Grondslagen en berekeningen

Project

21-017 : Damwanden Zijkanaal _ Amsterdam

Onderdeel

Damwandberekeningen Buiksloterdijk

Opdrachtgever

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1. Grondslagen van het constructief ontwerp (NEN-EN 1990)

1.1. Inleiding

De oeverbescherming langs Zijkanaal 1 te Amsterdam moet vervangen worden. Een aantal locaties moeten met voorrang uitgevoerd worden. Deze berekening betreft de damwandconstructie bij het perceel aan de Buiksloterdijk 5.1.2.e De damwand wordt uitgevoerd als een onverankerde stalen damwand.

1.2. Algemene uitgangspunten

Voor de berekening en de te realiseren constructies gelden de volgende algemene aanamen:
• De keuze van het constructieve systeem en het ontwerp en de berekening van de constructie zijn en worden gemaakt door terzake gekwalificeerd en ervaren personeel;
• de uitvoering wordt gedaan door personeel met de juiste vakbekwaamheid en ervaring;
• degelijk toezicht en kwaliteitscontrole zijn voorzien tijdens het verrichten van het werk, d.w.z. in ontwerp-/ingenieursbureaus, fabrieken, bedrijven en op de bouwplaats;
• de bouwmaterialen en producten zoals gespecificeerd in EN 1990 of in EN 1991 tot en met EN 1999 of in de desbetreffende uitvoeringsnormen, normatieve verwijzingen of productvoorschriften zijn gebruikt;
• de constructie zal degelijk worden onderhouden;
• de constructie zal worden gebruikt in overeenstemming met de ontwerp- en berekeningsaannamen.

1.3. Overige uitgangspunten

De volgende gegevens zijn door of namens de opdrachtgever ter beschikking gesteld en dienen als uitgangspunt voor de berekening/toetsing van de constructies:
• Tekeningen Tijhuis, project TI20350 (dwarsprofielen en situatie TK-01);
• grondgegevens uit het DinoLoket en grondboring HB1 project 904277 van VWB.

1.4. Aard van de constructie, ontwerplevensduur, bouwwijze, uitvoeringsmethode, bouwmaterialen

Bestemming: Grondkerende constructie, CC1/RC1 (geringe gevolgen), Bruggen en andere civieltechnische constructies.
Materialen: houtconstructies: Stalen damwand, standaard staalkwaliteit (S235 of gelijkwaardig)
Ontwerpsituaties: Blijvend, STR/GEO.

De volgens hoofdstuk 2.1(4)P van NEN-EN 1990 in aanmerking te nemen voorvallen die met de opdrachtgever en de overheid zijn overeegekomen zijn:
• Er zijn met/door de opdrachtgever en overheid geen aanvullende voorvallen overeengekomen/opgegeven.

1.5. Normen en overige uitgangspunten

De voorwaarden uit de volgende normenreeksen zijn aangehouden voor de uitgevoerde berekeningen:
- NEN-EN 1990, NEN-EN 1991, NEN-EN 1995 en NEN-EN1997;
- CUR166;
- grondgegevens uit het DinoLoket;
- tekening dwarsprofielen Tijhuis Ingenieurs.

2. Belastingen op constructies (NEN-EN 1991)

2.1. Algemeen

De belastingen bestaan uit de gronddrukken tegen de damwand, waarbij de gronddruk verhoogd wordt door de bovenbelasting achter de damwand. De bestemming van het achterliggende terrein is tuin. Voor de grond- en waterdruk worden de stappen 6.3 tot en met 6.5 conform de CUR166 aangehouden.

2.2. Permanente belasting

Permanente belastingen worden berekend binnen het rekenprogramma voor grondkerende constructies, D-Sheet Piling van Deltares. Het extra gewicht vanuit de verharding is als belasting van 10 kN/m^2 ingevoerd, waarbij het wegcunet in het dwarsprofiel gemodelleerd is.

2.3. Veranderlijke belasting

Het terrein achter de damwand kan belast worden door:
- personen, lichte stalling, gemiddeld gelijkmatige belasting 5,00 kN/m^2.

3. Ontwerp en berekening van geotechnische constructies (NEN-EN 1997)

3.1. Algemeen

De damwandconstructie is berekend met de meest recente versie van D-Sheet Piling van Deltares. Het programma rekent conform NEN-EN 9997+C1. Op basis van de aanwezige sonderingen en grondboringen zijn de grondlagen bepaald. De constructie is uitgerekend voor twee profieltypen, een koudgevormd en een warmgewalst damwandprofiel. In 3.2 zijn de rapporten van de D-Foundationberekeningen weergegeven.

Koudgevormde damwand
Damwandprofiel: ZK-675-7 (wanddikte 7 mm, opneembaar moment 324 kNm/m)
Maximaal optredend moment: 112 kNm/m
Maximale vervorming (stap 6.5): 15 mm
Stabiliteit: 2,29
De UC voor de damwand is 0,35. De wanddikte mag afnemen tot 2,4 mm, oftewel een afroesting van 4,6 mm totaal, 2,3 mm per zijde. De afroesting in zoetwater is 1,4 mm in 100 jaar, de afroesting in de grond is 1,2 mm tot 3,0 mm (schone grond tot verontreinigde geroerde grond). De totale afroesting na 100 jaar is 4,4 mm < 4,6 mm. Het maximale moment treedt op in de ongeroerde grond, zodat na 100 jaar ruimschoots voldoende profiel aanwezig zal zijn.

Warmgewalste damwand
Damwandprofiel: ZZ-12-770 (wanddikte 8,5 mm, opneembaar moment 300 kNm/m)
Maximaal optredend moment: 111 kNm/m
Maximale vervorming (stap 6.5): 17 mm
Stabiliteit: 2,29
De UC voor de damwand is 0,37. De wanddikte mag afnemen tot 3,1 mm, oftewel een afroesting van 5,4 mm totaal, 2,7 mm per zijde. De afroesting in zoetwater is 1,4 mm in 100 jaar, de afroesting in de grond is 1,2 mm tot 3,0 mm (schone grond tot verontreinigde geroerde grond). De totale afroesting na 100 jaar is 4,4 mm < 5,4 mm. Het maximale moment treedt op in de ongeroerde grond, zodat na 100 jaar ruimschoots voldoende profiel aanwezig zal zijn.

3.2. Rapporten berekeningen D-Sheet Piling

3.2.1. Koudgevormd damwandprofiel

Report for D-Sheet Piling 20.2

Design of Diaphragm and Sheet Pile Walls
Developed by Deltares

Date of report:	4/28/2021
Time of report:	6:07:40 PM
Report with version:	20.2.1.30962
Date of calculation:	4/28/2021
Time of calculation:	6:06:41 PM
Calculated with version:	20.2.1.30962
File name:	21-017 damwand Buiksloterdijk 5.1,2,e ZK
Project identification:	Damwand Buiksloterdijk 5.1,2,e Zijkanaal 1 Amsterdam

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

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2 Summary

2.1 Overview per Stage and Test

Stage nr.	Verification type	Displace-ment [mm]	Moment [kNm]	Shear force [kN]	Mob. perc. moment [%]	Mob. perc. resistance [%]	Status
1	EC7(NL)-Step 6.3		**-111.62**	**54.44**	**0.0**	**44.7**	
1	EC7(NL)-Step 6.4		-110.01	51.72	**0.0**	44.6	
1	EC7(NL)-Step 6.5	**14.7**	-46.36	-22.61	**0.0**	25.4	
1	EC7(NL)-Step 6.5 x 1.200		-55.64	-27.14			
Max		**14.7**	**-111.62**	**54.44**	**0.0**	**44.7**	

Stage nr.	Verification type	Vertical balance
1	EC7(NL)-Step 6.3	Upwards
1	EC7(NL)-Step 6.4	Upwards
1	EC7(NL)-Step 6.5	Upwards
1	EC7(NL)-Step 6.5 x 1.200	
Max		Sufficient

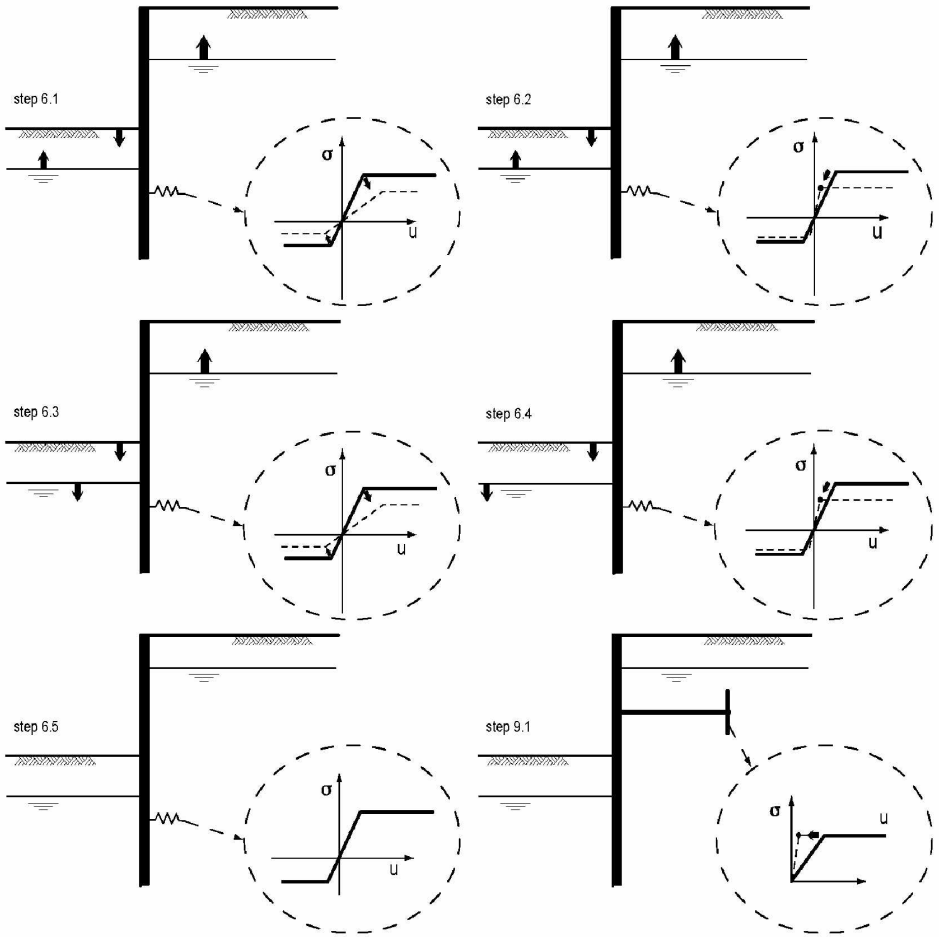
2.2 Overall Stability per Stage

Stage name	Stability factor [-]
Eindsituatie	2.29

2.3 Warnings

Vertical balance:
The resultant vertical friction force is directed upward in stage 1 because the friction force on the passive side exceeds that on the active side. This might be prevented by reducing the friction angle Delta on the passive side.

2.4 CUR Verification Steps



3 Input Data for all Stages

3.1 General Input Data

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

Model	Sheet piling
Check vertical balance	Yes
Number of construction stages	1
Unit weight of water	9.81 kN/m³
Number of curves for spring characteristics	3
Unloading curve on spring characteristic	No
Elastic calculation	Yes

3.2 Sheet Piling Properties

Length	9.00 m
Level top side	0.00 m
Number of sections	1
q_b;max	3.00 MPa
Xi factor	1.39

3.2.1 General Properties

Section name	From [m]	To [m]	Material type	Acting width [m]
ZK 675-7 (S240)	-9.00	0.00	Steel	1.00

3.2.2 Stiffness EI (elastic behaviour)

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor
ZK 675-7 (S240)	5.3966E+04	1.00	5.3966E+04	

3.2.3 Maximum Allowable Moments

Section name	Mr;char;el [kNm/m']	Modification factor [-]	Material factor [-]	Red. factor allow. moment [-]	Mr;d;el [kNm]
ZK 675-7 (S240)	324.00	1.00	1.00	1.00	324.00

3.2.4 Properties for Vertical Balance

Section name	From [m]	To [m]	Height [mm]	Coating area [m²/m² wall]	Section area [cm²/m']
ZK 675-7 (S240)	-9.00	0.00	378.00	1.53	108.00

3.3 Calculation Options

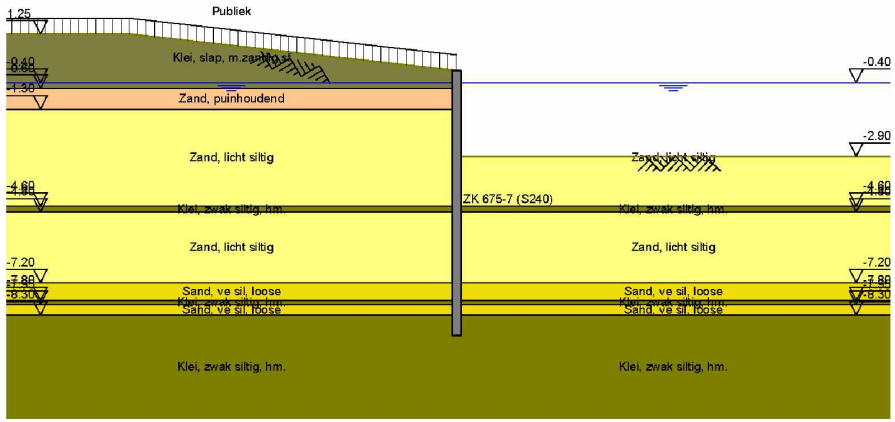
First stage represents initial situation	No
Calculation refinement	Coarse
Reduce delta(s) according to CUR	Yes
Verification	EC7 NA NL - method A: Partial factors (design values) in all stages. Eurocode 7 using the factors as described in the National Annex of the Netherlands. It is basically design approach III.
Used partial factor set	RC 1
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1.000
- Permanent load, favourable	1.000
- Variable load, unfavourable	1.000
- Variable load, favourable	0.000
Factors on loads - Constructive loads	

- Permanent load, unfavourable	1.215
- Permanent load, favourable	0.900
- Variable load, unfavourable	1.350
- Variable load, favourable	0.000
Material factors	
- Cohesion	1.150
- Tangent phi	1.150
- Delta (wall friction angle)*	1.150
- Modulus of low representative subgrade reaction	1.300
Geometry modification	
- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side **	0.20 m
- Raise in phreatic line on passive side **	0.20 m
- Raise in phreatic line on active side	0.05 m
Factors on representative values	
- Partial factor on M, D and Pmax	1.200
Overall stability factors	
- Cohesion	1.300
- Tangent phi	1.200
- Factor on unit weight soil	1.000
Vertical balance factors	
- Partial factor base resistance (gamma_b)	1.200

* For delta (wall friction angle), the input value of tangent phi is used
** This modification of the phreatic level does not apply when the sheet piling is completely submerged.

