Rock & Alluvium

CONTIGUOUS PILE FOUNDATION DESIGN

(Issued subject to mutual agreement of Sub-Contract)

Contract Number

16-0036

Site Address

Hampstead Green
London

Main Contractor

CAREY LONDON LIMITED

Date	Rev	Designed By	Approved By	Comments / Drawings Rev.s
20/04/2016	0	Kayvan Kiany Design Manager	Neil Stone Design Manager	

HAMPSTEAD GREEN, LONDON
CFA RETAINING WALL PILE DESIGN REV 0

Contents

1.0 Design Brief

The proposed redevelopment of the site involves the installation of Contiguous piles for the Hampstead Green project development in London. The piles are to be constructed using the continuous flight auger (CFA) technique.

Design consists of 400mm male piles at 550mm centres.

Analysis of the wall has been divided into five sections, allowing for varying retained heights and construction sequences.

Piles will be installed to a target verticality of 1:75

Piles will be installed to a plan tolerance of 75mm

Male piles to be constructed using C32/40 concrete providing DC-3 design concrete classification as a minimum.

Pile design requirements are summarised in *Fig.1*

Wall Section	PPL (mOD)	Retained level (mOD)	Formation level (mOD)	Retained height (m)	Male length (m)
1	75	75	71.5	3.5	10 to 18.1
2	72	72	67.2	4.8	10 to 18.1
3	72	72	67.6	4.4	10 to 18.1
4 (CP27-32)	75	75	67.6	7.4	10 to 18.1
5 (CP321-352)	75	75	71.5	3.5	10 to 18.1

Fig 1 Pile summary

2.0 Design Input

2.1 Site Investigation

Card Geotechnics Limited Geotechnical and geo-environmental report, rev 2, dated September 2014.

2.2 Drawings

Relevant Drawings: elliottwood Consulting drawings –
S/70 Proposed Pile Layout rev C2
S/71 Proposed Pile Layout Schedules rev C1
S/80 Proposed basement plan rev T1
S/80 Proposed basement plan rev T1
S/90 Proposed lower GF plan rev T1

2.3 Codes & Standards

CIRIA C580 Embedded retaining walls
BS EN 1992-1-1:2004 Eurocode 2: Design of Concrete Structures
ES EN 1997-1:2004 Eurocode 7: Geotechnical Design
BS EN1536: 2010 Execution of Special Geotechnical Work – Bored Piles

2.4 Specification

ICE Specification for piling and embedded retaining walls, 2nd Edition (SPERW), 2007.
elliottwood specification for piling works, tender issue dated 2015.

3.0 Design Philosophy & Ground/ Design Model

3.1 Design Philosophy

Design is in accordance with CIRIA report C580: Embedded retaining walls, which is provided as non-contradictory complementary information (NCCI) under BS EN 1997-1:2004. Analyses were performed using WALLAP computer software for both the Ultimate Limit State (ULS) and Serviceability Limit State (SLS). Design has been completed in accordance with design approach A based on a moderately conservative approach.

We have assessed the structure class to be Category 2 (Section 2.1) "Conventional types of structure and foundation with no exceptional risk or difficult soil and loading conditions".

The results from the WALLAP analyses can be viewed in Appendix C.

The results of both analyses are used in the final design of the piles. The ultimate design bending moments and shear forces are taken as the maximum of the result from ULS analysis or the result of the SLS analysis factored by 1.35. Deflections are taken from the results of the SLS analysis. Geotechnical and structural toe levels are taken from the ULS analysis.

Over dig has been allowed for in the ULS analysis, the lesser of 0.5m or 10% of the total retained height.

In the analysis in the temporary condition un-drained shear strength parameters for the London Clay are adopted on both sides of the wall. This approach is based on standard industry practice. We would expect the basement to be constructed before the London Clay reaches its drained state.

As noted in CIRIA C580 section A8.2.5,**"All loads and surcharges are applied in an un-factored manner"** within our analysis.

The resulting bending moments and shear forces have been used to calculate the required bending and shear reinforcement in accordance with BS EN 1992-1-1:2004 (see Appendix D).

3.2 Construction Sequence

Section 1 (Section 5 with lateral load)
Install Contiguous piles from a platform level of 75mOD (Retained level 75mOD)
Excavate and construct capping beam
Excavate to formation level of 71.5mOD
Install Base slab to act as permanent support

Section 2
Install Contiguous piles from a platform level of 72mOD (Retained level 72mOD)
Excavate and construct capping beam
Excavate to formation level of 67.215mOD
Install Base slab to act as permanent support
Install GF slab to act as permanent support

Section 3
Install Contiguous piles from a platform level of 72/75mOD (Retained level 72mOD)
Excavate and construct capping beam
Excavate to formation level of 67.6mOD
Install Base slab to act as permanent support
Install GF slab to act as permanent support
Ground level to be reduced to 72mOD before excavation of the basement where piles have been installed from a PPL of 75mOD.

Section 4
Install Contiguous piles from a platform level of 75mOD
Excavate and construct capping beam
(Wall propped by capping beam along GL B and also by the capping beam of piles CP21-26)
Excavate to formation level of 67.6mOD
Install Base slab to act as permanent support
Install GF slab to act as permanent support

3.3 Site Investigation

The site Investigation Report provided a total of 5 boreholes up to a maximum depth of 30m. Standard Penetration Tests (SPT's) and un-drained triaxial tests have been carried out.

3.4 Soil Model

The soil profile used within the design is illustrated below this profile was developed from a review of the aforementioned site investigation. *See Fig 2*.

Stratum	Level (mOD)
MG	75
Head Deposits	72.5
London Clay	71

Fig 2 Soil Model

Design is based on a groundwater level of 13mOD.

3.5 Soil Parameters

A correlation value of 5 has been applied to the SPT results to obtain the equivalent Undrained Shear Strength (kN/m^2) of the Clay strata.
The soil parameters shown in *Fig.3* are subsequently used for the design of the piles.
A summary of the characteristic, ULS & SLS design values used within the design is also located in *Fig 4.*

A plot of strength Vs depth can also be found in Appendix A.

STRATUM	BEARING PILE DESIGN PARAMETERS		
London CLAY *Firm to V Stiff CLAY (fissured silty CLAY)*	Bulk Density	γ_b	$= 20kN/m^3$
	SPT	'N'	Values as design lines
	Cohesion	c_u	Values as design lines, correlation factor = 5
	Adhesion factor	α	$= 0.60$
	Unit skin friction	q_s	Limited to maximum average of 110kPa

Fig 3 Soil Parameters

CHARACTERISTIC VALUES

Stratum	γ_{bulk} kN/m^3	γ_{dry} kN/m^3	K_o	S_u (+ gradient) kN/m^2	S_u (+ gradient) kN/m$^{2/}$m	c' kN/m^2	ϕ'	E_{un} (+gradient) kN/m^2	E_{un} (+gradient) kN/m$^{2/}$m	E' (+gradient) kN/m^2	E' (+gradient) kN/m$^{2/}$m
MG	18.0	18.0	0.530				28.0			10000	
Head deposits	20.0	20.0	0.590				24.0			18000	
London Clay	20.0	20.0	1.000	55.0	6.1	2.5	25.0	44000	4880	35200	3904

ULTIMATE LIMIT STATE VALUES $F_{sSu} = 1.50$ $F_{sc'} = 1.20$ $F_{s\phi'} = 1.20$

Stratum	γ_{bulk} kN/m^3	γ_{dry} kN/m^3	K_o	S_u (+ gradient) kN/m^2	S_u (+ gradient) kN/m$^{2/}$m	c' kN/m^2	ϕ'	Eun (+gradient) kN/m^2	Eun (+gradient) kN/m$^{2/}$m	E' (+gradient) kN/m^2	E' (+gradient) kN/m$^{2/}$m
MG	18.0	18.0	0.595				23.9			5000	
Head deposits	20.0	20.0	0.652				20.4			9000	
London Clay	20.0	20.0	1.000	29.3	3.3	2.1	21.2	22000	2440	17600	1952

SERVICEABILITY LIMIT STATE VALUES $F_{sSu} = 1.00$ $F_{sc'} = 1.00$ $F_{s\phi'} = 1.00$

Stratum	γ_{bulk} kN/m^3	γ_{dry} kN/m^3	K_o	S_u (+ gradient) kN/m^2	S_u (+ gradient) kN/m$^{2/}$m	c' kN/m^2	ϕ'	Eun (+gradient) kN/m^2	Eun (+gradient) kN/m$^{2/}$m	E' (+gradient) kN/m^2	E' (+gradient) kN/m$^{2/}$m
MG	18.0	18.0	0.530				28.0			10000	
Head deposits	20.0	20.0	0.590				24.0			18000	
London Clay	20.0	20.0	1.000	44.0	4.9	2.5	25.0	44000	4880	35200	3904

Fig 4 ULS / SLS design values

4.0 Specified Loads

4.1 Compression

Piles have been designed for vertical compression loads as specified on drawings listed in section 2.2. Design is based on a partial safety factor approach where characteristic pile resistance is calculated in accordance with BS EN 1997-1:2004, Design Approach 1 (section 2.4.7.3.4.2), design by calculation.

Design has been checked for Geotechnical and Structural Ultimate Limit States (ULS)

Design is based upon design actions < design resistance.

Dead Load (kN/m)	Load (kN/m)	C1 per pile (kN)	C2 per pile (kN)	Pile length (m)
75 - 850	25-200	77-796	60-611	10 to 18.1

The working load of the pile has been taken as the lowest of:

Design Approach 1 Combination 1:

$R_{b;k} = A_b\, q_{b;k}$

$R_{s;k} = A_{s;i}\, q_{s;i;k}$

$\gamma_b = 1.0$ (Base)
$\gamma_s = 1.0$ (Shaft Compression)
$\gamma_s = 1.0$ (Shaft Tension)
$\gamma_{Rd} = 1.4$ (Model Factor)
$R_{c;d} = (R_{b;k}/\gamma_b + R_{s;k}/\gamma_s)/\gamma_{Rd}$

$\gamma_G = 1.35$
$\gamma_Q = 1.5$

$\Psi 0 = 0.5$ $(Q_k > w_{L.})$
$F_{c;d} = G_k.\, \gamma_G + Q_k.\, \gamma_Q + w_{L.}\, \gamma_{Q.}\, \Psi 0$

$\Psi 0 = 0.7$ $(Q_k < w_{L.})$
$F_{c;d} = G_k.\, \gamma_G + Q_k.\, \gamma_Q .\, \Psi 0 + w_{L.}\, \gamma_Q$

$F_{c;d} < R_{c;d}$: OK

OR

Design Approach 1 Combination 2:

$R_{b;k} = A_b\, q_{b;k}$

$R_{s;k} = A_{s;i}\, q_{s;i;k}$

$\gamma_b = 2.0$ (Base)
$\gamma_s = 1.6$ (Compression)
$\gamma_s = 2.0$ (Tension)
$\gamma_{Rd} = 1.4$ (Model Factor)
$R_{c;d} = (R_{b;k}/\gamma_b + R_{s;k}/\gamma_s)/\gamma_{Rd}$

$\gamma_G = 1.0$
$\gamma_Q = 1.3$

$\Psi 0 = 0.5$ $(Q_k > w_{L.})$
$F_{c;d} = G_k.\, \gamma_G + Q_k.\, \gamma_Q + w_{L.}\, \gamma_{Q.}\, \Psi 0$

$\Psi 0 = 0.7$ $(Q_k < w_{L.})$
$F_{c;d} = G_k.\, \gamma_G + Q_k.\, \gamma_{Q.}\, \Psi 0 + w_{L.}\, \gamma_Q$

$F_{c;d} < R_{c;d}$: OK

Tension Loads, combination 1 for structural design and combination 2 for geotechnical design.

Design Approach 1 Combination 1:
$\text{Tension} = G_{kt}.\, \gamma_G + Q_{kt}.\, \gamma_Q + w_{Lt.}\, \gamma_{Q.} - (G_k \times 1)$

Design Approach 1 Combination 2:
$\text{Tension} = G_{kt}.\, \gamma_G + Q_{kt}.\, \gamma_Q + w_{Lt.}\, \gamma_{Q.} - (G_k \times 1)$

$F_{c;d}$	design axial compression load
γ_G	partial factor for permanent action
γ_Q	partial factor for variable action
$R_{c;d}$	design value R_c
$R_{b;k}$	characteristic value for base resistance of pile
γ_b	partial factor for base resistance of pile
$R_{s;k}$	characteristic value for shaft resistance of pile
γ_s	partial factor for shaft resistance of pile
$\gamma_{R;d}$	partial factor for uncertainty in a resistance model
$q_{s;i;k}$	characteristic value of shaft resistance in stratum i
$q_{b;k}$	characteristic value of base resistance in stratum i
$A_{s;i}$	pile shaft surface area in stratum i
G_k	permanent action
Q_k	variable action

4.2 Shear

Shear loads have not been specified for the Contiguous wall apart from on piles CP321-352 of 100kN/m, please note that these piles can only accommodate a load of 55kN/m run this is currently what they have been designed for.

4.3 Tension

Tension loads have not been specified for the Contiguous wall

4.4 Moments from Tolerances

Moment loads have not been specified for the Contiguous wall.

4.5 Surcharges

An HA loading of 10kN/m² has been applied surrounding the proposed basement.

5.0 Bearing Capacity

5.1 Bearing Capacity – Cohesive Soils

Shaft Resistance - Clay (ULS)

Characteristic Shaft Resistance of Stratum $q_{s;i;k} = \alpha \times C_{u\ av.}$

Characteristic Shaft Resistance of Pile $R_{s;k} = A_{s;i}\, q_{s;i;k}$

Where:

$A_{s;i}$ = π x dia x length of shaft in clay

$C_{u\ av.}$ = Av. Undrained shear strength over length of shaft

α = adhesion

Base Resistance - Clay (ULS)

Characteristic Base Resistance of Stratum $q_{b;k} = C_{u\ base} \times N_c$

Characteristic Base Resistance of Pile $R_{b;k} = A_b\, q_{b;k}$

Where:

A_b (Area of base) = π x dia^2 x 0.25

N_c (Bearing capacity factor) = 9.0

C_u base = Undrained design shear strength at base

Pile capacity calculations can be found in Appendix B

5.2 Design Check for Structural ULS – Concrete Compression

Where geotechnical ULS resistances and SLS performance have been satisfied, the structural capacity of the pile is determined in accordance with BS EN 1997-1:2004 and BS EN 1992-1-1:2004. Calculations for the maximum loading case are provided in Appendix E.

6.0 Structural Design

6.1 Structural Parameters

Pile diameters	=	400mm male piles spaced at 550mm c-c
Concrete, f_{cu}	=	32/40 N/mm^2 DC-3
Steel f_y	=	500 N/mm^2 [high yield]
Materials factor	=	1.15 (reinforcement)
Cover	=	75mm

6.2 Reinforcement Design

- Reinforcement calculations have been undertaken in accordance with BS EN 1992-1-1:2004 with respect to bending moments. Reinforcement calculations are provided in Appendix D.

- Projection steel has been calculated after Table 13, Section 10 in The Concrete Centre 'How to Design Structures Using Eurocode 2' (2006). A good bond is assumed as detailed in Figure 1 of the guide. Based on a capping beam concrete strength of 32/40N/mm² the required projection for the H20 bar is 660mm. This requirement can be reduced as the maximum bending moment does not occur at the top of the pile.

Section	SLS		ULS		Design	
	BM	SF	BM	SF	BM	SF
1	90	59	128	68	**128**	**80**
2	177	92	232	105	**239**	**124**
3	143	83	179	94	**193**	**112**
4 (CP27-32)	132	165	224	167	**224**	**223**
5 (CP321-352)	244	119	252	120	**329**	**161**

Fig 5 Design Bending moment and shear force summary

Section	Reinforcement	Cage length (m)
1	6H20, H8@160	10
2	6H25, H8@160	10
3	6H20, H8@160	10 and 12
4 (CP27-32)	6H25, H10@160	10
5 (CP321-352)	6H32, H10@160	10

Fig 6 Reinforcement Summary

7.0 Serviceability Performance

7.1 Wall deflection

A summary of the maximum wall deflection calculated using Wallap is presented below. Benefits from capping beam stiffness have not been considered. We also note that the Wallap analysis software over predicts deflections. We would expect true measured deflections to be in line with Table 2.4 of CIRIA report 580 which provides information on expected movements for cantilever walls in the London Clay from actual field studies. We anticipate deflections to be less than 20mm.

Wall Section	Calculated deflction ignoring capping beam stiffness (mm)	max deflection (mm) predicted from CIRIA C580
1	27	**14**
2	60	**20**
3	42	**20**
4 (CP27-32)	21	**20**
5 (CP321-352)	67	

Fig 9 Wall deflections

Rock & Alluvium have designed the wall not to exceed the deflection criteria and have made/will make no assessment with respect to any damage criteria. It is important that retention of the soil during breaking down of the piles and construction of the capping beam is maintained to minimise ground disturbance during construction.

As per best practise it is advised that the wall should be monitored for movement. It is recommended that clearly identified and protected “Hilti” nail monitoring points are placed in the capping beam above selected wall piles. These points should be monitored from a remote point away from the excavation. A “zero” reading should be established before bulk excavation commences. The horizontal inward movement of the wall should be checked on a daily basis during excavation and twice weekly (Monday and Friday) until the permanent slabs have been cast

8.0 Pile Testing / Validation Requirements

No load pile load testing is required.

9.0 Outstanding Issues

- **Construction Issue drawings**
- **The pile layout drawing needs to be revised to show 400mm diameter piles at 550mm spacing, the contiguous pile load table will also need updating.**
- **Piles CP321-352 can only accommodate a load of 55kN/m run this is currently what they have been designed for, 100kN/m run is not achievable.**

Appendix A

Strength Vs Depth Plots

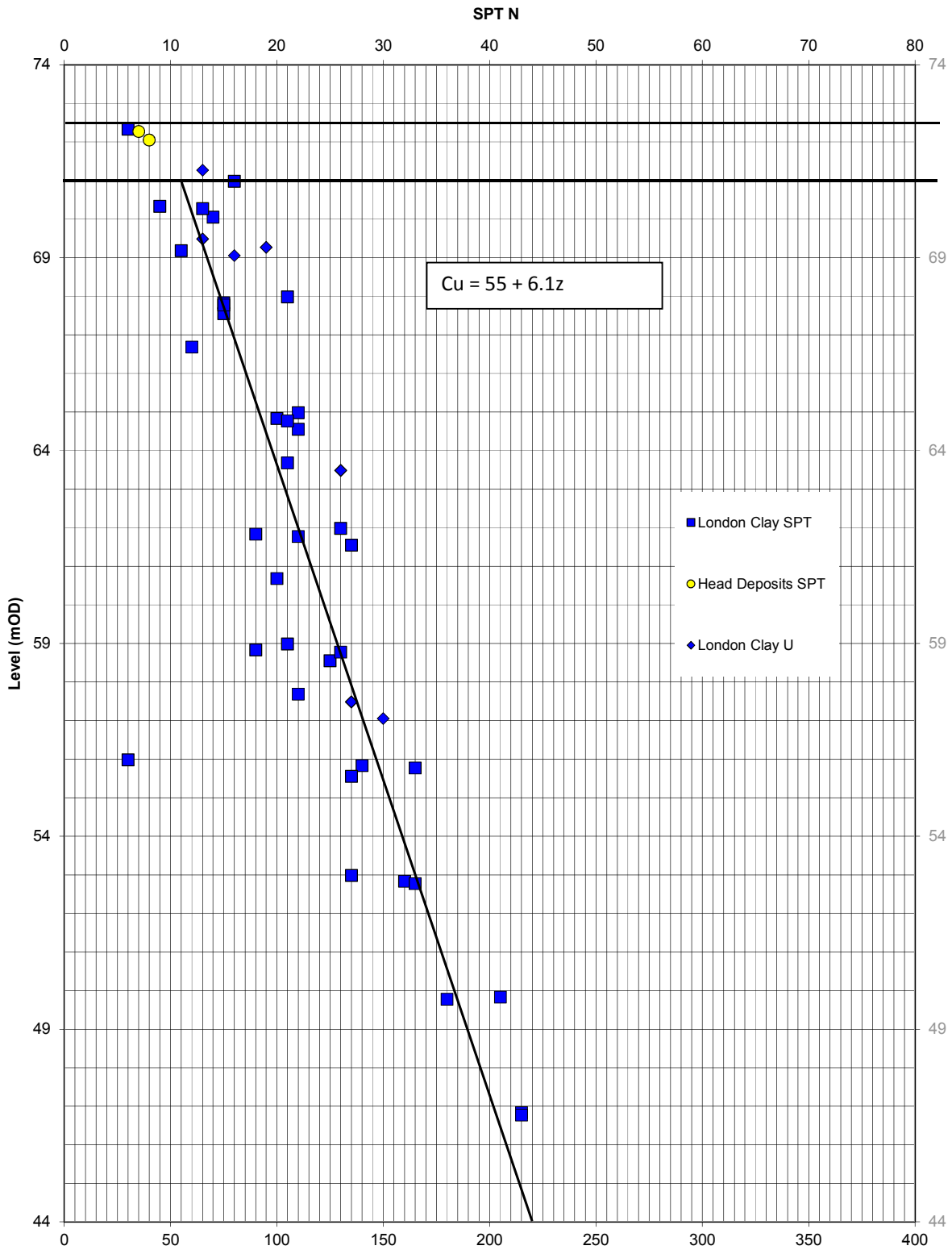
Site Address **Hampstead Green**

Reference **16-0036**

Date **22/01/2016**

Rock & Alluvium
Tel. 01372 389 333 enquiries@rockal.com
www.rockal.com

Cu = 5 * SPT



Design based on site investigation report by CGL dated: Sep 2014

Appendix B

CFA Bearing Pile Design Calculations

Static Pile Design

Piling Technique: CFA

Site Address : Hampstead Green

Contract No : 16-0036

RA-PG-06-025 (11.07)

