8	-4,979	12,00	12,00	15,00	Peat	--

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
9	-6,018	12,00	12,00	15,00	Peat	--
10	-6,538	16,00	16,00	17,50	Clay	--
11	-7,058	18,00	18,00	22,50	Clay	--
12	-8,358	16,00	16,00	17,50	Clay	--
13	-9,397	18,00	18,00	22,50	Clay	--
14	-13,036	16,00	16,00	17,50	Clay	--
15	-13,556	18,00	18,00	22,50	Clay	--
16	-15,636	18,00	19,00	27,50	Sand	0,200
17	-16,156	19,00	20,00	30,00	Sand	0,200
18	-31,210	19,00	20,00	30,00	Sand	0,200
19	-31,460	19,00	20,00	30,00	Sand	0,200

### 2.6.2 Soil Profile S12

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Pile tip level in [m. reference level] :

Top of positive skin friction zone in [m. reference level] :

Bottom of negative skin friction zone in [m. reference level] :

OCR-value foundation layer :

Expected groundlevel settlement in [m] :

Number of layers in profile :

S12

-0,50

-3,00

-18,50

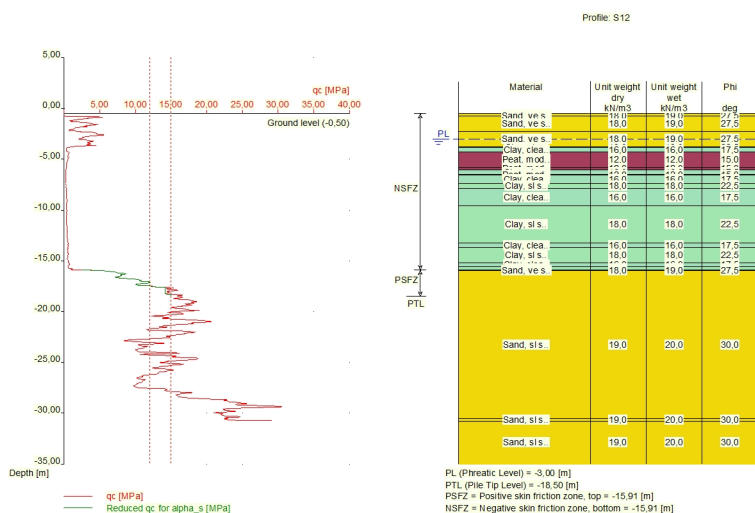
-15,91

-15,91

1,00

0,11

22



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-0,500	18,00	19,00	27,50	Sand	0,200
2	-0,740	18,00	19,00	27,50	Sand	0,200
3	-0,750	18,00	19,00	27,50	Sand	0,200
4	-2,250	18,00	19,00	27,50	Sand	0,200
5	-3,750	18,00	18,00	22,50	Clay	--
6	-3,850	16,00	16,00	17,50	Clay	--
7	-4,250	12,00	12,00	15,00	Peat	--

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
8	-5,769	12,00	12,00	15,00	Peat	--
9	-6,069	16,00	16,00	17,50	Clay	--
10	-6,469	12,00	12,00	15,00	Peat	--
11	-6,569	16,00	16,00	17,50	Clay	--
12	-7,369	18,00	18,00	22,50	Clay	--
13	-7,869	16,00	16,00	17,50	Clay	--
14	-9,569	18,00	18,00	22,50	Clay	--
15	-13,269	16,00	16,00	17,50	Clay	--
16	-13,669	18,00	18,00	22,50	Clay	--
17	-15,170	16,00	16,00	17,50	Clay	--
18	-15,570	18,00	18,00	22,50	Clay	--
19	-15,870	18,00	19,00	27,50	Sand	0,200
20	-15,970	19,00	20,00	30,00	Sand	0,200
21	-30,570	19,00	20,00	30,00	Sand	0,200
22	-30,770	19,00	20,00	30,00	Sand	0,200

## 2.6.3 Soil Profile S14

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Pile tip level in [m. reference level] :

Top of positive skin friction zone in [m. reference level] :

Bottom of negative skin friction zone in [m. reference level] :

OCR-value foundation layer :

Expected groundlevel settlement in [m] :

Number of layers in profile :

S14

-0,02

-3,00

-18,50

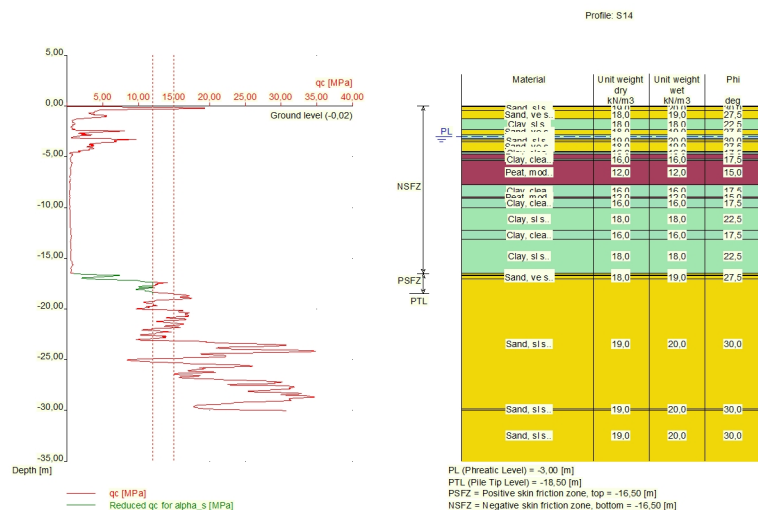
-16,50

-16,50

1,00

0,11

26



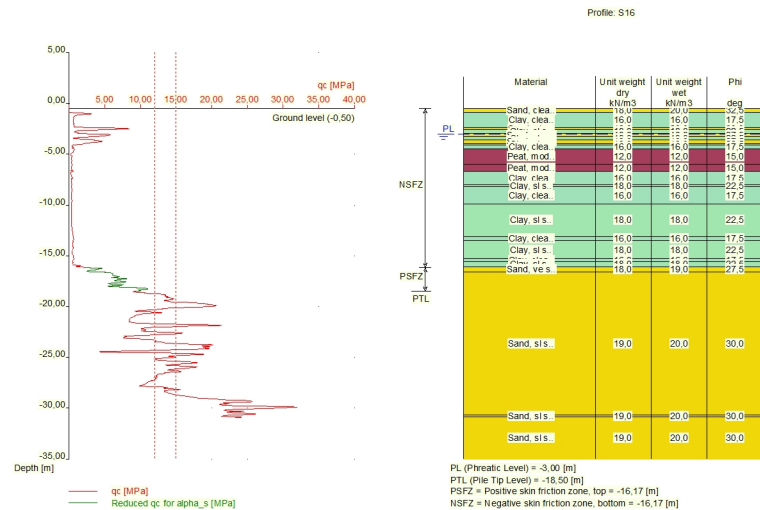
Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-0,020	19,00	20,00	30,00	Sand	0,200
2	-0,030	19,00	20,00	30,00	Sand	0,200
3	-0,430	18,00	19,00	27,50	Sand	0,200



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
4	-1,240	18,00	18,00	22,50	Clay	--
5	-2,330	18,00	19,00	27,50	Sand	0,200
6	-2,830	18,00	18,00	22,50	Clay	--
7	-3,230	18,00	19,00	27,50	Sand	0,200
8	-3,330	19,00	20,00	30,00	Sand	0,200
9	-3,530	18,00	19,00	27,50	Sand	0,200
10	-4,449	18,00	18,00	22,50	Clay	--
11	-4,549	16,00	16,00	17,50	Clay	--
12	-4,749	12,00	12,00	15,00	Peat	--
13	-5,249	16,00	16,00	17,50	Clay	--
14	-5,349	12,00	12,00	15,00	Peat	--
15	-7,749	16,00	16,00	17,50	Clay	--
16	-8,949	12,00	12,00	15,00	Peat	--
17	-9,049	16,00	16,00	17,50	Clay	--
18	-10,049	18,00	18,00	22,50	Clay	--
19	-12,249	16,00	16,00	17,50	Clay	--
20	-13,149	18,00	18,00	22,50	Clay	--
21	-16,449	18,00	19,00	27,50	Sand	0,200
22	-16,649	19,00	20,00	30,00	Sand	0,200
23	-16,749	18,00	19,00	27,50	Sand	0,200
24	-17,049	19,00	20,00	30,00	Sand	0,200
25	-29,850	19,00	20,00	30,00	Sand	0,200
26	-29,950	19,00	20,00	30,00	Sand	0,200

#### 2.6.4 Soil Profile S16

Belonging to CPT	S16
Surface level in [m. reference level] :	-0,50
Phreatic level in [m. reference level] :	-3,00
Pile tip level in [m. reference level] :	-18,50
Top of positive skin friction zone in [m. reference level] :	-16,17
Bottom of negative skin friction zone in [m. reference level] :	-16,17
OCR-value foundation layer :	1,00
Expected groundlevel settlement in [m] :	0,11
Number of layers in profile :	23



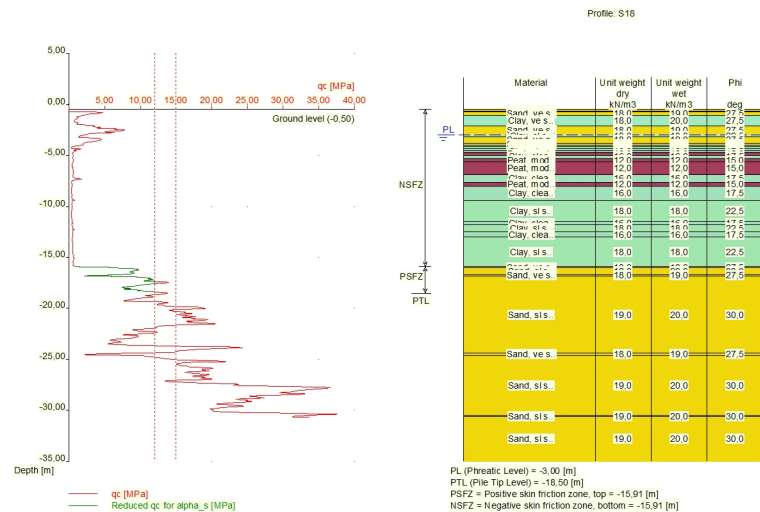
Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-0,500	18,00	20,00	32,50	Sand	0,200
2	-0,860	16,00	16,00	17,50	Clay	--
3	-2,370	19,00	20,00	30,00	Sand	0,200
4	-2,570	18,00	18,00	22,50	Clay	--
5	-2,970	18,00	19,00	27,50	Sand	0,200
6	-3,270	18,00	18,00	22,50	Clay	--
7	-3,570	18,00	19,00	27,50	Sand	0,200
8	-3,970	18,00	18,00	22,50	Clay	--
9	-4,070	16,00	16,00	17,50	Clay	--
10	-4,470	12,00	12,00	15,00	Peat	--
11	-5,970	12,00	12,00	15,00	Peat	--
12	-6,670	16,00	16,00	17,50	Clay	--
13	-7,989	18,00	18,00	22,50	Clay	--
14	-8,189	16,00	16,00	17,50	Clay	--
15	-9,889	18,00	18,00	22,50	Clay	--
16	-13,089	16,00	16,00	17,50	Clay	--
17	-13,489	18,00	18,00	22,50	Clay	--
18	-15,290	16,00	16,00	17,50	Clay	--
19	-15,590	18,00	18,00	22,50	Clay	--
20	-16,090	18,00	19,00	27,50	Sand	0,200
21	-16,590	19,00	20,00	30,00	Sand	0,200
22	-30,690	19,00	20,00	30,00	Sand	0,200
23	-30,890	19,00	20,00	30,00	Sand	0,200

### 2.6.5 Soil Profile S18

Belonging to CPT	S18
Surface level in [m. reference level] :	-0,50
Phreatic level in [m. reference level] :	-3,00
Pile tip level in [m. reference level] :	-18,50
Top of positive skin friction zone in [m. reference level] :	-15,91
Bottom of negative skin friction zone in [m. reference level] :	-15,91
OCR-value foundation layer :	1,00