4 Outline Stage 1: Eindsituatie

Outline - Stage 1: Eindsituatie

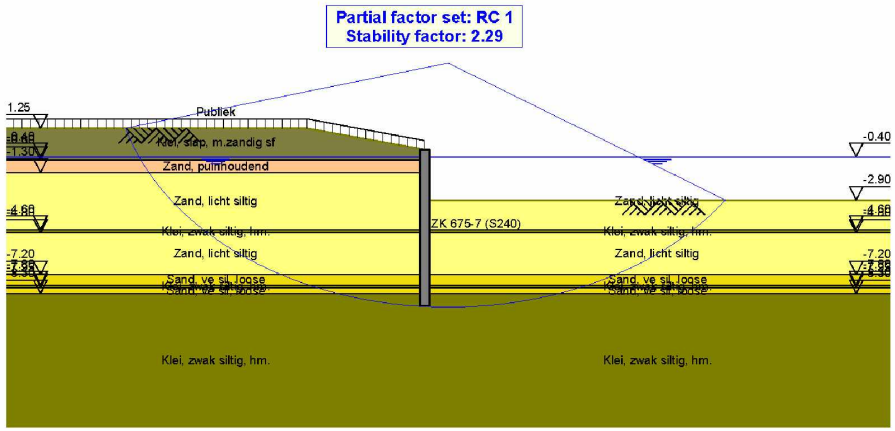


5 Overall Stability Stage 1: Eindsituatie

Stability factor : 2.29

5.1 Overall Stability

Overall Stability - Stage 1: Eindsituatie



6 Step 6.3 Stage 1: Eindsituatie

6.1 General Input Data

Passive side: D-Sheet Piling determined

6.2 Input Data Left

6.2.1 Calculation Method

Calculation method: C, phi, delta

6.2.2 Water Level

Water level: -0.35 [m]

6.2.3 Surface

X [m]	Y [m]
0.00	0.00
5.00	1.25

6.2.4 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle* Not reduced [°]	Delta friction angle* Reduced [°]
Klei, slap, m.za...	1.50	0.87	19.81	13.21	13.21
Zand, puinhoud...	-0.60	0.00	26.66	15.11	15.11
Zand, licht siltig	-1.30	0.00	26.66	17.77	17.77
Klei, zwak siltig,...	-4.60	0.87	19.81	8.80	8.80
Zand, licht siltig	-4.80	0.00	26.66	17.77	17.77
Sand, ve sil, loose	-7.20	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-7.80	0.87	19.81	8.80	8.80
Sand, ve sil, loose	-7.95	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-8.30	0.87	19.81	8.80	8.80

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

6.2.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	2307.69	2307.69	923.08	923.08
Zand, puinhoud...	-0.60	9230.77	9230.77	4615.38	4615.38
Zand, licht siltig	-1.30	12307.69	12307.69	6153.85	6153.85
Klei, zwak siltig,...	-4.60	1538.46	1538.46	615.38	615.38
Zand, licht siltig	-4.80	12307.69	12307.69	6153.85	6153.85
Sand, ve sil, loose	-7.20	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-7.80	1538.46	1538.46	615.38	615.38
Sand, ve sil, loose	-7.95	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-8.30	1538.46	1538.46	615.38	615.38

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	576.92	576.92
Zand, puinhoud...	-0.60	2307.69	2307.69
Zand, licht siltig	-1.30	3076.92	3076.92
Klei, zwak siltig,...	-4.60	384.62	384.62

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Zand, licht siltig	-4.80	3076.92	3076.92
Sand, ve sil, loose	-7.20	2692.31	2692.31
Klei, zwak siltig,...	-7.80	384.62	384.62
Sand, ve sil, loose	-7.95	2692.31	2692.31
Klei, zwak siltig,...	-8.30	384.62	384.62

6.2.6 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

6.3 Calculated Earth Pressure Coefficients Left

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
1	-0.17	2.8	41.7	0.23	0.95	7.77
2	-0.38	4.4	55.1	0.26	0.98	7.33
3	-0.50	4.9	60.2	0.27	1.01	7.39
4	-0.78	5.9	100.2	0.39	0.90	6.69
5	-1.13	7.5	128.1	0.39	0.86	6.73
6	-1.50	9.0	176.1	0.39	0.82	7.56
7	-1.90	10.8	183.7	0.39	0.77	6.60
8	-2.30	12.6	201.0	0.39	0.74	6.22
9	-2.70	14.3	221.3	0.39	0.71	6.02
10	-3.04	15.8	237.8	0.39	0.69	5.87
11	-3.37	17.3	250.5	0.39	0.67	5.69
12	-3.72	18.7	264.0	0.39	0.65	5.52
13	-4.07	19.7	277.3	0.38	0.64	5.37
14	-4.42	20.8	290.9	0.38	0.63	5.26
15	-4.65	26.9	210.2	0.47	0.71	3.65
16	-4.75	27.2	210.3	0.47	0.71	3.60

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
17	-5.00	22.5	308.6	0.37	0.61	5.06
18	-5.40	23.7	324.4	0.36	0.60	4.98
19	-5.80	24.8	340.3	0.36	0.59	4.92
20	-6.20	26.0	356.2	0.35	0.58	4.86
21	-6.60	27.1	373.3	0.35	0.58	4.83
22	-7.00	28.4	391.9	0.35	0.57	4.82
23	-7.35	34.7	317.2	0.41	0.63	3.74
24	-7.65	36.0	323.6	0.41	0.63	3.67
25	-7.88	40.3	280.5	0.45	0.66	3.10
26	-8.13	37.9	331.4	0.41	0.63	3.57
27	-8.47	42.8	285.9	0.45	0.65	2.97
28	-8.82	44.1	286.2	0.45	0.65	2.89

6.4 Calculated Force from a Layer - Left Side

Name	Force
Klei, slap, m.zandig sf	0.00
Zand, puinhoudend	4.67
Zand, licht siltig	50.23
Klei, zwak siltig, hm.	5.41
Zand, licht siltig	60.98
Sand, ve sil, loose	26.38
Klei, zwak siltig, hm.	8.93
Sand, ve sil, loose	22.39
Klei, zwak siltig, hm.	46.48

6.5 Input Data Right

6.5.1 Calculation Method

Calculation method: C, phi, delta

6.5.2 Water Level

Water level: -0.60 [m]

6.5.3 Surface

X [m]	Y [m]
0.00	-3.19

6.5.4 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	0.87	19.81	13.21	13.21
Zand, puinhoud...	-0.60	0.00	26.66	15.11	15.11
Zand, licht siltig	-1.30	0.00	26.66	17.77	17.77
Klei, zwak siltig,...	-4.60	0.87	19.81	8.80	8.80

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Zand, licht siltig	-4.80	0.00	26.66	17.77	17.77
Sand, ve sil, loose	-7.20	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-7.80	0.87	19.81	8.80	8.80
Sand, ve sil, loose	-7.95	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-8.30	0.87	19.81	8.80	8.80

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

6.5.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1 Top [kN/m³]	Branch 1 Bottom [kN/m³]	Branch 2 Top [kN/m³]	Branch 2 Bottom [kN/m³]
Klei, slap, m.za...	1.50	2307.69	2307.69	923.08	923.08
Zand, puinhoud...	-0.60	9230.77	9230.77	4615.38	4615.38
Zand, licht siltig	-1.30	12307.69	12307.69	6153.85	6153.85
Klei, zwak siltig,...	-4.60	1538.46	1538.46	615.38	615.38
Zand, licht siltig	-4.80	12307.69	12307.69	6153.85	6153.85
Sand, ve sil, loose	-7.20	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-7.80	1538.46	1538.46	615.38	615.38
Sand, ve sil, loose	-7.95	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-8.30	1538.46	1538.46	615.38	615.38

Layer name	Level [m]	Branch 3 Top [kN/m³]	Branch 3 Bottom [kN/m³]
Klei, slap, m.za...	1.50	576.92	576.92
Zand, puinhoud...	-0.60	2307.69	2307.69
Zand, licht siltig	-1.30	3076.92	3076.92
Klei, zwak siltig,...	-4.60	384.62	384.62
Zand, licht siltig	-4.80	3076.92	3076.92
Sand, ve sil, loose	-7.20	2692.31	2692.31
Klei, zwak siltig,...	-7.80	384.62	384.62
Sand, ve sil, loose	-7.95	2692.31	2692.31
Klei, zwak siltig,...	-8.30	384.62	384.62

6.6 Calculated Earth Pressure Coefficients Right

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
1	-3.37	0.5	7.1	0.32	0.55	4.41
2	-3.72	1.6	21.4	0.32	0.55	4.41

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
3	-4.07	2.6	35.7	0.32	0.55	4.41
4	-4.42	3.7	50.0	0.32	0.55	4.41
5	-4.65	4.8	38.3	0.36	0.66	2.87
6	-4.75	5.2	39.9	0.37	0.66	2.85
7	-5.00	5.2	71.6	0.32	0.55	4.41
8	-5.40	6.4	87.8	0.32	0.55	4.41
9	-5.80	7.6	104.0	0.32	0.55	4.41
10	-6.20	8.8	120.2	0.32	0.55	4.41
11	-6.60	10.0	136.4	0.32	0.55	4.41
12	-7.00	11.2	152.6	0.32	0.55	4.41
13	-7.35	14.8	122.9	0.39	0.62	3.24
14	-7.65	16.0	132.6	0.39	0.62	3.23
15	-7.88	18.2	115.3	0.42	0.66	2.68
16	-8.13	17.7	146.5	0.39	0.62	3.22
17	-8.47	20.6	128.6	0.42	0.66	2.65
18	-8.82	21.7	134.6	0.43	0.66	2.64

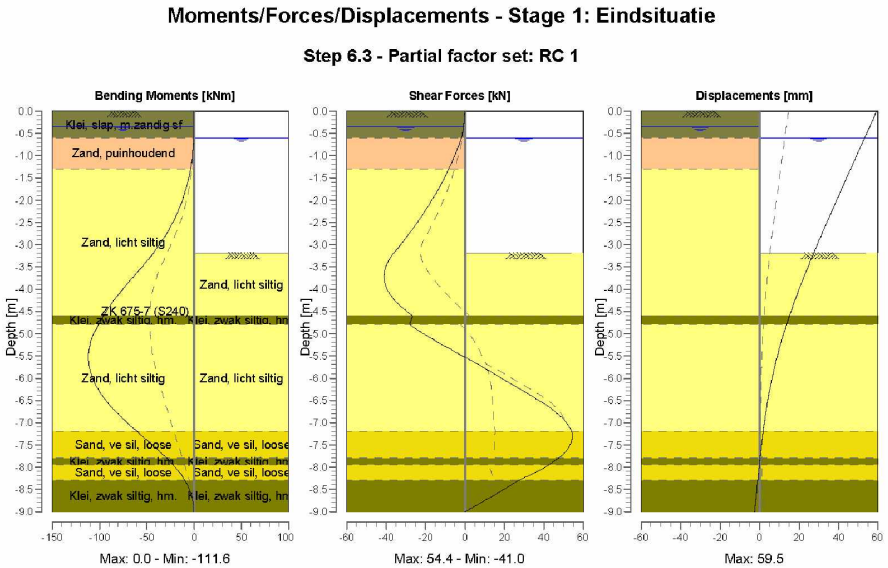
6.7 Calculated Force from a Layer - Right Side

