Report for D-Sheet Piling 19.3

Design of Diaphragm and Sheet Pile Walls
Developed by Deltares

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

1 Summary

1.1 Overview per Stage and Test

Stage nr.	Verification type	Displace-ment [mm]	Moment [kNm]	Shear force [kN]	Mob. perc. moment [%]	Mob. perc. resistance [%]	Vertical balance
1	EC7(NL)-Step 6.1		-0,93	0,55	0,0	8,1	Upwards
1	EC7(NL)-Step 6.2		-0,68	0,46	0,0	8,1	Upwards
1	EC7(NL)-Step 6.3		1,63	-0,91	0,0	8,2	Upwards
1	EC7(NL)-Step 6.4		1,18	-0,75	0,0	8,2	Upwards
1	EC7(NL)-Step 6.5	0,0	0,00	0,00	0,0	5,9	Sufficient
1	EC7(NL)-Step 6.5 * 1,200		0,00	0,00			
2	EC7(NL)-Step 6.3		82,01	20,82	0,0	10,7	Upwards
2	EC7(NL)-Step 6.4		74,89	-19,32	0,0	10,9	Upwards
2	EC7(NL)-Step 6.5	-13,9	44,11	11,45	0,0	7,5	Upwards
2	EC7(NL)-Step 6.5 * 1,200		52,93	13,74			
3	EC7(NL)-Step 6.3		54,25	15,88	9,2	10,6	Upwards
3	EC7(NL)-Step 6.4		53,01	15,56	9,2	10,6	Upwards
3	EC7(NL)-Step 6.5	-13,2	41,22	11,29	6,6	7,5	Sufficient
3	EC7(NL)-Step 6.5 * 1,200		49,47	13,55			
4	EC7(NL)-Step 6.3		105,41	29,11	9,6	11,5	Sufficient
4	EC7(NL)-Step 6.4		**106,86**	**29,25**	**9,7**	**11,7**	Sufficient
4	EC7(NL)-Step 6.5	**-22,7**	70,70	19,88	6,8	8,0	Sufficient
4	EC7(NL)-Step 6.5 * 1,200		84,84	23,86			
Max		**-22,7**	**106,86**	**29,25**	**9,7**	**11,7**	Sufficient

1.2 Anchors and Struts

Stage nr.	Verification type	Anchor/strut groutanker	
		Force [kN]	State
3	EC7(NL)-Step 6.1	-	
3	EC7(NL)-Step 6.2	-	
3	EC7(NL)-Step 6.3	7,60	Elastic
3	EC7(NL)-Step 6.4	7,60	Elastic
3	EC7(NL)-Step 6.5 x 1,200	9,12	Elastic
4	EC7(NL)-Step 6.1	-	
4	EC7(NL)-Step 6.2	-	
4	EC7(NL)-Step 6.3	**17,86**	Elastic
4	EC7(NL)-Step 6.4	15,20	Elastic
4	EC7(NL)-Step 6.5 x 1,200	13,77	Elastic
Max		**17,86**	

Due to multiplication of the representative value a force bigger than yield or buckling force may be present.