Expected groundlevel settlement in [m] :  
Number of layers in profile :

0,11  
32



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-0,500	18,00	19,00	27,50	Sand	0,200
2	-0,680	18,00	19,00	27,50	Sand	0,200
3	-0,690	18,00	19,00	27,50	Sand	0,200
4	-1,100	18,00	20,00	27,50	Clay	--
5	-2,090	18,00	19,00	27,50	Sand	0,200
6	-2,990	18,00	18,00	22,50	Clay	--
7	-3,190	18,00	19,00	27,50	Sand	0,200
8	-3,790	18,00	19,00	27,50	Sand	0,200
9	-3,990	18,00	18,00	22,50	Clay	--
10	-4,090	16,00	16,00	17,50	Clay	--
11	-4,290	18,00	18,00	22,50	Clay	--
12	-4,490	16,00	16,00	17,50	Clay	--
13	-4,690	12,00	12,00	15,00	Peat	--
14	-4,990	16,00	16,00	17,50	Clay	--
15	-5,290	12,00	12,00	15,00	Peat	--
16	-5,609	12,00	12,00	15,00	Peat	--
17	-6,909	16,00	16,00	17,50	Clay	--
18	-7,609	12,00	12,00	15,00	Peat	--
19	-8,009	16,00	16,00	17,50	Clay	--
20	-9,409	18,00	18,00	22,50	Clay	--
21	-11,509	16,00	16,00	17,50	Clay	--
22	-11,809	18,00	18,00	22,50	Clay	--
23	-12,509	16,00	16,00	17,50	Clay	--
24	-13,009	18,00	18,00	22,50	Clay	--
25	-15,910	18,00	19,00	27,50	Sand	0,200
26	-16,010	19,00	20,00	30,00	Sand	0,200
27	-16,710	18,00	19,00	27,50	Sand	0,200
28	-16,810	19,00	20,00	30,00	Sand	0,200
29	-24,410	18,00	19,00	27,50	Sand	0,200
30	-24,610	19,00	20,00	30,00	Sand	0,200
31	-30,510	19,00	20,00	30,00	Sand	0,200

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
32	-30,610	19,00	20,00	30,00	Sand	0,200

## 2.7 Pile Types

### 2.7.1 Pile type : Rect 320x320

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,320

Largest side pile tip [m] : 0,320

### 2.7.2 Pile type : Rect 250x250

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,250

Largest side pile tip [m] : 0,250

### 2.7.3 Pile type : Rect 290x290

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,290

Largest side pile tip [m] : 0,290

### 2.7.4 Pile type : Rect 350x350

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer : None

Pile shape : Rectangular pile

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] : 0,350

Largest side pile tip [m] : 0,350

**2.7.5 Pile type : Rect 400x400**

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.	
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.	
Pile dimensions :	
Smallest side pile tip [m] :	0,400
Largest side pile tip [m] :	0,400

**2.7.6 Pile type : LostTip 235**

Pile type :	User defined (vibrating)
Note: This user defined pile type is considered not to be of a in place formed type.	
Hence the characteristic value of the friction angle at the pile shaft (delta) will be taken as $0.75 * \phi$ .	

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves :	1
Materialtype for pile :	Steel
Slip layer :	None
Pile shape :	Round pile with lost tip
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.	
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.	
Pile dimensions :	
Diameter at tip [m] :	0,235
Diameter shaft [m] :	0,219
Effective height enlarged base [m] :	0,000

**2.7.7 Pile type : LostTip 290**

Pile type :	User defined (vibrating)
Note: This user defined pile type is considered not to be of a in place formed type.	
Hence the characteristic value of the friction angle at the pile shaft (delta) will be taken as $0.75 * \phi$ .	

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves :	1
Materialtype for pile :	Steel

Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Diameter at tip [m] : 0,290  
Diameter shaft [m] : 0,273  
Effective height enlarged base [m] : 0,000

### 2.7.8 Pile type : LostTip 340

Pile type : User defined (vibrating)  
Note: This user defined pile type is considered not to be of a in place formed type.  
Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.  
Pile dimensions :  
Diameter at tip [m] : 0,340  
Diameter shaft [m] : 0,324  
Effective height enlarged base [m] : 0,000

### 2.7.9 Pile type : LostTip 370

Pile type : User defined (vibrating)  
Note: This user defined pile type is considered not to be of a in place formed type.  
Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:  
Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:  
 $\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)  
NEN 9997-1+C2:2017  
Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :  
Closed-ended steel pipe pile

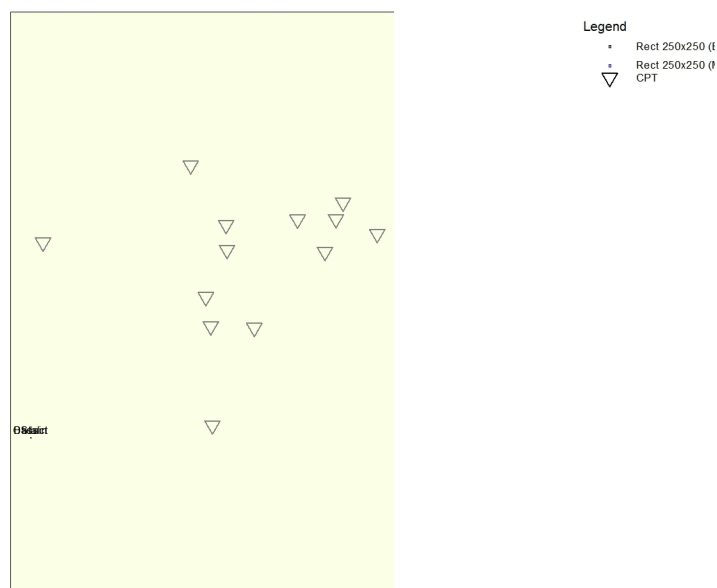
Pile type for use in load/settlement curves : 1  
Materialtype for pile : Steel  
Slip layer : None  
Pile shape : Round pile with lost tip  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.  
Pile dimensions :

Diameter at tip [m] : 0,370  
 Diameter shaft [m] : 0,356  
 Effective height enlarged base [m] : 0,000

## 2.8 Foundation Plan

Number of piles : 3  
 Number of collaborating piles\* : 1  
 \* : 0 = not defined, 1 = non rigid superstructure, >1 = rigid superstructure

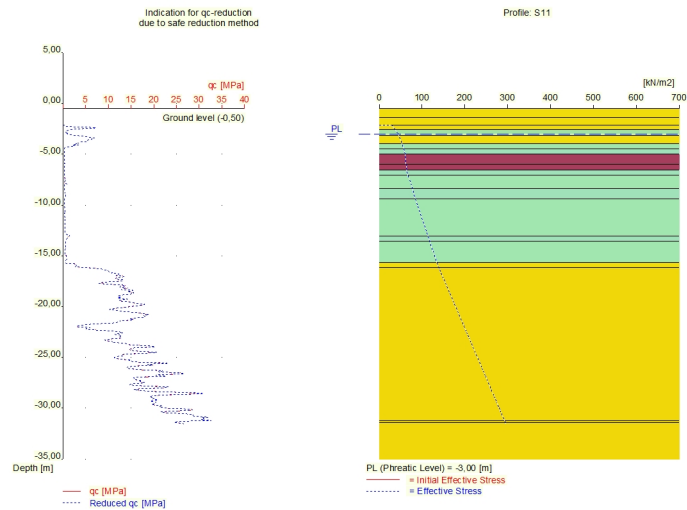
### 2.8.1 View of Foundation Plan



Pile nr/name	X-coordinate [m]	Y-coordinate [m]	Fc;d (EQU/STR/GEO) [kN]	Fc;d (SLS) [kN]	P0 [kN/m2]	Pile head level [m R.L.]
1: Oliduct	90660,37	438048,43	0,00	0,00	0,00	-0,80
2: Bassin	90660,37	438048,43	0,00	0,00	0,00	-0,80
3: Stal	90660,37	438048,43	0,00	0,00	0,00	-0,80

## 2.9 Excavation Data

Excavation level in [m. reference level] : 0,00  
 Reduction model : Safe (NEN)



## 2.10 Overruled Parameters

User defined Factor xi3 [-] :	1,39
User defined Factor xi4 [-] :	1,39
User defined gamma;b [-] :	1,20
User defined gamma;s [-] :	1,20
User defined gamma;f;nk [-] :	1,00

## 2.11 Model Options

Use pilegroup for negative skin friction (standard)

Do not create intermediate results file

Use reduction for continuous flight auger piles (standard)

Use the influence of excavations (standard).

## 2.12 Model Options

Selected pile types :

- Rect 250x250
- Rect 290x290
- Rect 320x320
- Rect 350x350

Selected profiles :

- S11
- S12
- S14
- S16
- S18



### 3 Bearing Piles (EC7-NL): Results Preliminary Design, Bearing capacity at fixed pile tip level

#### 3.1 Errors and Warnings

Warning : The factor  $\xi_3$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\xi_4$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{b,b}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{s,s}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{f,nk}$  (NEN 9997-1+C2:2017 art. 7.3.2.2) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Soil profile S11

Warning : The lowest pile head level lies below the surface level. The maximum value for the top of the friction zones is therefor reset to -0,80 m relative to reference level.

Soil profile S12

Warning : The lowest pile head level lies below the surface level. The maximum value for the top of the friction zones is therefor reset to -0,80 m relative to reference level.

Soil profile S14

Warning : The lowest pile head level lies below the surface level. The maximum value for the top of the friction zones is therefor reset to -0,80 m relative to reference level.

Soil profile S16

Warning : The lowest pile head level lies below the surface level. The maximum value for the top of the friction zones is therefor reset to -0,80 m relative to reference level.

Soil profile S18

Warning : The lowest pile head level lies below the surface level. The maximum value for the top of the friction zones is therefor reset to -0,80 m relative to reference level.

#### 3.2 Remarks

When checking the survey and testing of soil according to NEN 9997-1+C2:2017 art. 3.2.3 section (e), the program uses the provided CPT test level. It does NOT take into account possible different pile tip levels. When different pile tip levels are used in this calculation, the user itself must check for possibly required additional survey and testing of soil.

Note : The calculations performed are based on a single pile for limit state EQU/STR/GEO (= ultimate limit state). Due to the nature of preliminary design, a single pile is always assumed. A possible pileplan is disregarded when using the preliminary design option. Hence a non rigid superstructure is assumed and pile group effects are not considered.