Name	Force
Klei, slap, m.zandig sf	0.00
Zand, puinhoudend	0.00
Zand, licht siltig	40.07
Klei, zwak siltig, hm.	4.38
Zand, licht siltig	148.91
Sand, ve sil, loose	21.19
Klei, zwak siltig, hm.	4.28
Sand, ve sil, loose	7.85
Klei, zwak siltig, hm.	21.14

6.8 Calculation Results

Number of iterations: 6

6.8.1 Charts of Moments, Forces and Displacements



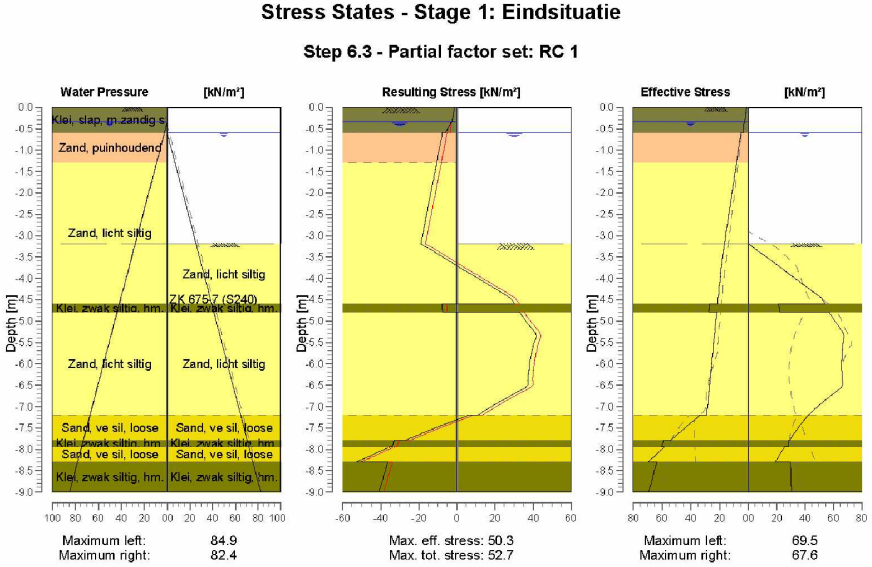
6.8.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	0.00	0.00	0.00	**59.5**
1	-0.35	-0.10	-0.65	55.9
2	-0.35	-0.10	-0.65	55.9
2	-0.40	-0.14	-0.81	55.4
3	-0.40	-0.14	-0.81	55.4
3	-0.60	-0.38	-1.75	53.4
4	-0.60	-0.38	-1.75	53.4
4	-0.95	-1.49	-4.67	49.8
5	-0.95	-1.49	-4.67	49.8
5	-1.30	-3.72	-8.14	46.3
6	-1.30	-3.72	-8.14	46.3
6	-1.70	-7.87	-12.73	42.2
7	-1.70	-7.87	-12.73	42.2
7	-2.10	-14.00	-18.03	38.2
8	-2.10	-14.00	-18.03	38.2
8	-2.50	-22.39	-24.03	34.2
9	-2.50	-22.39	-24.03	34.2
9	-2.90	-33.32	-30.74	30.2
10	-2.90	-33.32	-30.74	30.2
10	-3.19	-43.00	-36.05	27.5
11	-3.19	-43.00	-36.03	27.5
11	-3.54	-56.61	-40.46	24.2
12	-3.54	-56.61	-40.45	24.2
12	-3.90	-70.99	-40.35	21.0
13	-3.90	-70.99	-40.37	21.0
13	-4.25	-84.51	-35.60	18.0
14	-4.25	-84.51	-35.65	18.0
14	-4.60	-95.56	-26.43	15.2
15	-4.60	-95.56	-26.46	15.2
15	-4.70	-98.24	-27.23	14.4
16	-4.70	-98.24	-27.23	14.4

D-Sheet Piling 20.2

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
16	-4.80	-101.00	-27.98	13.7
17	-4.80	-101.00	-27.98	13.7
17	-5.20	-109.39	-13.52	10.9
18	-5.20	-109.39	-13.51	10.9
18	-5.60	**-111.52**	2.80	8.5
19	-5.60	**-111.52**	2.80	8.5
19	-6.00	-107.25	18.39	6.4
20	-6.00	-107.25	18.39	6.4
20	-6.40	-96.87	33.47	4.6
21	-6.40	-96.87	33.50	4.6
21	-6.80	-80.63	46.83	3.1
22	-6.80	-80.63	46.84	3.1
22	-7.20	-60.24	54.11	1.8
23	-7.20	-60.24	**54.12**	1.8
23	-7.50	-43.99	53.33	1.0
24	-7.50	-43.99	53.33	1.0
24	-7.80	-28.75	47.47	0.2
25	-7.80	-28.75	47.47	0.2
25	-7.95	-22.00	42.45	-0.1
26	-7.95	-22.00	42.45	-0.1
26	-8.30	-9.66	27.05	-1.0
27	-8.30	-9.66	27.05	-1.0
27	-8.65	-2.46	13.93	-1.7
28	-8.65	-2.46	13.93	-1.7
28	-9.00	0.00	0.00	-2.5
Max		**-111.52**	**54.12**	**59.5**
Max, minor nodes incl.		-111.62	54.44	59.5

6.8.3 Charts of Stresses



6.8.4 Stresses

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
1	0.00	1.15	0.00	A		0.00	0.00	-	
1	-0.35	2.56	0.00	A		0.00	0.00	-	
2	-0.35	2.85	0.00	A		0.00	0.00	-	

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
2	-0.40	2.95	0.49	A		0.00	0.00	-	
3	-0.40	3.06	0.49	A		0.00	0.00	-	
3	-0.60	3.46	2.45	A		0.00	0.00	-	
4	-0.60	5.10	2.45	A		0.00	0.00	-	
4	-0.95	6.68	5.89	A		0.00	3.43	-	
5	-0.95	6.67	5.89	A		0.00	3.43	-	
5	-1.30	8.24	9.32	A		0.00	6.87	-	
6	-1.30	8.14	9.32	A		0.00	6.87	-	
6	-1.70	9.91	13.24	A		0.00	10.79	-	
7	-1.70	9.92	13.24	A		0.00	10.79	-	
7	-2.10	11.66	17.17	A		0.00	14.71	-	
8	-2.10	11.69	17.17	A		0.00	14.71	-	
8	-2.50	13.42	21.09	A		0.00	18.64	-	
9	-2.50	13.46	21.09	A		0.00	18.64	-	
9	-2.90	15.18	25.02	A		0.00	22.56	-	
10	-2.90	15.22	25.02	A		0.00	22.56	-	
10	-3.19	16.46	27.86	A		0.00	25.41	-	
11	-3.19	16.51	27.86	A		0.00	25.41	P	
11	-3.54	18.01	31.32	A		14.28	28.87	P	
12	-3.54	17.94	31.32	A		14.28	28.87	P	
12	-3.90	19.41	34.78	A		28.56	32.32	P	
13	-3.90	19.01	34.78	A		28.56	32.32	P	
13	-4.25	20.44	38.23	A		42.83	35.78	P	
14	-4.25	20.11	38.23	A		42.83	35.78	P	
14	-4.60	21.51	41.69	A		54.26	39.24	3	95
15	-4.60	26.66	41.69	A		21.28	39.24	2	57
15	-4.70	27.06	42.67	A		21.97	40.22	2	56
16	-4.70	27.02	42.67	A		21.82	40.22	2	56
16	-4.80	27.41	43.65	A		22.51	41.20	2	55
17	-4.80	21.72	43.65	A		57.04	41.20	3	90
17	-5.20	23.25	47.58	A		65.18	45.13	3	82
18	-5.20	22.91	47.58	A		65.16	45.13	3	82
18	-5.60	24.41	51.50	A		66.66	49.05	2	70

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
19	-5.60	24.09	51.50	A		66.65	49.05	2	70
19	-6.00	25.56	55.43	A		66.01	52.97	2	59
20	-6.00	25.26	55.43	A		66.01	52.97	2	59
20	-6.40	26.70	59.35	A		66.43	56.90	2	52
21	-6.40	26.43	59.35	A		66.43	56.90	2	52
21	-6.80	27.85	63.27	A		56.00	60.82	1	39
22	-6.80	27.66	63.27	A		56.00	60.82	1	39
22	-7.20	29.05	67.20	A		42.38	64.75	1	26
23	-7.20	34.07	67.20	A		42.25	64.75	1	36
23	-7.50	44.18	70.14	1		35.19	67.69	1	28
24	-7.50	43.93	70.14	1		35.19	67.69	1	28
24	-7.80	54.16	73.08	1		28.92	70.63	1	21
25	-7.80	58.87	73.08	1		28.48	70.63	1	25
25	-7.95	60.20	74.56	1	21	28.64	72.10	1	
26	-7.95	58.41	74.56	1	18	25.71	72.10	1	
26	-8.30	69.49	77.99	1	21	19.23	75.54	1	
27	-8.30	63.52	77.99	1	23	29.75	75.54	1	
27	-8.65	66.51	81.42	1	23	30.20	78.97	1	
28	-8.65	66.29	81.42	1	23	30.20	78.97	1	
28	-9.00	69.26	84.86	1	24	30.67	82.40	1	

Stat* Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob** Percentage passive mobilized

6.8.5 Percentage Mobilized Resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	226.9	247.8
Water	367.0	346.1
Total	593.9	593.9

Considered as passive side	Right
Maximum passive effective resistance	554.39 kN
Mobilized passive effective resistance	247.83 kN
Percentage mobilized resistance	44.7 %

6.8.6 Vertical Force Balance

Xi factor	1.39
Partial factor base resistance	1.20
Maximum point resistance	3.000 [MPa]

Vertical force balance unplugged	Force [kN]
Vertical force active	-59.48
Vertical force passive	72.82
Resulting vertical force (no dead weight)	13.34
Vertical toe capacity Rb;d	19.42
Resultant goes up	

Vertical force balance plugged	Force [kN]
Vertical force active	-59.48
Vertical force passive	72.82
Resulting vertical force (no dead weight)	13.34
Vertical toe capacity Rb;d	679.86
Resultant goes up	

6.8.7 Vertical Force Balance - Contribution per Layer

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
1.50	Klei, slap, m.za...	0.00	1.50	Klei, slap, m.za...	0.00
-0.60	Zand, puinhoud...	-1.26	-0.60	Zand, puinhoud...	0.00
-1.30	Zand, licht siltig	-16.10	-1.30	Zand, licht siltig	12.84

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
-4.60	Klei, zwak siltig,...	-0.84	-4.60	Klei, zwak siltig,...	0.68
-4.80	Zand, licht siltig	-19.55	-4.80	Zand, licht siltig	47.73
-7.20	Sand, ve sil, loose	-6.93	-7.20	Sand, ve sil, loose	5.57
-7.80	Klei, zwak siltig,...	-1.38	-7.80	Klei, zwak siltig,...	0.66
-7.95	Sand, ve sil, loose	-5.88	-7.95	Sand, ve sil, loose	2.06
-8.30	Klei, zwak siltig,...	-7.20	-8.30	Klei, zwak siltig,...	3.27

6.8.8 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

7 Step 6.5 Stage 1: Eindsituatie

7.1 Input Data Left

7.1.1 Water Level

Water level: -0.40 [m]

7.1.2 Surface

X [m]	Y [m]
0.00	0.00
5.00	1.25

7.1.3 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	1.00	22.50	15.00	15.00
Zand, puinhoud...	-0.60	0.00	30.00	17.00	17.00
Zand, licht siltig	-1.30	0.00	30.00	20.00	20.00
Klei, zwak siltig,...	-4.60	1.00	22.50	10.00	10.00
Zand, licht siltig	-4.80	0.00	30.00	20.00	20.00
Sand, ve sil, loose	-7.20	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-7.80	1.00	22.50	10.00	10.00
Sand, ve sil, loose	-7.95	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-8.30	1.00	22.50	10.00	10.00

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

7.1.4 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	3000.00	3000.00	1200.00	1200.00
Zand, puinhoud...	-0.60	12000.00	12000.00	6000.00	6000.00
Zand, licht siltig	-1.30	16000.00	16000.00	8000.00	8000.00
Klei, zwak siltig,...	-4.60	2000.00	2000.00	800.00	800.00
Zand, licht siltig	-4.80	16000.00	16000.00	8000.00	8000.00
Sand, ve sil, loose	-7.20	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-7.80	2000.00	2000.00	800.00	800.00
Sand, ve sil, loose	-7.95	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-8.30	2000.00	2000.00	800.00	800.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	750.00	750.00
Zand, puinhoud...	-0.60	3000.00	3000.00
Zand, licht siltig	-1.30	4000.00	4000.00
Klei, zwak siltig,...	-4.60	500.00	500.00
Zand, licht siltig	-4.80	4000.00	4000.00
Sand, ve sil, loose	-7.20	3500.00	3500.00
Klei, zwak siltig,...	-7.80	500.00	500.00
Sand, ve sil, loose	-7.95	3500.00	3500.00
Klei, zwak siltig,...	-8.30	500.00	500.00