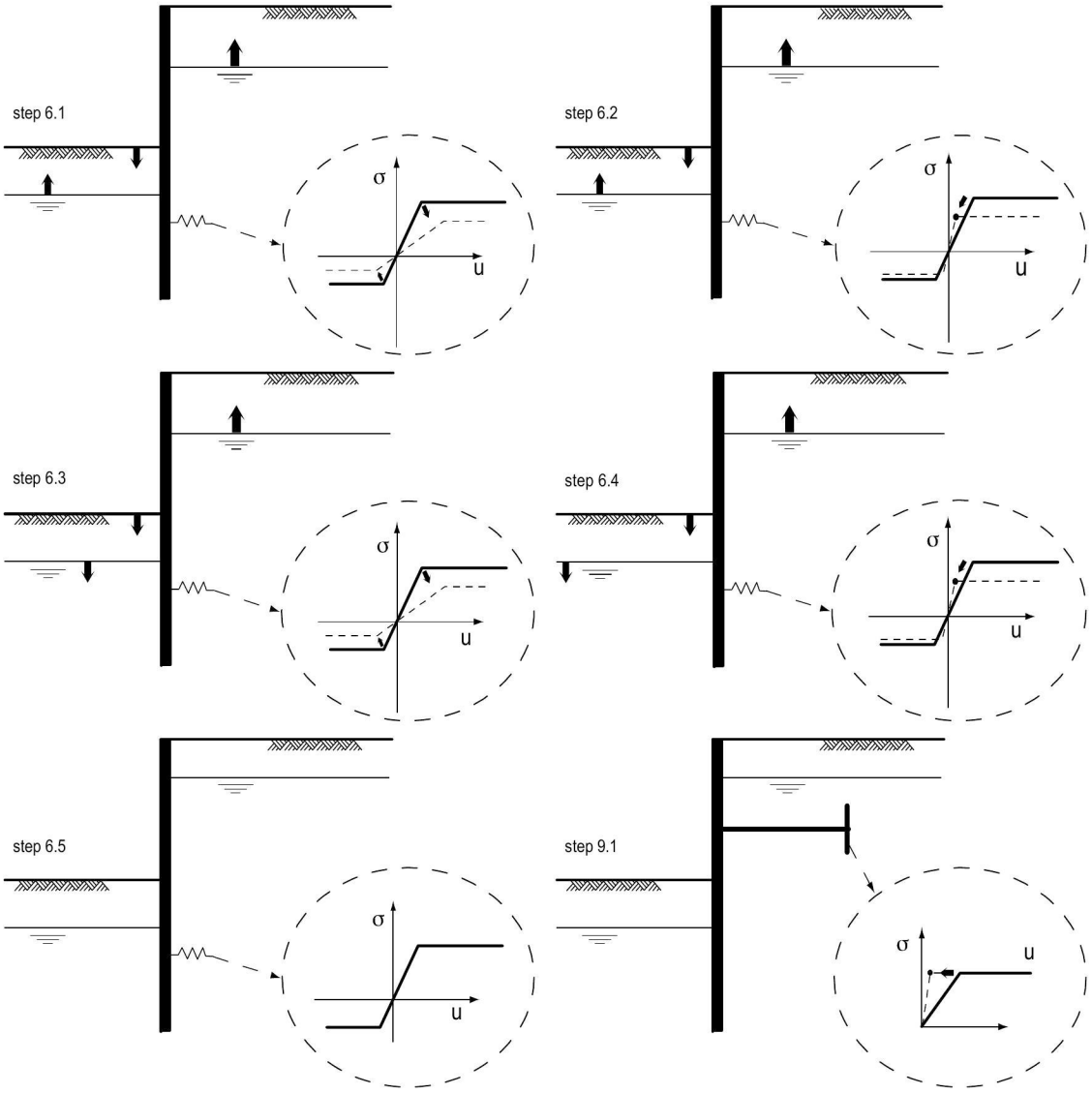
1.3 Overall Stability per Stage

Stage name	Stability factor [-]
Initieel	10000,00
Huidig profiel	5,44
ankers aanbrengen	5,44
Huidig profiel + belasting	5,01

1.4 Warnings

* Vertical balance: The resultant vertical friction force is directed upward in stage 1, 2 & 3
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.

1.5 CUR Verification Steps



2 Input Data for all Stages

2.1 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	4
Unit weight of water	9,81 kN/m³
Number of curves for spring characteristics	3
Unloading curve on spring characteristic	No
Elastic calculation	Yes

2.2 Sheet Piling Properties

Length	19,20 m
Level top side	1,20 m
Number of sections	1
q_b;max	3,00 MPa
Xi factor	1,39

2.2.1 General Properties

Section name	From [m]	To [m]	Material type	Acting width [m]
PSp 500 -10 (S...	-18,00	1,20	Steel	0,38

2.2.2 Stiffness EI (elastic behaviour)

Section name	Elastic stiffness EI [kNm²/m']	Red. factor on EI [-]	Corrected elas. stiffness EI [kNm²]	Note to reduction factor
PSp 500 -10 (S...	4,5287E+05	1,00	1,7209E+05	1