#### 3.3 Calculation Parameters

##### 3.3.1 Pile Factors

$\gamma_{b,b}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\gamma_{s,s}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\xi_3$ (user defined) :	1,39
$\xi_4$ (user defined) :	1,39

##### 3.3.2 Pile type : Rect 250x250

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete

Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,250
Largest side pile tip [m] :	0,250

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
9:S11	0,0100	--	0,7000
10:S12	0,0100	--	0,7000
11:S14	0,0100	--	0,7000
12:S16	0,0100	--	0,7000
13:S18	0,0100	--	0,7000

### 3.3.3 Pile type : Rect 290x290

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,290
Largest side pile tip [m] :	0,290

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
9:S11	0,0100	--	0,7000
10:S12	0,0100	--	0,7000
11:S14	0,0100	--	0,7000
12:S16	0,0100	--	0,7000
13:S18	0,0100	--	0,7000

### 3.3.4 Pile type : Rect 320x320

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,320
Largest side pile tip [m] :	0,320

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
9:S11	0,0100	--	0,7000
10:S12	0,0100	--	0,7000
11:S14	0,0100	--	0,7000
12:S16	0,0100	--	0,7000
13:S18	0,0100	--	0,7000

### 3.3.5 Pile type : Rect 350x350

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,350
Largest side pile tip [m] :	0,350

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
9:S11	0,0100	--	0,7000
10:S12	0,0100	--	0,7000
11:S14	0,0100	--	0,7000
12:S16	0,0100	--	0,7000
13:S18	0,0100	--	0,7000

### 3.4 Results for pile type : Rect 250x250

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
9:S11	-18.50	-0,50	482	262	743	446	300	300
10:S12	-18.50	-0,50	592	286	878	526	283	283
11:S14	-18.50	-0,02	424	180	604	362	331	331
12:S16	-18.50	-0,50	340	154	495	297	277	277
13:S18	-18.50	-0,50	333	240	573	343	281	281

### 3.5 Results for pile type : Rect 290x290

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
9:S11	-18.50	-0,50	626	303	929	557	347	347
10:S12	-18.50	-0,50	775	332	1106	663	328	328
11:S14	-18.50	-0,02	539	209	748	448	384	384
12:S16	-18.50	-0,50	447	179	626	376	322	322
13:S18	-18.50	-0,50	431	279	710	425	326	326

### 3.6 Results for pile type : Rect 320x320

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
9:S11	-18.50	-0,50	738	335	1073	643	383	383
10:S12	-18.50	-0,50	910	366	1276	765	362	362
11:S14	-18.50	-0,02	615	231	846	507	423	423
12:S16	-18.50	-0,50	535	197	733	439	355	355
13:S18	-18.50	-0,50	508	307	816	489	360	360

**3.7 Results for pile type : Rect 350x350**

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
9:S11	-18.50	-0,50	856	366	1222	733	419	419
10:S12	-18.50	-0,50	1053	400	1453	871	396	396
11:S14	-18.50	-0,02	705	252	957	574	463	463
12:S16	-18.50	-0,50	633	216	849	509	388	388
13:S18	-18.50	-0,50	592	336	928	556	394	394

**3.8 Summary Net Bearing Capacity in kN**

Number/Name CPT	Groundlevel [m R.L.]	Level [m R.L.]	Rect 250x250 Rc;net;d [kN]	Rect 290x290 Rc;net;d [kN]	Rect 320x320 Rc;net;d [kN]	Rect 350x350 Rc;net;d [kN]
9:S11	-0,50	-18,50	146,00	210,00	260,00	314,00
10:S12	-0,50	-18,50	243,00	335,00	403,00	475,00
11:S14	-0,02	-18,50	31,00	64,00	84,00	111,00
12:S16	-0,50	-18,50	20,00	54,00	84,00	121,00
13:S18	-0,50	-18,50	62,00	99,00	129,00	162,00

**End of Report**

Bijlage 4      Berekeningsvoorbeeld paal*druk*weerstanden olifantenbassin

## Report for D-Foundations 23.1

Design and Verification according to Eurocode 7 of Bearing/Tension Piles and Shallow Foundations  
Developed by Deltares



Company:	Geobest B.V.
Date of report:	5-12-2023
Time of report:	12:24:50
Report with version:	23.1.1.40340
Date of calculation:	5-12-2023
Time of calculation:	12:23:56
Calculated with version:	23.1.1.40340
File name:	P54467_Druk Normaal_v0.00
Project identification:	Olifantenverblijf Diergaarde Oliduct, stal, bassin D-Foundations P54467_Druk Normaal_v0.00

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## 2 Input Data

### 2.1 General Input Data

Model Bearing Piles (EC7-NL)

### 2.2 General Report Data

Geotechnical consultant : RBO  
 Design engineer superstructure :  
 Principal :  
 Title 1 : Olifantenverblijf Diergaarde  
 Title 2 : Oliduct, stal, bassin  
 Title 3 : D-Foundations P54467\_Druk Normaal\_v0.00  
 Number of project : P54437  
 Location of project : Blijdorplaan 8 Rotterdam

### 2.3 Application Area Model Bearing Piles

The verifications performed by the model BEARING PILES of D-FOUNDATIONS concern pile foundations on which axial static or quasi-static loads cause pressures in the piles. The calculations of pile forces and pile displacements are based on Cone Penetration Tests. Possible rise of (tension-)piles and horizontal displacements of piles and/or pile groups are not taken into account.

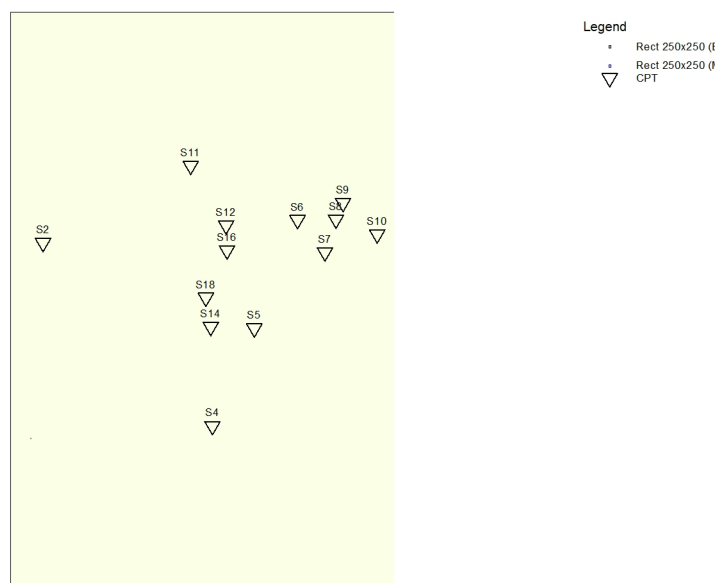
### 2.4 Superstructure

Rigidity of the superstructure : Non-Rigid

### 2.5 General CPT Data

Number of CPT's : 5  
 Timing of CPT's : CPT - Excavation - Install

#### 2.5.1 View of CPT's in Foundation Plan





Name CPT	Pile tip level [m R.L.]	Top of pos. friction zone [m R.L.]	Bottom of neg. friction zone [m R.L.]	X-coordinate [m]	Y-coordinate [m]
S6	-18,50	-16,62	-16,62	90767,83	438136,07
S7	-18,50	-16,13	-16,13	90778,91	438123,16
S8	-18,50	-17,36	-17,36	90783,35	438136,29
S9	-18,50	-17,18	-17,18	90786,19	438143,01
S10	-18,50	-17,19	-17,19	90799,95	438130,35

## 2.6 Soil Data

Number of soil profiles (= number of CPT's) : 5

### 2.6.1 Soil Profile S6

Belonging to CPT

Surface level in [m. reference level] :

S6

Phreatic level in [m. reference level] :

-1,09

Pile tip level in [m. reference level] :

-3,00

Top of positive skin friction zone in [m. reference level] :

-18,50

Bottom of negative skin friction zone in [m. reference level] :

-16,62

OCR-value foundation layer :

-16,62

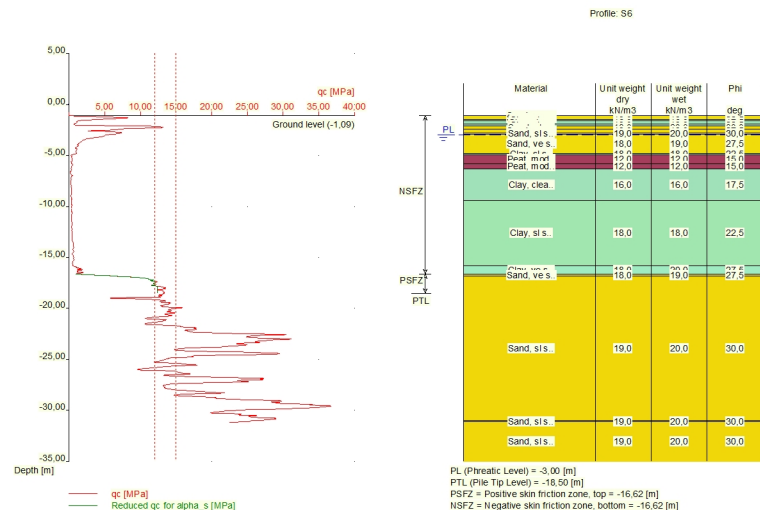
Expected groundlevel settlement in [m] :

1,00

Number of layers in profile :

0,11

19



Number layer	Top layer [m R.L.]	Gamma [kN/m <sup>3</sup> ]	Gamma;sat [kN/m <sup>3</sup> ]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,090	18,00	19,00	27,50	Sand	0,200
2	-1,100	18,00	19,00	27,50	Sand	0,200
3	-1,500	18,00	18,00	22,50	Clay	--
4	-1,600	16,00	16,00	17,50	Clay	--
5	-1,900	18,00	18,00	22,50	Clay	--
6	-2,100	19,00	20,00	30,00	Sand	0,200
7	-2,400	18,00	19,00	27,50	Sand	0,200
8	-2,800	19,00	20,00	30,00	Sand	0,200

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
9	-2,900	18,00	19,00	27,50	Sand	0,200
10	-4,819	18,00	18,00	22,50	Clay	--
11	-4,919	12,00	12,00	15,00	Peat	--
12	-5,819	12,00	12,00	15,00	Peat	--
13	-6,319	16,00	16,00	17,50	Clay	--
14	-9,420	18,00	18,00	22,50	Clay	--
15	-15,820	18,00	20,00	27,50	Clay	--
16	-16,620	18,00	19,00	27,50	Sand	0,200
17	-16,820	19,00	20,00	30,00	Sand	0,200
18	-31,020	19,00	20,00	30,00	Sand	0,200
19	-31,120	19,00	20,00	30,00	Sand	0,200

### 2.6.2 Soil Profile S7

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Pile tip level in [m. reference level] :

Top of positive skin friction zone in [m. reference level] :

Bottom of negative skin friction zone in [m. reference level] :

OCR-value foundation layer :

Expected groundlevel settlement in [m] :

Number of layers in profile :

S7

-1,40

-3,00

-18,50

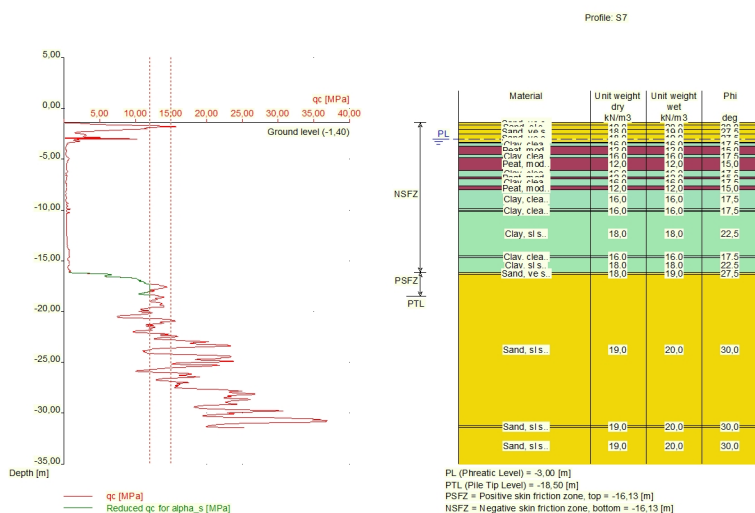
-16,13

-16,13

1,00

0,11

24



Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,400	18,00	19,00	27,50	Sand	0,200
2	-1,410	18,00	19,00	27,50	Sand	0,200
3	-1,610	19,00	20,00	30,00	Sand	0,200
4	-2,110	18,00	19,00	27,50	Sand	0,200
5	-2,510	18,00	19,00	27,50	Sand	0,200
6	-3,310	18,00	18,00	22,50	Clay	--
7	-3,410	16,00	16,00	17,50	Clay	--

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma:sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
8	-3,710	12,00	12,00	15,00	Peat	--
9	-4,529	16,00	16,00	17,50	Clay	--
10	-4,829	12,00	12,00	15,00	Peat	--
11	-6,130	16,00	16,00	17,50	Clay	--
12	-6,730	12,00	12,00	15,00	Peat	--
13	-6,930	16,00	16,00	17,50	Clay	--
14	-7,630	12,00	12,00	15,00	Peat	--
15	-8,030	16,00	16,00	17,50	Clay	--
16	-9,830	18,00	18,00	22,50	Clay	--
17	-10,030	16,00	16,00	17,50	Clay	--
18	-10,130	18,00	18,00	22,50	Clay	--
19	-14,530	16,00	16,00	17,50	Clay	--
20	-14,730	18,00	18,00	22,50	Clay	--
21	-16,130	18,00	19,00	27,50	Sand	0,200
22	-16,330	19,00	20,00	30,00	Sand	0,200
23	-31,230	19,00	20,00	30,00	Sand	0,200
24	-31,430	19,00	20,00	30,00	Sand	0,200