7.1.5 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

7.2 Input Data Right

7.2.1 Water Level

Water level: -0.40 [m]

7.2.2 Surface

X [m]	Y [m]
0.00	-2.90

7.2.3 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	1.00	22.50	15.00	15.00
Zand, puinhoud...	-0.60	0.00	30.00	17.00	17.00
Zand, licht siltig	-1.30	0.00	30.00	20.00	20.00
Klei, zwak siltig,...	-4.60	1.00	22.50	10.00	10.00
Zand, licht siltig	-4.80	0.00	30.00	20.00	20.00
Sand, ve sil, loose	-7.20	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-7.80	1.00	22.50	10.00	10.00
Sand, ve sil, loose	-7.95	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-8.30	1.00	22.50	10.00	10.00

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

7.2.4 Modulus of Subgrade Reaction (Secant)

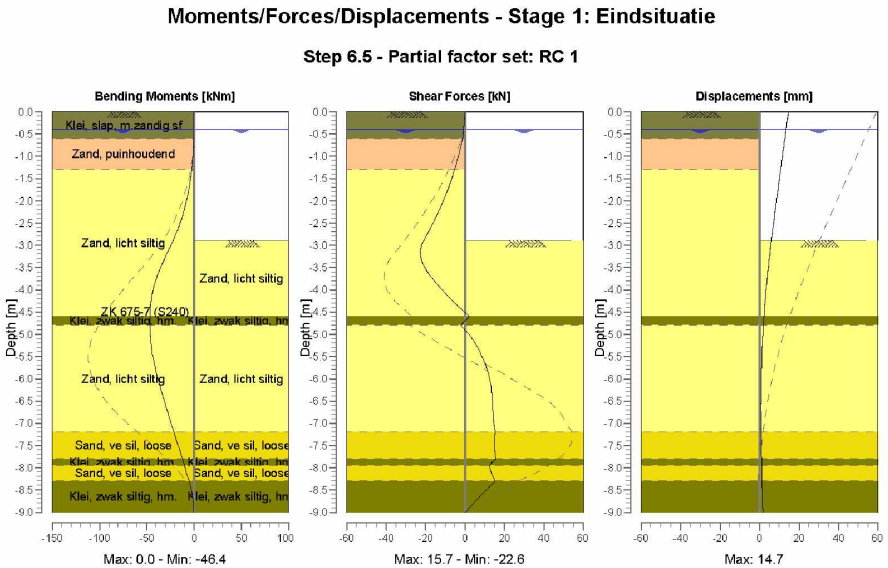
Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	3000.00	3000.00	1200.00	1200.00
Zand, puinhoud...	-0.60	12000.00	12000.00	6000.00	6000.00
Zand, licht siltig	-1.30	16000.00	16000.00	8000.00	8000.00
Klei, zwak siltig,...	-4.60	2000.00	2000.00	800.00	800.00
Zand, licht siltig	-4.80	16000.00	16000.00	8000.00	8000.00
Sand, ve sil, loose	-7.20	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-7.80	2000.00	2000.00	800.00	800.00
Sand, ve sil, loose	-7.95	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-8.30	2000.00	2000.00	800.00	800.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	750.00	750.00
Zand, puinhoud...	-0.60	3000.00	3000.00
Zand, licht siltig	-1.30	4000.00	4000.00
Klei, zwak siltig,...	-4.60	500.00	500.00
Zand, licht siltig	-4.80	4000.00	4000.00
Sand, ve sil, loose	-7.20	3500.00	3500.00
Klei, zwak siltig,...	-7.80	500.00	500.00
Sand, ve sil, loose	-7.95	3500.00	3500.00
Klei, zwak siltig,...	-8.30	500.00	500.00

7.3 Calculation Results

Number of iterations: 5

7.3.1 Charts of Moments, Forces and Displacements

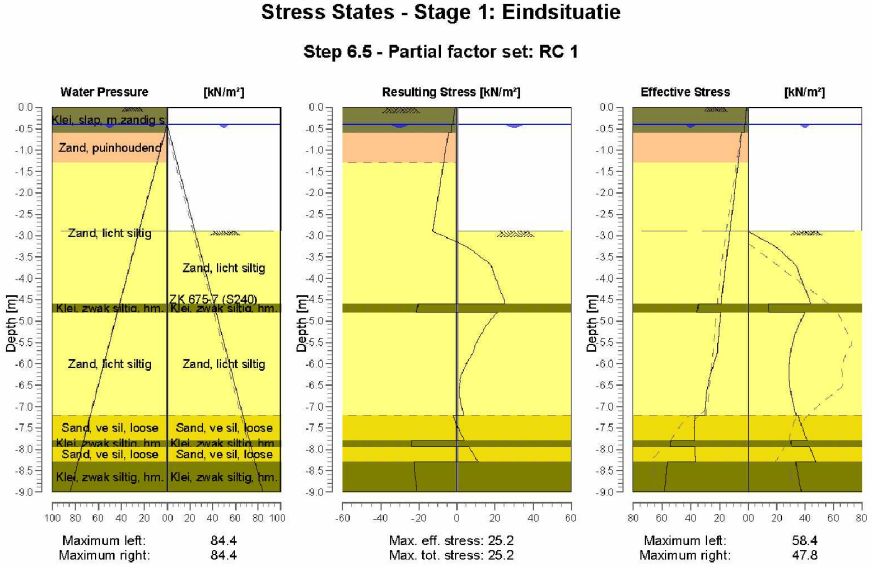


7.3.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	0.00	0.00	0.00	**14.7**
1	-0.40	-0.11	-0.63	13.4
2	-0.40	-0.11	-0.63	13.4
2	-0.60	-0.29	-1.19	12.8
3	-0.60	-0.29	-1.19	12.8
3	-0.95	-1.00	-2.96	11.8
4	-0.95	-1.00	-2.96	11.8
4	-1.30	-2.42	-5.19	10.7
5	-1.30	-2.42	-5.19	10.7
5	-1.70	-5.09	-8.25	9.5
6	-1.70	-5.09	-8.25	9.5
6	-2.10	-9.10	-11.90	8.3
7	-2.10	-9.10	-11.90	8.3
7	-2.50	-14.68	-16.13	7.1
8	-2.50	-14.68	-16.13	7.1
8	-2.90	-22.08	-20.95	6.0
9	-2.90	-22.08	-20.95	6.0
9	-3.33	-31.51	**-21.98**	4.9
10	-3.33	-31.51	**-21.98**	4.9
10	-3.75	-39.83	-16.34	3.9
11	-3.75	-39.83	-16.33	3.9
11	-4.17	-45.01	-7.84	3.0
12	-4.17	-45.01	-7.84	3.0
12	-4.60	**-46.27**	2.19	2.3
13	-4.60	**-46.27**	2.21	2.3
13	-4.70	-46.15	0.16	2.1
14	-4.70	-46.15	0.16	2.1
14	-4.80	-46.24	-1.95	2.0
15	-4.80	-46.24	-1.95	2.0
15	-5.20	-45.54	4.98	1.5
16	-5.20	-45.54	4.98	1.5

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
16	-5.60	-42.56	9.60	1.2
17	-5.60	-42.56	9.60	1.2
17	-6.00	-38.06	12.55	0.9
18	-6.00	-38.06	12.55	0.9
18	-6.40	-32.75	13.76	0.8
19	-6.40	-32.75	13.75	0.8
19	-6.80	-27.13	14.30	0.8
20	-6.80	-27.13	14.29	0.8
20	-7.20	-21.24	15.31	0.9
21	-7.20	-21.24	15.31	0.9
21	-7.50	-16.70	15.05	1.0
22	-7.50	-16.70	15.04	1.0
22	-7.80	-12.11	15.74	1.1
23	-7.80	-12.11	15.74	1.1
23	-7.95	-10.02	12.20	1.2
24	-7.95	-10.02	12.20	1.2
24	-8.30	-5.27	15.24	1.4
25	-8.30	-5.27	15.23	1.4
25	-8.65	-1.30	7.46	1.5
26	-8.65	-1.30	7.46	1.5
26	-9.00	0.00	0.00	1.7
Max		**-46.27**	**-21.98**	**14.7**
Max, minor nodes incl.		-46.36	-22.61	14.7

7.3.3 Charts of Stresses



7.3.4 Stresses

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
1	0.00	0.93	0.00	A		0.00	0.00	-	
1	-0.40	2.23	0.00	A		0.00	0.00	-	
2	-0.40	2.62	0.00	A		0.00	0.00	-	

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
2	-0.60	2.95	1.96	A		0.00	1.96	-	
3	-0.60	4.41	1.96	A		0.00	1.96	-	
3	-0.95	5.72	5.40	A		0.00	5.40	-	
4	-0.95	5.71	5.40	A		0.00	5.40	-	
4	-1.30	7.02	8.83	A		0.00	8.83	-	
5	-1.30	6.92	8.83	A		0.00	8.83	-	
5	-1.70	8.38	12.75	A		0.00	12.75	-	
6	-1.70	8.39	12.75	A		0.00	12.75	-	
6	-2.10	9.84	16.68	A		0.00	16.68	-	
7	-2.10	9.86	16.68	A		0.00	16.68	-	
7	-2.50	11.30	20.60	A		0.00	20.60	-	
8	-2.50	11.33	20.60	A		0.00	20.60	-	
8	-2.90	12.76	24.52	A		0.00	24.52	-	
9	-2.90	12.80	24.52	A		0.00	24.52	P	
9	-3.33	14.30	28.69	A		21.62	28.69	3	96
10	-3.33	14.36	28.69	A		21.62	28.69	3	96
10	-3.75	15.85	32.86	A		34.28	32.86	2	76
11	-3.75	15.92	32.86	A		34.28	32.86	2	76
11	-4.17	17.40	37.03	A		39.12	37.03	2	58
12	-4.17	17.43	37.03	A		39.12	37.03	2	58
12	-4.60	18.89	41.20	A		44.05	41.20	1	49
13	-4.60	34.32	41.20	1		14.17	41.20	1	27
13	-4.70	35.19	42.18	1		14.32	42.18	1	26
14	-4.70	35.03	42.18	1		14.32	42.18	1	26
14	-4.80	35.88	43.16	1		14.48	43.16	1	25
15	-4.80	19.05	43.16	A		40.12	43.16	1	41
15	-5.20	20.38	47.09	A		34.29	47.09	1	29
16	-5.20	20.09	47.09	A		34.29	47.09	1	29
16	-5.60	21.39	51.01	A		30.62	51.01	1	22
17	-5.60	21.11	51.01	A		30.62	51.01	1	22
17	-6.00	24.32	54.94	1		28.97	54.94	1	18
18	-6.00	23.82	54.94	1		28.97	54.94	1	18
18	-6.40	27.70	58.86	1		29.11	58.86	1	16

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
19	-6.40	27.23	58.86	1		29.11	58.86	1	16
19	-6.80	29.52	62.78	1		30.81	62.78	1	15
20	-6.80	29.09	62.78	1		30.81	62.78	1	15
20	-7.20	30.06	66.71	1		33.79	66.71	1	15
21	-7.20	37.09	66.71	1		35.04	66.71	1	23
21	-7.50	37.69	69.65	1		38.15	69.65	1	23
22	-7.50	37.42	69.65	1		38.15	69.65	1	23
22	-7.80	37.61	72.59	1		41.65	72.59	1	23
23	-7.80	53.87	72.59	1		30.14	72.59	1	21
23	-7.95	54.47	74.07	1		30.95	74.07	1	21
24	-7.95	36.95	74.07	1		43.25	74.07	1	24
24	-8.30	36.67	77.50	1		47.80	77.50	1	24
25	-8.30	56.02	77.50	1		33.50	77.50	1	21
25	-8.65	57.32	80.93	1		35.44	80.93	1	22
26	-8.65	57.09	80.93	1		35.44	80.93	1	22
26	-9.00	58.37	84.37	1		37.38	84.37	1	22

Stat* Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob** Percentage passive mobilized

7.3.5 Percentage Mobilized Resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	197.2	197.2
Water	362.8	362.8
Total	560.0	560.0

Considered as passive side	Right
Maximum passive effective resistance	776.75 kN
Mobilized passive effective resistance	197.19 kN
Percentage mobilized resistance	25.4 %

7.3.6 Vertical Force Balance

Xi factor	1.39
Partial factor base resistance	1.20
Maximum point resistance	3.000 [MPa]

Vertical force balance unplugged	Force [kN]
Vertical force active	-58.79
Vertical force passive	63.21
Resulting vertical force (no dead weight)	4.42
Vertical toe capacity Rb;d	19.42
Resultant goes up	

Vertical force balance plugged	Force [kN]
Vertical force active	-58.79
Vertical force passive	63.21
Resulting vertical force (no dead weight)	4.42
Vertical toe capacity Rb;d	679.86
Resultant goes up	