Revision : 0

Rock & Alluvium
BRIDGE HOUSE
27 BRIDGE STREET
LEATHERHEAD
SURREY
KT22 8BL
TEL) 01372 389 333
enquiries@rockal.com
www.rockal.com

Comments : 0=72mOD
Wall piles

Model Factor =	1.4		
F of S shaft =	1.6	F of S shaft =	1.2
F of S base =	2	F of S base =	########

Depth Interval
1.00 m

(1)		(2)	S-1	S-2	S-3	S-4	S-5	C-1	C-2	C-3	C-4	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Depth Range		Soil Description	Sand Input Parameters					Clay Input Parameters				N.S.F. Parameter	Bulk Unit Weight	Submerged Unit Weight	Effective o'burden pressure	Unit Skin Friction	Unit Base Resistance	CFA Piles		0.400	size in m	CFA Piles		0.400	size in m
			SPT	k_s	Δ	D/B Ratio	Nq	C_u	C_u	Δ C_u	Alpha	Beta				[1] 225	[2] 15500								
Start	End		'N'		ΔΦ = 1.00	(for info)		Bottom	Grad-ient?	Gradient	(α)	(β)	(γ)	(γ')	(σ_v')	(q_s)	(q_b)	Ult. Shaft (Q_s)	Ult. Base (Q_b)	Ult. N.S.F.	Allowable Capacity	Ult. Shaft (Q_s)	Ult. Base (Q_b)	Ult. N.S.F.	Allowable Capacity
m								kN/m²		kN/m²			kN/m³	kN/m³	kN/m²	kN/m²	kN/m²	kN	kN	kN	kN	kN	kN	kN	kN
0.00	1.00	Ignore				3									0.0	0.0	0.0	0.0	0.0	0.0	**0**	0	0	0.0	**0**
1.00	2.00	Ignore				5									0.0	0.0	0.0	0.0	0.0	0.0	**0**	0	0	0.0	**0**
2.00	3.00	Ignore				8									0.0	0.0	0.0	0.0	0.0	0.0	**0**	0	0	0.0	**0**
3.00	4.00	Ignore				10									0.0	0.0	0.0	0.0	0.0	0.0	**0**	0	0	0.0	**0**
4.00	5.00	London Clay				13		**76.4**	y		**0.60**				0.0	45.8	687.6	57.6	86.4	0.0	**57**	58	86	0.0	**48**
5.00	6.00	London Clay				15		**85.5**	y	9.1	**0.60**				0.0	48.6	769.5	118.6	96.7	0.0	**87**	119	97	0.0	**99**
6.00	7.00	London Clay				18		**91.6**	y	6.1	**0.60**				0.0	53.1	824.4	185.4	103.6	0.0	**120**	185	104	0.0	**155**
7.00	8.00	London Clay				20		**97.7**	y	6.1	**0.60**				0.0	56.8	879.3	256.8	110.5	0.0	**154**	257	110	0.0	**214**
8.00	9.00	London Clay				23		**103.8**	y	6.1	**0.60**				0.0	60.5	934.2	332.7	117.4	0.0	**190**	333	117	0.0	**277**
9.00	10.00	London Clay				25		**109.9**	y	6.1	**0.60**				0.0	64.1	989.1	413.3	124.3	0.0	**229**	413	124	0.0	**344**
10.00	11.00	London Clay				28		**116.0**	y	6.1	**0.60**				0.0	67.8	1044.0	498.5	131.2	0.0	**269**	498	131	0.0	**415**
11.00	12.00	London Clay				30		**122.1**	y	6.1	**0.60**				0.0	71.4	1098.9	588.2	138.1	0.0	**312**	588	138	0.0	**490**
12.00	13.00	London Clay				33		**128.2**	y	6.1	**0.60**				0.0	75.1	1153.8	682.6	145.0	0.0	**357**	683	145	0.0	**569**
13.00	14.00	London Clay				35		**134.3**	y	6.1	**0.60**				0.0	78.8	1208.7	781.5	151.9	0.0	**403**	782	152	0.0	**651**
14.00	15.00	London Clay				38		**140.4**	y	6.1	**0.60**				0.0	82.4	1263.6	885.1	158.8	0.0	**452**	885	159	0.0	**738**
15.00	16.00	London Clay				40		**146.5**	y	6.1	**0.60**				0.0	86.1	1318.5	993.3	165.7	0.0	**503**	993	166	0.0	**828**
16.00	17.00	London Clay				43		**152.6**	y	6.1	**0.60**				0.0	89.7	1373.4	1106.0	172.6	0.0	**555**	1106	173	0.0	**922**
17.00	18.00	London Clay				45		**158.7**	y	6.1	**0.60**				0.0	93.4	1428.3	1223.4	179.5	0.0	**610**	1223	179	0.0	**1019**
18.00	19.00	London Clay				48		**164.8**	y	6.1	**0.60**				0.0	97.1	1483.2	1345.3	186.4	0.0	**667**	1345	186	0.0	**1121**
19.00	20.00	London Clay				50		**170.9**	y	6.1	**0.60**				0.0	100.7	1538.1	1471.9	193.3	0.0	**726**	1472	193	0.0	**1227**
20.00	21.00	London Clay				53		**177.0**	y	6.1	**0.60**				0.0	104.4	1593.0	1603.0	200.2	0.0	**787**	1603	200	0.0	**1336**
21.00	22.00	London Clay				55		**183.1**	y	6.1	**0.60**				0.0	108.0	1647.9	1738.8	207.1	0.0	**850**	1739	207	0.0	**1449**
22.00	23.00	London Clay				58		**189.2**	y	6.1	**0.60**				0.0	111.7	1702.8	1879.1	214.0	0.0	**915**	1879	214	0.0	**1566**
23.00	24.00	London Clay				60		**195.3**	y	6.1	**0.60**				0.0	115.4	1757.7	2024.1	220.9	0.0	**983**	2024	221	0.0	**1687**
24.00	25.00	London Clay				63		**201.4**	y	6.1	**0.60**				0.0	119.0	1812.6	2173.7	227.8	0.0	**1052**	2174	228	0.0	**1811**
25.00	26.00	London Clay				65		**207.5**	y	6.1	**0.60**				0.0	122.7	1867.5	2327.8	234.7	0.0	**1123**	2328	235	0.0	**1940**

Average unit skin in granular soils = 0.0 kN/m²
Average unit skin in cohesive soils = 84.2 kN/m²
Average unit skin in chalk soils = 0.0 kN/m²

[1] Limiting value for unit skin friction per m depth (in kN/m²)
[2] Limiting value for unit base resistance (in kN/m²)

Appendix C

Wallap Analysis

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	18000	0.590	OC (0.200)	0.376 (0.000)	3.077 (0.000)	
2	LC DR (71.00)	20.00	35200 (3904)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	2.500d
3	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
4	MG	18.00	10000	0.530	OC (0.200)	0.309 (0.000)	3.868 (0.000)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	24.00	0.500	0.00	24.00	0.500	0.00
2	LC DR	25.00	0.500	0.00	25.00	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	28.00	0.670	0.00	28.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	71.00	71.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	71.50	71.50	0.0
					2	71.50	74.00	25.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	71.60	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	71.50	-0.00(P)	20.00	20.00	25.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00 No analysis at this stage
3	Excavate to elevation 71.50 on PASSIVE side
4	Install strut or anchor no.1 at elevation 71.60
5	Apply surcharge no.2 at elevation 71.50
6	Apply water pressure profile no.1 No analysis at this stage
7	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
8	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Excav. to elev. 71.50 on PASSIVE side	Yes	Yes	Yes
4	Install strut no.1 at elev. 71.60	No	No	No
5	Apply surcharge no.2 at elev. 71.50	No	No	No
6	Apply water pressure profile no.1	No	No	No
7	Change soil type 3 to soil type 2	No	No	No
8	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 8 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
8	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	0.027	6.27E-03	0.0	-0.0		31986
2	74.50	3.34	0.024	6.26E-03	0.8	0.1		31986
3	74.00	6.95	0.021	6.26E-03	3.4	1.1		31986
4	73.60	12.34	0.018	6.23E-03	7.3	3.2		31986
5	73.20	17.58	0.016	6.16E-03	13.3	7.2		31986
6	72.60	25.30	0.012	5.92E-03	26.1	18.3		31986
7	72.00	32.92	0.009	5.37E-03	43.6	37.9		31986
		35.74	0.009	5.37E-03	43.6	37.9		
8	71.60	41.31	0.007	4.75E-03	59.0	57.0	67.8	31986
		41.31	0.007	4.75E-03	-8.8	57.0		
9	71.50	42.70	0.006	4.57E-03	-4.6	57.5		31986
		17.70	0.006	4.57E-03	-4.6	57.5		
10	71.00	5.35	0.004	3.65E-03	1.2	62.5		31986
		-12.92	0.004	3.65E-03	1.2	62.5		
11	70.60	-24.44	0.003	2.91E-03	-6.3	66.2		31986
12	70.20	-16.06	0.002	2.18E-03	-14.4	64.0		31986
13	69.60	-9.78	0.001	1.24E-03	-22.1	47.5		31986
14	69.00	3.93	0.000	5.84E-04	-23.9	29.5		31986
15	68.40	13.25	0.000	1.97E-04	-18.7	14.3		31986
16	67.80	12.68	0.000	2.02E-05	-10.9	4.6		31986
17	67.20	8.44	0.000	-3.32E-05	-4.6	0.1		31986
18	66.60	3.98	0.000	-3.48E-05	-0.9	-1.1		31986
19	66.00	0.46	0.000	-2.64E-05	0.4	-0.7		31986
20	65.50	-0.80	0.000	-2.30E-05	0.4	-0.2		31986
21	65.00	-0.60	0.000	-2.24E-05	0.0	0.0		---

At elev. 71.60 Strut force = 67.8 kN/strut = 67.8 kN/m run

(continued)

Stage No.8 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	3468
2	74.50	0.00	10.82	3.34	41.84	3.34	3.34a	3468
3	74.00	0.00	22.50	6.95	87.03	6.95	6.95a	3468
4	73.60	4.00	26.99	8.34	104.40	8.34	12.34a	3468
5	73.20	8.00	31.01	9.58	119.95	9.58	17.58a	3468
6	72.60	14.00	36.57	11.30	141.45	11.30	25.30a	3468
7	72.00	20.00	41.81	12.92	161.74	12.92	32.92a	3468
		20.00	41.81	15.74	128.66	15.74	35.74a	6242
8	71.60	24.00	46.01	17.31	141.56	17.31	41.31a	6242
9	71.50	25.00	47.05	17.70	144.76	17.70	42.70a	6242
10	71.00	30.00	52.20	19.64	160.61	20.73	50.73	6242
		30.00	52.20	15.42	181.86	15.42	45.42a	12207
11	70.60	34.00	56.27	16.89	195.11	16.89	50.89a	12749
12	70.20	38.00	60.31	18.35	208.26	38.25	76.25	13290
13	69.60	44.00	66.33	20.52	227.83	63.93	107.93	14103
14	69.00	50.00	72.30	22.68	247.24	80.36	130.36	14915
15	68.40	56.00	78.23	24.82	266.54	90.24	146.24	15727
16	67.80	62.00	84.13	26.95	285.75	96.45	158.45	16540
17	67.20	68.00	90.01	29.07	304.88	101.21	169.21	17352
18	66.60	74.00	95.88	31.19	323.95	105.76	179.76	18164
19	66.00	80.00	101.73	33.30	342.97	110.53	190.53	18977
20	65.50	85.00	106.59	35.06	358.79	115.19	200.19	63288
21	65.00	90.00	111.45	36.81	374.60	120.50	210.50	65468

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	71.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		25.00	0.00	0.00	0.00	0.00	25.00	5500
10	71.00	30.00	5.00	1.88	15.38	15.38	45.38p	5500
		30.00	5.00	0.00	28.34	28.34	58.34p	10755
11	70.60	34.00	8.99	0.00	41.33	41.33	75.33p	11232
12	70.20	38.00	12.98	1.26	54.31	54.31	92.31p	11709
13	69.60	44.00	18.95	3.42	73.71	73.71	117.71p	12425
14	69.00	50.00	24.89	5.56	93.03	76.43	126.43	13141
15	68.40	56.00	30.80	7.69	112.25	76.99	132.99	13856
16	67.80	62.00	36.67	9.81	131.37	83.78	145.78	14572
17	67.20	68.00	42.52	11.93	150.38	92.78	160.78	15288
18	66.60	74.00	48.34	14.03	169.31	101.78	175.78	16003
19	66.00	80.00	54.14	16.12	188.17	110.08	190.08	16719
20	65.50	85.00	58.96	17.86	203.85	115.99	200.99	63288

(continued)

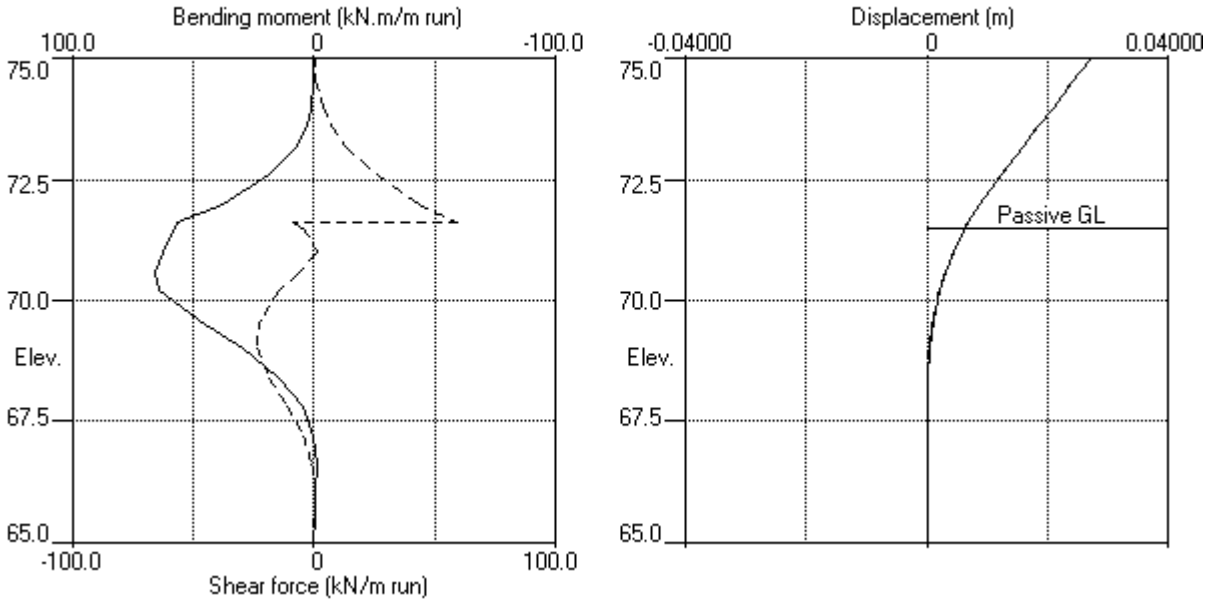
Stage No.8 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	65.00	90.00	63.77	19.60	219.51	121.11	211.11	65468

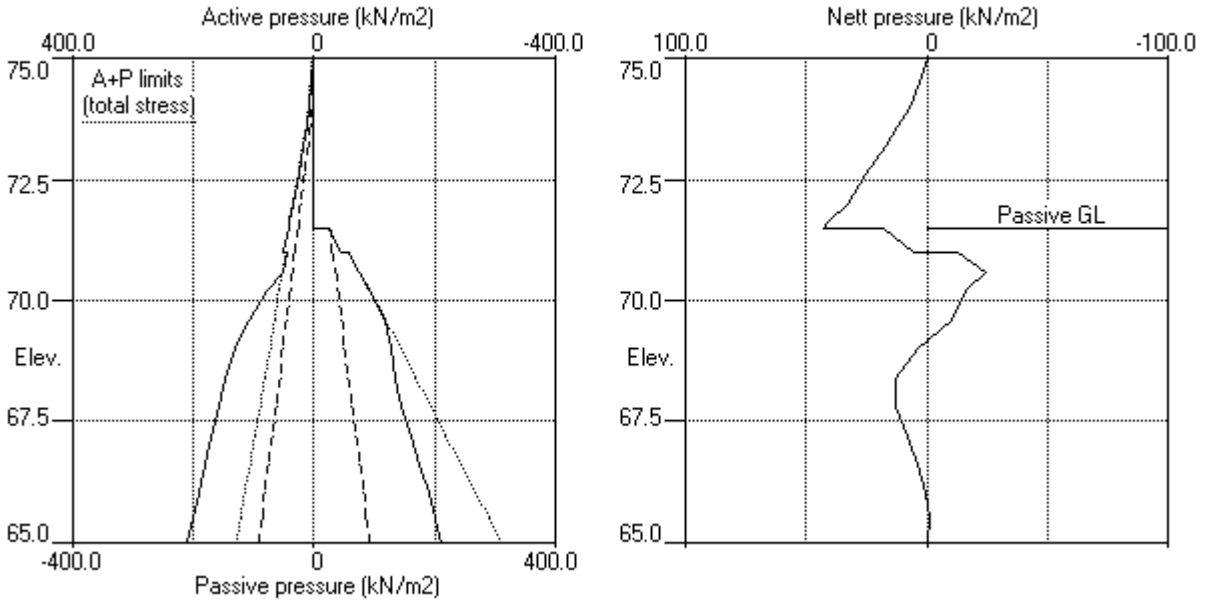
Note: 50.89a Soil pressure at active limit
117.71p Soil pressure at passive limit

Units: kN,m

Stage No.8 Change EI of wall to 31986kN.m2/m run



Stage No.8 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00		No analysis at this stage			
3	75.00	71.50	Cant.	2.126	65.84	68.77	2.73
4	75.00	71.50		No analysis at this stage			
5	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
6	75.00	71.50		No analysis at this stage			
7	75.00	71.50		No analysis at this stage			
8	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.027	0.000	0.0	-0.0	0.0	0.0
2	74.50	0.024	0.000	0.1	0.0	0.9	0.0
3	74.00	0.021	0.000	1.2	0.0	3.7	0.0
4	73.60	0.018	0.000	3.4	0.0	7.3	0.0
5	73.20	0.016	0.000	7.2	0.0	13.3	0.0
6	72.60	0.012	0.000	18.3	0.0	26.1	0.0
7	72.00	0.009	0.000	37.9	0.0	43.6	0.0
8	71.60	0.007	0.000	57.0	0.0	59.0	-8.8
9	71.50	0.006	0.000	57.5	0.0	45.5	-4.6
10	71.00	0.004	0.000	75.8	0.0	50.3	0.0
11	70.60	0.003	0.000	89.5	0.0	9.9	-6.3
12	70.20	0.002	0.000	87.9	0.0	0.0	-23.0
13	69.60	0.001	0.000	63.5	0.0	0.0	-42.7
14	69.00	0.001	-0.000	36.6	0.0	0.0	-39.7
15	68.40	0.001	-0.000	15.9	0.0	0.0	-27.7
16	67.80	0.001	-0.000	4.6	0.0	0.0	-15.0
17	67.20	0.001	0.000	0.1	-2.1	0.0	-5.4
18	66.60	0.001	0.000	0.0	-3.1	0.2	-0.9
19	66.00	0.001	0.000	0.0	-1.9	2.3	0.0
20	65.50	0.001	0.000	0.0	-0.7	1.9	0.0
21	65.00	0.001	0.000	0.0	0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	No calculation at this stage							
3	85.2	70.60	-2.9	66.60	49.2	71.00	-40.9	69.60
4	No calculation at this stage							
5	89.5	70.60	-3.1	66.60	50.3	71.00	-42.7	69.60
6	No calculation at this stage							
7	No calculation at this stage							
8	66.2	70.60	-1.1	66.60	59.0	71.60	-23.9	69.00

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum	elev.	minimum	elev.	Stage description
	m		m		
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 75.00
3	0.023	75.00	0.000	75.00	Excav. to elev. 71.50 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 71.60
5	0.023	75.00	-0.000	68.40	Apply surcharge no.2 at elev. 71.50
6	No calculation at this stage				Apply water pressure profile no.1
7	No calculation at this stage				Change soil type 3 to soil type 2
8	0.027	75.00	0.000	75.00	Change EI of wall to 31986kN.m2/m run

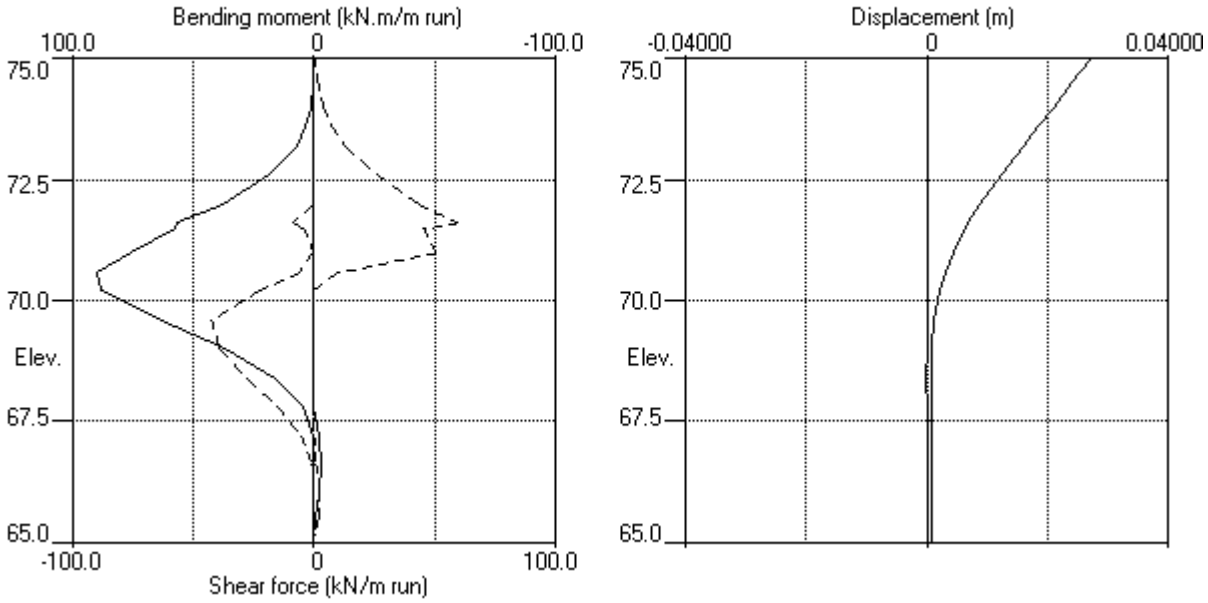
Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 71.60	
	kN/m run	kN/strut
5	slack	slack
8	67.76	67.76