### 2.6.3 Soil Profile S8

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Pile tip level in [m. reference level] :

Top of positive skin friction zone in [m. reference level] :

Bottom of negative skin friction zone in [m. reference level] :

OCR-value foundation layer :

Expected groundlevel settlement in [m] :

Number of layers in profile :

S8

-1,40

-3,00

-18,50

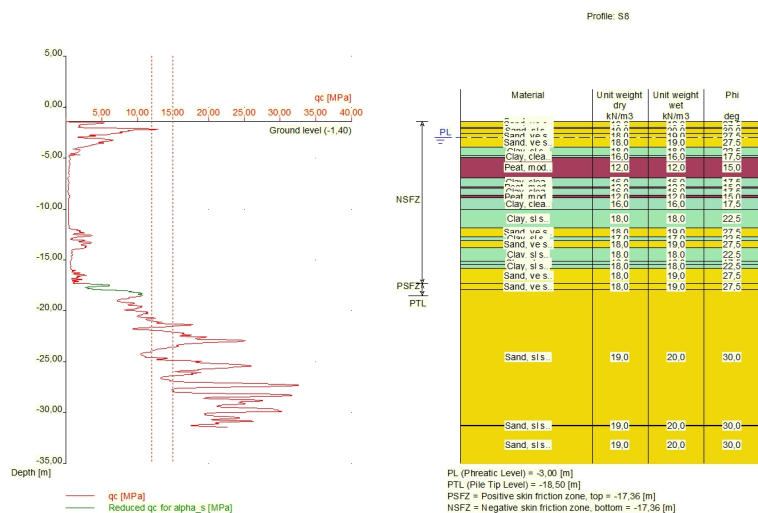
-17,36

-17,36

1,00

0,11

26

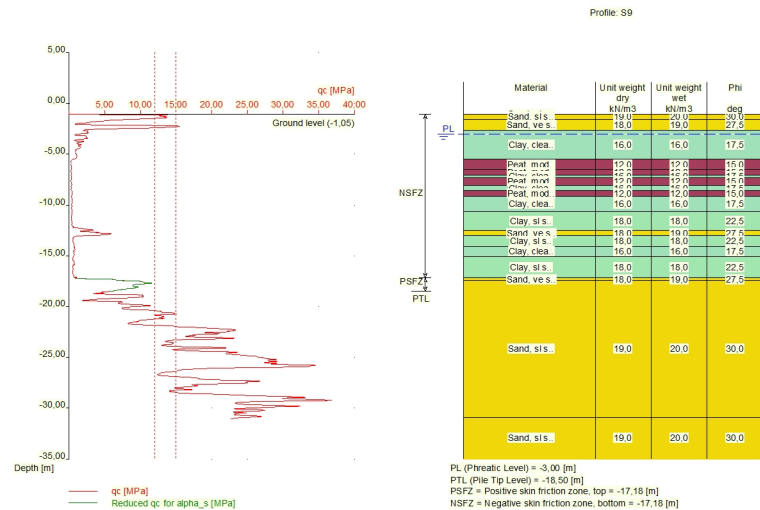


Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,400	18,00	19,00	27,50	Sand	0,200

Number layer	Top layer [m R.L.]	Gamma [kN/m3]	Gamma;sat [kN/m3]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
2	-1,410	18,00	19,00	27,50	Sand	0,200
3	-2,010	18,00	19,00	27,50	Sand	0,200
4	-2,110	19,00	20,00	30,00	Sand	0,200
5	-2,610	18,00	19,00	27,50	Sand	0,200
6	-3,010	18,00	19,00	27,50	Sand	0,200
7	-3,910	18,00	18,00	22,50	Clay	--
8	-4,729	16,00	16,00	17,50	Clay	--
9	-4,929	12,00	12,00	15,00	Peat	--
10	-6,929	16,00	16,00	17,50	Clay	--
11	-7,829	12,00	12,00	15,00	Peat	--
12	-7,929	16,00	16,00	17,50	Clay	--
13	-8,630	12,00	12,00	15,00	Peat	--
14	-8,930	16,00	16,00	17,50	Clay	--
15	-10,030	18,00	18,00	22,50	Clay	--
16	-11,830	18,00	19,00	27,50	Sand	0,200
17	-12,730	17,00	17,00	22,50	Clay	--
18	-13,130	18,00	19,00	27,50	Sand	0,200
19	-13,830	18,00	18,00	22,50	Clay	--
20	-15,130	16,00	16,00	17,50	Clay	--
21	-15,430	18,00	18,00	22,50	Clay	--
22	-15,830	18,00	19,00	27,50	Sand	0,200
23	-17,330	18,00	19,00	27,50	Sand	0,200
24	-17,930	19,00	20,00	30,00	Sand	0,200
25	-31,230	19,00	20,00	30,00	Sand	0,200
26	-31,330	19,00	20,00	30,00	Sand	0,200

#### 2.6.4 Soil Profile S9

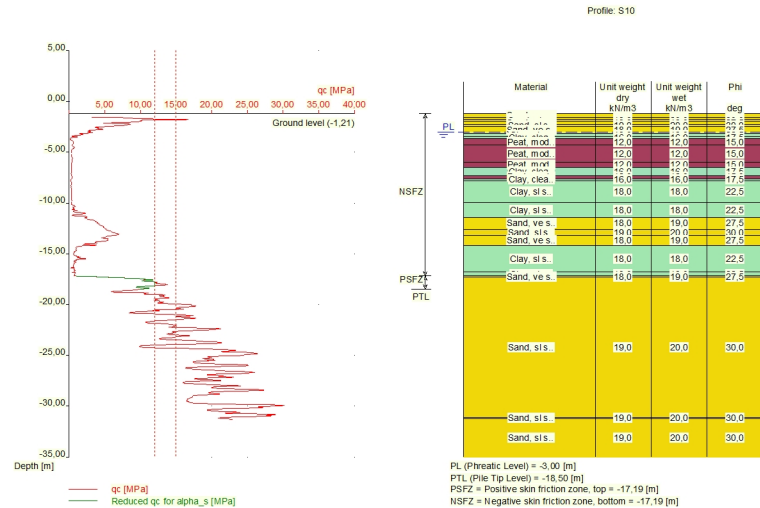
Belonging to CPT	S9
Surface level in [m. reference level] :	-1,05
Phreatic level in [m. reference level] :	-3,00
Pile tip level in [m. reference level] :	-18,50
Top of positive skin friction zone in [m. reference level] :	-17,18
Bottom of negative skin friction zone in [m. reference level] :	-17,18
OCR-value foundation layer :	1,00
Expected groundlevel settlement in [m] :	0,11
Number of layers in profile :	19



Number layer	Top layer [m R.L.]	Gamma [kN/m <sup>3</sup> ]	Gamma,sat [kN/m <sup>3</sup> ]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,050	19,00	20,00	30,00	Sand	0,200
2	-1,060	19,00	20,00	30,00	Sand	0,200
3	-1,580	18,00	19,00	27,50	Sand	0,200
4	-2,620	16,00	16,00	17,50	Clay	--
5	-5,479	12,00	12,00	15,00	Peat	--
6	-6,519	12,00	12,00	15,00	Peat	--
7	-7,039	16,00	16,00	17,50	Clay	--
8	-7,299	12,00	12,00	15,00	Peat	--
9	-8,079	16,00	16,00	17,50	Clay	--
10	-8,599	12,00	12,00	15,00	Peat	--
11	-9,118	16,00	16,00	17,50	Clay	--
12	-10,678	18,00	18,00	22,50	Clay	--
13	-12,497	18,00	19,00	27,50	Sand	0,200
14	-13,017	18,00	18,00	22,50	Clay	--
15	-14,057	16,00	16,00	17,50	Clay	--
16	-15,096	18,00	18,00	22,50	Clay	--
17	-17,175	18,00	19,00	27,50	Sand	0,200
18	-17,435	19,00	20,00	30,00	Sand	0,200
19	-30,900	19,00	20,00	30,00	Sand	0,200

## 2.6.5 Soil Profile S10

Belonging to CPT	S10
Surface level in [m. reference level] :	-1,21
Phreatic level in [m. reference level] :	-3,00
Pile tip level in [m. reference level] :	-18,50
Top of positive skin friction zone in [m. reference level] :	-17,19
Bottom of negative skin friction zone in [m. reference level] :	-17,19
OCR-value foundation layer :	1,00
Expected groundlevel settlement in [m] :	0,11
Number of layers in profile :	25



Number layer	Top layer [m R.L.]	Gamma [kN/m <sup>3</sup> ]	Gamma,sat [kN/m <sup>3</sup> ]	Phi [deg]	Soil Type	Median (Sand/Gravel) [mm]
1	-1,210	18,00	19,00	27,50	Sand	0,200
2	-1,570	18,00	19,00	27,50	Sand	0,200
3	-1,770	19,00	20,00	30,00	Sand	0,200
4	-1,970	18,00	19,00	27,50	Sand	0,200
5	-2,270	19,00	20,00	30,00	Sand	0,200
6	-2,470	18,00	19,00	27,50	Sand	0,200
7	-3,170	18,00	18,00	22,50	Clay	--
8	-3,470	16,00	16,00	17,50	Clay	--
9	-3,670	12,00	12,00	15,00	Peat	--
10	-4,289	12,00	12,00	15,00	Peat	--
11	-5,989	12,00	12,00	15,00	Peat	--
12	-6,489	16,00	16,00	17,50	Clay	--
13	-7,290	12,00	12,00	15,00	Peat	--
14	-7,590	16,00	16,00	17,50	Clay	--
15	-7,790	18,00	18,00	22,50	Clay	--
16	-9,990	18,00	18,00	22,50	Clay	--
17	-11,390	18,00	19,00	27,50	Sand	0,200
18	-12,590	19,00	20,00	30,00	Sand	0,200
19	-13,190	18,00	19,00	27,50	Sand	0,200
20	-14,190	18,00	18,00	22,50	Clay	--
21	-16,790	18,00	18,00	22,50	Clay	--
22	-17,190	18,00	19,00	27,50	Sand	0,200
23	-17,290	19,00	20,00	30,00	Sand	0,200
24	-31,110	19,00	20,00	30,00	Sand	0,200
25	-31,210	19,00	20,00	30,00	Sand	0,200

## 2.7 Pile Types

### 2.7.1 Pile type : Rect 320x320

Pile type :

Prefabricated concrete pile

Materialtype for pile : Concrete  
Slip layer : None  
Pile shape : Rectangular pile  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crossection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Smallest side pile tip [m] : 0,320  
Largest side pile tip [m] : 0,320

**2.7.2 Pile type : Rect 250x250**

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete  
Slip layer : None  
Pile shape : Rectangular pile  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crossection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Smallest side pile tip [m] : 0,250  
Largest side pile tip [m] : 0,250

**2.7.3 Pile type : Rect 290x290**

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete  
Slip layer : None  
Pile shape : Rectangular pile  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crossection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Smallest side pile tip [m] : 0,290  
Largest side pile tip [m] : 0,290

**2.7.4 Pile type : Rect 350x350**

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete  
Slip layer : None  
Pile shape : Rectangular pile  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crossection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :  
Smallest side pile tip [m] : 0,350  
Largest side pile tip [m] : 0,350

**2.7.5 Pile type : Rect 400x400**

Pile type : Prefabricated concrete pile

Materialtype for pile : Concrete  
Slip layer : None  
Pile shape : Rectangular pile  
beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.  
s (factor for influence of the shape of the crossection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Smallest side pile tip [m] :	0,400
Largest side pile tip [m] :	0,400

### 2.7.6 Pile type : LostTip 235

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

1

Materialtype for pile :

Steel

Slip layer :

None

Pile shape :

Round pile with lost tip

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Diameter at tip [m] :	0,235
Diameter shaft [m] :	0,219
Effective height enlarged base [m] :	0,000

### 2.7.7 Pile type : LostTip 290

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

1

Materialtype for pile :

Steel

Slip layer :

None

Pile shape :

Round pile with lost tip

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Diameter at tip [m] :	0,290
Diameter shaft [m] :	0,273
Effective height enlarged base [m] :	0,000



**2.7.8 Pile type : LostTip 340**

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

1

Materialtype for pile :

Steel

Slip layer :

None

Pile shape :

Round pile with lost tip

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Diameter at tip [m] :

0,340

Diameter shaft [m] :

0,324

Effective height enlarged base [m] :

0,000

**2.7.9 Pile type : LostTip 370**

Pile type : User defined (vibrating)

Note: This user defined pile type is considered not to be of a in place formed type.