7.3.7 Vertical Force Balance - Contribution per Layer

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
1.50	Klei, slap, m.za...	0.00	1.50	Klei, slap, m.za...	0.00
-0.60	Zand, puinhoud...	-1.22	-0.60	Zand, puinhoud...	0.00
-1.30	Zand, licht siltig	-15.56	-1.30	Zand, licht siltig	18.24

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
-4.60	Klei, zwak siltig,...	-1.24	-4.60	Klei, zwak siltig,...	0.51
-4.80	Zand, licht siltig	-21.37	-4.80	Zand, licht siltig	27.65
-7.20	Sand, ve sil, loose	-6.74	-7.20	Sand, ve sil, loose	6.87
-7.80	Klei, zwak siltig,...	-1.43	-7.80	Klei, zwak siltig,...	0.81
-7.95	Sand, ve sil, loose	-3.86	-7.95	Sand, ve sil, loose	4.77
-8.30	Klei, zwak siltig,...	-7.06	-8.30	Klei, zwak siltig,...	4.37

End of Report

3.2.2. Warmgewalst damwandprofiel

Report for D-Sheet Piling 20.2

Design of Diaphragm and Sheet Pile Walls
Developed by Deltares

Date of report:	4/28/2021
Time of report:	6:05:10 PM
Report with version:	20.2.1.30962
Date of calculation:	4/28/2021
Time of calculation:	6:03:16 PM
Calculated with version:	20.2.1.30962
File name:	21-017 damwand Buiksloterdijk 5.1.2.e
Project identification:	Damwand Buiksloterdijk 5.1.2.e Zijkanaal 1 Amsterdam

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

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2 Summary

2.1 Overview per Stage and Test

Stage nr.	Verification type	Displace-ment [mm]	Moment [kNm]	Shear force [kN]	Mob. perc. moment [%]	Mob. perc. resistance [%]	Status
1	EC7(NL)-Step 6.3		**-111.37**	**54.01**	**0.0**	**44.7**	
1	EC7(NL)-Step 6.4		-109.66	51.31	**0.0**	44.6	
1	EC7(NL)-Step 6.5	**16.6**	-45.81	-22.61	**0.0**	25.4	
1	EC7(NL)-Step 6.5 x 1.200		-54.97	-27.14			
Max		**16.6**	**-111.37**	**54.01**	**0.0**	**44.7**	

Stage nr.	Verification type	Vertical balance
1	EC7(NL)-Step 6.3	Upwards
1	EC7(NL)-Step 6.4	Upwards
1	EC7(NL)-Step 6.5	Upwards
1	EC7(NL)-Step 6.5 x 1.200	
Max		Sufficient

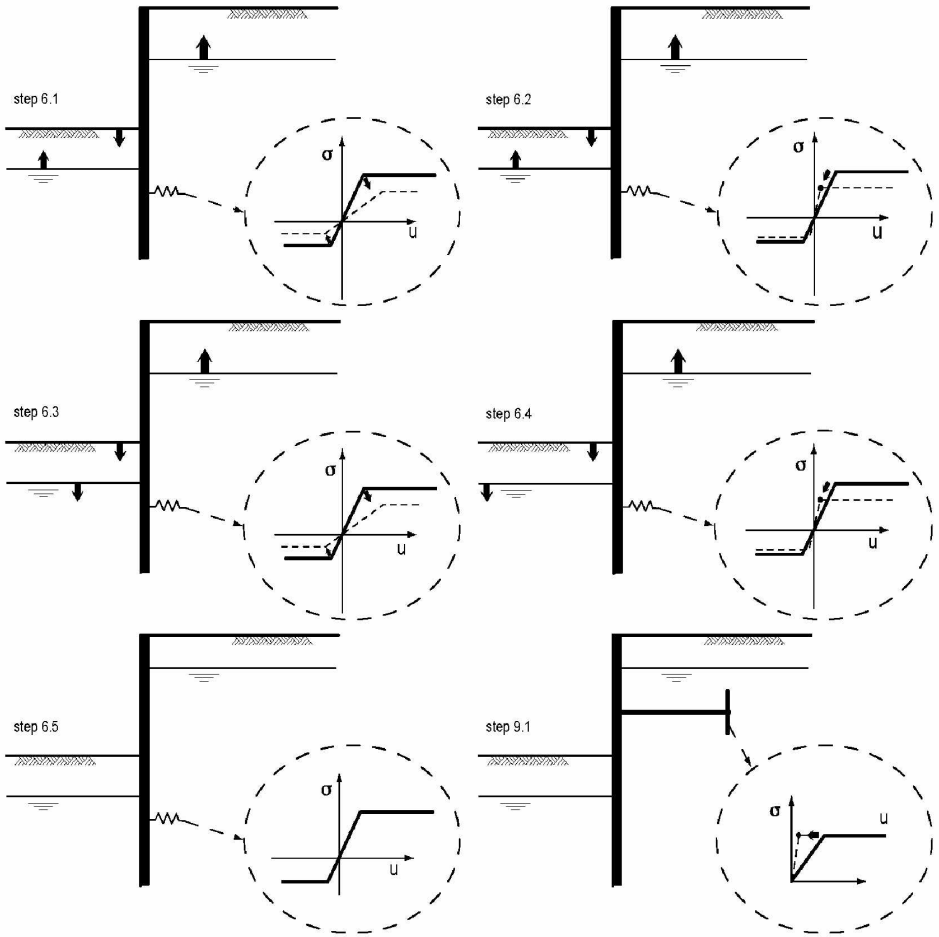
2.2 Overall Stability per Stage

Stage name	Stability factor [-]
Eindsituatie	2.29

2.3 Warnings

Vertical balance:
The resultant vertical friction force is directed upward in stage 1 because the friction force on the passive side exceeds that on the active side. This might be prevented by reducing the friction angle Delta on the passive side.

2.4 CUR Verification Steps



3 Input Data for all Stages

3.1 General Input Data

Verification according to National Annex of Eurocode 7 in the Netherlands (NEN 9997-1:2016)

Model	Sheet piling
Check vertical balance	Yes
Number of construction stages	1
Unit weight of water	9.81 kN/m³
Number of curves for spring characteristics	3
Unloading curve on spring characteristic	No
Elastic calculation	Yes

3.2 Sheet Piling Properties

Length	9.00 m
Level top side	0.00 m
Number of sections	1
q_b;max	3.00 MPa
Xi factor	1.39

3.2.1 General Properties

Section name	From [m]	To [m]	Material type	Acting width [m]
ZZ 12-770 (S240)	-9.00	0.00	Steel	1.00

3.2.2 Stiffness EI (elastic behaviour)

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor
ZZ 12-770 (S240)	4.5142E+04	1.00	4.5142E+04	

3.2.3 Maximum Allowable Moments

Section name	Mr;char;el [kNm/m']	Modification factor [-]	Material factor [-]	Red. factor allow. moment [-]	Mr;d;el [kNm]
ZZ 12-770 (S240)	300.00	1.00	1.00	1.00	300.00

3.2.4 Properties for Vertical Balance

Section name	From [m]	To [m]	Height [mm]	Coating area [m²/m² wall]	Section area [cm²/m']
ZZ 12-770 (S240)	-9.00	0.00	344.00	1.28	120.00

3.3 Calculation Options

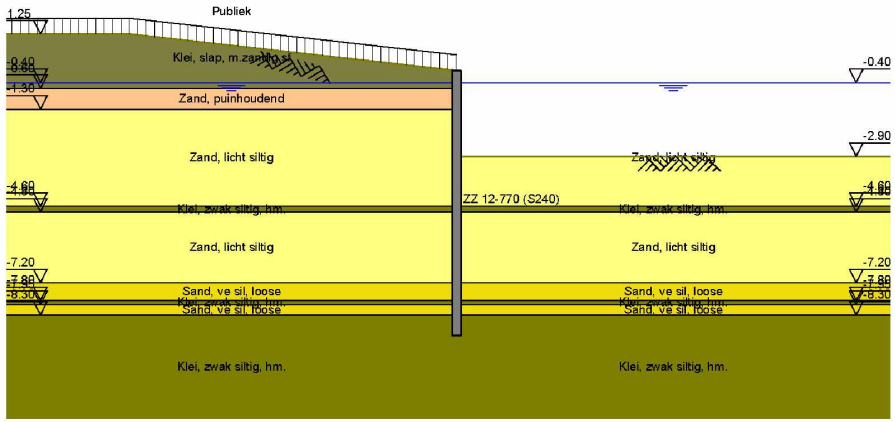
First stage represents initial situation	No
Calculation refinement	Coarse
Reduce delta(s) according to CUR	Yes
Verification	EC7 NA NL - method A: Partial factors (design values) in all stages. Eurocode 7 using the factors as described in the National Annex of the Netherlands. It is basically design approach III.
Used partial factor set	RC 1
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1.000
- Permanent load, favourable	1.000
- Variable load, unfavourable	1.000
- Variable load, favourable	0.000
Factors on loads - Constructive loads	

- Permanent load, unfavourable	1.215
- Permanent load, favourable	0.900
- Variable load, unfavourable	1.350
- Variable load, favourable	0.000
Material factors	
- Cohesion	1.150
- Tangent phi	1.150
- Delta (wall friction angle)*	1.150
- Modulus of low representative subgrade reaction	1.300
Geometry modification	
- Increase retaining height	10.00 %
- Maximum increase retaining height	0.50 m
- Reduction in phreatic line on passive side **	0.20 m
- Raise in phreatic line on passive side **	0.20 m
- Raise in phreatic line on active side	0.05 m
Factors on representative values	
- Partial factor on M, D and Pmax	1.200
Overall stability factors	
- Cohesion	1.300
- Tangent phi	1.200
- Factor on unit weight soil	1.000
Vertical balance factors	
- Partial factor base resistance (gamma_b)	1.200

* For delta (wall friction angle), the input value of tangent phi is used
** This modification of the phreatic level does not apply when the sheet piling is completely submerged.

4 Outline Stage 1: Eindsituatie

Outline - Stage 1: Eindsituatie

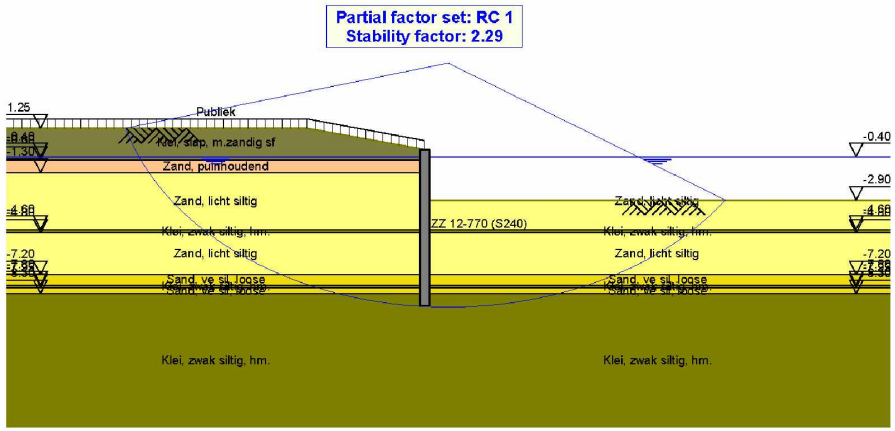


5 Overall Stability Stage 1: Eindsituatie

Stability factor : 2.29

5.1 Overall Stability

Overall Stability - Stage 1: Eindsituatie



6 Step 6.3 Stage 1: Eindsituatie

6.1 General Input Data

Passive side: D-Sheet Piling determined

6.2 Input Data Left

6.2.1 Calculation Method

Calculation method: C, phi, delta

6.2.2 Water Level

Water level: -0.35 [m]

6.2.3 Surface

X [m]	Y [m]
0.00	0.00
5.00	1.25

6.2.4 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle* Not reduced [°]	Delta friction angle* Reduced [°]
Klei, slap, m.za...	1.50	0.87	19.81	13.21	13.21
Zand, puinhoud...	-0.60	0.00	26.66	15.11	15.11
Zand, licht siltig	-1.30	0.00	26.66	17.77	17.77
Klei, zwak siltig,...	-4.60	0.87	19.81	8.80	8.80
Zand, licht siltig	-4.80	0.00	26.66	17.77	17.77
Sand, ve sil, loose	-7.20	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-7.80	0.87	19.81	8.80	8.80
Sand, ve sil, loose	-7.95	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-8.30	0.87	19.81	8.80	8.80

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

6.2.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	2307.69	2307.69	923.08	923.08
Zand, puinhoud...	-0.60	9230.77	9230.77	4615.38	4615.38
Zand, licht siltig	-1.30	12307.69	12307.69	6153.85	6153.85
Klei, zwak siltig,...	-4.60	1538.46	1538.46	615.38	615.38
Zand, licht siltig	-4.80	12307.69	12307.69	6153.85	6153.85
Sand, ve sil, loose	-7.20	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-7.80	1538.46	1538.46	615.38	615.38
Sand, ve sil, loose	-7.95	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-8.30	1538.46	1538.46	615.38	615.38