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	9000	0.650	OC (0.200)	0.436 (0.000)	2.540 (0.000)	
2	LC DR (71.00)	20.00	17600 (1952)	1.000	OC (0.200)	0.422 (1.489)	2.648 (4.248)	2.100d
3	LC UN (71.00)	20.00	22000 (2440)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	29.30u (3.300)
4	MG	18.00	5000	0.590	OC (0.200)	0.368 (0.000)	3.060 (0.000)	

Additional soil parameters associated with Ka and Kp

		--- parameters for Ka ---			--- parameters for Kp ---		
------- Soil type ------- No.	Description	Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	20.40	0.500	0.00	20.40	0.500	0.00
2	LC DR	21.20	0.500	0.00	21.20	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	23.90	0.670	0.00	23.90	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	71.00	71.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	71.50	71.50	0.0
					2	71.50	74.00	25.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	71.60	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	71.50	-0.00(P)	20.00	20.00	25.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00 No analysis at this stage
3	Excavate to elevation 71.15 on PASSIVE side
4	Fill to elevation 71.50 on PASSIVE side with soil type 1
5	Install strut or anchor no.1 at elevation 71.60
6	Apply surcharge no.2 at elevation 71.50
7	Apply water pressure profile no.1 No analysis at this stage
8	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
9	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Excav. to elev. 71.15 on PASSIVE side	Yes	Yes	Yes
4	Fill to elev. 71.50 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 71.60	No	No	No
6	Apply surcharge no.2 at elev. 71.50	No	No	No
7	Apply water pressure profile no.1	No	No	No
8	Change soil type 3 to soil type 2	No	No	No
9	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 9 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
9	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	0.052	1.03E-02	0.0	0.0		31986
2	74.50	3.98	0.047	1.03E-02	1.0	0.1		31986
3	74.00	8.28	0.041	1.03E-02	4.1	1.4		31986
4	73.60	13.93	0.037	1.02E-02	8.5	3.9		31986
5	73.20	19.41	0.033	1.02E-02	15.2	8.5		31986
6	72.60	28.50	0.027	9.92E-03	29.5	21.5		31986
7	72.00	37.50	0.021	9.29E-03	49.3	44.0		31986
		41.53	0.021	9.29E-03	49.3	44.0		
8	71.60	48.35	0.018	8.58E-03	67.3	66.0	73.1	31986
		48.35	0.018	8.58E-03	-5.7	66.0		
9	71.50	50.01	0.017	8.37E-03	-0.8	67.0		31986
		25.01	0.017	8.37E-03	-0.8	67.0		
10	71.15	18.34	0.014	7.62E-03	6.8	72.4		31986
11	71.00	16.09	0.013	7.29E-03	9.3	75.5		31986
		-3.24	0.013	7.29E-03	9.3	75.5		
12	70.60	-12.10	0.010	6.40E-03	6.3	82.9		31986
13	70.20	-20.95	0.008	5.47E-03	-0.3	86.4		31986
14	69.60	-19.98	0.005	4.07E-03	-12.6	86.2		31986
15	69.00	-10.59	0.003	2.75E-03	-21.8	75.3		31986
16	68.40	-7.70	0.002	1.65E-03	-27.3	55.5		31986
17	67.80	8.40	0.001	8.80E-04	-27.1	35.0		31986
18	67.20	13.71	0.001	4.07E-04	-20.4	18.6		31986
19	66.60	12.71	0.000	1.64E-04	-12.5	8.0		31986
20	66.00	8.65	0.000	6.19E-05	-6.1	2.5		31986
21	65.50	4.32	0.000	3.27E-05	-2.8	0.7		31986
22	65.00	7.08	0.000	2.58E-05	0.0	0.0		---

At elev. 71.60 Strut force = 73.1 kN/strut = 73.1 kN/m run

(continued)

Stage No.9 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	959
2	74.50	0.00	10.82	3.98	33.10	3.98	3.98a	959
3	74.00	0.00	22.50	8.28	68.85	8.28	8.28a	959
4	73.60	4.00	26.99	9.93	82.59	9.93	13.93a	959
5	73.20	8.00	31.01	11.41	94.89	11.41	19.41a	959
6	72.60	14.00	36.57	13.46	111.90	14.50	28.50	959
7	72.00	20.00	41.81	15.39	127.95	17.50	37.50	959
		20.00	41.81	18.24	106.20	21.53	41.53	1725
8	71.60	24.00	46.01	20.07	116.85	24.35	48.35	1725
9	71.50	25.00	47.05	20.53	119.49	25.01	50.01	1725
10	71.15	28.50	50.66	22.10	128.66	27.22	55.72	1725
11	71.00	30.00	52.20	22.77	132.57	28.13	58.13	1725
		30.00	52.20	18.91	147.12	18.91	48.91a	3374
12	70.60	34.00	56.27	20.63	157.91	20.63	54.63a	3524
13	70.20	38.00	60.31	22.34	168.61	22.34	60.34a	3674
14	69.60	44.00	66.33	24.88	184.54	39.11	83.11	3898
15	69.00	50.00	72.30	27.40	200.35	64.23	114.23	4123
16	68.40	56.00	78.23	29.91	216.06	82.25	138.25	4347
17	67.80	62.00	84.13	32.40	231.69	94.39	156.39	4572
18	67.20	68.00	90.01	34.89	247.26	102.43	170.43	4796
19	66.60	74.00	95.88	37.36	262.78	108.06	182.06	5021
20	66.00	80.00	101.73	39.83	278.27	112.51	192.51	5245
21	65.50	85.00	106.59	41.89	291.15	115.84	200.84	5432
22	65.00	90.00	111.45	43.94	304.02	122.76	212.76	163195

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	71.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		25.00	0.00	0.00	0.00	0.00	25.00	2128
10	71.15	28.50	3.50	1.53	8.89	8.89	37.39p	2128
11	71.00	30.00	5.00	2.18	12.69	12.05	42.05	2128
		30.00	5.00	0.00	22.16	22.16	52.16p	4161
12	70.60	34.00	8.99	0.67	32.73	32.73	66.73p	4345
13	70.20	38.00	12.98	2.35	43.30	43.30	81.30p	4530
14	69.60	44.00	18.95	4.87	59.09	59.09	103.09p	4807
15	69.00	50.00	24.89	7.38	74.82	74.82	124.82p	5084
16	68.40	56.00	30.80	9.88	90.46	89.95	145.95	5360
17	67.80	62.00	36.67	12.36	106.02	85.98	147.98	5637
18	67.20	68.00	42.52	14.83	121.50	88.72	156.72	5914
19	66.60	74.00	48.34	17.29	136.91	95.35	169.35	6191

(continued)

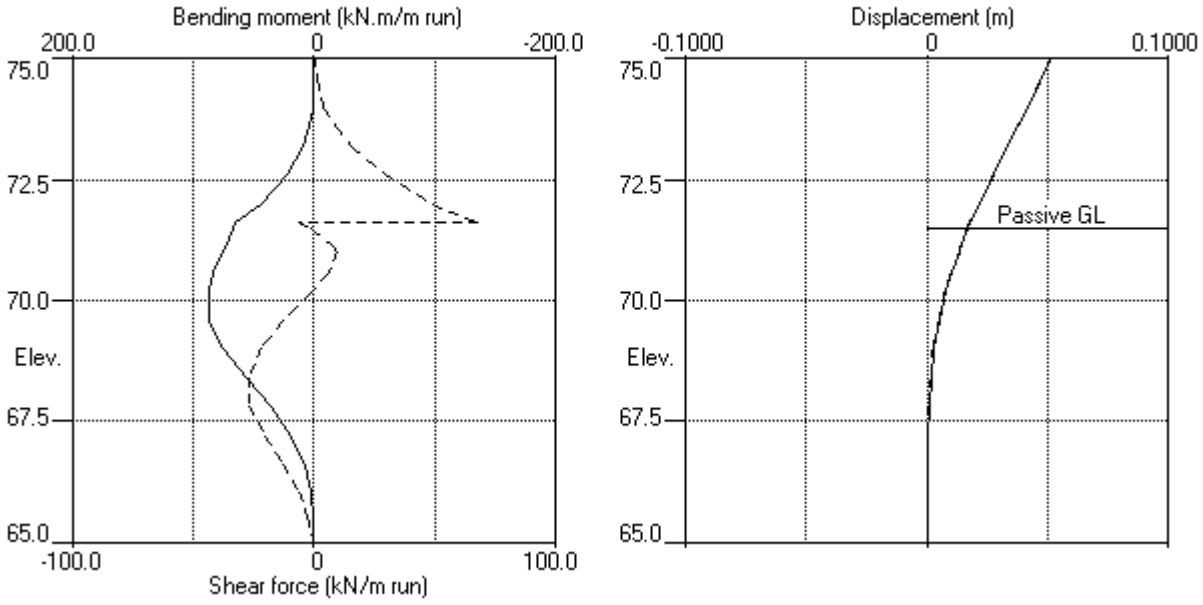
Stage No.9 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
20	66.00	80.00	54.14	19.73	152.26	103.85	183.85	6468
21	65.50	85.00	58.96	21.77	165.03	111.52	196.52	6699
22	65.00	90.00	63.77	23.80	177.77	115.68	205.68	163195

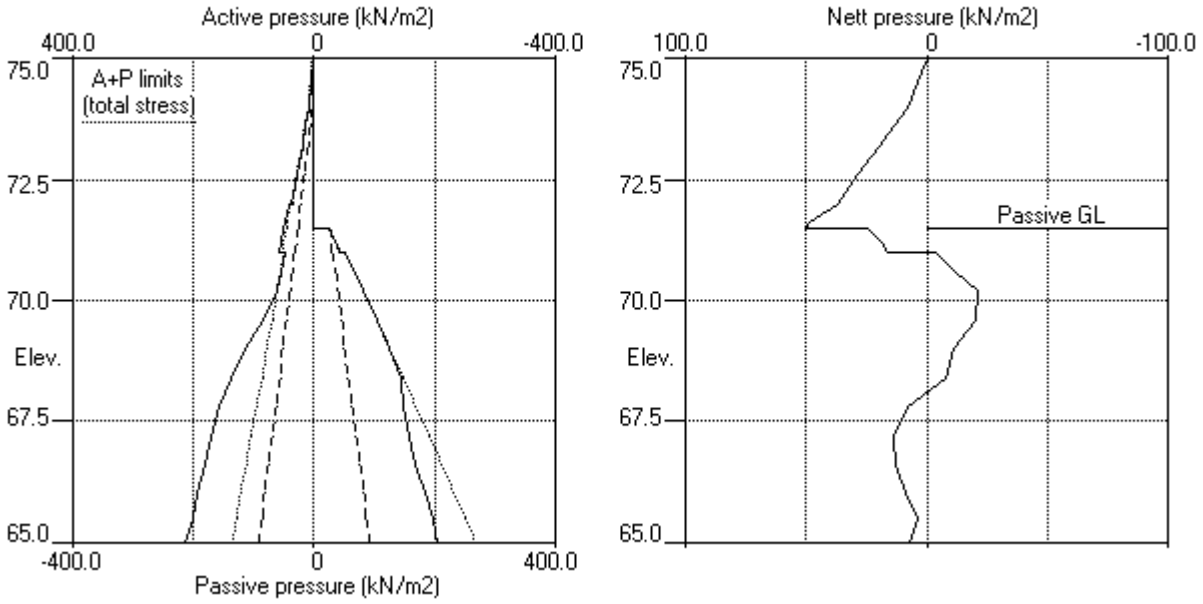
Note: 60.34a Soil pressure at active limit
124.82p Soil pressure at passive limit

Units: kN,m

Stage No.9 Change EI of wall to 31986kN.m2/m run



Stage No.9 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00		No analysis at this stage			
3	75.00	71.15	Cant.	1.403	65.75	67.62	3.53
4	75.00	71.50	Cant.	1.485	65.79	67.88	3.62
5	75.00	71.50		No analysis at this stage			
6	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
7	75.00	71.50		No analysis at this stage			
8	75.00	71.50		No analysis at this stage			
9	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.052	0.000	0.0	0.0	0.0	0.0
2	74.50	0.047	0.000	0.2	0.0	1.2	0.0
3	74.00	0.041	0.000	1.6	0.0	4.8	0.0
4	73.60	0.037	0.000	4.3	0.0	9.2	0.0
5	73.20	0.033	0.000	9.1	0.0	15.2	0.0
6	72.60	0.027	0.000	21.5	0.0	29.5	0.0
7	72.00	0.021	0.000	44.0	0.0	49.3	0.0
8	71.60	0.018	0.000	66.0	0.0	67.3	-5.7
9	71.50	0.017	0.000	67.0	0.0	55.0	-0.8
10	71.15	0.014	0.000	84.3	0.0	63.3	0.0
11	71.00	0.013	0.000	94.1	0.0	66.9	0.0
12	70.60	0.010	0.000	115.9	0.0	43.3	0.0
13	70.20	0.008	0.000	127.3	0.0	16.6	-0.3
14	69.60	0.005	0.000	127.0	0.0	0.0	-24.8
15	69.00	0.003	0.000	106.4	0.0	0.0	-48.6
16	68.40	0.002	0.000	73.4	0.0	0.0	-52.5
17	67.80	0.002	-0.000	43.4	0.0	0.0	-43.5
18	67.20	0.001	-0.000	21.2	0.0	0.0	-29.8
19	66.60	0.002	-0.000	8.0	0.0	0.0	-16.5
20	66.00	0.002	-0.000	2.5	0.0	0.0	-6.5
21	65.50	0.002	0.000	0.7	-0.1	0.0	-2.8
22	65.00	0.002	0.000	0.0	0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	No calculation at this stage							
3	121.8	69.60	-0.0	65.50	66.3	71.00	-50.3	68.40
4	123.1	69.60	-0.0	65.50	66.8	71.00	-50.8	68.40
5	No calculation at this stage							
6	127.3	70.20	-0.1	65.50	66.9	71.00	-52.5	68.40
7	No calculation at this stage							
8	No calculation at this stage							
9	86.4	70.20	0.0	75.00	67.3	71.60	-27.3	68.40

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 75.00
3	0.049	75.00	0.000	75.00	Excav. to elev. 71.15 on PASSIVE side
4	0.049	75.00	0.000	75.00	Fill to elev. 71.50 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 71.60
6	0.048	75.00	-0.000	67.20	Apply surcharge no.2 at elev. 71.50
7	No calculation at this stage				Apply water pressure profile no.1
8	No calculation at this stage				Change soil type 3 to soil type 2
9	0.052	75.00	0.000	75.00	Change EI of wall to 31986kN.m2/m run

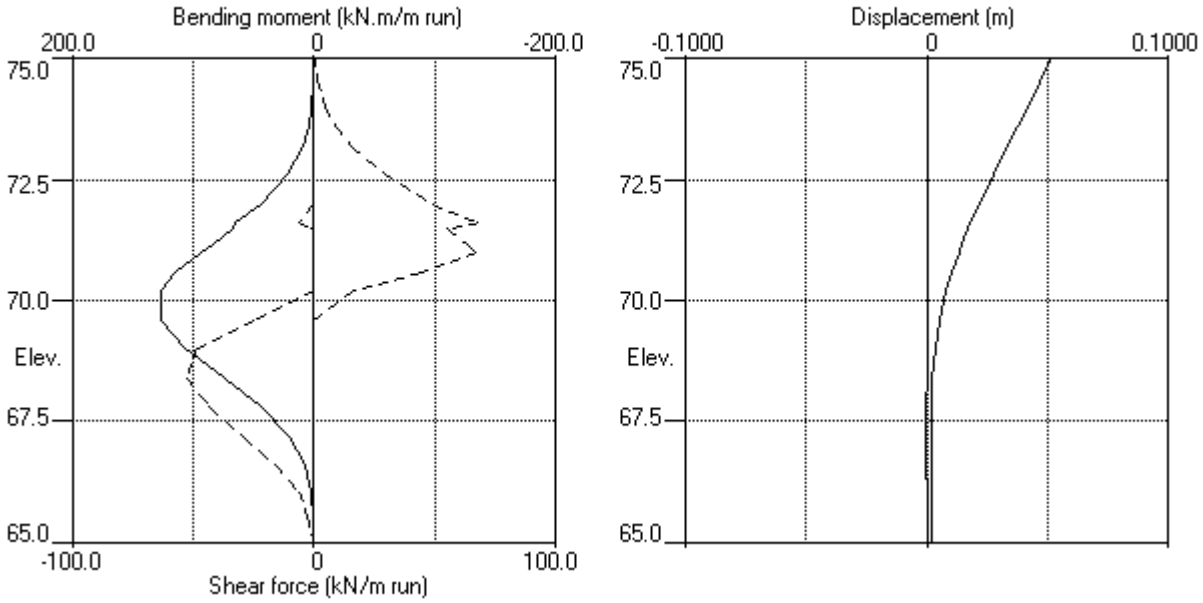
Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 71.60 kN/m run	kN/strut
6	slack	slack
9	73.06	73.06

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	72.00	1 Head deposits	1 Head deposits
2	71.00	3 LC UN	3 LC UN
3	67.20	3 LC UN	4 LC UN
4	66.70	3 LC UN	3 LC UN

SOIL PROPERTIES

No.	Soil type Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	18000	0.590	OC (0.200)	0.376 (0.000)	3.077 (0.000)	
2	LC DR (71.00)	20.00	35200 (3904)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	2.500d
3	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
4	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
5	LC soft (67.20)	20.00	1 (125088)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	1.000u (125.0)

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	24.00	0.500	0.00	24.00	0.500	0.00
2	LC DR	25.00	0.500	0.00	25.00	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
5	LC soft	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	67.00	67.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	71.00	71.00	0.0	1	67.20	67.20	0.0
					2	67.20	71.00	38.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 62.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	72.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.20	-0.00(P)	20.00	20.00	38.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 72.00 No analysis at this stage
3	Excavate to elevation 67.20 on PASSIVE side
4	Change properties of soil type 4 to soil type 5 Ko pressures will not be reset
5	Install strut or anchor no.1 at elevation 67.90
6	Apply surcharge no.2 at elevation 67.20
7	Install strut or anchor no.2 at elevation 71.50
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change properties of soil type 5 to soil type 2 No analysis at this stage Ko pressures will not be reset
11	Change EI of wall to 31986 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 5.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 72.00	No	No	No
3	Excav. to elev. 67.20 on PASSIVE side	Yes	Yes	Yes
4	Change soil type 4 to soil type 5	No	No	No
5	Install strut no.1 at elev. 67.90	No	No	No
6	Apply surcharge no.2 at elev. 67.20	No	No	No
7	Install strut no.2 at elev. 71.50	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change soil type 5 to soil type 2	No	No	No
11	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
11	72.00	67.20		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	72.00	0.00	0.060	1.10E-02	0.0	0.0		31986
2	71.50	4.45	0.054	1.10E-02	1.1	0.2	4.7	31986
		4.45	0.054	1.10E-02	-3.6	0.2		
3	71.00	9.22	0.049	1.11E-02	-0.2	-0.3		31986
		5.42	0.049	1.11E-02	-0.2	-0.3		
4	70.60	11.33	0.044	1.11E-02	3.2	0.6		31986
5	70.20	17.07	0.040	1.10E-02	8.9	3.2		31986
6	69.60	25.51	0.033	1.09E-02	21.7	11.9		31986
7	69.00	33.84	0.027	1.06E-02	39.5	28.8		31986
8	68.45	42.66	0.021	9.86E-03	60.5	54.2		31986
9	67.90	50.73	0.016	8.55E-03	86.2	91.5	128.1	31986
		50.73	0.016	8.55E-03	-41.9	91.5		
10	67.55	53.74	0.013	7.55E-03	-23.6	87.4		31986
11	67.20	58.52	0.011	6.65E-03	-4.0	89.9		31986
		8.44	0.011	6.65E-03	-4.0	89.9		
12	67.00	2.67	0.009	6.16E-03	-2.9	93.3		31986
13	66.70	-6.01	0.008	5.42E-03	-3.4	97.4		31986
14	66.35	-16.11	0.006	4.56E-03	-7.2	99.9		31986
15	66.00	-26.20	0.005	3.72E-03	-14.6	97.6		31986
16	65.40	-9.04	0.003	2.43E-03	-25.2	74.6		31986
17	64.80	2.54	0.002	1.47E-03	-27.2	46.5		31986
18	64.20	10.91	0.001	8.38E-04	-23.1	26.0		31986
19	63.60	13.49	0.000	4.57E-04	-15.8	12.1		31986
20	63.00	7.69	0.000	2.53E-04	-9.5	5.3		31986
21	62.50	0.83	0.000	1.68E-04	-7.3	2.4		31986
22	62.00	28.50	0.000	1.40E-04	0.0	-0.0		---