Hence the characteristic value of the friction angle at the pile shaft ( $\delta$ ) will be taken as  $0.75 \cdot \phi$ .

Pile type for determination of execution factor  $\alpha_s$  in sand/gravel:

Closed-ended steel pipe pile

Pile type for determination of execution factor  $\alpha_s$  in clay/loam/peat:

$\alpha_s$  clay/loam/peat according to table 7.d, art. 7.6.2.3 (i)

NEN 9997-1+C2:2017

Note :  $\alpha_s$  depends on the soiltype and relative depth.

Pile type for determination of pile class factor  $\alpha_p$  :

Closed-ended steel pipe pile

Pile type for use in load/settlement curves :

1

Materialtype for pile :

Steel

Slip layer :

None

Pile shape :

Round pile with lost tip

beta (Shape factor) according to figure 7.i, NEN 9997-1+C2:2017.

s (factor for influence of the shape of the crosssection of the pile base) according to NEN 9997-1+C2:2017.

Pile dimensions :

Diameter at tip [m] :

0,370

Diameter shaft [m] :

0,356

Effective height enlarged base [m] :

0,000

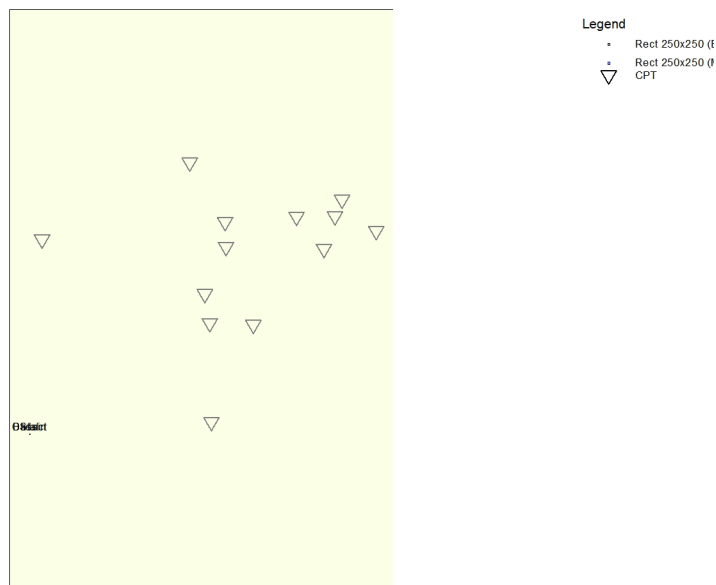
**2.8 Foundation Plan**

Number of piles : 3

Number of collaborating piles\* : 1

\* : 0 = not defined, 1 = non rigid superstructure, >1 = rigid superstructure

### 2.8.1 View of Foundation Plan

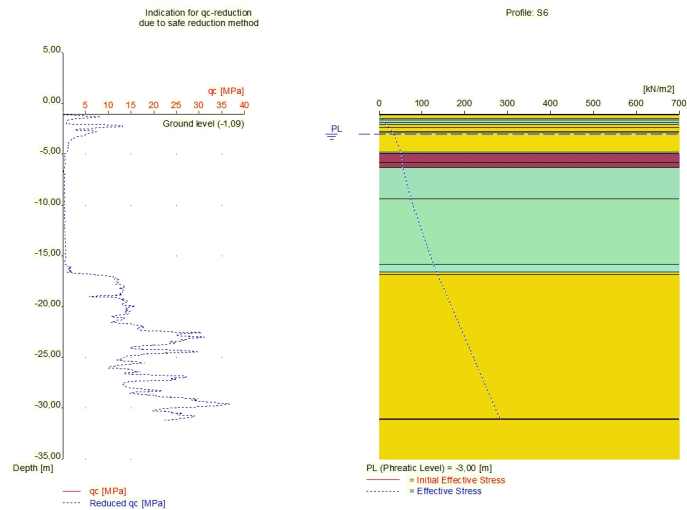


Pile nr/name	X-coordinate [m]	Y-coordinate [m]	Fc;d (EQU/STR/GEO) [kN]	Fc;d (SLS) [kN]	P0 [kN/m2]	Pile head level [m R.L.]
1: Oliduct	90660,37	438048,43	0,00	0,00	0,00	-0,80
2: Bassin	90660,37	438048,43	0,00	0,00	0,00	-0,80
3: Stal	90660,37	438048,43	0,00	0,00	0,00	-0,80

### 2.9 Excavation Data

Excavation level in [m. reference level] :  
Reduction model :

0,00  
Safe (NEN)



## 2.10 Overruled Parameters

User defined Factor xi3 [-] :	1,39
User defined Factor xi4 [-] :	1,39
User defined gamma;b [-] :	1,20
User defined gamma;s [-] :	1,20
User defined gamma;f;nk [-] :	1,00

## 2.11 Model Options

Use pilegroup for negative skin friction (standard)

Do not create intermediate results file

Use reduction for continuous flight auger piles (standard)

Use the influence of excavations (standard).

## 2.12 Model Options

Selected pile types :

- Rect 250x250
- Rect 290x290
- Rect 320x320
- Rect 350x350

Selected profiles :

- S6
- S7
- S8
- S9
- S10

## 3 Bearing Piles (EC7-NL): Results Preliminary Design, Bearing capacity at fixed pile tip level

### 3.1 Errors and Warnings

Warning : The factor  $\xi_3$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\xi_4$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{mb}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{ms}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{f;nk}$  (NEN 9997-1+C2:2017 art. 7.3.2.2) is user defined. Evidence to support this from the NEN deviating value has to be provided.

### 3.2 Remarks

When checking the survey and testing of soil according to NEN 9997-1+C2:2017 art. 3.2.3 section (e), the program uses the provided CPT test level. It does NOT take into account possible different pile tip levels. When different pile tip levels are used in this calculation, the user itself must check for possibly required additional survey and testing of soil.

Note : The calculations performed are based on a single pile for limit state EQU/STR/GEO (= ultimate limit state). Due to the nature of preliminary design, a single pile is always assumed. A possible pileplan is disregarded when using the preliminary design option. Hence a non rigid superstructure is assumed and pile group effects are not considered.

### 3.3 Calculation Parameters

#### 3.3.1 Pile Factors

$\gamma_{mb}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\gamma_{ms}$ (Limit State EQU/STR/GEO, user defined) :	1,20
$\xi_3$ (user defined) :	1,39
$\xi_4$ (user defined) :	1,39

#### 3.3.2 Pile type : Rect 250x250

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
$\beta$ (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
$s$ (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,250
Largest side pile tip [m] :	0,250

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
4:S6	0,0100	--	0,7000
5:S7	0,0100	--	0,7000
6:S8	0,0100	--	0,7000
7:S9	0,0100	--	0,7000
8:S10	0,0100	--	0,7000

### 3.3.3 Pile type : Rect 290x290

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,290
Largest side pile tip [m] :	0,290

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
4:S6	0,0100	--	0,7000
5:S7	0,0100	--	0,7000
6:S8	0,0100	--	0,7000
7:S9	0,0100	--	0,7000
8:S10	0,0100	--	0,7000

### 3.3.4 Pile type : Rect 320x320

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	
Smallest side pile tip [m] :	0,320
Largest side pile tip [m] :	0,320

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
4:S6	0,0100	--	0,7000
5:S7	0,0100	--	0,7000
6:S8	0,0100	--	0,7000
7:S9	0,0100	--	0,7000
8:S10	0,0100	--	0,7000

### 3.3.5 Pile type : Rect 350x350

Pile type :	Prefabricated concrete pile
Materialtype for pile :	Concrete
Slip layer :	None
Pile shape :	Rectangular pile
beta (Shape factor: figure 7.i, NEN 9997-1+C2:2017 art. 7.6.2.3(g) : Pile tip) :	1,00
s (NEN 9997-1+C2:2017 art. 7.6.2.3(h) : factor for the influence of the shape of the crosssection of the pile base) :	1,00
Pile dimensions :	

Smallest side pile tip [m] : 0,350  
Largest side pile tip [m] : 0,350

Number/Name CPT	Alpha_s Sand/ Gravel	Alpha_s Clay/Loam Peat	Alpha_p
4:S6	0,0100	--	0,7000
5:S7	0,0100	--	0,7000
6:S8	0,0100	--	0,7000
7:S9	0,0100	--	0,7000
8:S10	0,0100	--	0,7000

### 3.4 Results for pile type : Rect 250x250

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
4:S6	-18.50	-1,09	292	201	493	295	279	279
5:S7	-18.50	-1,40	485	238	723	433	216	216
6:S8	-18.50	-1,40	236	78	314	188	269	269
7:S9	-18.50	-1,05	134	108	242	145	264	264
8:S10	-18.50	-1,21	225	132	357	214	267	267

### 3.5 Results for pile type : Rect 290x290

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
4:S6	-18.50	-1,09	377	233	610	366	324	324
5:S7	-18.50	-1,40	595	276	871	522	250	250
6:S8	-18.50	-1,40	309	90	399	239	312	312
7:S9	-18.50	-1,05	173	125	299	179	306	306
8:S10	-18.50	-1,21	290	153	443	265	309	309

### 3.6 Results for pile type : Rect 320x320

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
4:S6	-18.50	-1,09	447	257	704	422	357	357
5:S7	-18.50	-1,40	697	304	1001	600	276	276
6:S8	-18.50	-1,40	369	99	468	281	344	344
7:S9	-18.50	-1,05	206	138	344	207	338	338
8:S10	-18.50	-1,21	344	169	512	307	341	341

### 3.7 Results for pile type : Rect 350x350

Number/Name CPT	Level [m R.L.]	Groundlevel [m R.L.]	Rb;cal;max [kN]	Rs;cal;max [kN]	Rc;cal;max [kN]	Rc;d [kN]	F;nsf;k [kN]	Fnsf;d [kN]
4:S6	-18.50	-1,09	522	281	803	482	391	391
5:S7	-18.50	-1,40	797	333	1130	678	302	302
6:S8	-18.50	-1,40	435	109	543	326	376	376
7:S9	-18.50	-1,05	247	151	398	239	370	370
8:S10	-18.50	-1,21	402	184	586	352	373	373

### 3.8 Summary Net Bearing Capacity in kN

Number/Name CPT	Groundlevel [m R.L.]	Level [m R.L.]	Rect 250x250 Rc;net;d [kN]	Rect 290x290 Rc;net;d [kN]	Rect 320x320 Rc;net;d [kN]	Rect 350x350 Rc;net;d [kN]
4:S6	-1,09	-18,50	16,00	42,00	65,00	91,00
5:S7	-1,40	-18,50	217,00	272,00	324,00	376,00
6:S8	-1,40	-18,50	-81,00	-73,00	-63,00	-50,00
7:S9	-1,05	-18,50	-119,00	-127,00	-131,00	-131,00
8:S10	-1,21	-18,50	-53,00	-44,00	-34,00	-21,00

## End of Report

Bijlage 5      Berekeningsvoorbeeld paal*trek*weerstanden olifantenbassin

## Report for D-Foundations 23.1

Design and Verification according to Eurocode 7 of Bearing/Tension Piles and Shallow Foundations  
Developed by Deltares



Company: Geobest B.V.