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	576.92	576.92
Zand, puinhoud...	-0.60	2307.69	2307.69
Zand, licht siltig	-1.30	3076.92	3076.92
Klei, zwak siltig,...	-4.60	384.62	384.62

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Zand, licht siltig	-4.80	3076.92	3076.92
Sand, ve sil, loose	-7.20	2692.31	2692.31
Klei, zwak siltig,...	-7.80	384.62	384.62
Sand, ve sil, loose	-7.95	2692.31	2692.31
Klei, zwak siltig,...	-8.30	384.62	384.62

6.2.6 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

6.3 Calculated Earth Pressure Coefficients Left

Segment number	Level [m]	Horizontal pressure		Fictive earth pressure coefficients		
		Active [kN/m²]	Passive [kN/m²]	Ka [-]	Ko [-]	Kp [-]
1	-0.17	2.8	41.7	0.23	0.95	7.77
2	-0.38	4.4	55.1	0.26	0.98	7.33
3	-0.50	4.9	60.2	0.27	1.01	7.39
4	-0.78	5.9	100.2	0.39	0.90	6.69
5	-1.13	7.5	128.1	0.39	0.86	6.73
6	-1.50	9.0	176.1	0.39	0.82	7.56
7	-1.90	10.8	183.7	0.39	0.77	6.60
8	-2.30	12.6	201.0	0.39	0.74	6.22
9	-2.70	14.3	221.3	0.39	0.71	6.02
10	-3.04	15.8	237.8	0.39	0.69	5.87
11	-3.37	17.3	250.5	0.39	0.67	5.69
12	-3.72	18.7	264.0	0.39	0.65	5.52
13	-4.07	19.7	277.3	0.38	0.64	5.37
14	-4.42	20.8	290.9	0.38	0.63	5.26
15	-4.65	26.9	210.2	0.47	0.71	3.65
16	-4.75	27.2	210.3	0.47	0.71	3.60

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
17	-5.00	22.5	308.6	0.37	0.61	5.06
18	-5.40	23.7	324.4	0.36	0.60	4.98
19	-5.80	24.8	340.3	0.36	0.59	4.92
20	-6.20	26.0	356.2	0.35	0.58	4.86
21	-6.60	27.1	373.3	0.35	0.58	4.83
22	-7.00	28.4	391.9	0.35	0.57	4.82
23	-7.35	34.7	317.2	0.41	0.63	3.74
24	-7.65	36.0	323.6	0.41	0.63	3.67
25	-7.88	40.3	280.5	0.45	0.66	3.10
26	-8.13	37.9	331.4	0.41	0.63	3.57
27	-8.47	42.8	285.9	0.45	0.65	2.97
28	-8.82	44.1	286.2	0.45	0.65	2.89

6.4 Calculated Force from a Layer - Left Side

Name	Force
Klei, slap, m.zandig sf	0.00
Zand, puinhoudend	4.67
Zand, licht siltig	50.23
Klei, zwak siltig, hm.	5.41
Zand, licht siltig	60.98
Sand, ve sil, loose	26.65
Klei, zwak siltig, hm.	8.93
Sand, ve sil, loose	22.16
Klei, zwak siltig, hm.	46.29

6.5 Input Data Right

6.5.1 Calculation Method

Calculation method: C, phi, delta

6.5.2 Water Level

Water level: -0.60 [m]

6.5.3 Surface

X [m]	Y [m]
0.00	-3.19

6.5.4 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	0.87	19.81	13.21	13.21
Zand, puinhoud...	-0.60	0.00	26.66	15.11	15.11
Zand, licht siltig	-1.30	0.00	26.66	17.77	17.77
Klei, zwak siltig,...	-4.60	0.87	19.81	8.80	8.80

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Zand, licht siltig	-4.80	0.00	26.66	17.77	17.77
Sand, ve sil, loose	-7.20	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-7.80	0.87	19.81	8.80	8.80
Sand, ve sil, loose	-7.95	0.00	22.07	14.72	14.72
Klei, zwak siltig,...	-8.30	0.87	19.81	8.80	8.80

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

6.5.5 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1 Top [kN/m³]	Branch 1 Bottom [kN/m³]	Branch 2 Top [kN/m³]	Branch 2 Bottom [kN/m³]
Klei, slap, m.za...	1.50	2307.69	2307.69	923.08	923.08
Zand, puinhoud...	-0.60	9230.77	9230.77	4615.38	4615.38
Zand, licht siltig	-1.30	12307.69	12307.69	6153.85	6153.85
Klei, zwak siltig,...	-4.60	1538.46	1538.46	615.38	615.38
Zand, licht siltig	-4.80	12307.69	12307.69	6153.85	6153.85
Sand, ve sil, loose	-7.20	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-7.80	1538.46	1538.46	615.38	615.38
Sand, ve sil, loose	-7.95	10769.23	10769.23	5384.62	5384.62
Klei, zwak siltig,...	-8.30	1538.46	1538.46	615.38	615.38

Layer name	Level [m]	Branch 3 Top [kN/m³]	Branch 3 Bottom [kN/m³]
Klei, slap, m.za...	1.50	576.92	576.92
Zand, puinhoud...	-0.60	2307.69	2307.69
Zand, licht siltig	-1.30	3076.92	3076.92
Klei, zwak siltig,...	-4.60	384.62	384.62
Zand, licht siltig	-4.80	3076.92	3076.92
Sand, ve sil, loose	-7.20	2692.31	2692.31
Klei, zwak siltig,...	-7.80	384.62	384.62
Sand, ve sil, loose	-7.95	2692.31	2692.31
Klei, zwak siltig,...	-8.30	384.62	384.62

6.6 Calculated Earth Pressure Coefficients Right

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
1	-3.37	0.5	7.1	0.32	0.55	4.41
2	-3.72	1.6	21.4	0.32	0.55	4.41

Segment number	Level [m]	Horizontal pressure Active [kN/m²]	Horizontal pressure Passive [kN/m²]	Fictive earth pressure coefficients Ka [-]	Ko [-]	Kp [-]
3	-4.07	2.6	35.7	0.32	0.55	4.41
4	-4.42	3.7	50.0	0.32	0.55	4.41
5	-4.65	4.8	38.3	0.36	0.66	2.87
6	-4.75	5.2	39.9	0.37	0.66	2.85
7	-5.00	5.2	71.6	0.32	0.55	4.41
8	-5.40	6.4	87.8	0.32	0.55	4.41
9	-5.80	7.6	104.0	0.32	0.55	4.41
10	-6.20	8.8	120.2	0.32	0.55	4.41
11	-6.60	10.0	136.4	0.32	0.55	4.41
12	-7.00	11.2	152.6	0.32	0.55	4.41
13	-7.35	14.8	122.9	0.39	0.62	3.24
14	-7.65	16.0	132.6	0.39	0.62	3.23
15	-7.88	18.2	115.3	0.42	0.66	2.68
16	-8.13	17.7	146.5	0.39	0.62	3.22
17	-8.47	20.6	128.6	0.42	0.66	2.65
18	-8.82	21.7	134.6	0.43	0.66	2.64

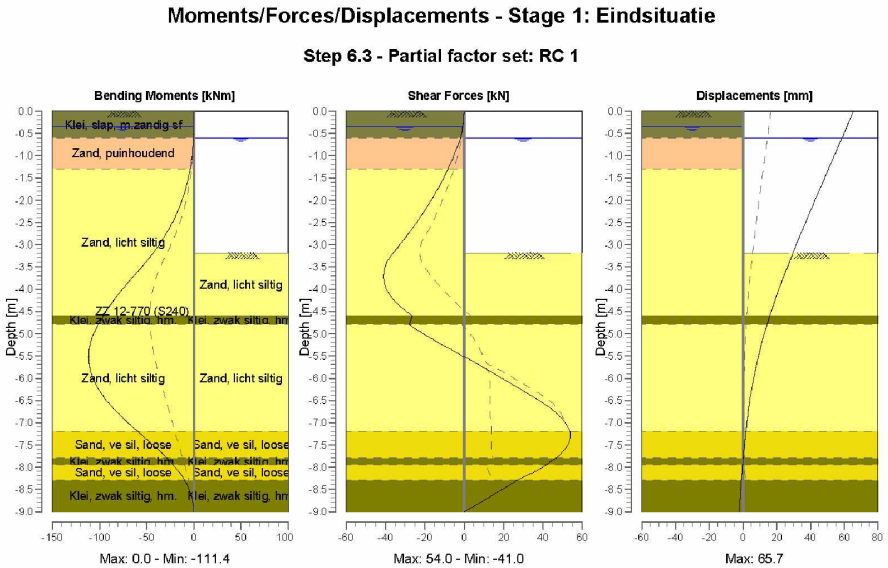
6.7 Calculated Force from a Layer - Right Side

Name	Force
Klei, slap, m.zandig sf	0.00
Zand, puinhoudend	0.00
Zand, licht siltig	40.15
Klei, zwak siltig, hm.	4.42
Zand, licht siltig	148.49
Sand, ve sil, loose	20.90
Klei, zwak siltig, hm.	4.29
Sand, ve sil, loose	8.09
Klei, zwak siltig, hm.	21.33

6.8 Calculation Results

Number of iterations: 7

6.8.1 Charts of Moments, Forces and Displacements

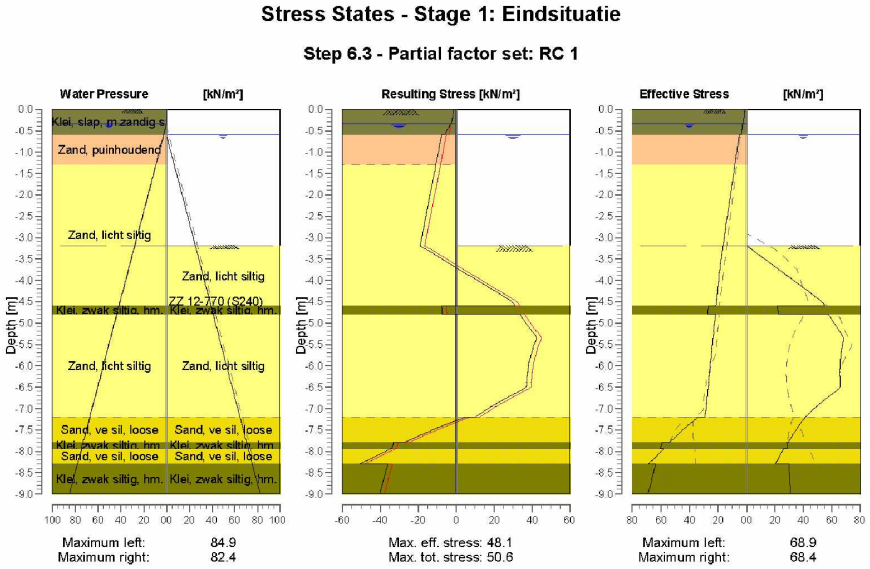


6.8.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	0.00	0.00	0.00	**65.7**
1	-0.35	-0.10	-0.65	61.7
2	-0.35	-0.10	-0.65	61.7
2	-0.40	-0.14	-0.81	61.1
3	-0.40	-0.14	-0.81	61.1
3	-0.60	-0.38	-1.75	58.8
4	-0.60	-0.38	-1.75	58.8
4	-0.95	-1.49	-4.67	54.8
5	-0.95	-1.49	-4.67	54.8
5	-1.30	-3.72	-8.14	50.8
6	-1.30	-3.72	-8.14	50.8
6	-1.70	-7.87	-12.73	46.2
7	-1.70	-7.87	-12.73	46.2
7	-2.10	-14.00	-18.03	41.7
8	-2.10	-14.00	-18.03	41.7
8	-2.50	-22.39	-24.03	37.2
9	-2.50	-22.39	-24.03	37.2
9	-2.90	-33.32	-30.74	32.8
10	-2.90	-33.32	-30.74	32.8
10	-3.19	-43.00	-36.05	29.6
11	-3.19	-43.00	-36.03	29.6
11	-3.54	-56.61	-40.46	25.9
12	-3.54	-56.61	-40.45	25.9
12	-3.90	-70.99	-40.35	22.4
13	-3.90	-70.99	-40.37	22.4
13	-4.25	-84.51	-35.60	19.1
14	-4.25	-84.51	-35.65	19.1
14	-4.60	-95.55	-26.34	15.9
15	-4.60	-95.55	-26.37	15.9
15	-4.70	-98.23	-27.12	15.1
16	-4.70	-98.23	-27.12	15.1