At elev. 71.50 Strut force = 4.7 kN/strut = 4.7 kN/m run
At elev. 67.90 Strut force = 128.1 kN/strut = 128.1 kN/m run

(continued)

Stage No.11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	31863
2	71.50	0.00	11.82	4.45	36.36	4.45	4.45a	4793
3	71.00	0.00	24.50	9.22	75.38	9.22	9.22a	4793
		0.00	24.50	5.42	91.76	5.42	5.42a	9373
4	70.60	4.00	29.79	7.33	108.97	7.33	11.33a	9789
5	70.20	8.00	34.61	9.07	124.65	9.07	17.07a	10204
6	69.60	14.00	41.37	11.51	146.63	11.51	25.51a	10828
7	69.00	20.00	47.81	13.84	167.60	13.84	33.84a	11452
8	68.45	25.50	53.56	15.91	186.31	17.16	42.66	12023
9	67.90	31.00	59.22	17.95	204.70	19.73	50.73	12595
10	67.55	34.50	62.78	19.24	216.27	19.24	53.74a	12959
11	67.20	38.00	66.31	20.52	227.78	20.52	58.52a	13323
12	67.00	40.00	68.32	21.24	234.32	21.24	61.24a	13531
13	66.70	43.00	71.33	22.33	244.09	22.33	65.33a	13843
14	66.35	46.50	74.82	23.59	255.45	23.59	70.09a	14206
15	66.00	50.00	78.30	24.84	266.76	24.84	74.84a	14570
16	65.40	56.00	84.23	26.98	286.06	61.37	117.37	15194
17	64.80	62.00	90.13	29.12	305.26	92.18	154.18	15818
18	64.20	68.00	96.01	31.24	324.39	110.75	178.75	16441
19	63.60	74.00	101.88	33.35	343.46	120.62	194.62	17065
20	63.00	80.00	107.73	35.47	362.48	126.44	206.44	17689
21	62.50	85.00	112.59	37.22	378.31	130.03	215.03	18209
22	62.00	90.00	117.45	38.98	394.12	150.82	240.82	149417

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	67.55	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	67.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		38.00	-0.00	0.00	12.08	12.08	50.08p	13993
12	67.00	40.00	2.00	0.00	18.57	18.57	58.57p	14211
13	66.70	43.00	5.00	0.00	28.33	28.33	71.33p	14539
14	66.35	46.50	8.49	0.00	39.70	39.70	86.20p	14921
15	66.00	50.00	11.98	0.90	51.04	51.04	101.04p	15303
16	65.40	56.00	17.93	3.05	70.41	70.41	126.41p	15958
17	64.80	62.00	23.85	5.18	89.65	89.65	151.65p	16613
18	64.20	68.00	29.71	7.30	108.73	99.84	167.84	17268
19	63.60	74.00	35.53	9.40	127.66	107.12	181.12	17923
20	63.00	80.00	41.31	11.49	146.44	118.76	198.76	18578
21	62.50	85.00	46.08	13.21	161.98	129.20	214.20	19124

(continued)

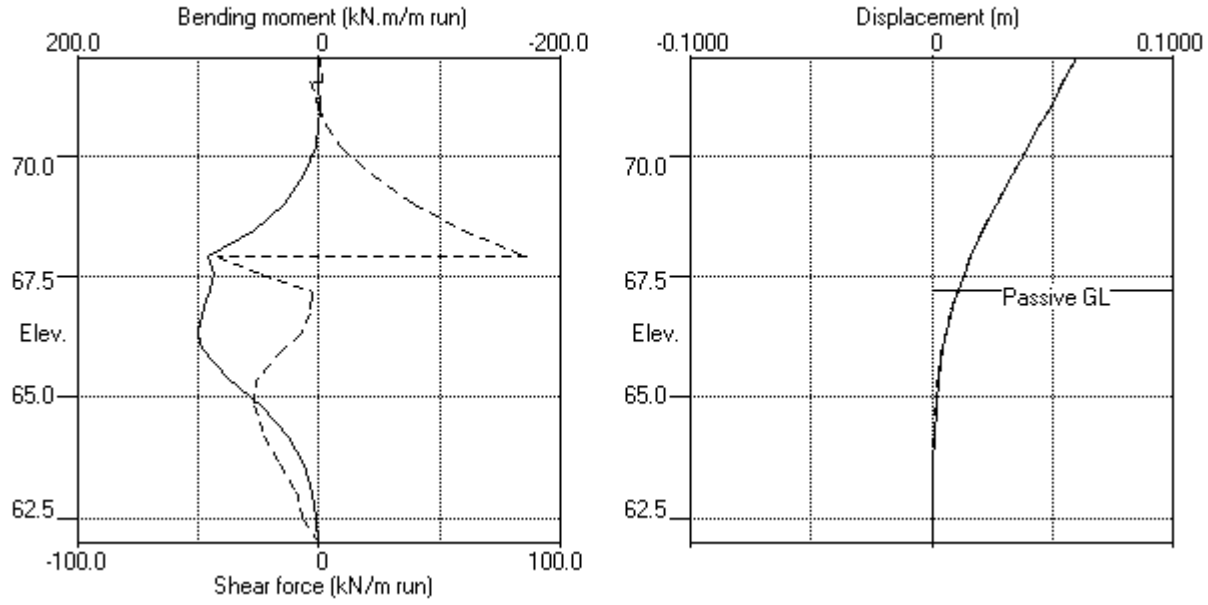
Stage No.11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
22	62.00	90.00	50.84	14.93	177.44	122.32	212.32	149417

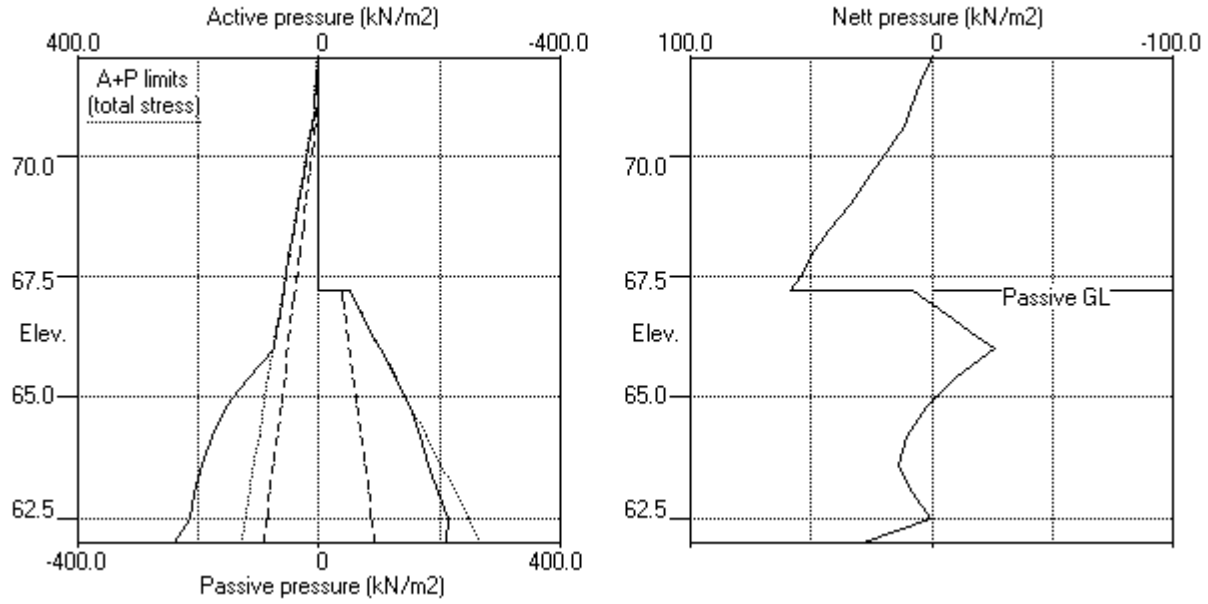
Note: 74.84a Soil pressure at active limit
151.65p Soil pressure at passive limit

Units: kN,m

Stage No.11 Change EI of wall to 31986kN.m2/m run



Stage No.11 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
1	72.00	72.00	Cant.	Conditions not suitable for FoS calc.			
2	72.00	72.00		No analysis at this stage			
3	72.00	67.20	Cant.	2.175	62.70	64.52	2.68
4	72.00	67.20	Cant.	2.049	62.76	64.12	3.08
5	72.00	67.20		No analysis at this stage			
6	72.00	67.20	67.90	Conditions not suitable for FoS calc.			
7	72.00	67.20		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	72.00	0.060	0.000	0.0	0.0	0.0	0.0
2	71.50	0.054	0.000	0.2	0.0	1.1	-3.6
3	71.00	0.049	0.000	1.5	-0.3	4.5	-0.2
4	70.60	0.044	0.000	3.8	-0.0	6.9	0.0
5	70.20	0.040	-0.000	7.1	-0.0	10.1	0.0
6	69.60	0.033	-0.000	15.1	-0.0	21.7	0.0
7	69.00	0.027	-0.000	28.8	-0.0	39.5	0.0
8	68.45	0.021	-0.000	54.2	-0.0	60.5	0.0
9	67.90	0.016	-0.000	91.5	0.0	86.2	-41.9
10	67.55	0.013	-0.000	96.5	0.0	73.1	-23.6
11	67.20	0.011	-0.000	124.8	0.0	89.2	-4.0
12	67.00	0.009	-0.000	142.5	0.0	85.7	-2.9
13	66.70	0.008	-0.000	164.5	0.0	57.2	-3.4
14	66.35	0.006	-0.000	176.9	0.0	5.9	-29.2
15	66.00	0.005	0.000	171.7	0.0	0.0	-64.0
16	65.40	0.003	0.000	121.4	0.0	0.0	-91.4
17	64.80	0.002	-0.000	64.7	0.0	0.0	-80.5
18	64.20	0.001	-0.000	26.0	0.0	0.0	-50.4
19	63.60	0.001	-0.000	12.1	-1.9	0.0	-22.3
20	63.00	0.001	-0.000	5.3	-3.3	0.9	-9.5
21	62.50	0.001	0.000	2.4	-1.5	3.4	-7.3
22	62.00	0.001	0.000	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	64.80	-0.0	63.00	0.0	72.00	0.0	72.00
2	No calculation at this stage							
3	144.4	66.70	-3.3	63.00	79.4	67.20	-77.7	65.40
4	169.4	66.35	-1.9	63.00	80.4	67.00	-88.0	65.40
5	No calculation at this stage							
6	176.9	66.35	-1.9	63.00	89.2	67.20	-91.4	65.40
7	No calculation at this stage							
8	No calculation at this stage							
9	No calculation at this stage							
10	No calculation at this stage							
11	99.9	66.35	-0.3	71.00	86.2	67.90	-41.9	67.90

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	62.00	-0.000	67.20	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 72.00
3	0.048	72.00	0.000	72.00	Excav. to elev. 67.20 on PASSIVE side
4	0.059	72.00	0.000	72.00	Change soil type 4 to soil type 5
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	0.060	72.00	-0.000	64.20	Apply surcharge no.2 at elev. 67.20
7	No calculation at this stage				Install strut no.2 at elev. 71.50
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	No calculation at this stage				Change soil type 5 to soil type 2
11	0.060	72.00	0.000	72.00	Change EI of wall to 31986kN.m2/m run

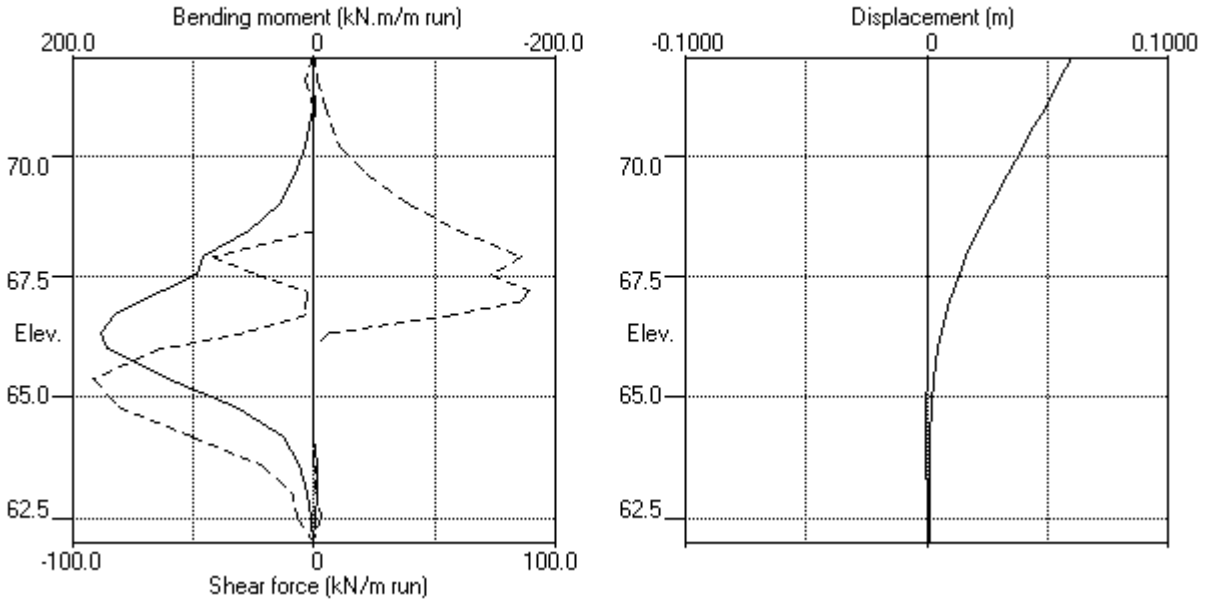
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90 kN/m run	Strut no. 1 at elev. 67.90 kN/strut	Strut no. 2 at elev. 71.50 kN/m run	Strut no. 2 at elev. 71.50 kN/strut
6	slack	slack	---	---
11	128.08	128.08	4.68	4.68

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Soil types: Passive side
1	72.00	1 Head deposits	1 Head deposits
2	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	9000	0.650	OC (0.200)	0.436 (0.000)	2.540 (0.000)	
2	LC DR (71.00)	20.00	17600 (1952)	1.000	OC (0.200)	0.422 (1.489)	2.648 (4.248)	2.100d
3	LC UN (71.00)	20.00	22000 (2440)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	29.30u (3.300)

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	20.40	0.500	0.00	20.40	0.500	0.00
2	LC DR	21.20	0.500	0.00	21.20	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	66.20	66.20

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	71.00	71.00	0.0	1	67.20	67.20	0.0
					2	67.20	71.00	38.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 62.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin-ation (degs)	Pre-stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	72.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.20	-0.00(P)	20.00	20.00	38.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 72.00 No analysis at this stage
3	Excavate to elevation 66.70 on PASSIVE side
4	Fill to elevation 67.20 on PASSIVE side with soil type 3
5	Install strut or anchor no.1 at elevation 67.90
6	Apply surcharge no.2 at elevation 67.20
7	Install strut or anchor no.2 at elevation 71.50
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change EI of wall to 31986 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 5.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 72.00	No	No	No
3	Excav. to elev. 66.70 on PASSIVE side	Yes	Yes	Yes
4	Fill to elev. 67.20 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 67.90	No	No	No
6	Apply surcharge no.2 at elev. 67.20	No	No	No
7	Install strut no.2 at elev. 71.50	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	72.00	67.20		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	72.00	0.00	0.116	1.89E-02	0.0	0.0		31986
2	71.50	5.16	0.106	1.89E-02	1.3	0.2	2.1	31986
		5.16	0.106	1.89E-02	-0.8	0.2		
3	71.00	10.69	0.097	1.89E-02	3.1	0.9		31986
		7.22	0.097	1.89E-02	3.1	0.9		
4	70.60	13.45	0.089	1.89E-02	7.2	3.0		31986
5	70.20	19.49	0.082	1.89E-02	13.8	7.1		31986
6	69.60	28.34	0.070	1.86E-02	28.2	18.5		31986
7	69.00	37.06	0.059	1.80E-02	47.8	39.0		31986
8	68.45	46.23	0.050	1.70E-02	70.7	68.4		31986
9	67.90	55.26	0.041	1.54E-02	98.6	110.7	144.5	31986
		55.26	0.041	1.54E-02	-45.9	110.7		
10	67.55	59.31	0.035	1.41E-02	-25.9	106.2		31986
11	67.20	62.88	0.031	1.30E-02	-4.5	108.4		31986
		15.95	0.031	1.30E-02	-4.5	108.4		
12	66.70	4.84	0.024	1.14E-02	0.7	118.3		31986
13	66.20	-6.27	0.019	9.86E-03	0.4	127.2		31986
14	65.80	-15.13	0.015	8.59E-03	-3.9	129.7		31986
15	65.40	-23.96	0.012	7.35E-03	-11.7	126.7		31986
16	64.80	-31.72	0.008	5.58E-03	-28.5	115.7		31986
17	64.20	-7.47	0.006	4.03E-03	-40.2	88.6		31986
18	63.60	4.72	0.003	2.92E-03	-41.0	52.9		31986
19	63.00	15.95	0.002	2.28E-03	-34.8	24.1		31986
20	62.50	35.30	0.001	2.06E-03	-22.0	6.9		31986
21	62.00	52.82	-0.000	2.01E-03	0.0	-0.0		---

At elev. 71.50 Strut force = 2.1 kN/strut = 2.1 kN/m run
At elev. 67.90 Strut force = 144.5 kN/strut = 144.5 kN/m run

(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	23725
2	71.50	0.00	11.82	5.16	30.01	5.16	5.16a	2143
3	71.00	0.00	24.50	10.69	62.22	10.69	10.69a	2143
		0.00	24.50	7.22	73.79	7.22	7.22a	4191
4	70.60	4.00	29.79	9.45	87.79	9.45	13.45a	4377
5	70.20	8.00	34.61	11.49	100.56	11.49	19.49a	4563
6	69.60	14.00	41.37	14.34	118.45	14.34	28.34a	4842
7	69.00	20.00	47.81	17.06	135.52	17.06	37.06a	5121
8	68.45	25.50	53.56	19.49	150.75	20.73	46.23	5377
9	67.90	31.00	59.22	21.88	165.71	24.26	55.26	5633
10	67.55	34.50	62.78	23.38	175.14	24.81	59.31	5795
11	67.20	38.00	66.31	24.88	184.50	24.88	62.88a	5958
12	66.70	43.00	71.33	26.99	197.78	26.99	69.99a	6190
13	66.20	48.00	76.31	29.10	210.98	29.10	77.10a	6423
14	65.80	52.00	80.28	30.77	221.48	30.77	82.77a	6609
15	65.40	56.00	84.23	32.44	231.94	32.44	88.44a	6795
16	64.80	62.00	90.13	34.94	247.58	40.34	102.34	7074
17	64.20	68.00	96.01	37.42	263.15	80.13	148.13	7353
18	63.60	74.00	101.88	39.90	278.67	107.72	181.72	7631
19	63.00	80.00	107.73	42.36	294.15	127.61	207.61	7910
20	62.50	85.00	112.59	44.42	307.04	141.43	226.43	8143
21	62.00	90.00	117.45	46.47	319.90	154.75	244.75	8375

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	67.55	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	67.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		38.00	-0.00	0.00	8.92	8.92	46.92p	5958
12	66.70	43.00	5.00	0.00	22.15	22.15	65.15p	6190
13	66.20	48.00	9.99	1.09	35.37	35.37	83.37p	6423
14	65.80	52.00	13.97	2.77	45.90	45.90	97.90p	6609
15	65.40	56.00	17.93	4.45	56.40	56.40	112.40p	6795
16	64.80	62.00	23.85	6.94	72.06	72.06	134.06p	7074
17	64.20	68.00	29.71	9.42	87.60	87.60	155.60p	7353
18	63.60	74.00	35.53	11.88	103.01	103.01	177.01p	7631
19	63.00	80.00	41.31	14.32	118.29	111.66	191.66	7910
20	62.50	85.00	46.08	16.33	130.94	106.13	191.13	8143
21	62.00	90.00	50.84	18.34	143.52	101.93	191.93	8375

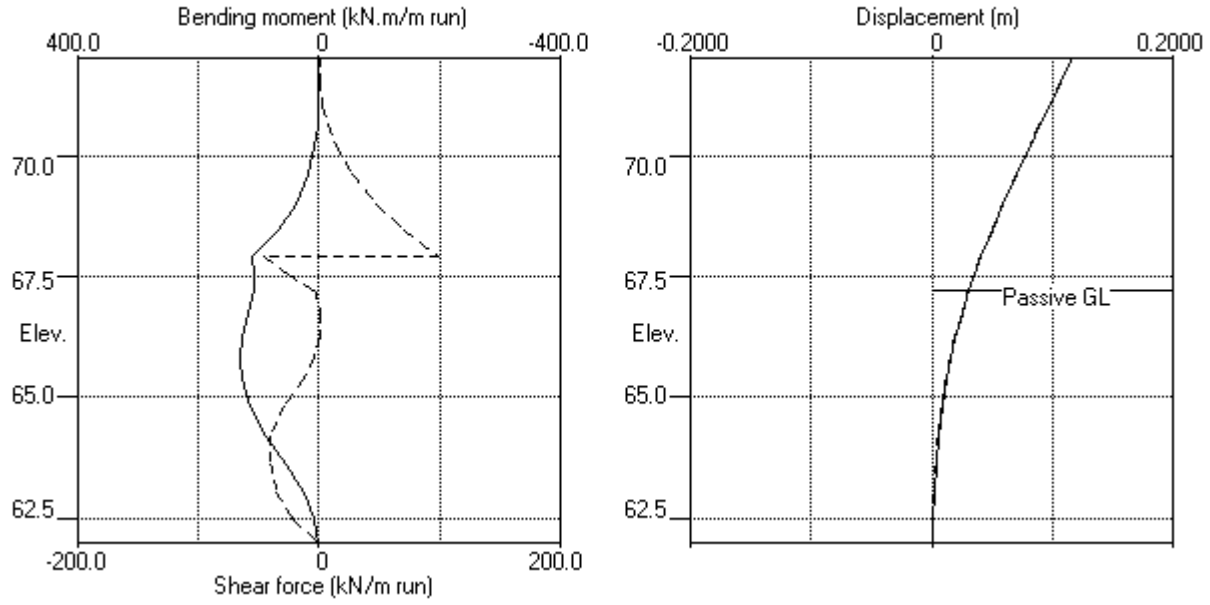
(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