Date of report: 5-12-2023

Time of report: 12:16:37

Report with version: 23.1.1.40340

Date of calculation: 5-12-2023

Time of calculation: 12:15:44

Calculated with version: 23.1.1.40340

File name: Paalfundering-trek-E3\_AUTO\_E4\_AUTO

Project identification: Olifantenverblijf Diergaarde  
Trekpalen bassin  
D-Foundations Paalfundering-trek-E3\_AUTO\_E4\_AUTO



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## 2 Input Data

### 2.1 General Input Data

Model Tension Piles (EC7-NL)

### 2.2 General Report Data

Geotechnical consultant : RBO  
 Design engineer superstructure :  
 Principal :  
 Title 1 : Olifantenverblijf Diergaarde  
 Title 2 : Trekpalen bassin  
 Title 3 : D-Foundations Paalfundering-trek-E3\_AUTO\_E4\_AUTO  
 Number of project : P54437  
 Location of project : Blijdorplaan 8 Rotterdam

### 2.3 Application Area Model Tension Piles (EC7-NL)

The design and verifications performed by the TENSION PILES (EC7-NL) model of D-FOUNDATIONS concern pile foundations on which axial static or quasi-static loads cause tensile forces in the piles. Pilegroup effects are taken into account. Calculation of pile forces and rise is based on Cone Penetration Tests. Pile capacities are based on the NEN 9997-1+C2:2017, chapter 7 and where pile/safety factors are concerned, on Dutch Standards NEN 9997-1+C2:2017. Horizontal displacements of piles are not taken into account. Vertical displacements of piles (rise) are calculated based on the same NEN-articles that are used for the displacements of bearing piles. Design of Tension piles based on NEN 9997-1+C2:2017 is limited to piles with lengths between 7 and 50 m and a minimum Length over (equivalent) diameter ratio of 13.5.

### 2.4 General CPT Data

Number of CPT's : 2  
 Timing of CPT's : CPT - Excavation - Install

#### 2.4.1 View of CPT's in Foundation Plan



Name CPT	X-coor- dinate [m]	Y-coor- dinate [m]
S10	90799,95	438130,35
S9	90786,19	438143,01

## 2.5 Soil Data

Number of soil profiles (= number of CPT's) : 2

### 2.5.1 Soil Profile S10

Belonging to CPT

Surface level in [m. reference level] :

Phreatic level in [m. reference level] :

Top of tension zone [m. reference level]:

Pile tip level in [m. reference level] :

Number of layers in profile :

S10

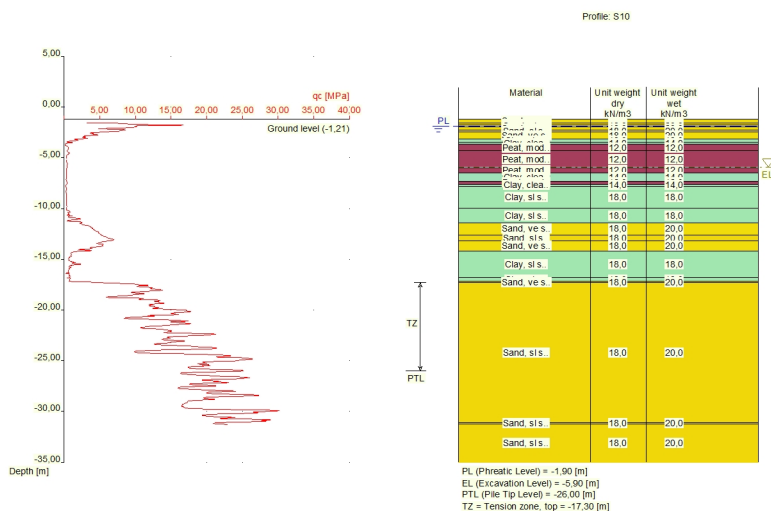
-1,21

-1,90

-17,30

-26,00

25



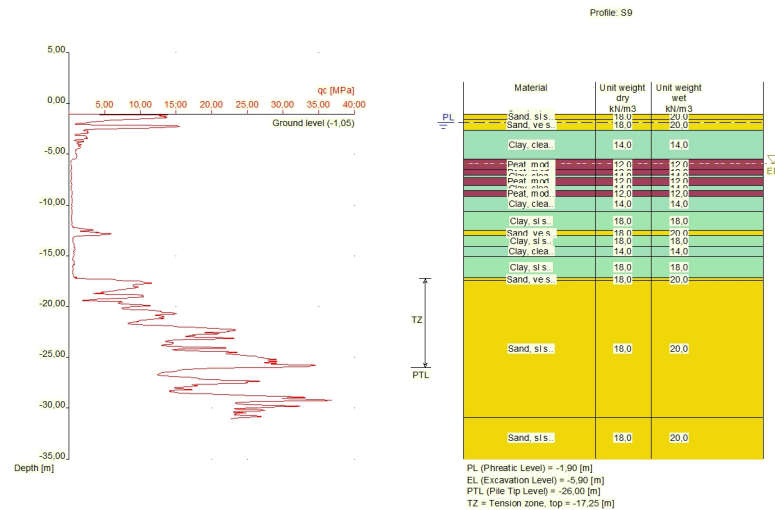
Number layer	Top layer [m R.L.]	Soil Type	Gamma [kN/m3]	Gamma sat [kN/m3]	Min. Void Ratio [%]	Max. Void Ratio [%]	Median [mm]	Max. Cone resistance [kPa]	Use Max. Cone resistance
1	-1,210	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
2	-1,570	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
3	-1,770	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
4	-1,970	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
5	-2,270	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
6	-2,470	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
7	-3,170	Clay	18,00	18,00	0,40	0,80		12/15	Standard
8	-3,470	Clay	14,00	14,00	0,40	0,80		12/15	Standard
9	-3,670	Peat	12,00	12,00	0,40	0,80		12/15	Standard
10	-4,289	Peat	12,00	12,00	0,40	0,80		12/15	Standard
11	-5,989	Peat	12,00	12,00	0,40	0,80		12/15	Standard
12	-6,489	Clay	14,00	14,00	0,40	0,80		12/15	Standard
13	-7,290	Peat	12,00	12,00	0,40	0,80		12/15	Standard
14	-7,590	Clay	14,00	14,00	0,40	0,80		12/15	Standard

Number layer	Top layer [m R.L.]	Soil Type	Gamma [kN/m <sup>3</sup> ]	Gamma sat [kN/m <sup>3</sup> ]	Min. Void Ratio [%]	Max. Void Ratio [%]	Median [mm]	Max. Cone resistance [kPa]	Use Max. Cone resistance
15	-7,790	Clay	18,00	18,00	0,40	0,80		12/15	Standard
16	-9,990	Clay	18,00	18,00	0,40	0,80		12/15	Standard
17	-11,390	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
18	-12,590	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
19	-13,190	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
20	-14,190	Clay	18,00	18,00	0,40	0,80		12/15	Standard
21	-16,790	Clay	18,00	18,00	0,40	0,80		12/15	Standard
22	-17,190	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
23	-17,290	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
24	-31,110	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
25	-31,210	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard

Number layer	Top layer [m R.L.]	Soil Type	Phi [deg]	Addit. PP at top [kN/m <sup>2</sup> ]	Addit. PP at bottom [kN/m <sup>2</sup> ]	OCR value [-]	Use Tension
1	-1,210	Sand	25,00	0,00	0,00	1,000	True
2	-1,570	Sand	25,00	0,00	0,00	1,000	True
3	-1,770	Sand	27,00	0,00	0,00	1,000	True
4	-1,970	Sand	25,00	0,00	0,00	1,000	True
5	-2,270	Sand	27,00	0,00	0,00	1,000	True
6	-2,470	Sand	25,00	0,00	0,00	1,000	True
7	-3,170	Clay	22,50	0,00	0,00	1,000	True
8	-3,470	Clay	17,50	0,00	0,00	1,000	True
9	-3,670	Peat	15,00	0,00	0,00	1,000	False
10	-4,289	Peat	15,00	0,00	0,00	1,000	False
11	-5,989	Peat	15,00	0,00	0,00	1,000	False
12	-6,489	Clay	17,50	0,00	0,00	1,000	True
13	-7,290	Peat	15,00	0,00	0,00	1,000	False
14	-7,590	Clay	17,50	0,00	0,00	1,000	True
15	-7,790	Clay	22,50	0,00	0,00	1,000	True
16	-9,990	Clay	22,50	0,00	0,00	1,000	True
17	-11,390	Sand	25,00	0,00	0,00	1,000	True
18	-12,590	Sand	27,00	0,00	0,00	1,000	True
19	-13,190	Sand	25,00	0,00	0,00	1,000	True
20	-14,190	Clay	22,50	0,00	0,00	1,000	True
21	-16,790	Clay	22,50	0,00	0,00	1,000	True
22	-17,190	Sand	25,00	0,00	0,00	1,000	True
23	-17,290	Sand	27,00	0,00	0,00	1,000	True
24	-31,110	Sand	27,00	0,00	0,00	1,000	True
25	-31,210	Sand	27,00	0,00	0,00	1,000	True

## 2.5.2 Soil Profile S9

Belonging to CPT	S9
Surface level in [m. reference level] :	-1,05
Phreatic level in [m. reference level] :	-1,90
Top of tension zone [m. reference level]:	-17,25
Pile tip level in [m. reference level] :	-26,00
Number of layers in profile :	19



Number layer	Top layer [m R.L.]	Soil Type	Gamma [kN/m3]	Gamma sat [kN/m3]	Min. Void Ratio [%]	Max. Void Ratio [%]	Median [mm]	Max. Cone resistance [kPa]	Use Max. Cone resistance
1	-1,050	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
2	-1,060	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
3	-1,580	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
4	-2,620	Clay	14,00	14,00	0,40	0,80		12/15	Standard
5	-5,479	Peat	12,00	12,00	0,40	0,80		12/15	Standard
6	-6,519	Peat	12,00	12,00	0,40	0,80		12/15	Standard
7	-7,039	Clay	14,00	14,00	0,40	0,80		12/15	Standard
8	-7,299	Peat	12,00	12,00	0,40	0,80		12/15	Standard
9	-8,079	Clay	14,00	14,00	0,40	0,80		12/15	Standard
10	-8,599	Peat	12,00	12,00	0,40	0,80		12/15	Standard
11	-9,118	Clay	14,00	14,00	0,40	0,80		12/15	Standard
12	-10,678	Clay	18,00	18,00	0,40	0,80		12/15	Standard
13	-12,497	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
14	-13,017	Clay	18,00	18,00	0,40	0,80		12/15	Standard
15	-14,057	Clay	14,00	14,00	0,40	0,80		12/15	Standard
16	-15,096	Clay	18,00	18,00	0,40	0,80		12/15	Standard
17	-17,175	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
18	-17,435	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard
19	-30,900	Sand	18,00	20,00	0,40	0,80	0,200	12/15	Standard

Number layer	Top layer [m R.L.]	Soil Type	Phi [deg]	Addit. PP at top [kN/m2]	Addit. PP at bottom [kN/m2]	OCR value [-]	Use Tension
1	-1,050	Sand	27,00	0,00	0,00	1,000	True
2	-1,060	Sand	27,00	0,00	0,00	1,000	True
3	-1,580	Sand	25,00	0,00	0,00	1,000	True
4	-2,620	Clay	17,50	0,00	0,00	1,000	True
5	-5,479	Peat	15,00	0,00	0,00	1,000	False
6	-6,519	Peat	15,00	0,00	0,00	1,000	False
7	-7,039	Clay	17,50	0,00	0,00	1,000	True
8	-7,299	Peat	15,00	0,00	0,00	1,000	False
9	-8,079	Clay	17,50	0,00	0,00	1,000	True
10	-8,599	Peat	15,00	0,00	0,00	1,000	False

Number layer	Top layer [m R.L.]	Soil Type	Phi [deg]	Addit. PP at top [kN/m2]	Addit. PP at bottom [kN/m2]	OCR value [-]	Use Tension
11	-9,118	Clay	17,50	0,00	0,00	1,000	True
12	-10,678	Clay	22,50	0,00	0,00	1,000	True
13	-12,497	Sand	25,00	0,00	0,00	1,000	True
14	-13,017	Clay	22,50	0,00	0,00	1,000	True
15	-14,057	Clay	17,50	0,00	0,00	1,000	True
16	-15,096	Clay	22,50	0,00	0,00	1,000	True
17	-17,175	Sand	25,00	0,00	0,00	1,000	True
18	-17,435	Sand	27,00	0,00	0,00	1,000	True
19	-30,900	Sand	27,00	0,00	0,00	1,000	True