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
16	-4.80	-100.98	-27.85	14.3
17	-4.80	-100.98	-27.85	14.3
17	-5.20	-109.27	-13.20	11.3
18	-5.20	-109.27	-13.19	11.3
18	-5.60	**-111.23**	3.34	8.6
19	-5.60	**-111.23**	3.34	8.6
19	-6.00	-106.73	19.01	6.4
20	-6.00	-106.73	19.01	6.4
20	-6.40	-96.10	34.03	4.5
21	-6.40	-96.11	34.06	4.5
21	-6.80	-79.70	47.02	3.0
22	-6.80	-79.70	47.02	3.0
22	-7.20	-59.34	53.81	1.7
23	-7.20	-59.34	**53.83**	1.7
23	-7.50	-43.24	52.63	0.9
24	-7.50	-43.24	52.63	0.9
24	-7.80	-28.24	46.61	0.2
25	-7.80	-28.24	46.60	0.2
25	-7.95	-21.62	41.60	-0.1
26	-7.95	-21.62	41.60	-0.1
26	-8.30	-9.51	26.68	-0.9
27	-8.30	-9.51	26.67	-0.9
27	-8.65	-2.42	13.70	-1.6
28	-8.65	-2.42	13.70	-1.6
28	-9.00	0.00	0.00	-2.3
Max		**-111.23**	**53.83**	**65.7**
Max, minor nodes incl.		-111.37	54.01	65.7

6.8.3 Charts of Stresses



6.8.4 Stresses

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
1	0.00	1.15	0.00	A		0.00	0.00	-	
1	-0.35	2.56	0.00	A		0.00	0.00	-	
2	-0.35	2.85	0.00	A		0.00	0.00	-	

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
2	-0.40	2.95	0.49	A		0.00	0.00	-	
3	-0.40	3.06	0.49	A		0.00	0.00	-	
3	-0.60	3.46	2.45	A		0.00	0.00	-	
4	-0.60	5.10	2.45	A		0.00	0.00	-	
4	-0.95	6.68	5.89	A		0.00	3.43	-	
5	-0.95	6.67	5.89	A		0.00	3.43	-	
5	-1.30	8.24	9.32	A		0.00	6.87	-	
6	-1.30	8.14	9.32	A		0.00	6.87	-	
6	-1.70	9.91	13.24	A		0.00	10.79	-	
7	-1.70	9.92	13.24	A		0.00	10.79	-	
7	-2.10	11.66	17.17	A		0.00	14.71	-	
8	-2.10	11.69	17.17	A		0.00	14.71	-	
8	-2.50	13.42	21.09	A		0.00	18.64	-	
9	-2.50	13.46	21.09	A		0.00	18.64	-	
9	-2.90	15.18	25.02	A		0.00	22.56	-	
10	-2.90	15.22	25.02	A		0.00	22.56	-	
10	-3.19	16.46	27.86	A		0.00	25.41	-	
11	-3.19	16.51	27.86	A		0.00	25.41	P	
11	-3.54	18.01	31.32	A		14.28	28.87	P	
12	-3.54	17.94	31.32	A		14.28	28.87	P	
12	-3.90	19.41	34.78	A		28.56	32.32	P	
13	-3.90	19.01	34.78	A		28.56	32.32	P	
13	-4.25	20.44	38.23	A		42.83	35.78	P	
14	-4.25	20.11	38.23	A		42.83	35.78	P	
14	-4.60	21.51	41.69	A		55.03	39.24	3	96
15	-4.60	26.66	41.69	A		21.51	39.24	2	58
15	-4.70	27.06	42.67	A		22.17	40.22	2	56
16	-4.70	27.02	42.67	A		22.03	40.22	2	57
16	-4.80	27.41	43.65	A		22.69	41.20	2	55
17	-4.80	21.72	43.65	A		57.65	41.20	3	91
17	-5.20	23.25	47.58	A		65.52	45.13	3	82
18	-5.20	22.91	47.58	A		65.51	45.13	3	82
18	-5.60	24.41	51.50	A		67.11	49.05	2	70

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
19	-5.60	24.09	51.50	A		67.10	49.05	2	70
19	-6.00	25.56	55.43	A		66.00	52.97	2	59
20	-6.00	25.26	55.43	A		66.00	52.97	2	59
20	-6.40	26.70	59.35	A		66.16	56.90	2	52
21	-6.40	26.43	59.35	A		66.16	56.90	2	52
21	-6.80	27.85	63.27	A		54.72	60.82	1	38
22	-6.80	27.66	63.27	A		54.72	60.82	1	38
22	-7.20	29.05	67.20	A		41.34	64.75	1	26
23	-7.20	34.07	67.20	A		41.35	64.75	1	35
23	-7.50	44.70	70.14	1		34.67	67.69	1	27
24	-7.50	44.44	70.14	1		34.67	67.69	1	27
24	-7.80	54.15	73.08	1		28.93	70.63	1	21
25	-7.80	58.87	73.08	1		28.48	70.63	1	25
25	-7.95	60.16	74.56	1	21	28.68	72.10	1	
26	-7.95	58.10	74.56	1	18	26.02	72.10	1	
26	-8.30	68.42	77.99	1	20	20.30	75.54	1	
27	-8.30	63.36	77.99	1	22	29.90	75.54	1	
27	-8.65	66.24	81.42	1	23	30.47	78.97	1	
28	-8.65	66.02	81.42	1	23	30.47	78.97	1	
28	-9.00	68.87	84.86	1	24	31.05	82.40	1	

Stat* Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob** Percentage passive mobilized

6.8.5 Percentage Mobilized Resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	226.8	247.7
Water	367.0	346.1
Total	593.8	593.8

Considered as passive side	Right
Maximum passive effective resistance	554.39 kN
Mobilized passive effective resistance	247.67 kN
Percentage mobilized resistance	44.7 %

6.8.6 Vertical Force Balance

Xi factor	1.39
Partial factor base resistance	1.20
Maximum point resistance	3.000 [MPa]

Vertical force balance unplugged	Force [kN]
Vertical force active	-59.45
Vertical force passive	72.73
Resulting vertical force (no dead weight)	13.28
Vertical toe capacity Rb;d	21.58
Resultant goes up	

Vertical force balance plugged	Force [kN]
Vertical force active	-59.45
Vertical force passive	72.73
Resulting vertical force (no dead weight)	13.28
Vertical toe capacity Rb;d	618.71
Resultant goes up	

6.8.7 Vertical Force Balance - Contribution per Layer

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
1.50	Klei, slap, m.za...	0.00	1.50	Klei, slap, m.za...	0.00
-0.60	Zand, puinhoud...	-1.26	-0.60	Zand, puinhoud...	0.00
-1.30	Zand, licht siltig	-16.10	-1.30	Zand, licht siltig	12.87

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
-4.60	Klei, zwak siltig,...	-0.84	-4.60	Klei, zwak siltig,...	0.68
-4.80	Zand, licht siltig	-19.55	-4.80	Zand, licht siltig	47.59
-7.20	Sand, ve sil, loose	-7.00	-7.20	Sand, ve sil, loose	5.49
-7.80	Klei, zwak siltig,...	-1.38	-7.80	Klei, zwak siltig,...	0.66
-7.95	Sand, ve sil, loose	-5.82	-7.95	Sand, ve sil, loose	2.13
-8.30	Klei, zwak siltig,...	-7.17	-8.30	Klei, zwak siltig,...	3.30

6.8.8 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

7 Step 6.5 Stage 1: Eindsituatie

7.1 Input Data Left

7.1.1 Water Level

Water level: -0.40 [m]

7.1.2 Surface

X [m]	Y [m]
0.00	0.00
5.00	1.25

7.1.3 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight Unsat [kN/m³]	Unit weight Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	1.00	22.50	15.00	15.00
Zand, puinhoud...	-0.60	0.00	30.00	17.00	17.00
Zand, licht siltig	-1.30	0.00	30.00	20.00	20.00
Klei, zwak siltig,...	-4.60	1.00	22.50	10.00	10.00
Zand, licht siltig	-4.80	0.00	30.00	20.00	20.00
Sand, ve sil, loose	-7.20	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-7.80	1.00	22.50	10.00	10.00
Sand, ve sil, loose	-7.95	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-8.30	1.00	22.50	10.00	10.00

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

7.1.4 Modulus of Subgrade Reaction (Secant)

Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	3000.00	3000.00	1200.00	1200.00
Zand, puinhoud...	-0.60	12000.00	12000.00	6000.00	6000.00
Zand, licht siltig	-1.30	16000.00	16000.00	8000.00	8000.00
Klei, zwak siltig,...	-4.60	2000.00	2000.00	800.00	800.00
Zand, licht siltig	-4.80	16000.00	16000.00	8000.00	8000.00
Sand, ve sil, loose	-7.20	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-7.80	2000.00	2000.00	800.00	800.00
Sand, ve sil, loose	-7.95	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-8.30	2000.00	2000.00	800.00	800.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	750.00	750.00
Zand, puinhoud...	-0.60	3000.00	3000.00
Zand, licht siltig	-1.30	4000.00	4000.00
Klei, zwak siltig,...	-4.60	500.00	500.00
Zand, licht siltig	-4.80	4000.00	4000.00
Sand, ve sil, loose	-7.20	3500.00	3500.00
Klei, zwak siltig,...	-7.80	500.00	500.00
Sand, ve sil, loose	-7.95	3500.00	3500.00
Klei, zwak siltig,...	-8.30	500.00	500.00

7.1.5 Uniform Loads

Name	Characteristic load [kN/m²]	Favourable / Unfavourable	Permanent / Variable
Publiek	5.00	Unfavourable	Variable

7.2 Input Data Right

7.2.1 Water Level

Water level: -0.40 [m]

7.2.2 Surface

X [m]	Y [m]
0.00	-2.90

7.2.3 Soil Material Properties in Profile: Basisprofiel met klei

Layer name	Level [m]	Unit weight	
		Unsat [kN/m³]	Sat. [kN/m³]
Klei, slap, m.za...	1.50	15.00	15.00
Zand, puinhoud...	-0.60	18.00	19.00
Zand, licht siltig	-1.30	18.00	19.00
Klei, zwak siltig,...	-4.60	17.00	17.00
Zand, licht siltig	-4.80	18.00	19.00
Sand, ve sil, loose	-7.20	18.00	20.00
Klei, zwak siltig,...	-7.80	17.00	17.00
Sand, ve sil, loose	-7.95	18.00	20.00
Klei, zwak siltig,...	-8.30	17.00	17.00

Layer name	Level [m]	Cohesion [kN/m²]	Friction angle phi [°]	Delta friction angle*	
				Not reduced [°]	Reduced [°]
Klei, slap, m.za...	1.50	1.00	22.50	15.00	15.00
Zand, puinhoud...	-0.60	0.00	30.00	17.00	17.00
Zand, licht siltig	-1.30	0.00	30.00	20.00	20.00
Klei, zwak siltig,...	-4.60	1.00	22.50	10.00	10.00
Zand, licht siltig	-4.80	0.00	30.00	20.00	20.00
Sand, ve sil, loose	-7.20	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-7.80	1.00	22.50	10.00	10.00
Sand, ve sil, loose	-7.95	0.00	25.00	16.67	16.67
Klei, zwak siltig,...	-8.30	1.00	22.50	10.00	10.00

* The 'not reduced' Delta angle is used for the calculation of the active earth pressure coefficient of Culmann whereas the 'reduced' Delta angle is used for the passive earth pressure coefficient.

Layer name	Level [m]	Shell factor [-]	OCR [-]	Grain type
Klei, slap, m.za...	1.50	1.50	1.00	Fine
Zand, puinhoud...	-0.60	1.00	1.00	Fine
Zand, licht siltig	-1.30	1.00	1.00	Fine
Klei, zwak siltig,...	-4.60	1.00	1.00	Fine
Zand, licht siltig	-4.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.20	1.00	1.00	Fine
Klei, zwak siltig,...	-7.80	1.00	1.00	Fine
Sand, ve sil, loose	-7.95	1.00	1.00	Fine
Klei, zwak siltig,...	-8.30	1.00	1.00	Fine

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Klei, slap, m.za...	1.50	n.a.	n.a.	n.a.	0.00	0.00
Zand, puinhoud...	-0.60	n.a.	n.a.	n.a.	0.00	0.00
Zand, licht siltig	-1.30	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-4.60	n.a.	n.a.	n.a.	0.00	0.00

Layer name	Level [m]	Earth pressure coefficients			Additional pore pressure	
		Active [-]	Neutral [-]	Passive [-]	Top [kN/m²]	Bottom [kN/m²]
Zand, licht siltig	-4.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.20	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-7.80	n.a.	n.a.	n.a.	0.00	0.00
Sand, ve sil, loose	-7.95	n.a.	n.a.	n.a.	0.00	0.00
Klei, zwak siltig,...	-8.30	n.a.	n.a.	n.a.	0.00	0.00