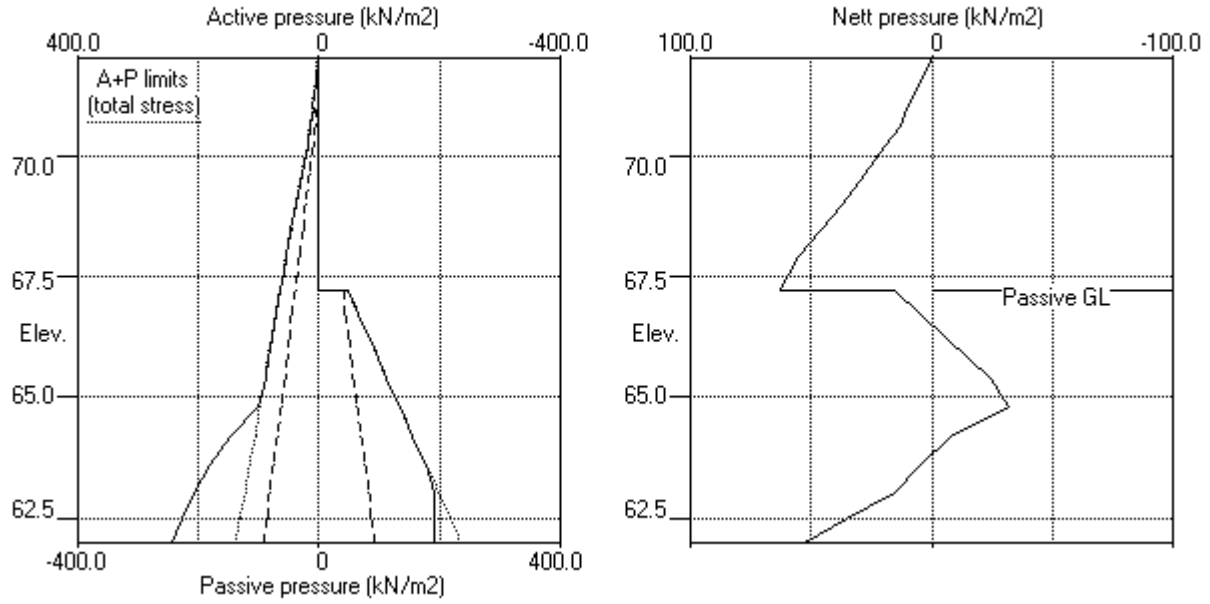
Note: 88.44a Soil pressure at active limit
177.01p Soil pressure at passive limit

Units: kN,m

Stage No.10 Change EI of wall to 31986kN.m2/m run



Stage No.10 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
1	72.00	72.00	Cant.	Conditions not suitable for FoS calc.			
2	72.00	72.00		No analysis at this stage			
3	72.00	66.70	Cant.	1.224	62.81	62.84	3.86
4	72.00	67.20	Cant.	1.463	62.69	63.79	3.41
5	72.00	67.20		No analysis at this stage			
6	72.00	67.20	67.90	Conditions not suitable for FoS calc.			
7	72.00	67.20		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	72.00	0.116	0.000	0.0	-0.0	0.0	0.0
2	71.50	0.106	0.000	0.2	0.0	1.3	-0.8
3	71.00	0.097	0.000	1.7	-0.0	5.3	0.0
4	70.60	0.089	-0.000	4.3	-0.0	7.7	0.0
5	70.20	0.082	-0.000	8.0	-0.0	13.8	0.0
6	69.60	0.070	-0.000	18.5	-0.0	28.2	0.0
7	69.00	0.059	-0.000	39.0	0.0	47.8	0.0
8	68.45	0.050	-0.000	68.4	0.0	70.7	0.0
9	67.90	0.041	-0.000	110.7	0.0	98.6	-45.9
10	67.55	0.035	-0.000	106.2	0.0	75.9	-25.9
11	67.20	0.031	-0.000	130.3	0.0	92.6	-4.5
12	66.70	0.024	-0.000	178.8	0.0	101.8	0.0
13	66.20	0.019	0.000	217.8	0.0	55.1	0.0
14	65.80	0.015	0.000	231.6	0.0	17.3	-3.9
15	65.40	0.012	0.000	228.8	0.0	0.0	-28.2
16	64.80	0.008	0.000	198.3	0.0	0.0	-82.7
17	64.20	0.006	0.000	142.6	0.0	0.0	-104.8
18	63.60	0.003	-0.000	79.4	-0.0	0.0	-92.5
19	63.00	0.002	-0.001	31.6	-0.0	0.0	-62.0
20	62.50	0.001	-0.001	8.0	-0.0	0.0	-31.6
21	62.00	0.001	-0.001	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	65.40	-0.0	63.00	0.0	72.00	0.0	72.00
2	No calculation at this stage							
3	219.2	65.80	0.0	72.00	96.3	66.70	-100.4	64.20
4	221.8	65.80	0.0	72.00	98.1	66.70	-101.3	64.20
5	No calculation at this stage							
6	231.6	65.80	-0.0	62.00	101.8	66.70	-104.8	64.20
7	No calculation at this stage							
8	No calculation at this stage							
9	No calculation at this stage							
10	129.7	65.80	-0.0	62.00	98.6	67.90	-45.9	67.90

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	62.00	-0.000	67.55	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 72.00
3	0.114	72.00	0.000	72.00	Excav. to elev. 66.70 on PASSIVE side
4	0.114	72.00	0.000	72.00	Fill to elev. 67.20 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	0.116	72.00	-0.001	62.50	Apply surcharge no.2 at elev. 67.20
7	No calculation at this stage				Install strut no.2 at elev. 71.50
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	0.116	72.00	-0.000	62.00	Change EI of wall to 31986kN.m2/m run

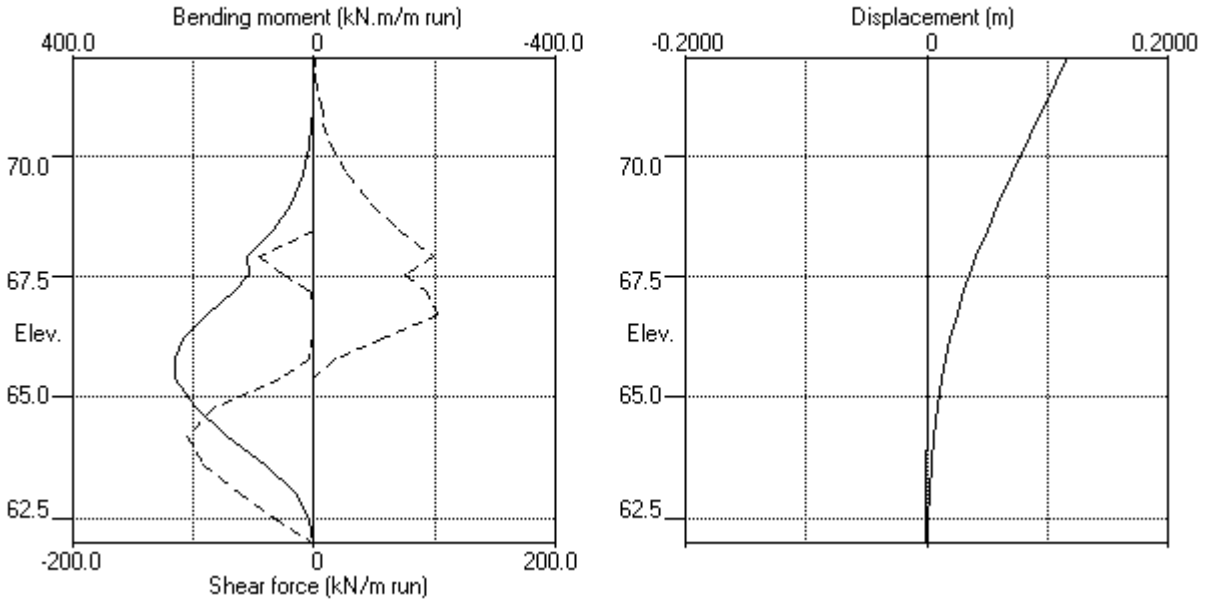
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90 kN/m run	Strut no. 1 at elev. 67.90 kN/strut	Strut no. 2 at elev. 71.50 kN/m run	Strut no. 2 at elev. 71.50 kN/strut
6	slack	slack	---	---
10	144.55	144.55	2.14	2.14

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	72.00	1 Head deposits	1 Head deposits
2	71.00	3 LC UN	3 LC UN
3	67.60	3 LC UN	4 LC UN
4	67.10	3 LC UN	3 LC UN

SOIL PROPERTIES

No.	Soil type Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	18000	0.590	OC (0.200)	0.376 (0.000)	3.077 (0.000)	
2	LC DR (71.00)	20.00	35200 (3904)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	2.500d
3	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
4	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
5	LC soft (67.60)	20.00	1 (126064)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	1.000u (126.0)

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	24.00	0.500	0.00	24.00	0.500	0.00
2	LC DR	25.00	0.500	0.00	25.00	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
5	LC soft	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	67.40	67.40

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	71.00	71.00	0.0	1	67.60	67.60	0.0
					2	67.60	71.00	34.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 62.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	72.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.60	-0.00(P)	20.00	20.00	34.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 72.00 No analysis at this stage
3	Excavate to elevation 67.60 on PASSIVE side
4	Change properties of soil type 4 to soil type 5 Ko pressures will not be reset
5	Install strut or anchor no.1 at elevation 67.90
6	Apply surcharge no.2 at elevation 67.60
7	Install strut or anchor no.2 at elevation 71.50
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change properties of soil type 5 to soil type 2 No analysis at this stage Ko pressures will not be reset
11	Change EI of wall to 31986 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 5.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 72.00	No	No	No
3	Excav. to elev. 67.60 on PASSIVE side	Yes	Yes	Yes
4	Change soil type 4 to soil type 5	No	No	No
5	Install strut no.1 at elev. 67.90	No	No	No
6	Apply surcharge no.2 at elev. 67.60	No	No	No
7	Install strut no.2 at elev. 71.50	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change soil type 5 to soil type 2	No	No	No
11	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
11	72.00	67.60		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	72.00	0.00	0.041	7.99E-03	0.0	-0.0		31986
2	71.50	4.45	0.037	7.99E-03	1.1	0.2	8.2	31986
		4.45	0.037	7.99E-03	-7.0	0.2		
3	71.00	9.22	0.033	8.01E-03	-3.6	-1.7		31986
		5.42	0.033	8.01E-03	-3.6	-1.7		
4	70.60	11.33	0.030	8.04E-03	-0.3	-1.8		31986
5	70.20	17.07	0.027	8.08E-03	5.4	-0.3		31986
6	69.60	25.51	0.022	8.06E-03	18.2	6.7		31986
7	69.00	33.84	0.017	7.83E-03	36.0	22.0		31986
8	68.45	41.87	0.013	7.27E-03	56.8	46.1		31986
9	67.90	52.18	0.009	6.15E-03	82.7	81.9	112.5	31986
		52.18	0.009	6.15E-03	-29.8	81.9		
10	67.60	56.54	0.008	5.40E-03	-13.5	81.4		31986
		10.47	0.008	5.40E-03	-13.5	81.4		
11	67.40	4.54	0.007	4.92E-03	-12.0	82.6		31986
12	67.10	-6.71	0.005	4.24E-03	-12.3	83.7		31986
13	66.55	-23.32	0.003	3.00E-03	-20.6	88.1		31986
14	66.00	-1.83	0.002	1.91E-03	-27.5	66.0		31986
15	65.40	5.38	0.001	1.08E-03	-26.4	40.1		31986
16	64.80	12.59	0.001	5.70E-04	-21.0	21.1		31986
17	64.20	13.88	0.000	2.91E-04	-13.1	8.6		31986
18	63.60	8.85	0.000	1.59E-04	-6.3	2.7		31986
19	63.00	3.17	0.000	9.72E-05	-2.7	0.9		31986
20	62.50	-1.37	0.000	7.00E-05	-2.2	0.6		31986
21	62.00	10.23	0.000	6.00E-05	0.0	-0.0		---

At elev. 71.50 Strut force = 8.2 kN/strut = 8.2 kN/m run
At elev. 67.90 Strut force = 112.5 kN/strut = 112.5 kN/m run

(continued)

Stage No.11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	30298
2	71.50	0.00	11.82	4.45	36.36	4.45	4.45a	4566
3	71.00	0.00	24.50	9.22	75.38	9.22	9.22a	4566
		0.00	24.50	5.42	91.76	5.42	5.42a	8929
4	70.60	4.00	29.79	7.33	108.97	7.33	11.33a	9325
5	70.20	8.00	34.61	9.07	124.65	9.07	17.07a	9722
6	69.60	14.00	41.37	11.51	146.63	11.51	25.51a	10316
7	69.00	20.00	47.81	13.84	167.60	13.84	33.84a	10910
8	68.45	25.50	53.56	15.91	186.31	16.37	41.87	11455
9	67.90	31.00	59.22	17.95	204.70	21.18	52.18	11999
10	67.60	34.00	62.27	19.06	214.63	22.54	56.54	12296
11	67.40	36.00	64.29	19.79	221.21	23.11	59.11	12495
12	67.10	39.00	67.32	20.88	231.05	21.62	60.62	12792
13	66.55	44.50	72.83	22.87	248.97	22.87	67.37a	13336
14	66.00	50.00	78.30	24.84	266.76	62.16	112.16	13881
15	65.40	56.00	84.23	26.98	286.06	88.68	144.68	14475
16	64.80	62.00	90.13	29.12	305.26	103.87	165.87	15069
17	64.20	68.00	96.01	31.24	324.39	111.96	179.96	15664
18	63.60	74.00	101.88	33.35	343.46	117.12	191.12	16258
19	63.00	80.00	107.73	35.47	362.48	121.56	201.56	16852
20	62.50	85.00	112.59	37.22	378.31	125.07	210.07	51374
21	62.00	90.00	117.45	38.98	394.12	136.61	226.61	108298

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	67.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		34.00	-0.00	0.00	12.08	12.08	46.08p	13256
11	67.40	36.00	2.00	0.00	18.58	18.58	54.58p	13470
12	67.10	39.00	5.00	0.00	28.33	28.33	67.33p	13790
13	66.55	44.50	10.49	0.36	46.19	46.19	90.69p	14378
14	66.00	50.00	15.96	2.34	63.98	63.98	113.98p	14965
15	65.40	56.00	21.89	4.48	83.29	83.29	139.29p	15605
16	64.80	62.00	27.79	6.61	102.48	91.28	153.28	16246
17	64.20	68.00	33.65	8.72	121.52	98.08	166.08	16887
18	63.60	74.00	39.46	10.82	140.43	108.28	182.28	17527
19	63.00	80.00	45.23	12.90	159.21	118.39	198.39	18168
20	62.50	85.00	50.02	14.63	174.78	126.44	211.44	51374
21	62.00	90.00	54.79	16.35	190.29	126.38	216.38	108298

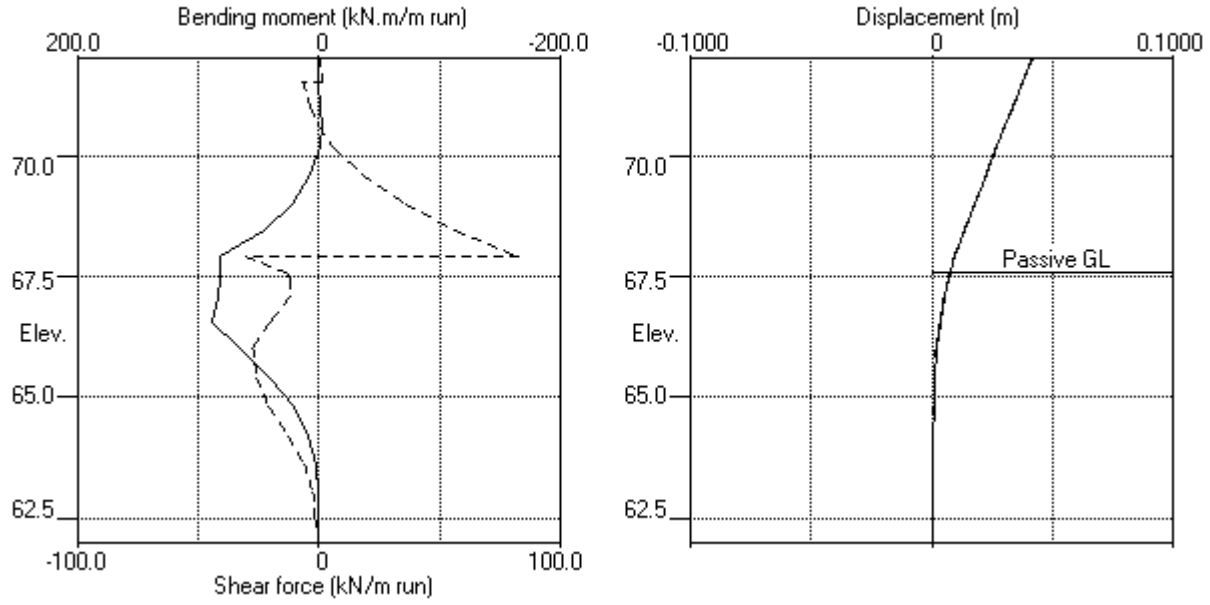
(continued)

Stage No.11 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

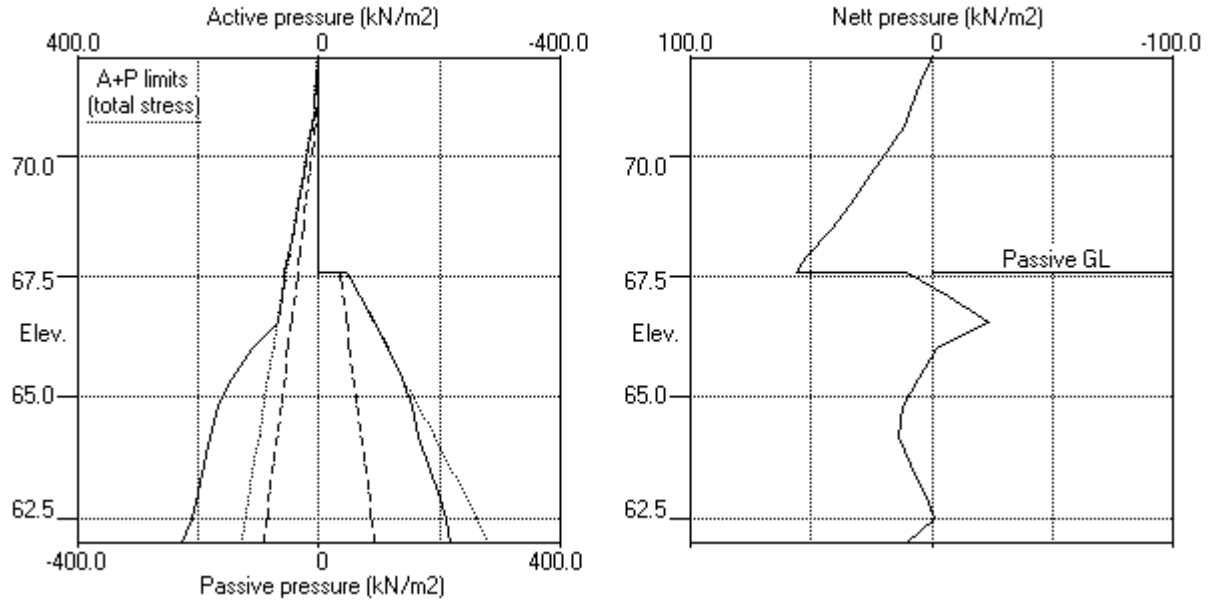
Note: 67.37a Soil pressure at active limit
139.29p Soil pressure at passive limit

Units: kN,m

Stage No.11 Change EI of wall to 31986kN.m2/m run



Stage No.11 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
1	72.00	72.00	Cant.	Conditions not suitable for FoS calc.			
2	72.00	72.00		No analysis at this stage			
3	72.00	67.60	Cant.	2.487	62.59	65.22	2.38
4	72.00	67.60	Cant.	2.388	62.63	64.83	2.77
5	72.00	67.60		No analysis at this stage			
6	72.00	67.60	67.90	Conditions not suitable for FoS calc.			
7	72.00	67.60		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	72.00	0.042	0.000	0.0	-0.0	0.0	0.0
2	71.50	0.037	0.000	0.2	-0.0	1.1	-7.0
3	71.00	0.033	0.000	1.5	-1.7	4.5	-3.6
4	70.60	0.030	0.000	3.8	-1.8	6.9	-0.3
5	70.20	0.027	0.000	7.1	-0.3	10.1	0.0
6	69.60	0.022	0.000	15.1	-0.0	18.2	0.0
7	69.00	0.017	-0.000	28.2	-0.0	36.0	0.0
8	68.45	0.013	-0.000	47.2	-0.0	56.8	0.0
9	67.90	0.009	-0.000	81.9	-0.0	82.7	-29.8
10	67.60	0.008	-0.000	95.6	-0.0	73.9	-13.5
11	67.40	0.007	-0.000	110.2	-0.0	70.0	-12.0
12	67.10	0.005	-0.000	127.6	0.0	43.1	-12.3
13	66.55	0.003	-0.000	142.6	0.0	0.0	-44.3
14	66.00	0.002	-0.000	106.8	0.0	0.0	-71.3
15	65.40	0.001	-0.000	59.9	0.0	0.0	-68.5
16	64.80	0.001	-0.000	24.6	0.0	0.0	-46.0
17	64.20	0.001	-0.000	8.6	-0.6	0.0	-23.1
18	63.60	0.001	-0.000	2.7	-3.9	0.0	-6.8
19	63.00	0.001	0.000	0.9	-3.5	2.8	-2.7
20	62.50	0.001	0.000	0.6	-1.6	3.5	-2.2
21	62.00	0.001	0.000	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	64.20	-0.0	63.00	0.0	72.00	0.0	72.00
2	No calculation at this stage							
3	108.7	67.10	-3.9	63.60	65.0	67.60	-60.8	66.00
4	136.0	66.55	-3.4	63.00	65.1	67.40	-68.3	66.00
5	No calculation at this stage							
6	142.6	66.55	-3.5	63.00	73.9	67.60	-71.3	66.00
7	No calculation at this stage							
8	No calculation at this stage							
9	No calculation at this stage							
10	No calculation at this stage							
11	88.1	66.55	-1.8	70.60	82.7	67.90	-29.8	67.90