## 2.6 Pile Types

Note : if alpha;t is not user defined, the next rules apply :

- alpha;t according to table 7.c and table 7.d of NEN 9997-1+C2:2017
- for clay: alpha;t depends on the CPT-value and relative depth
- for peat: alpha;t = 0
- for sand/gravel: alpha;t also depends on the median

Number of pile types :

5

### 2.6.1 Pile type : Rect 320x320

Pile type for shaft friction factor (alpha;t) sand/gravel :

Prefabricated concrete pile

Pile type for shaft friction factor (alpha;t) clay :

According to standard

Materialtype for pile :

Concrete

Pile shape :

Rectangular pile

Pile dimensions :

Smallest side pile tip [m] :

0,320

Largest side pile tip [m] :

0,320

### 2.6.2 Pile type : Rect 250x250

Pile type for shaft friction factor (alpha;t) sand/gravel :

Prefabricated concrete pile

Pile type for shaft friction factor (alpha;t) clay :

According to standard

Materialtype for pile :

Concrete

Pile shape :

Rectangular pile

Pile dimensions :

Smallest side pile tip [m] :

0,250

Largest side pile tip [m] :

0,250

### 2.6.3 Pile type : Rect 290x290

Pile type for shaft friction factor (alpha;t) sand/gravel :

Prefabricated concrete pile

Pile type for shaft friction factor (alpha;t) clay :

According to standard

Materialtype for pile :

Concrete

Pile shape :

Rectangular pile

Pile dimensions :

Smallest side pile tip [m] :

0,290

Largest side pile tip [m] :

0,290

### 2.6.4 Pile type : Rect 350x350

Pile type for shaft friction factor (alpha;t) sand/gravel :

Prefabricated concrete pile

Pile type for shaft friction factor (alpha;t) clay : According to standard  
 Materialtype for pile : Concrete  
 Pile shape : Rectangular pile

Pile dimensions :  
 Smallest side pile tip [m] : 0,350  
 Largest side pile tip [m] : 0,350

## 2.6.5 Pile type : Rect 400x400

Pile type for shaft friction factor (alpha;t) sand/gravel : Prefabricated concrete pile

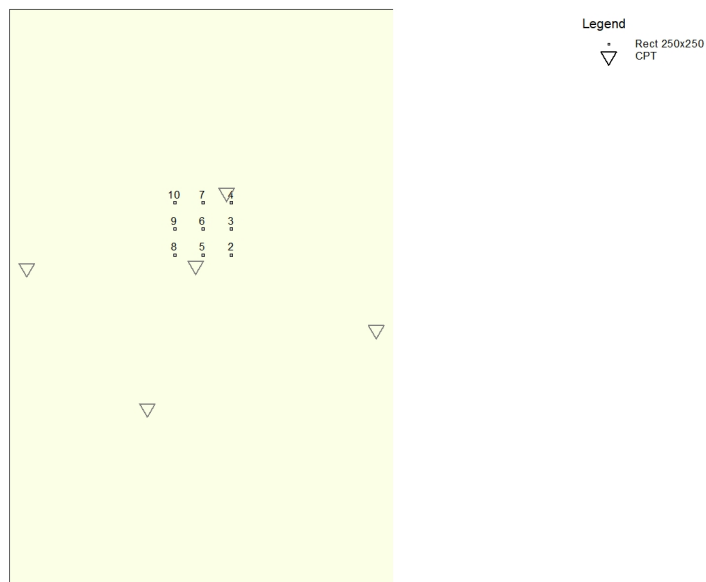
Pile type for shaft friction factor (alpha;t) clay : According to standard  
 Materialtype for pile : Concrete  
 Pile shape : Rectangular pile

Pile dimensions :  
 Smallest side pile tip [m] : 0,400  
 Largest side pile tip [m] : 0,400

## 2.7 Foundation Plan

Number of piles : 9  
 Number of collaborating piles\* : 1  
 \* : 0 = not defined, 1 = non rigid superstructure, >1 = rigid superstructure

### 2.7.1 View of Foundation Plan



Pile nr./code	X-coordinate [m]	Y-coordinate [m]	Maximum load [kN]	Minimum load [kN]	Pile head level [m R.L.]	Use alternat. loads	Factor Gamma;var
1: 2	90786,62	438137,29	277,00	-1000,00	-5,90	False	n.a.
2: 3	90786,62	438139,69	277,00	-1000,00	-5,90	False	n.a.
3: 4	90786,62	438142,09	277,00	-1000,00	-5,90	False	n.a.
4: 5	90784,01	438137,29	277,00	-1000,00	-5,90	False	n.a.



Pile nr./code	X-coordinate [m]	Y-coordinate [m]	Maximum load [kN]	Minimum load [kN]	Pile head level [m R.L.]	Use alternat. loads	Factor Gamma;var
5: 6	90784,01	438139,69	277,00	-1000,00	-5,90	False	n.a.
6: 7	90784,01	438142,09	277,00	-1000,00	-5,90	False	n.a.
7: 8	90781,41	438137,29	277,00	-1000,00	-5,90	False	n.a.
8: 9	90781,41	438139,69	277,00	-1000,00	-5,90	False	n.a.
9: 10	90781,41	438142,09	277,00	-1000,00	-5,90	False	n.a.

Note regarding the loads above: tension forces are positive, compressive forces are negative

Note 2: See OVERRULED PARAMETERS for gamma;var

Pile nr./code	Fc;d (EQU/STR/GEO) [kN]	Fc;d (SLS) [kN]
1: 2	0,00	0,00
2: 3	0,00	0,00
3: 4	0,00	0,00
4: 5	0,00	0,00
5: 6	0,00	0,00
6: 7	0,00	0,00
7: 8	0,00	0,00
8: 9	0,00	0,00
9: 10	0,00	0,00

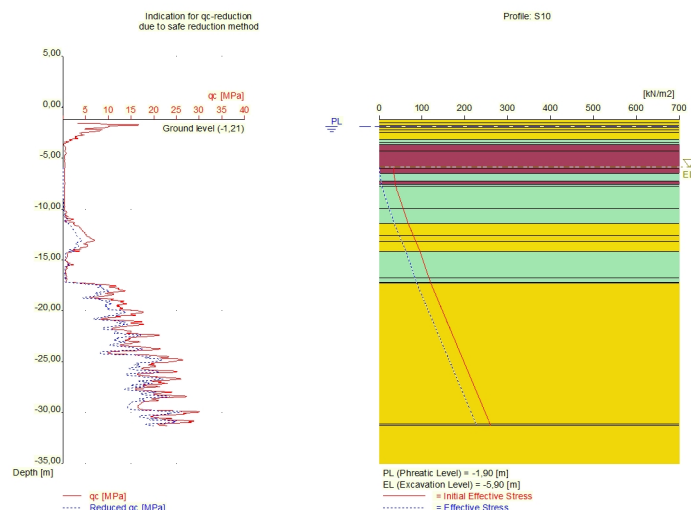
## 2.8 Excavation Data

Excavation level in [m. reference level] :

-5,90

Reduction model :

Safe (NEN)



## 2.9 Optional Parameters

Unit weight water [kN/m<sup>3</sup>] :

10,00

Surcharge [kN/m<sup>2</sup>] :

0,00

## 2.10 Overruled Parameters

User defined gamma;var [-]	1,50
User defined Factor xi3 [-] :	1,28
User defined Factor xi4 [-] :	1,03
User defined gamma;st [-]	1,35

## 2.11 Model Options

Suppress compaction

If compaction is used, according to NEN 9997-1+C2:2017 CPT's should be made after installation to verify this assumption

Use the influence of excavations (standard).

Use excess pore pressure

## 2.12 Model Options

Selected pile types :

- Rect 250x250
- Rect 290x290
- Rect 320x320
- Rect 350x350
- Rect 400x400

Selected profiles :

- S10
- S9

### 3 Tension Piles (EC7-NL): Bearing capacity at fixed pile tip levels

#### 3.1 Errors and Warnings

Warning : The factor  $\xi_3$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\xi_4$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{st}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

Warning : The factor  $\gamma_{var}$  (NEN 9997-1+C2:2017) is user defined. Evidence to support this from the NEN deviating value has to be provided.

#### 3.2 Remarks

When calculating the max. mobilized soil weight, the topangle is used according to NEN 9997-1+C2:2017.

#### 3.3 Calculation Parameters

##### 3.3.1 Pile Factors

$\xi_3$ (user defined) :	1,28
$\xi_4$ (user defined) :	1,03
User defined $\gamma_{var}$ [-]	1,500
User defined $\gamma_{st}$ [-]	1,350
Factor $\gamma_{\gamma}$ according to NEN 9997-1+C2:2017 table A.4a [-]	1,1

##### 3.3.2 Pile type : Rect 250x250

Pile type for shaft friction factor ( $\alpha$ ;t) sand/gravel :	Prefabricated concrete pile
Pile type for shaft friction factor ( $\alpha$ ;t) clay :	According to standard
Materialtype for pile :	Concrete
Pile shape :	Rectangular pile
Pile dimensions :	
Smallest side pile tip [m] :	0,250
Largest side pile tip [m] :	0,250

##### 3.3.3 Pile type : Rect 290x290

Pile type for shaft friction factor ( $\alpha$ ;t) sand/gravel :	Prefabricated concrete pile
Pile type for shaft friction factor ( $\alpha$ ;t) clay :	According to standard
Materialtype for pile :	Concrete
Pile shape :	Rectangular pile
Pile dimensions :	
Smallest side pile tip [m] :	0,290
Largest side pile tip [m] :	0,290

##### 3.3.4 Pile type : Rect 320x320

Pile type for shaft friction factor ( $\alpha$ ;t) sand/gravel :	Prefabricated concrete pile
Pile type for shaft friction factor ( $\alpha$ ;t) clay :	According to standard
Materialtype for pile :	Concrete
Pile shape :	Rectangular pile
Pile dimensions :	

Smallest side pile tip [m] : 0,320  
Largest side pile tip [m] : 0,320

### 3.3.5 Pile type : Rect 350x350

Pile type for shaft friction factor (alpha;t) sand/gravel : Prefabricated concrete pile  
Pile type for shaft friction factor (alpha;t) clay : According to standard  
Materialtype for pile : Concrete  
Pile shape : Rectangular pile  
Pile dimensions :  
Smallest side pile tip [m] : 0,350  
Largest side pile tip [m] : 0,350

### 3.3.6 Pile type : Rect 400x400

Pile type for shaft friction factor (alpha;t) sand/gravel : Prefabricated concrete pile  
Pile type for shaft friction factor (alpha;t) clay : According to standard  
Materialtype for pile : Concrete  
Pile shape : Rectangular pile  
Pile dimensions :  
Smallest side pile tip [m] : 0,400  
Largest side pile tip [m] : 0,400

## 3.4 Results for all CPT's

### 3.4.1 Results for pile type : Rect 250x250

#### 3.4.1.1 Pile group 1

Number of piles belonging to this pile group : 2  
Names of piles belonging to this pile group  
2  
4

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	277,38	243,37	243,37	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

#### 3.4.1.2 Pile group 2

Number of piles belonging to this pile group : 1  
Names of piles belonging to this pile group  
3

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	268,16	237,12	237,12	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.1.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	269,77	238,21	238,21	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.1.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	264,25	234,48	234,48	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.1.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	277,32	243,33	243,33	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.1.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	268,10	237,08	237,08	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

## 3.4.2 Results for pile type : Rect 290x290

### 3.4.2.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	321,07	282,72	282,72	Ksi3

Rt;d min:  $[(Rs;cal)min / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)avg / Ksi3] / \Gamma_{s;t}$

#### 3.4.2.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	308,65	274,28	274,28	Ksi3

Rt;d min:  $[(Rs;cal)min / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)avg / Ksi3] / \Gamma_{s;t}$