7.2.4 Modulus of Subgrade Reaction (Secant)

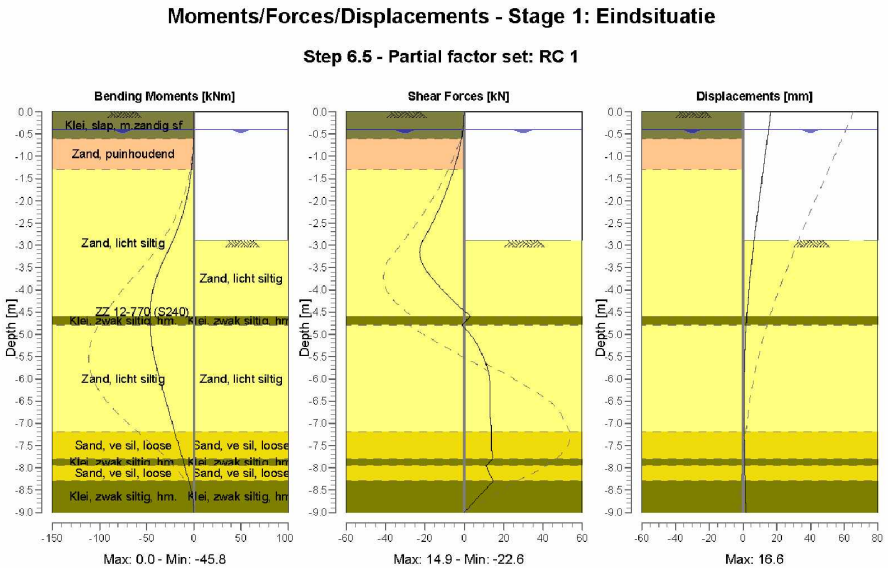
Layer name	Level [m]	Branch 1		Branch 2	
		Top [kN/m³]	Bottom [kN/m³]	Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	3000.00	3000.00	1200.00	1200.00
Zand, puinhoud...	-0.60	12000.00	12000.00	6000.00	6000.00
Zand, licht siltig	-1.30	16000.00	16000.00	8000.00	8000.00
Klei, zwak siltig,...	-4.60	2000.00	2000.00	800.00	800.00
Zand, licht siltig	-4.80	16000.00	16000.00	8000.00	8000.00
Sand, ve sil, loose	-7.20	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-7.80	2000.00	2000.00	800.00	800.00
Sand, ve sil, loose	-7.95	14000.00	14000.00	7000.00	7000.00
Klei, zwak siltig,...	-8.30	2000.00	2000.00	800.00	800.00

Layer name	Level [m]	Branch 3	
		Top [kN/m³]	Bottom [kN/m³]
Klei, slap, m.za...	1.50	750.00	750.00
Zand, puinhoud...	-0.60	3000.00	3000.00
Zand, licht siltig	-1.30	4000.00	4000.00
Klei, zwak siltig,...	-4.60	500.00	500.00
Zand, licht siltig	-4.80	4000.00	4000.00
Sand, ve sil, loose	-7.20	3500.00	3500.00
Klei, zwak siltig,...	-7.80	500.00	500.00
Sand, ve sil, loose	-7.95	3500.00	3500.00
Klei, zwak siltig,...	-8.30	500.00	500.00

7.3 Calculation Results

Number of iterations: 5

7.3.1 Charts of Moments, Forces and Displacements

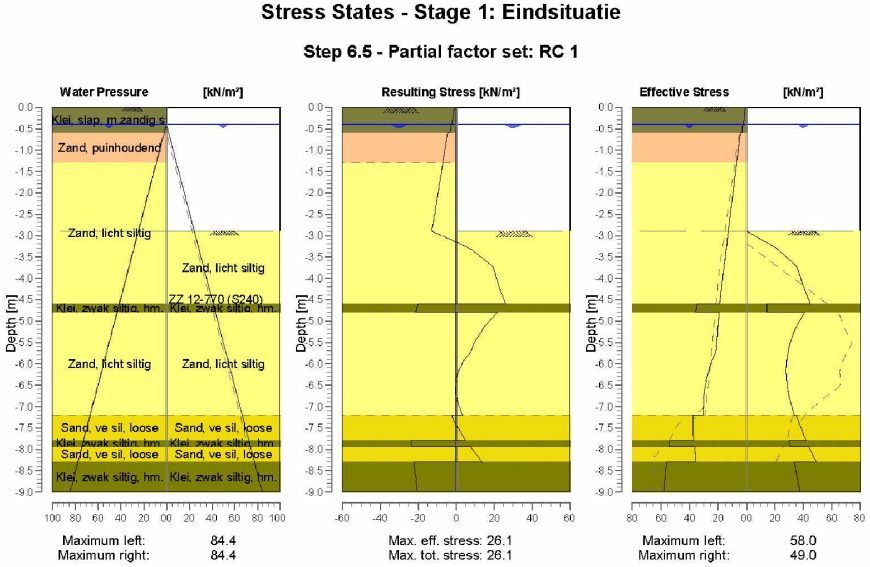


7.3.2 Moments, Forces and Displacements

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
1	0.00	0.00	0.00	**16.6**
1	-0.40	-0.11	-0.63	15.2
2	-0.40	-0.11	-0.63	15.2
2	-0.60	-0.29	-1.19	14.5
3	-0.60	-0.29	-1.19	14.5
3	-0.95	-1.00	-2.96	13.3
4	-0.95	-1.00	-2.96	13.3
4	-1.30	-2.42	-5.19	12.0
5	-1.30	-2.42	-5.19	12.0
5	-1.70	-5.09	-8.25	10.7
6	-1.70	-5.09	-8.25	10.7
6	-2.10	-9.10	-11.90	9.3
7	-2.10	-9.10	-11.90	9.3
7	-2.50	-14.68	-16.13	7.9
8	-2.50	-14.68	-16.13	7.9
8	-2.90	-22.08	-20.95	6.6
9	-2.90	-22.08	-20.95	6.6
9	-3.33	-31.51	**-21.95**	5.3
10	-3.33	-31.51	**-21.95**	5.3
10	-3.75	-39.77	-16.06	4.2
11	-3.75	-39.77	-16.05	4.2
11	-4.17	-44.73	-7.13	3.2
12	-4.17	-44.73	-7.13	3.2
12	-4.60	**-45.63**	3.15	2.3
13	-4.60	**-45.63**	3.15	2.3
13	-4.70	-45.42	1.13	2.2
14	-4.70	-45.42	1.13	2.2
14	-4.80	-45.41	-0.95	2.0
15	-4.80	-45.41	-0.96	2.0
15	-5.20	-44.28	6.06	1.5
16	-5.20	-44.28	6.06	1.5

Segment number	Level [m]	Moment [kNm]	Shear force [kN]	Displacement [mm]
16	-5.60	-40.89	10.50	1.1
17	-5.60	-40.89	10.51	1.1
17	-6.00	-36.12	12.95	0.9
18	-6.00	-36.12	12.95	0.9
18	-6.40	-30.79	13.45	0.8
19	-6.40	-30.79	13.45	0.8
19	-6.80	-25.42	13.40	0.8
20	-6.80	-25.42	13.40	0.8
20	-7.20	-19.96	14.08	0.9
21	-7.20	-19.96	14.07	0.9
21	-7.50	-15.81	13.79	1.0
22	-7.50	-15.81	13.79	1.0
22	-7.80	-11.57	14.68	1.1
23	-7.80	-11.57	14.68	1.1
23	-7.95	-9.63	11.16	1.2
24	-7.95	-9.63	11.16	1.2
24	-8.30	-5.13	14.88	1.4
25	-8.30	-5.13	14.88	1.4
25	-8.65	-1.26	7.26	1.7
26	-8.65	-1.26	7.26	1.7
26	-9.00	0.00	0.00	1.9
Max		**-45.63**	**-21.95**	**16.6**
Max, minor nodes incl.		-45.81	-22.61	16.6

7.3.3 Charts of Stresses



7.3.4 Stresses

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
1	0.00	0.93	0.00	A		0.00	0.00	-	
1	-0.40	2.23	0.00	A		0.00	0.00	-	
2	-0.40	2.62	0.00	A		0.00	0.00	-	

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
2	-0.60	2.95	1.96	A		0.00	1.96	-	
3	-0.60	4.41	1.96	A		0.00	1.96	-	
3	-0.95	5.72	5.40	A		0.00	5.40	-	
4	-0.95	5.71	5.40	A		0.00	5.40	-	
4	-1.30	7.02	8.83	A		0.00	8.83	-	
5	-1.30	6.92	8.83	A		0.00	8.83	-	
5	-1.70	8.38	12.75	A		0.00	12.75	-	
6	-1.70	8.39	12.75	A		0.00	12.75	-	
6	-2.10	9.84	16.68	A		0.00	16.68	-	
7	-2.10	9.86	16.68	A		0.00	16.68	-	
7	-2.50	11.30	20.60	A		0.00	20.60	-	
8	-2.50	11.33	20.60	A		0.00	20.60	-	
8	-2.90	12.76	24.52	A		0.00	24.52	-	
9	-2.90	12.80	24.52	A		0.00	24.52	P	
9	-3.33	14.30	28.69	A		22.22	28.69	3	99
10	-3.33	14.36	28.69	A		22.22	28.69	3	99
10	-3.75	15.85	32.86	A		35.59	32.86	2	79
11	-3.75	15.92	32.86	A		35.59	32.86	2	79
11	-4.17	17.40	37.03	A		39.88	37.03	2	59
12	-4.17	17.43	37.03	A		39.88	37.03	2	59
12	-4.60	18.89	41.20	A		44.95	41.20	2	50
13	-4.60	34.16	41.20	1		14.33	41.20	1	27
13	-4.70	35.07	42.18	1		14.44	42.18	1	26
14	-4.70	34.91	42.18	1		14.44	42.18	1	26
14	-4.80	35.79	43.16	1		14.57	43.16	1	26
15	-4.80	19.05	43.16	A		40.80	43.16	1	42
15	-5.20	20.38	47.09	A		34.13	47.09	1	29
16	-5.20	20.09	47.09	A		34.13	47.09	1	29
16	-5.60	21.39	51.01	A		29.95	51.01	1	21
17	-5.60	21.11	51.01	A		29.95	51.01	1	21
17	-6.00	25.20	54.94	1		28.09	54.94	1	17
18	-6.00	24.69	54.94	1		28.09	54.94	1	17
18	-6.40	28.53	58.86	1		28.27	58.86	1	16

Node number	Level [m]	Left				Right			
		Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]	Effective Stress [kN/m²]	Water stress [kN/m²]	Stat*	Mob** [%]
19	-6.40	28.07	58.86	1		28.27	58.86	1	16
19	-6.80	30.13	62.78	1		30.20	62.78	1	15
20	-6.80	29.70	62.78	1		30.20	62.78	1	15
20	-7.20	30.28	66.71	1		33.57	66.71	1	15
21	-7.20	37.28	66.71	1		34.85	66.71	1	22
21	-7.50	37.55	69.65	1		38.29	69.65	1	23
22	-7.50	37.29	69.65	1		38.29	69.65	1	23
22	-7.80	37.10	72.59	1		42.16	72.59	1	24
23	-7.80	53.80	72.59	1		30.21	72.59	1	21
23	-7.95	54.36	74.07	1		31.05	74.07	1	21
24	-7.95	36.23	74.07	1		43.97	74.07	1	24
24	-8.30	35.44	77.50	1		49.03	77.50	1	25
25	-8.30	55.85	77.50	1		33.68	77.50	1	22
25	-8.65	57.07	80.93	1		35.69	80.93	1	22
26	-8.65	56.84	80.93	1		35.69	80.93	1	22
26	-9.00	58.04	84.37	1		37.71	84.37	1	22

Stat* Status (A=active, P=passive, Number is branche, 0 is unloading)
Mob** Percentage passive mobilized

7.3.5 Percentage Mobilized Resistance

Horizontal soil pressure	Left [kN]	Right [kN]
Effective	197.6	197.6
Water	362.8	362.8
Total	560.3	560.3

Considered as passive side	Right
Maximum passive effective resistance	776.75 kN
Mobilized passive effective resistance	197.58 kN
Percentage mobilized resistance	25.4 %

7.3.6 Vertical Force Balance

Xi factor	1.39
Partial factor base resistance	1.20
Maximum point resistance	3.000 [MPa]

Vertical force balance unplugged	Force [kN]
Vertical force active	-58.99
Vertical force passive	63.29
Resulting vertical force (no dead weight)	4.30
Vertical toe capacity Rb;d	21.58
Resultant goes up	

Vertical force balance plugged	Force [kN]
Vertical force active	-58.99
Vertical force passive	63.29
Resulting vertical force (no dead weight)	4.30
Vertical toe capacity Rb;d	618.71
Resultant goes up	

7.3.7 Vertical Force Balance - Contribution per Layer

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
1.50	Klei, slap, m.za...	0.00	1.50	Klei, slap, m.za...	0.00
-0.60	Zand, puinhoud...	-1.22	-0.60	Zand, puinhoud...	0.00
-1.30	Zand, licht siltig	-15.56	-1.30	Zand, licht siltig	18.59

Left			Right		
Level [m]	Layer name	Contribution [kN]	Level [m]	Layer name	Contribution [kN]
-4.60	Klei, zwak siltig,...	-1.23	-4.60	Klei, zwak siltig,...	0.51
-4.80	Zand, licht siltig	-21.73	-4.80	Zand, licht siltig	27.21
-7.20	Sand, ve sil, loose	-6.71	-7.20	Sand, ve sil, loose	6.89
-7.80	Klei, zwak siltig,...	-1.43	-7.80	Klei, zwak siltig,...	0.81
-7.95	Sand, ve sil, loose	-3.76	-7.95	Sand, ve sil, loose	4.87
-8.30	Klei, zwak siltig,...	-7.03	-8.30	Klei, zwak siltig,...	4.41

End of Report