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	62.00	-0.000	66.55	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 72.00
3	0.033	72.00	0.000	72.00	Excav. to elev. 67.60 on PASSIVE side
4	0.041	72.00	0.000	72.00	Change soil type 4 to soil type 5
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	0.042	72.00	-0.000	64.80	Apply surcharge no.2 at elev. 67.60
7	No calculation at this stage				Install strut no.2 at elev. 71.50
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	No calculation at this stage				Change soil type 5 to soil type 2
11	0.041	72.00	0.000	72.00	Change EI of wall to 31986kN.m2/m run

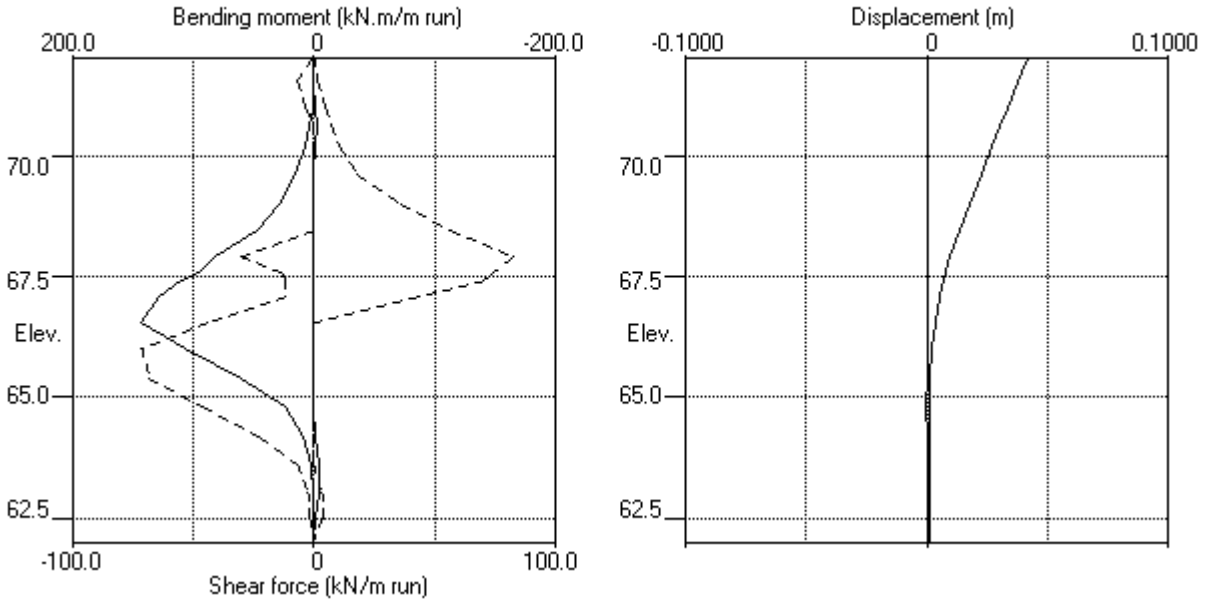
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90 kN/m run	Strut no. 1 at elev. 67.90 kN/strut	Strut no. 2 at elev. 71.50 kN/m run	Strut no. 2 at elev. 71.50 kN/strut
6	slack	slack	---	---
11	112.47	112.47	8.15	8.15

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types: Active side	Passive side
1	72.00	1 Head deposits	1 Head deposits
2	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	9000	0.650	OC (0.200)	0.436 (0.000)	2.540 (0.000)	
2	LC DR (71.00)	20.00	17600 (1952)	1.000	OC (0.200)	0.422 (1.489)	2.648 (4.248)	2.100d
3	LC UN (71.00)	20.00	22000 (2440)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	29.30u (3.300)

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	20.40	0.500	0.00	20.40	0.500	0.00
2	LC DR	21.20	0.500	0.00	21.20	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	67.00	67.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	71.00	71.00	0.0	1	67.60	67.60	0.0
					2	67.60	71.00	34.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 62.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin-ation (degs)	Pre-stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	72.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.60	-0.00(P)	20.00	20.00	34.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 72.00 No analysis at this stage
3	Excavate to elevation 67.20 on PASSIVE side
4	Fill to elevation 67.60 on PASSIVE side with soil type 3
5	Install strut or anchor no.1 at elevation 67.90
6	Apply surcharge no.2 at elevation 67.60
7	Install strut or anchor no.2 at elevation 71.50
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change EI of wall to 31986 kN.m2/m run From elevation 72.00 to 62.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 5.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 72.00	No	No	No
3	Excav. to elev. 67.20 on PASSIVE side	Yes	Yes	Yes
4	Fill to elev. 67.60 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 67.90	No	No	No
6	Apply surcharge no.2 at elev. 67.60	No	No	No
7	Install strut no.2 at elev. 71.50	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	72.00	67.60		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	72.00	0.00	0.075	1.30E-02	0.0	0.0		31986
2	71.50	5.16	0.068	1.30E-02	1.3	0.2	7.0	31986
		5.16	0.068	1.30E-02	-5.7	0.2		
3	71.00	10.69	0.062	1.30E-02	-1.8	-1.0		31986
		7.22	0.062	1.30E-02	-1.8	-1.0		
4	70.60	13.45	0.057	1.31E-02	2.4	-0.4		31986
5	70.20	19.49	0.051	1.31E-02	9.0	2.1		31986
6	69.60	28.34	0.043	1.30E-02	23.3	11.3		31986
7	69.00	37.06	0.036	1.26E-02	42.9	29.5		31986
8	68.45	46.01	0.029	1.19E-02	65.8	57.0		31986
9	67.90	56.14	0.023	1.05E-02	93.9	97.5	125.2	31986
		56.14	0.023	1.05E-02	-31.3	97.5		
10	67.60	60.69	0.020	9.58E-03	-13.8	96.9		31986
		17.77	0.020	9.58E-03	-13.8	96.9		
11	67.20	8.41	0.016	8.41E-03	-8.5	100.7		31986
12	67.00	3.56	0.015	7.84E-03	-7.3	102.9		31986
13	66.50	-10.17	0.011	6.47E-03	-9.0	104.8		31986
14	66.00	-21.24	0.008	5.16E-03	-16.8	103.7		31986
15	65.40	-10.41	0.005	3.69E-03	-26.3	92.3		31986
16	64.80	2.07	0.004	2.48E-03	-28.8	65.6		31986
17	64.20	5.19	0.002	1.65E-03	-26.7	41.1		31986
18	63.60	9.04	0.002	1.12E-03	-22.4	22.5		31986
19	63.00	13.26	0.001	8.46E-04	-15.7	9.0		31986
20	62.50	13.43	0.001	7.54E-04	-9.0	2.6		31986
21	62.00	22.67	0.000	7.31E-04	0.0	-0.0		---

At elev. 71.50 Strut force = 7.0 kN/strut = 7.0 kN/m run
At elev. 67.90 Strut force = 125.2 kN/strut = 125.2 kN/m run

(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	15027
2	71.50	0.00	11.82	5.16	30.01	5.16	5.16a	2147
3	71.00	0.00	24.50	10.69	62.22	10.69	10.69a	2147
		0.00	24.50	7.22	73.79	7.22	7.22a	4199
4	70.60	4.00	29.79	9.45	87.79	9.45	13.45a	4385
5	70.20	8.00	34.61	11.49	100.56	11.49	19.49a	4572
6	69.60	14.00	41.37	14.34	118.45	14.34	28.34a	4851
7	69.00	20.00	47.81	17.06	135.52	17.06	37.06a	5131
8	68.45	25.50	53.56	19.49	150.75	20.51	46.01	5387
9	67.90	31.00	59.22	21.88	165.71	25.14	56.14	5643
10	67.60	34.00	62.27	23.17	173.80	26.69	60.69	5783
11	67.20	38.00	66.31	24.88	184.50	27.92	65.92	5969
12	67.00	40.00	68.32	25.73	189.82	28.36	68.36	6062
13	66.50	45.00	73.33	27.84	203.07	27.84	72.84a	6295
14	66.00	50.00	78.30	29.94	216.23	29.94	79.94a	6528
15	65.40	56.00	84.23	32.44	231.94	56.48	112.48	6807
16	64.80	62.00	90.13	34.94	247.58	84.58	146.58	7087
17	64.20	68.00	96.01	37.42	263.15	103.20	171.20	7366
18	63.60	74.00	101.88	39.90	278.67	115.54	189.54	7645
19	63.00	80.00	107.73	42.36	294.15	124.39	204.39	7925
20	62.50	85.00	112.59	44.42	307.04	130.63	215.63	8158
21	62.00	90.00	117.45	46.47	319.90	141.55	231.55	613005

Node no.	Y coord	PASSIVE side						
			Effective stresses				Total	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	earth pressure	stiffness coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	67.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		34.00	-0.00	0.00	8.92	8.92	42.92p	5783
11	67.20	38.00	4.00	0.00	19.51	19.51	57.51p	5969
12	67.00	40.00	6.00	0.00	24.80	24.80	64.80p	6062
13	66.50	45.00	10.99	1.51	38.01	38.01	83.01p	6295
14	66.00	50.00	15.96	3.61	51.17	51.17	101.17p	6528
15	65.40	56.00	21.89	6.12	66.89	66.89	122.89p	6807
16	64.80	62.00	27.79	8.61	82.51	82.51	144.51p	7087
17	64.20	68.00	33.65	11.08	98.01	98.01	166.01p	7366
18	63.60	74.00	39.46	13.54	113.40	106.50	180.50	7645
19	63.00	80.00	45.23	15.97	128.69	111.13	191.13	7925
20	62.50	85.00	50.02	18.00	141.36	117.20	202.20	8158
21	62.00	90.00	54.79	20.01	153.98	118.88	208.88	613005

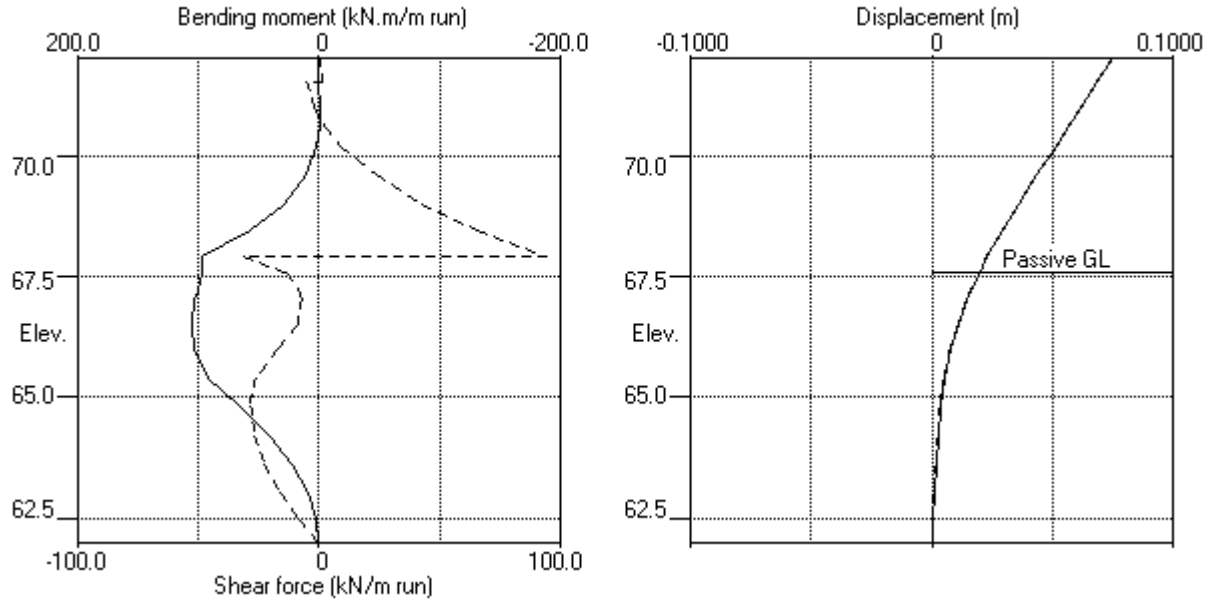
(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 72.00 to 62.00
Yield moment not defined
Allow wall to relax with new modulus value

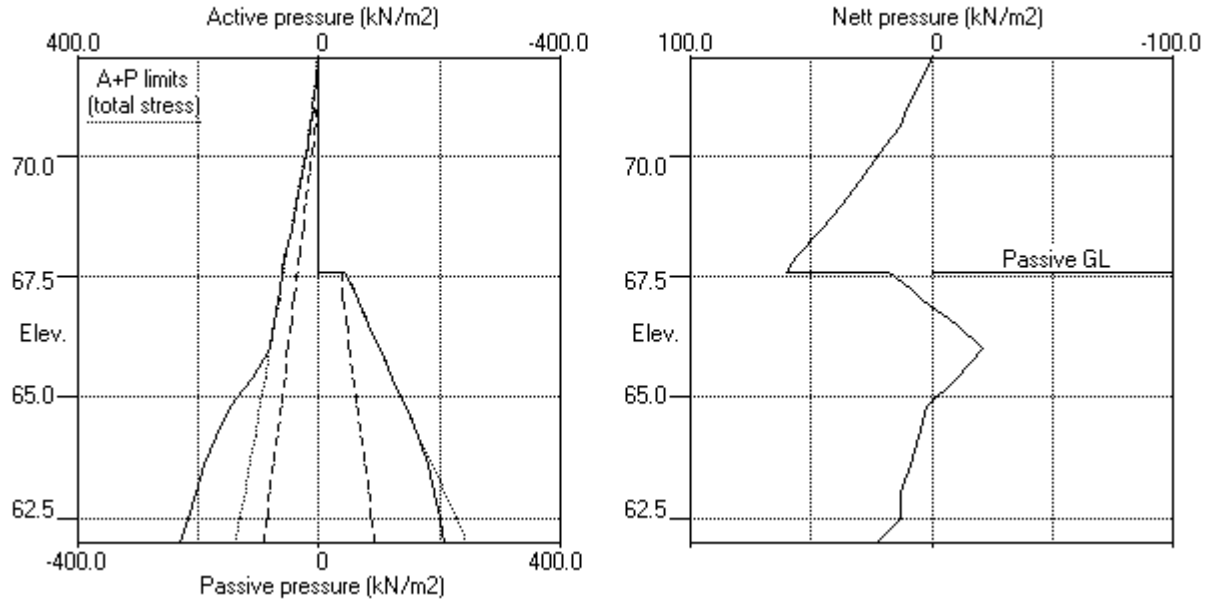
Note: 79.94a Soil pressure at active limit
166.01p Soil pressure at passive limit

Units: kN,m

Stage No.10 Change EI of wall to 31986kN.m2/m run



Stage No.10 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 62.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	72.00	72.00	Cant.	Conditions not suitable for FoS calc.			
2	72.00	72.00		No analysis at this stage			
3	72.00	67.20	Cant.	1.462	62.69	63.74	3.46
4	72.00	67.60	Cant.	1.670	62.58	64.50	3.10
5	72.00	67.60		No analysis at this stage			
6	72.00	67.60	67.90	Conditions not suitable for FoS calc.			
7	72.00	67.60		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	72.00	0.075	0.000	0.0	0.0	0.0	0.0
2	71.50	0.068	0.000	0.2	0.0	1.3	-5.7
3	71.00	0.062	0.000	1.7	-1.0	5.3	-1.8
4	70.60	0.057	-0.000	4.3	-0.4	7.7	0.0
5	70.20	0.051	-0.000	8.0	-0.0	10.9	0.0
6	69.60	0.043	-0.000	16.4	-0.0	23.3	0.0
7	69.00	0.036	-0.000	30.1	0.0	42.9	0.0
8	68.45	0.029	-0.000	57.0	0.0	65.8	0.0
9	67.90	0.023	-0.000	97.5	0.0	93.9	-31.3
10	67.60	0.020	-0.000	100.5	0.0	76.9	-13.8
11	67.20	0.016	-0.000	132.9	0.0	86.3	-8.5
12	67.00	0.015	-0.000	148.6	0.0	71.0	-7.3
13	66.50	0.011	-0.000	173.4	0.0	28.1	-9.0
14	66.00	0.008	0.000	178.2	0.0	0.0	-21.2
15	65.40	0.005	0.000	154.8	0.0	0.0	-64.9
16	64.80	0.004	0.000	106.7	0.0	0.0	-77.9
17	64.20	0.002	-0.000	61.4	0.0	0.0	-65.4
18	63.60	0.002	-0.000	28.2	-0.0	0.0	-43.7
19	63.00	0.001	-0.000	9.0	-0.0	0.0	-22.6
20	62.50	0.002	-0.000	2.6	-0.0	0.0	-9.0
21	62.00	0.002	0.000	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	65.40	-0.0	63.00	0.0	72.00	0.0	72.00
2	No calculation at this stage							
3	167.6	66.00	-0.0	62.00	80.2	67.20	-73.7	64.80
4	169.7	66.00	-0.0	62.00	81.8	67.20	-74.5	64.80
5	No calculation at this stage							
6	178.2	66.00	-0.0	62.00	86.3	67.20	-77.9	64.80
7	No calculation at this stage							
8	No calculation at this stage							
9	No calculation at this stage							
10	104.8	66.50	-1.0	71.00	93.9	67.90	-31.3	67.90

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum	elev.	minimum	elev.	Stage description
	m		m		
1	0.000	62.00	-0.000	67.60	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 72.00
3	0.074	72.00	0.000	72.00	Excav. to elev. 67.20 on PASSIVE side
4	0.074	72.00	0.000	72.00	Fill to elev. 67.60 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	0.075	72.00	-0.000	63.60	Apply surcharge no.2 at elev. 67.60
7	No calculation at this stage				Install strut no.2 at elev. 71.50
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	0.075	72.00	0.000	72.00	Change EI of wall to 31986kN.m2/m run

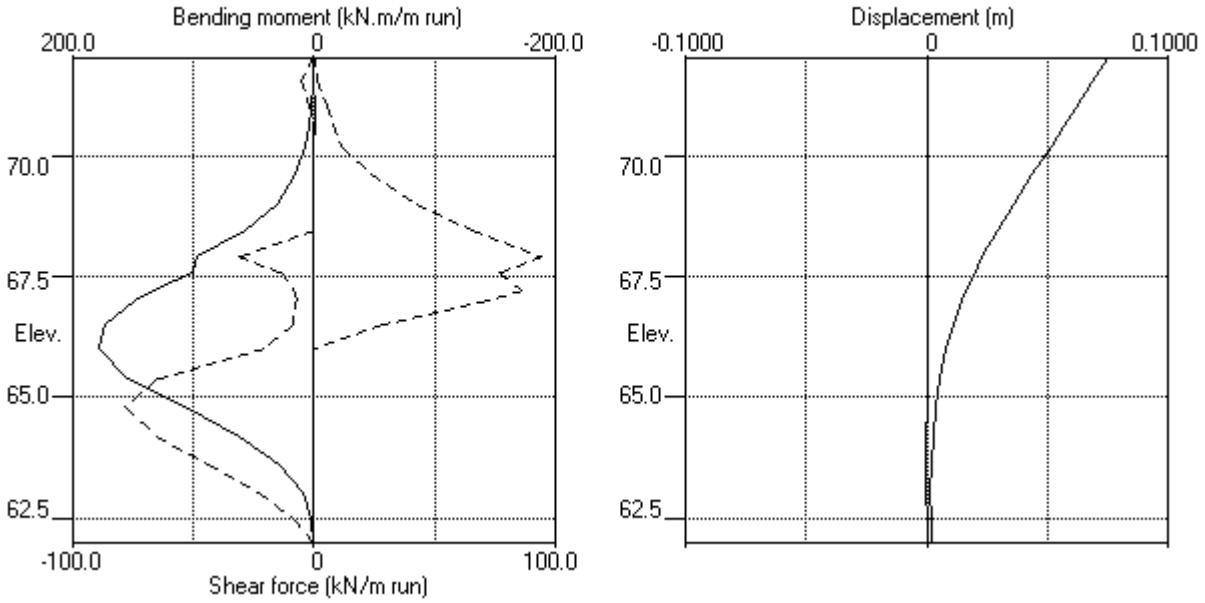
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90		Strut no. 2 at elev. 71.50	
	kN/m run	kN/strut	kN/m run	kN/strut
6	slack	slack	---	---
10	125.15	125.15	7.01	7.01