#### 3.4.2.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	310,82	275,76	275,76	Ksi3

Rt;d min:  $[(Rs;cal)min / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)avg / Ksi3] / \Gamma_{s;t}$

#### 3.4.2.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	303,39	270,73	270,73	Ksi3

Rt;d min:  $[(Rs;cal)min / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)avg / Ksi3] / \Gamma_{s;t}$

#### 3.4.2.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	320,99	282,66	282,66	Ksi3

Rt;d min:  $[(Rs;cal)min / Ksi4] / \Gamma_{s;t}$

Rt;d avg:  $[(Rs;cal)avg / Ksi3] / \Gamma_{s;t}$

#### 3.4.2.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	308,57	274,23	274,23	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

### 3.4.3 Results for pile type : Rect 320x320

#### 3.4.3.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	353,70	312,29	312,29	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.3.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	338,56	302,00	302,00	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.3.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	341,20	303,81	303,81	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.3.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	332,14	297,66	297,66	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

#### 3.4.3.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8  
10

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	353,59	312,21	312,21	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

#### 3.4.3.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	338,46	301,93	301,93	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.4 Results for pile type : Rect 350x350

#### 3.4.4.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2  
4

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	386,20	341,90	341,90	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

#### 3.4.4.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	368,06	329,57	329,57	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

#### 3.4.4.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5



7

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	371,23	331,74	331,74	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.4.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	360,38	324,38	324,38	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.4.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	386,08	341,82	341,82	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

#### 3.4.4.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	367,95	329,49	329,49	Ksi3

 $Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$ 
 $Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$ 

### 3.4.5 Results for pile type : Rect 400x400

#### 3.4.5.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	440,09	391,36	391,36	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.5.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	416,33	375,19	375,19	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.5.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	420,49	378,03	378,03	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.5.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	406,27	368,38	368,38	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.5.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	439,92	391,24	391,24	Ksi3

Rt;d min:  $[(Rs;cal)_{min} / Ksi4] / \Gamma_{s;t}$   
Rt;d avg:  $[(Rs;cal)_{avg} / Ksi3] / \Gamma_{s;t}$

### 3.4.5.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Level [m R.L.]	Rt;d min [kN]	Rt;d avg [kN]	Rt;d [kN]	Ksi used [-]
-26,00	416,18	375,08	375,08	Ksi3

$$Rt;d \text{ min: } [(Rs;cal)_{min} / Ksi4] / \text{Gamma}_{s;t}$$

$$Rt;d \text{ avg: } [(Rs;cal)_{avg} / Ksi3] / \text{Gamma}_{s;t}$$

### 3.5 INDICATIVE: Results using Ksi3

#### 3.5.1 Results for pile type : Rect 250x250

##### 3.5.1.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	257,77	6410,62	14,85	0,00
4:S9	-26,00	228,97	4437,92	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

##### 3.5.1.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	251,25	2367,69	14,85	0,00
4:S9	-26,00	222,98	1751,66	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

##### 3.5.1.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	252,40	2464,07	14,85	0,00
4:S9	-26,00	224,03	1831,55	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.1.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	248,50	828,85	14,85	0,00
4:S9	-26,00	220,45	697,55	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.1.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	257,73	6407,36	14,85	0,00
4:S9	-26,00	228,93	4435,21	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.1.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	251,21	2366,07	14,85	0,00
4:S9	-26,00	222,94	1750,30	14,85	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.2 Results for pile type : Rect 290x290

## 3.5.2.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	299,32	6444,19	19,98	0,00
4:S9	-26,00	266,11	4462,92	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

## 3.5.2.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	290,53	2374,87	19,98	0,00
4:S9	-26,00	258,03	1757,04	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

## 3.5.2.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	292,07	2471,40	19,98	0,00
4:S9	-26,00	259,45	1837,08	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

## 3.5.2.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	286,83	826,94	19,98	0,00
4:S9	-26,00	254,62	696,10	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.2.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	299,26	6440,92	19,98	0,00
4:S9	-26,00	266,06	4460,20	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.2.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	290,47	2373,25	19,98	0,00
4:S9	-26,00	257,98	1755,68	19,98	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

## 3.5.3 Results for pile type : Rect 320x320

### 3.5.3.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	330,52	6469,17	24,32	0,00
4:S9	-26,00	294,05	4481,49	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.3.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	319,80	2379,98	24,32	0,00
4:S9	-26,00	284,19	1760,84	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.3.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	321,69	2476,61	24,32	0,00
4:S9	-26,00	285,92	1840,99	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.3.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	315,29	825,22	24,32	0,00
4:S9	-26,00	280,04	694,77	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.3.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8  
10

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	330,45	6465,90	24,32	0,00
4:S9	-26,00	293,98	4478,77	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.3.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	319,73	2378,35	24,32	0,00
4:S9	-26,00	284,13	1759,48	24,32	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.4 Results for pile type : Rect 350x350

#### 3.5.4.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	361,76	6493,98	29,10	0,00
4:S9	-26,00	322,05	4499,93	29,10	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

#### 3.5.4.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	348,90	2384,86	29,10	0,00
4:S9	-26,00	310,24	1764,44	29,10	0,00



Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.4.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	351,17	2481,60	29,10	0,00
4:S9	-26,00	312,31	1844,70	29,10	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.4.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

6

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	343,50	823,24	29,10	0,00
4:S9	-26,00	305,26	693,22	29,10	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.4.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

8

10

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	361,67	6490,70	29,10	0,00
4:S9	-26,00	321,97	4497,20	29,10	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.4.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

9

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	348,82	2383,23	29,10	0,00
4:S9	-26,00	310,16	1763,08	29,10	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.5 Results for pile type : Rect 400x400

#### 3.5.5.1 Pile group 1

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

2

4

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	413,87	6534,94	38,01	0,00
4:S9	-26,00	368,85	4530,32	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

#### 3.5.5.2 Pile group 2

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group

3

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	397,01	2392,46	38,01	0,00
4:S9	-26,00	353,36	1770,00	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

#### 3.5.5.3 Pile group 3

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group

5

7

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	399,98	2489,38	38,01	0,00
4:S9	-26,00	356,09	1850,43	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.5.4 Pile group 4

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group  
6

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	389,93	819,36	38,01	0,00
4:S9	-26,00	346,84	690,14	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.5.5 Pile group 5

Number of piles belonging to this pile group : 2

Names of piles belonging to this pile group  
8  
10

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	413,75	6531,66	38,01	0,00
4:S9	-26,00	368,74	4527,59	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

### 3.5.5.6 Pile group 6

Number of piles belonging to this pile group : 1

Names of piles belonging to this pile group  
9

Number/Name CPT	Level [m R.L.]	Rt;d Indicative [kN]	Max. mobilized soil weight [kN]	Pile weight [kN]	Tension from cohesive layers [%]
5:S10	-26,00	396,90	2390,83	38,01	0,00
4:S9	-26,00	353,26	1768,63	38,01	0,00

Number/Name CPT	Alpha t aver. overall	Alpha t aver. sand/gravel	Alpha t aver. clay/peat/loam
5:S10	0,0070	0,0070	0,0000
4:S9	0,0070	0,0070	0,0000

**End of Report**

Bijlage 6      Algemene uitvoeringsrichtlijnen heiwerkzaamheden

Voor de aanvang van het heiwerk moeten de volgende zaken bekend zijn:

- Het palenplan met de paalafmetingen en de paalpuntniveaus. Hierop dienen de sondeerlocaties en de gedachte heivolgorde tevens te zijn aangegeven.
- De maaiveldhoogten ter plaatse van de te heien palen.
- De maaiveldhoogten ter plaatse van de sondeerlocaties.
- Het grondonderzoek en het bijbehorende funderingsadvies.

In principe dient het heiwerk te worden gestart ter plaatse van het diepst geadviseerde paalpuntniveau, en vervolgens dient van het diepste naar het hoogste niveau te worden geheid.

Omdat de funderingsgrondslag tussen sondeerlocaties kan variëren is een controle hierop noodzakelijk. Dit kan door de palen tijdens het inheien te kalenderen<sup>1)</sup> en de daarbij verkregen kalenderwaarden<sup>2)</sup> vervolgens uit te zetten tegen de inheidiepte. Het zo verkregen diagram wordt een slagdiagram<sup>3)</sup> genoemd. Bij een goede keuze van het heiblok zal onder gelijke omstandigheden meestal een duidelijke correlatie te zien zijn tussen het slagdiagram en het sondeerdiagram.

Om de verkregen kalenderwaarden goed te kunnen vergelijken verdient het aanbeveling de eerste paal op of nabij een sondeerlocatie te heien ("ijken"). Bij de eerste paal en alle overige nabij een sondeerlocatie gesitueerde palen, kalendert men bij voorkeur over een zo groot mogelijk traject tussen het maaiveld en het te bereiken paalpuntniveau. Nadat de kalenderwaarden van de eerste paal tot een slagdiagram zijn verwerkt moet aan de hand van dit slagdiagram worden vastgesteld over welk traject de overige palen minimaal moeten worden gekalenderd.

Op de geadviseerde paalpuntniveaus kunnen kalenderwaarden worden gevonden die slechter zijn dan de vereiste of de verwachte normen. Dit is op zich nog geen reden om de palen naar een dieper paalpuntniveau te heien. Door het heien kunnen de waterspanningen in de poriën rondom de paalpunt namelijk tijdelijk oplopen. Door deze wateroverspanning kan de heiweerstand sterk afnemen. Bij geprefabriceerde palen kan dit tijdelijke verschijnsel eenvoudig worden geconstateerd door de betreffende paal na een voldoende lange pauze, veelal de volgende ochtend, na te heien. Ook bij het na heien moet worden gekalenderd; ditmaal echter over bijvoorbeeld 4 à 5 trajecten van elk 50 mm beneden het oorspronkelijk bereikte paalpuntniveau. Uit het na heien zal een verdwenen wateroverspanning moeten blijken uit hogere kalenderwaarden, die dan moeten aansluiten bij het verwachtingspatroon.

Het eventueel optreden van wateroverspanning verdient bij het heien naast belendingen extra aandacht omdat het optreden van wateroverspanning kan leiden tot het tijdelijk afnemen van het draagvermogen van de bestaande paalfundering.

In geval van in de grond gevormde palen kunnen de palen onmiddellijk na elkaar worden vervaardigd, indien de onderlinge hart op hart afstand ten minste 4 maal de paalschoendiameter bedraagt. Een kleinere afstand is toegestaan, als de tijd tussen het maken van de eerste en de tweede paal zodanig lang is dat de specie in de eerst gemaakte paal voldoende is opgestijfd. Hiervoor moet minimaal 20 uur worden aangehouden. Indien een vertragende hulpstof wordt toegepast, moet de tijdsduur zonodig worden verlengd.

In geval van in de grond gevormde palen dient na het bereiken van het geadviseerde paalpuntniveau een controle op de aanwezigheid van water of grond in de buis plaats te vinden. Bij afkeuring dient de buis voor het trekken te worden gevuld met beton, grout of - wanneer daar geen geohydrologische bezwaren tegen bestaan - een mengsel van zand en grind. Het paalpuntniveau van een nieuwe (vervangende) paal dient ten minste zo diep te zijn als het bereikte paalpuntniveau van de afgekeurde paal.

Om nodeloos zwaar heiwerk te vermijden moet sluitend heien worden voorkomen. Bij poeren moet dus bij voorkeur van binnen naar buiten worden geheid.

Bij heien nabij belendingen verdient het (veelal) de voorkeur het heiwerk te starten op de kleinste afstand van de belendingen en vervolgens een heivolgorde te hanteren met een ten opzichte van de belendingen toenemende afstand.

Verder wordt verwezen naar NEN EN 12699, NEN 6741, NEN 6742, BRL 2356 en CUR-Aanbeveling 114.

In twijfelgevallen is het raadzaam de geotechnische adviseur te raadplegen. Deze kan aangeven of het zinvol is om controlesonderingen te laten maken. Deze sonderingen mogen niet worden uitgevoerd wanneer in de nabijheid wordt geheid (wateroverspanning).