2.2.3 Maximum Allowable Moments

Section name	Mr;char;el [kNm/m']	Modification factor [-]	Material factor [-]	Red. factor allow. moment [-]	Mr;d;el [kNm]
PSp 500 -10 (S...	442,32	1,00	1,00	1,00	168,08

2.2.4 Properties for Vertical Balance

Section name	From [m]	To [m]	Height [mm]	Coating area [m²/m² wall]	Section area [cm²/m']
PSp 500 -10 (S...	-18,00	1,20	380,00	1,00	65,74

2.3 Calculation Options

First stage represents initial situation	No
Calculation refinement	Coarse
Reduce delta(s) according to CUR	Yes
Verification	EC7 NA NL - method B: Partial factors (design values) in verified stage only. Eurocode 7 using the factors as described in the National Annex of the Netherlands. It is basically design approach III.
Verification of stage	1: Initieel
Multiplication factor for anchor stiffness	1,000

Used partial factor set	RC 2
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1,000
- Permanent load, favourable	1,000
- Variable load, unfavourable	1,100
- Variable load, favourable	0,000
Factors on loads - Constructive loads	
- Permanent load, unfavourable	1,350
- Permanent load, favourable	0,900
- Variable load, unfavourable	1,500
- Variable load, favourable	0,000
Material factors	
- Cohesion	1,250
- Tangent phi	1,175
- Delta (wall friction angle)*	1,175
- 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 **	0,25 m
- Raise in phreatic line on passive side **	0,25 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	1,450
- Tangent phi	1,250
- Factor on unit weight soil	1,000
Vertical balance factors	
- Partial factor base resistance (gamma_b)	1,200
Verification of stage	2: Huidig profiel
Multiplication factor for anchor stiffness	1,000
Used partial factor set	RC 2
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1,000
- Permanent load, favourable	1,000
- Variable load, unfavourable	1,100
- Variable load, favourable	0,000
Factors on loads - Constructive loads	
- Permanent load, unfavourable	1,350
- Permanent load, favourable	0,900
- Variable load, unfavourable	1,500
- Variable load, favourable	0,000
Material factors	
- Cohesion	1,250
- Tangent phi	1,175
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- Raise in phreatic line on passive side **	0,25 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	1,450
- Tangent phi	1,250
- Factor on unit weight soil	1,000
Vertical balance factors	
- Partial factor base resistance (gamma_b)	1,200
Verification of stage	3: ankers aanbrengen
Multiplication factor for anchor stiffness	1,000
Used partial factor set	RC 2
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1,000
- Permanent load, favourable	1,000
- Variable load, unfavourable	1,100
- Variable load, favourable	0,000
Factors on loads - Constructive loads	
- Permanent load, unfavourable	1,350
- Permanent load, favourable	0,900
- Variable load, unfavourable	1,500
- Variable load, favourable	0,000
Material factors	
- Cohesion	1,250
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- Increase retaining height	10,00 %
- Maximum increase retaining height	0,50 m
- Reduction in phreatic line on passive side **	0,25 m
- Raise in phreatic line on passive side **	0,25 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	1,450
- Tangent phi	1,250
- Factor on unit weight soil	1,000
Vertical balance factors	
- Partial factor base resistance (gamma_b)	1,200
Verification of stage	4: Huidig profiel + belasting
Multiplication factor for anchor stiffness	1,000
Used partial factor set	RC 2
Factors on loads - Geotechnical loads	
- Permanent load, unfavourable	1,000
- Permanent load, favourable	1,000
- Variable load, unfavourable	1,100
- Variable load, favourable	0,000
Factors on loads - Constructive loads	
- Permanent load, unfavourable	1,350
- Permanent load, favourable	0,900

- Variable load, unfavourable	1,500
- Variable load, favourable	0,000
Material factors	
- Cohesion	1,250
- Tangent phi	1,175
- Delta (wall friction angle)*	1,175
- 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 **	0,25 m
- Raise in phreatic line on passive side **	0,25 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	1,450
- Tangent phi	1,250
- 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.

End of Report