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	18000	0.652	OC (0.200)	0.376 (0.000)	3.077 (0.000)	
2	LC DR (71.00)	20.00	35200 (3904)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	2.500d
3	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
4	MG	18.00	10000	0.530	OC (0.200)	0.309 (0.000)	3.868 (0.000)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	24.00	0.500	0.00	24.00	0.500	0.00
2	LC DR	25.00	0.500	0.00	25.00	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	28.00	0.670	0.00	28.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	67.30	67.30

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	67.60	67.60	0.0
					2	67.60	74.00	64.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	74.75	10.00	0.030000	1.600E+06	0.10	0.00	0	No
3	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.60	-0.00(P)	20.00	20.00	64.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00
3	Install strut or anchor no.2 at elevation 74.75
4	Excavate to elevation 67.60 on PASSIVE side
5	Install strut or anchor no.1 at elevation 67.90
6	Install strut or anchor no.3 at elevation 71.50
7	Apply surcharge no.2 at elevation 67.60
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Install strut no.2 at elev. 74.75	No	No	No
4	Excav. to elev. 67.60 on PASSIVE side	Yes	Yes	Yes
5	Install strut no.1 at elev. 67.90	No	No	No
6	Install strut no.3 at elev. 71.50	No	No	No
7	Apply surcharge no.2 at elev. 67.60	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	75.00	67.60		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	-0.001	-7.69E-03	0.0	-0.0		31986
2	74.75	2.96	0.001	-7.69E-03	0.4	0.0	42.3	31986
		2.96	0.001	-7.69E-03	-41.9	0.0		
3	74.38	5.37	0.004	-7.60E-03	-40.4	-16.4		31986
4	74.00	7.72	0.007	-7.34E-03	-37.9	-32.2		31986
5	73.60	13.05	0.010	-6.87E-03	-33.7	-47.8		31986
6	73.20	18.30	0.012	-6.24E-03	-27.5	-61.4		31986
7	72.60	26.09	0.016	-5.05E-03	-14.2	-76.5		31986
8	72.00	33.77	0.018	-3.72E-03	3.8	-83.1		31986
		37.67	0.018	-3.72E-03	3.8	-83.1		
9	71.50	44.24	0.020	-2.63E-03	24.3	-79.7	89.3	31986
		44.24	0.020	-2.63E-03	-65.0	-79.7		
10	71.00	49.94	0.021	-1.39E-03	-41.5	-101.3		31986
		45.42	0.021	-1.39E-03	-41.5	-101.3		
11	70.60	50.89	0.021	-1.61E-04	-22.2	-110.9		31986
12	70.20	56.35	0.021	1.18E-03	-0.8	-113.4		31986
13	69.60	64.52	0.020	3.15E-03	35.5	-102.1		31986
14	69.00	72.68	0.017	4.71E-03	76.7	-70.5		31986
15	68.45	80.14	0.015	5.40E-03	118.7	-21.3		31986
16	67.90	87.59	0.012	4.97E-03	164.8	49.6	217.5	31986
		87.59	0.012	4.97E-03	-52.6	49.6		
17	67.60	91.66	0.010	4.42E-03	-25.8	47.5		31986
		15.58	0.010	4.42E-03	-25.8	47.5		
18	67.30	6.89	0.009	3.96E-03	-22.4	48.2		31986
19	66.95	-3.24	0.008	3.50E-03	-21.7	48.3		31986
20	66.60	-10.59	0.007	3.11E-03	-24.2	42.6		31986
21	66.00	7.83	0.005	2.60E-03	-25.0	30.5		31986
22	65.50	21.05	0.004	2.37E-03	-17.8	10.7		31986
23	65.00	50.03	0.002	2.31E-03	0.0	0.0		---

At elev. 74.75 Strut force = 422.9 kN/strut = 42.3 kN/m run
At elev. 71.50 Strut force = 89.3 kN/strut = 89.3 kN/m run
At elev. 67.90 Strut force = 217.5 kN/strut = 217.5 kN/m run

(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	5792
2	74.75	0.00	4.91	1.52	18.97	2.96	2.96	5792
3	74.38	0.00	13.85	4.28	53.57	5.37	5.37	5792
4	74.00	0.00	22.50	6.95	87.03	7.72	7.72	5792
5	73.60	4.00	26.99	8.34	104.40	9.05	13.05	5792
6	73.20	8.00	31.01	9.58	119.95	10.30	18.30	5792
7	72.60	14.00	36.57	11.30	141.45	12.09	26.09	3121
8	72.00	20.00	41.81	12.92	161.74	13.77	33.77	3121
		20.00	41.81	15.74	128.66	17.67	37.67	5618
9	71.50	25.00	47.05	17.70	144.76	19.24	44.24	5618
10	71.00	30.00	52.20	19.64	160.61	19.94	49.94	5618
		30.00	52.20	15.42	181.86	15.42	45.42a	10986
11	70.60	34.00	56.27	16.89	195.11	16.89	50.89a	11473
12	70.20	38.00	60.31	18.35	208.26	18.35	56.35a	11960
13	69.60	44.00	66.33	20.52	227.83	20.52	64.52a	12692
14	69.00	50.00	72.30	22.68	247.24	22.68	72.68a	13423
15	68.45	55.50	77.74	24.64	264.94	24.64	80.14a	14093
16	67.90	61.00	83.15	26.59	282.55	26.59	87.59a	14763
17	67.60	64.00	86.10	27.66	292.13	27.66	91.66a	15128
18	67.30	67.00	89.04	28.72	301.69	28.72	95.72a	15494
19	66.95	70.50	92.46	29.95	312.83	29.95	100.45a	15920
20	66.60	74.00	95.88	31.19	323.95	33.95	107.95	16347
21	66.00	80.00	101.73	33.30	342.97	71.68	151.68	17078
22	65.50	85.00	106.59	35.06	358.79	100.84	185.84	17687
23	65.00	90.00	111.45	36.81	374.60	137.40	227.40	18296

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.38	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	67.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		64.00	-0.00	0.00	12.08	12.08	76.08p	15128
18	67.30	67.00	3.00	0.00	21.82	21.82	88.82p	15494
19	66.95	70.50	6.49	0.00	33.20	33.20	103.70p	15920

(continued)

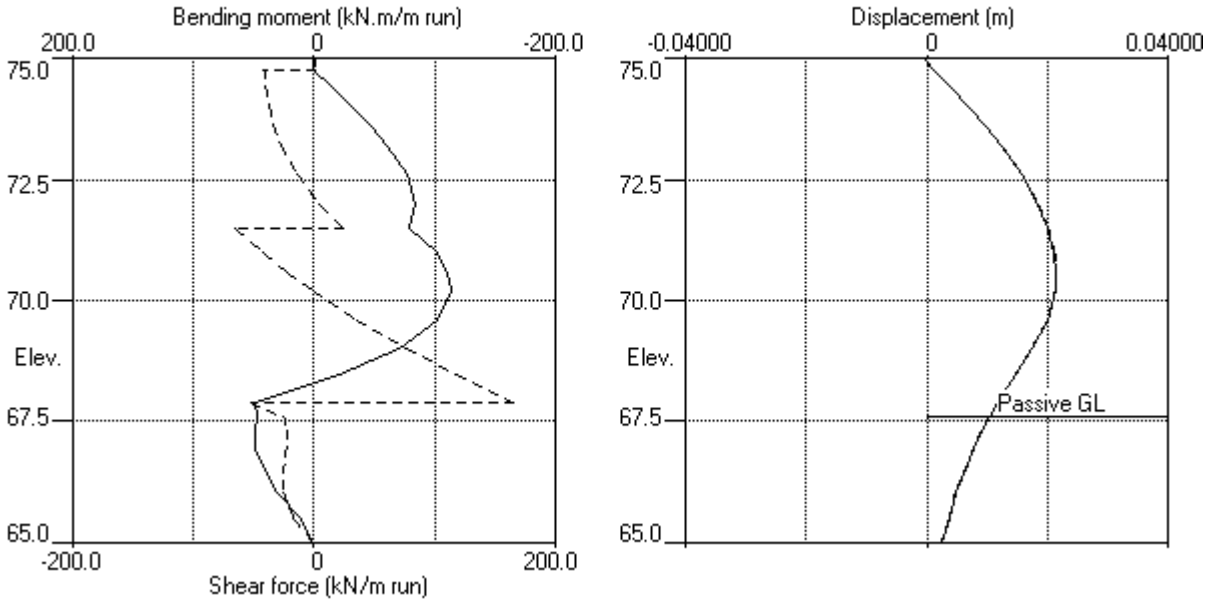
Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	66.60	74.00	9.98	0.18	44.53	44.53	118.53p	16347
21	66.00	80.00	15.91	2.32	63.85	63.85	143.85p	17078
22	65.50	85.00	20.81	4.09	79.78	79.78	164.78p	17687
23	65.00	90.00	25.66	5.84	95.54	87.36	177.36	18296

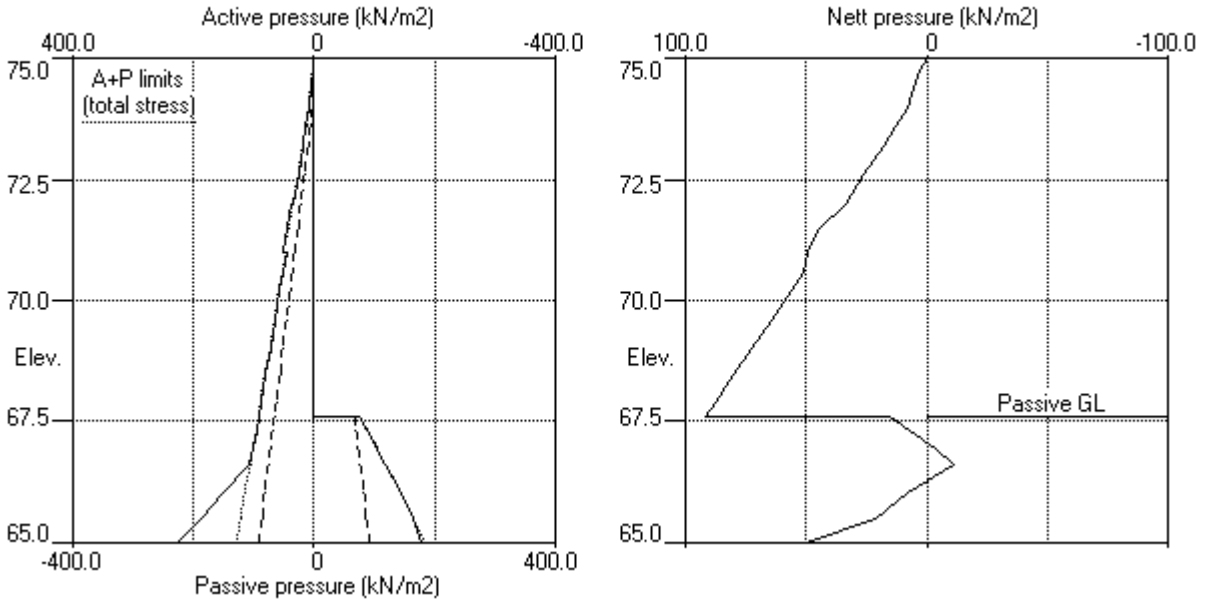
Note: 100.45a Soil pressure at active limit
164.78p Soil pressure at passive limit

Units: kN,m

Stage No.10 Change EI of wall to 31986kN.m2/m run



Stage No.10 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
3	75.00	75.00		No analysis at this stage			
4	75.00	67.60	74.75	1.649	n/a	66.84	0.76
5	75.00	67.60		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.000	-0.001	0.0	-0.0	0.0	0.0
2	74.75	0.001	0.000	0.0	0.0	0.4	-54.0
3	74.38	0.004	0.000	0.0	-20.1	0.0	-52.9
4	74.00	0.007	0.000	0.0	-39.5	0.0	-50.8
5	73.60	0.010	0.000	0.0	-59.3	0.0	-47.5
6	73.20	0.012	0.000	0.0	-77.4	0.0	-43.2
7	72.60	0.016	0.000	0.0	-101.0	0.0	-34.9
8	72.00	0.018	0.000	0.0	-118.9	3.8	-24.5
9	71.50	0.020	0.000	0.0	-128.1	24.3	-65.0
10	71.00	0.021	0.000	0.0	-131.8	2.8	-41.5
11	70.60	0.021	0.000	0.0	-130.2	11.2	-22.2
12	70.20	0.021	0.000	0.0	-125.0	20.4	-0.8
13	69.60	0.020	0.000	0.0	-109.7	35.7	0.0
14	69.00	0.017	0.000	0.0	-83.7	76.7	0.0
15	68.45	0.015	0.000	0.1	-48.9	118.7	0.0
16	67.90	0.012	0.000	49.6	-1.4	164.8	-52.6
17	67.60	0.010	0.000	47.5	0.0	115.0	-25.8
18	67.30	0.009	0.000	59.0	0.0	74.2	-22.4
19	66.95	0.008	0.000	78.8	0.0	26.5	-21.7
20	66.60	0.007	0.000	79.7	0.0	0.0	-24.2
21	66.00	0.005	0.000	59.4	0.0	0.0	-62.2
22	65.50	0.004	0.000	22.6	0.0	0.0	-59.4
23	65.00	0.002	-0.001	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	0.1	67.60	-0.8	72.60	0.4	72.00	-0.5	74.00
3	No calculation at this stage							
4	72.7	66.60	-129.7	71.00	99.7	67.60	-57.0	66.00
5	No calculation at this stage							
6	No calculation at this stage							
7	79.7	66.60	-131.8	71.00	115.0	67.60	-62.2	66.00
8	No calculation at this stage							
9	No calculation at this stage							
10	49.6	67.90	-113.4	70.20	164.8	67.90	-65.0	71.50

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	0.000	72.60	0.000	75.00	Apply surcharge no.1 at elev. 75.00
3	No calculation at this stage				Install strut no.2 at elev. 74.75
4	0.020	70.60	-0.000	75.00	Excav. to elev. 67.60 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	No calculation at this stage				Install strut no.3 at elev. 71.50
7	0.020	70.60	-0.001	65.00	Apply surcharge no.2 at elev. 67.60
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	0.021	70.60	-0.001	75.00	Change EI of wall to 31986kN.m2/m run

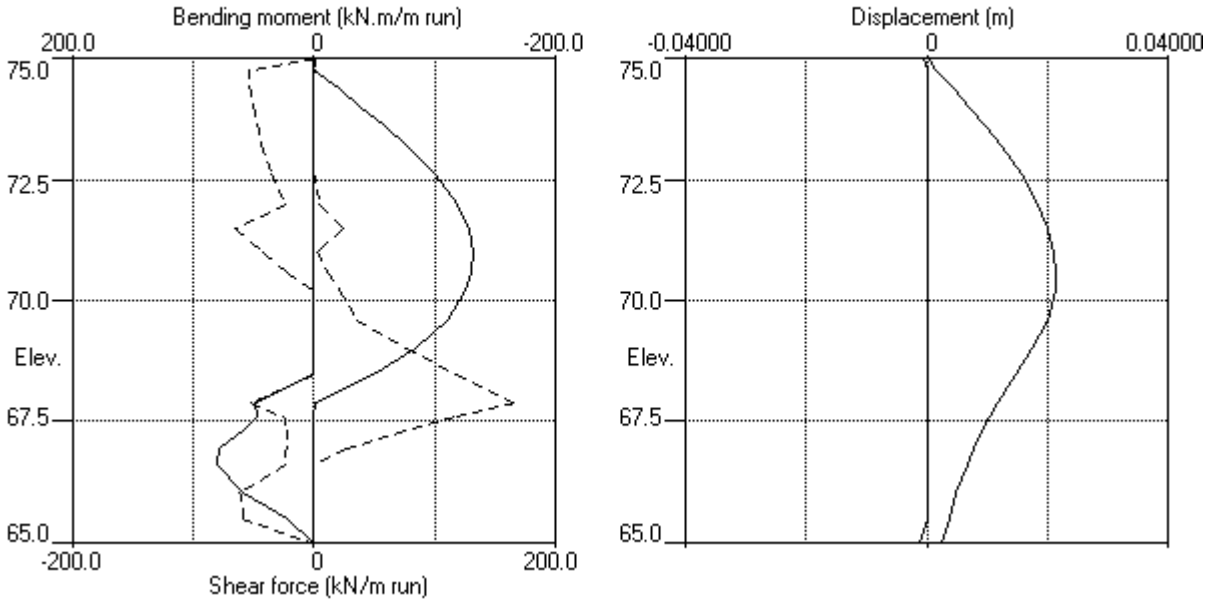
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90 kN/m run	Strut no. 1 kN/strut	Strut no. 2 at elev. 74.75 kN/m run	Strut no. 2 kN/strut	Strut no. 3 at elev. 71.50 kN/m run	Strut no. 3 kN/strut
4	---	---	54.01	540.14	---	---
7	slack	slack	54.21	542.14	2.74	2.74
10	217.46	217.46	42.29	422.85	89.29	89.29

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	9000	0.652	OC (0.200)	0.436 (0.000)	2.540 (0.000)	
2	LC DR (71.00)	20.00	17600 (1952)	1.000	OC (0.200)	0.422 (1.489)	2.648 (4.248)	2.100d
3	LC UN (71.00)	20.00	22000 (2440)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	29.30u (3.300)
4	MG	18.00	5000	0.530	OC (0.200)	0.368 (0.000)	3.060 (0.000)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	20.40	0.500	0.00	20.40	0.500	0.00
2	LC DR	21.20	0.500	0.00	21.20	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	23.90	0.670	0.00	23.90	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	67.30	67.30

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	67.60	67.60	0.0
					2	67.60	74.00	64.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	67.90	1.00	0.400000	1.500E+07	20.00	0.00	0	No
2	74.75	10.00	0.030000	1.600E+06	0.10	0.00	0	No
3	71.50	1.00	0.400000	1.500E+07	20.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	67.60	-0.00(P)	20.00	20.00	64.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00
3	Install strut or anchor no.2 at elevation 74.75
4	Excavate to elevation 67.60 on PASSIVE side
5	Install strut or anchor no.1 at elevation 67.90
6	Install strut or anchor no.3 at elevation 71.50
7	Apply surcharge no.2 at elevation 67.60
8	Apply water pressure profile no.1 No analysis at this stage
9	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
10	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Install strut no.2 at elev. 74.75	No	No	No
4	Excav. to elev. 67.60 on PASSIVE side	Yes	Yes	Yes
5	Install strut no.1 at elev. 67.90	No	No	No
6	Install strut no.3 at elev. 71.50	No	No	No
7	Apply surcharge no.2 at elev. 67.60	No	No	No
8	Apply water pressure profile no.1	No	No	No
9	Change soil type 3 to soil type 2	No	No	No
10	Change EI of wall to 31986kN.m2/m run	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	75.00	67.60		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	-0.002	-1.48E-02	0.0	0.0		31986
2	74.75	3.08	0.002	-1.48E-02	0.4	0.0	61.8	31986
		3.08	0.002	-1.48E-02	-61.4	0.0		
3	74.38	6.10	0.008	-1.47E-02	-59.7	-24.3		31986
4	74.00	9.02	0.013	-1.43E-02	-56.9	-47.8		31986
5	73.60	14.90	0.019	-1.36E-02	-52.1	-71.5		31986
6	73.20	20.66	0.024	-1.26E-02	-45.0	-92.9		31986
7	72.60	29.14	0.031	-1.08E-02	-30.0	-119.0		31986
8	72.00	37.55	0.037	-8.70E-03	-10.0	-135.4		31986
		41.61	0.037	-8.70E-03	-10.0	-135.4		
9	71.50	49.11	0.041	-6.82E-03	12.7	-139.2	92.4	31986
		49.11	0.041	-6.82E-03	-79.7	-139.2		
10	71.00	56.11	0.044	-4.67E-03	-53.4	-168.0		31986
		48.91	0.044	-4.67E-03	-53.4	-168.0		
11	70.60	54.63	0.045	-2.64E-03	-32.7	-182.5		31986
12	70.20	60.34	0.046	-4.53E-04	-9.7	-189.5		31986
13	69.60	68.88	0.045	2.86E-03	29.1	-183.9		31986
14	69.00	77.40	0.042	5.84E-03	73.0	-156.4		31986
15	68.45	85.20	0.039	7.87E-03	117.7	-109.3		31986
16	67.90	92.99	0.034	8.79E-03	166.7	-38.6	196.9	31986
		92.99	0.034	8.79E-03	-30.2	-38.6		
17	67.60	97.23	0.031	8.94E-03	-1.7	-35.1		31986
		24.31	0.031	8.94E-03	-1.7	-35.1		
18	67.30	17.62	0.029	9.12E-03	4.6	-27.5		31986
19	66.95	9.81	0.025	9.31E-03	9.4	-18.9		31986
20	66.60	2.02	0.022	9.47E-03	11.4	-11.3		31986
21	66.00	-11.23	0.016	9.65E-03	8.7	-3.1		31986
22	65.50	-20.59	0.011	9.69E-03	0.7	3.1		31986
23	65.00	17.68	0.007	9.68E-03	0.0	0.0		---

At elev. 74.75 Strut force = 618.0 kN/strut = 61.8 kN/m run
At elev. 71.50 Strut force = 92.4 kN/strut = 92.4 kN/m run
At elev. 67.90 Strut force = 196.9 kN/strut = 196.9 kN/m run

(continued)

Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	ACTIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	3237
2	74.75	0.00	4.91	1.81	15.01	3.08	3.08	3237
3	74.38	0.00	13.85	5.10	42.38	6.10	6.10	3237
4	74.00	0.00	22.50	8.28	68.85	9.02	9.02	3237
5	73.60	4.00	26.99	9.93	82.59	10.90	14.90	3237
6	73.20	8.00	31.01	11.41	94.89	12.66	20.66	3237
7	72.60	14.00	36.57	13.46	111.90	15.14	29.14	2005
8	72.00	20.00	41.81	15.39	127.95	17.55	37.55	2004
		20.00	41.81	18.24	106.20	21.61	41.61	3606
9	71.50	25.00	47.05	20.53	119.49	24.11	49.11	3606
10	71.00	30.00	52.20	22.77	132.57	26.11	56.11	3606
		30.00	52.20	18.91	147.12	18.91	48.91a	7052
11	70.60	34.00	56.27	20.63	157.91	20.63	54.63a	7365
12	70.20	38.00	60.31	22.34	168.61	22.34	60.34a	7678
13	69.60	44.00	66.33	24.88	184.54	24.88	68.88a	8148
14	69.00	50.00	72.30	27.40	200.35	27.40	77.40a	8617
15	68.45	55.50	77.74	29.70	214.75	29.70	85.20a	9047
16	67.90	61.00	83.15	31.99	229.09	31.99	92.99a	9477
17	67.60	64.00	86.10	33.23	236.89	33.23	97.23a	9712
18	67.30	67.00	89.04	34.47	244.67	34.47	101.47a	9947
19	66.95	70.50	92.46	35.92	253.73	35.92	106.42a	10220
20	66.60	74.00	95.88	37.36	262.78	37.36	111.36a	10494
21	66.00	80.00	101.73	39.83	278.27	39.83	119.83a	10963
22	65.50	85.00	106.59	41.89	291.15	43.44	128.44	11355
23	65.00	90.00	111.45	43.94	304.02	94.54	184.54	11746

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.38	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	70.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	70.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	69.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	69.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	68.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	67.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	67.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		64.00	-0.00	0.00	8.92	8.92	72.92p	9720
18	67.30	67.00	3.00	0.00	16.85	16.85	83.85p	9955
19	66.95	70.50	6.49	0.00	26.11	26.11	96.61p	10229

(continued)

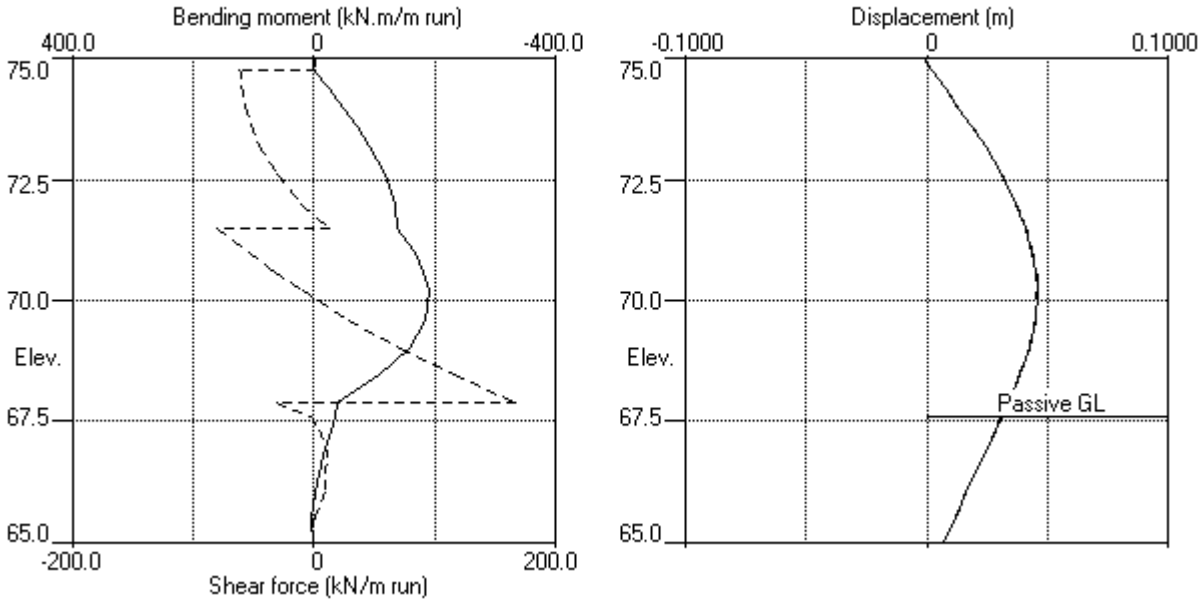
Stage No.10 Change EI of wall to 31986 kN.m2/m run
From elevation 75.00 to 65.00
Yield moment not defined
Allow wall to relax with new modulus value

Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
20	66.60	74.00	9.98	1.09	35.34	35.34	109.34p	10503
21	66.00	80.00	15.91	3.59	51.06	51.06	131.06p	10973
22	65.50	85.00	20.81	5.66	64.03	64.03	149.03p	11364
23	65.00	90.00	25.66	7.71	76.86	76.86	166.86p	11756

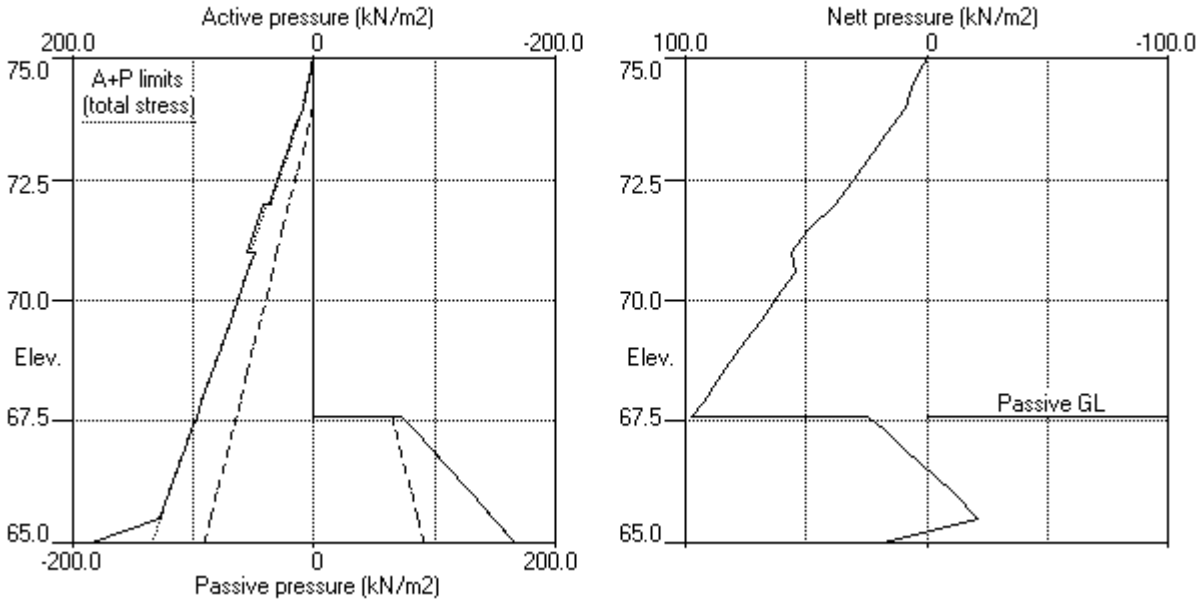
Note: 119.83a Soil pressure at active limit
166.86p Soil pressure at passive limit

Units: kN,m

Stage No.10 Change EI of wall to 31986kN.m2/m run



Stage No.10 Change EI of wall to 31986kN.m2/m run



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
3	75.00	75.00		No analysis at this stage			
4	75.00	67.60	74.75	1.107	n/a	65.84	1.76
5	75.00	67.60		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.001	-0.002	0.0	0.0	0.0	0.0
2	74.75	0.002	0.000	0.0	0.0	0.4	-80.5
3	74.38	0.008	0.000	0.0	-30.0	0.0	-79.2
4	74.00	0.013	0.000	0.0	-59.2	0.0	-76.7
5	73.60	0.019	0.000	0.0	-89.2	0.0	-72.8
6	73.20	0.024	0.000	0.0	-117.3	0.0	-67.6
7	72.60	0.031	0.000	0.0	-155.0	0.0	-57.7
8	72.00	0.037	0.000	0.0	-186.0	0.3	-45.3
9	71.50	0.041	0.000	0.0	-205.1	12.7	-79.7
10	71.00	0.044	0.000	0.0	-217.7	0.2	-53.4
11	70.60	0.045	0.000	0.0	-222.6	0.3	-32.7
12	70.20	0.046	0.000	0.0	-223.9	4.6	-9.7
13	69.60	0.045	0.000	0.0	-217.8	29.1	0.0
14	69.00	0.042	0.000	0.0	-199.9	73.0	0.0
15	68.45	0.039	0.000	0.0	-170.0	117.7	0.0
16	67.90	0.034	0.000	0.1	-124.2	166.7	-30.2
17	67.60	0.031	0.000	0.1	-93.5	120.3	-1.7
18	67.30	0.029	0.000	0.1	-64.5	98.9	0.0
19	66.95	0.025	0.000	0.1	-36.3	74.1	-0.0
20	66.60	0.022	0.000	0.1	-14.7	51.7	-0.0
21	66.00	0.016	0.000	9.8	-3.1	13.1	-0.1
22	65.50	0.011	0.000	8.8	0.0	0.7	-18.3
23	65.00	0.007	-0.001	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	0.1	67.30	-0.9	72.60	0.3	72.00	-0.6	74.00
3	No calculation at this stage							
4	7.1	65.50	-216.6	70.20	103.2	67.60	-79.6	74.75
5	No calculation at this stage							
6	No calculation at this stage							
7	9.8	66.00	-223.9	70.20	120.3	67.60	-80.5	74.75
8	No calculation at this stage							
9	No calculation at this stage							
10	3.1	65.50	-189.5	70.20	166.7	67.90	-79.7	71.50

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	0.001	73.60	0.000	75.00	Apply surcharge no.1 at elev. 75.00
3	No calculation at this stage				Install strut no.2 at elev. 74.75
4	0.045	70.20	-0.001	75.00	Excav. to elev. 67.60 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 67.90
6	No calculation at this stage				Install strut no.3 at elev. 71.50
7	0.045	70.20	-0.001	75.00	Apply surcharge no.2 at elev. 67.60
8	No calculation at this stage				Apply water pressure profile no.1
9	No calculation at this stage				Change soil type 3 to soil type 2
10	0.046	70.20	-0.002	75.00	Change EI of wall to 31986kN.m2/m run

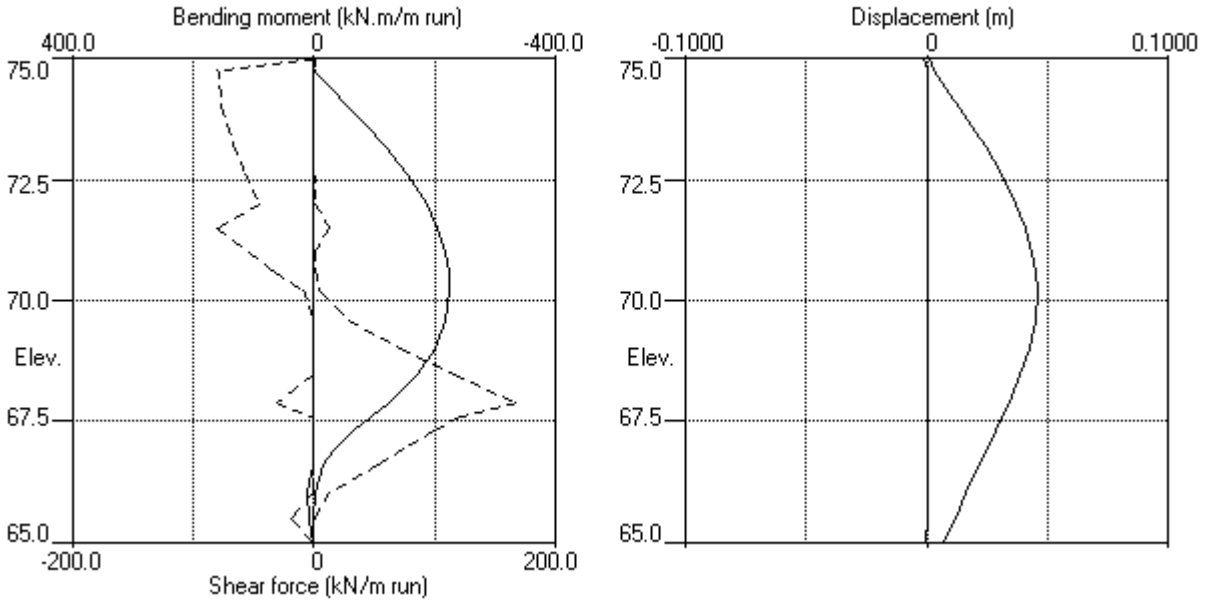
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 67.90 kN/m run	Strut no. 1 kN/strut	Strut no. 2 at elev. 74.75 kN/m run	Strut no. 2 kN/strut	Strut no. 3 at elev. 71.50 kN/m run	Strut no. 3 kN/strut
4	---	---	79.85	798.45	---	---
7	slack	slack	80.72	807.22	2.65	2.65
10	196.92	196.92	61.80	618.02	92.36	92.36

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	18000	0.590	OC (0.200)	0.376 (0.000)	3.077 (0.000)	
2	LC DR (71.00)	20.00	35200 (3904)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	2.500d
3	LC UN (71.00)	20.00	44000 (4880)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	44.00u (4.900)
4	MG	18.00	10000	0.530	OC (0.200)	0.309 (0.000)	3.868 (0.000)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	24.00	0.500	0.00	24.00	0.500	0.00
2	LC DR	25.00	0.500	0.00	25.00	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	28.00	0.670	0.00	28.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	71.00	71.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	71.50	71.50	0.0
					2	71.50	74.00	25.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	71.60	1.00	0.400000	1.500E+07	20.00	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	75.00	55.00	0	0	N/A

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	71.50	-0.00(P)	20.00	20.00	25.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00 No analysis at this stage
3	Excavate to elevation 71.50 on PASSIVE side
4	Install strut or anchor no.1 at elevation 71.60
5	Apply surcharge no.2 at elevation 71.50
6	Apply water pressure profile no.1 No analysis at this stage
7	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
8	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
9	Apply load no.1 at elevation 75.00

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Excav. to elev. 71.50 on PASSIVE side	Yes	Yes	Yes
4	Install strut no.1 at elev. 71.60	No	No	No
5	Apply surcharge no.2 at elev. 71.50	No	No	No
6	Apply water pressure profile no.1	No	No	No
7	Change soil type 3 to soil type 2	No	No	No
8	Change EI of wall to 31986kN.m2/m run	No	No	No
9	Apply load no.1 at elev. 75.00	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 9 Apply load no.1 at elevation 75.00

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
9	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	0.067	2.10E-02	55.0	0.0	-55.0	31986
2	74.50	3.34	0.056	2.07E-02	55.8	27.6		31986
3	74.00	6.95	0.046	2.01E-02	58.4	56.1		31986
4	73.60	12.34	0.038	1.92E-02	62.3	80.2		31986
5	73.20	17.58	0.030	1.81E-02	68.3	106.2		31986
6	72.60	25.30	0.020	1.57E-02	81.1	150.3		31986
7	72.00	32.92	0.012	1.23E-02	98.6	202.9		31986
		35.74	0.012	1.23E-02	98.6	202.9		
8	71.60	41.31	0.007	9.55E-03	114.0	244.0	232.4	31986
		41.31	0.007	9.55E-03	-118.4	244.0		
9	71.50	42.70	0.006	8.80E-03	-114.2	233.5		31986
		17.70	0.006	8.80E-03	-114.2	233.5		
10	71.00	21.46	0.003	5.55E-03	-104.4	183.7		31986
		18.59	0.003	5.55E-03	-104.4	183.7		
11	70.60	20.03	0.001	3.55E-03	-96.7	147.7		31986
12	70.20	32.24	-0.000	2.00E-03	-86.2	112.9		31986
13	69.60	33.26	-0.001	4.73E-04	-66.6	61.9		31986
14	69.00	35.49	-0.001	-2.80E-04	-45.9	25.1		31986
15	68.40	32.64	-0.000	-5.13E-04	-25.5	2.3		31986
16	67.80	22.16	-0.000	-4.59E-04	-9.1	-7.9		31986
17	67.20	11.27	0.000	-3.03E-04	1.0	-9.7		31986
18	66.60	2.73	0.000	-1.59E-04	5.2	-7.0		31986
19	66.00	-3.24	0.000	-7.21E-05	5.0	-3.2		31986
20	65.50	-5.45	0.000	-4.42E-05	2.8	-0.9		31986
21	65.00	-5.88	0.000	-3.84E-05	0.0	0.0		---

At elev. 71.60 Strut force = 232.4 kN/strut = 232.4 kN/m run

(continued)

Stage No.9 Apply load no.1 at elevation 75.00

Node no.	Y coord	ACTIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	4412
2	74.50	0.00	10.82	3.34	41.84	3.34	3.34a	4412
3	74.00	0.00	22.50	6.95	87.03	6.95	6.95a	4412
4	73.60	4.00	26.99	8.34	104.40	8.34	12.34a	4412
5	73.20	8.00	31.01	9.58	119.95	9.58	17.58a	4412
6	72.60	14.00	36.57	11.30	141.45	11.30	25.30a	4412
7	72.00	20.00	41.81	12.92	161.74	12.92	32.92a	4412
		20.00	41.81	15.74	128.66	15.74	35.74a	7941
8	71.60	24.00	46.01	17.31	141.56	17.31	41.31a	7941
9	71.50	25.00	47.05	17.70	144.76	17.70	42.70a	7941
10	71.00	30.00	52.20	19.64	160.61	28.78	58.78	5749
		30.00	52.20	15.42	181.86	31.17	61.17	11242
11	70.60	34.00	56.27	16.89	195.11	39.13	73.13	11741
12	70.20	38.00	60.31	18.35	208.26	62.40	100.40	12240
13	69.60	44.00	66.33	20.52	227.83	85.45	129.45	12988
14	69.00	50.00	72.30	22.68	247.24	96.14	146.14	13736
15	68.40	56.00	78.23	24.82	266.54	99.93	155.93	14484
16	67.80	62.00	84.13	26.95	285.75	101.20	163.20	15232
17	67.20	68.00	90.01	29.07	304.88	102.63	170.63	15980
18	66.60	74.00	95.88	31.19	323.95	105.14	179.14	24006
19	66.00	80.00	101.73	33.30	342.97	108.68	188.68	25080
20	65.50	85.00	106.59	35.06	358.79	112.87	197.87	25975
21	65.00	90.00	111.45	36.81	374.60	117.86	207.86	26869

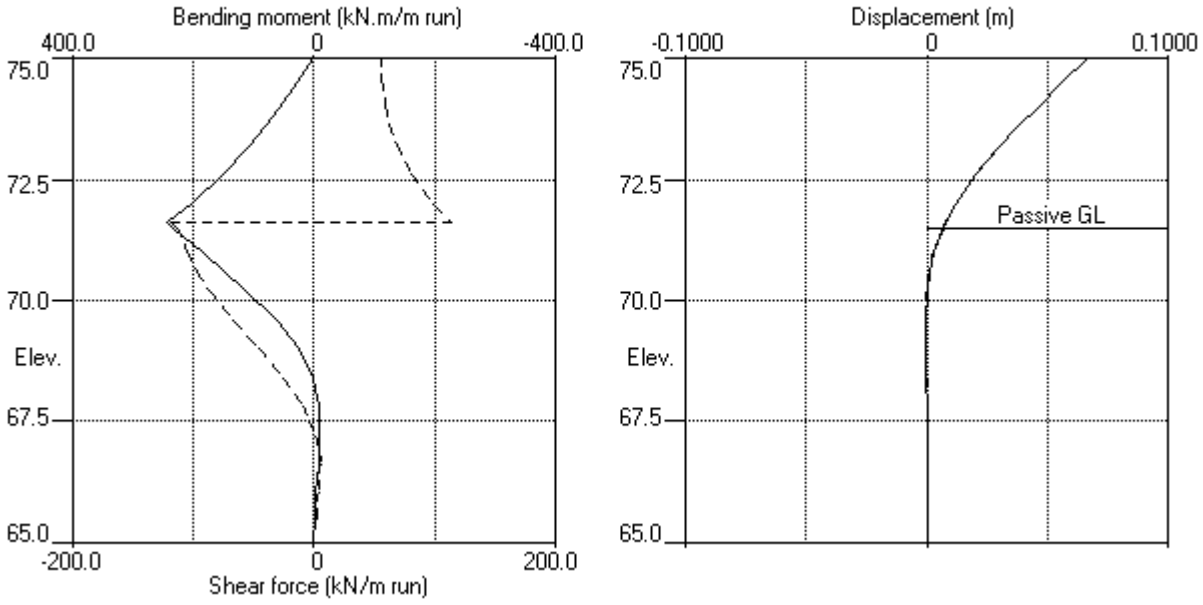
Node no.	Y coord	PASSIVE side						
			Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	71.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		25.00	0.00	0.00	0.00	0.00	25.00	84580
10	71.00	30.00	5.00	1.88	15.38	7.32	37.32	5749
		30.00	5.00	0.00	28.34	12.58	42.58	11242
11	70.60	34.00	8.99	0.00	41.33	19.10	53.10	11741
12	70.20	38.00	12.98	1.26	54.31	30.16	68.16	12240
13	69.60	44.00	18.95	3.42	73.71	52.19	96.19	12988
14	69.00	50.00	24.89	5.56	93.03	60.65	110.65	13736
15	68.40	56.00	30.80	7.69	112.25	67.30	123.30	14484
16	67.80	62.00	36.67	9.81	131.37	79.03	141.03	15232
17	67.20	68.00	42.52	11.93	150.38	91.36	159.36	15980
18	66.60	74.00	48.34	14.03	169.31	102.41	176.41	24006
19	66.00	80.00	54.14	16.12	188.17	111.93	191.93	25080
20	65.50	85.00	58.96	17.86	203.85	118.31	203.31	25975
21	65.00	90.00	63.77	19.60	219.51	123.75	213.75	26869

(continued)

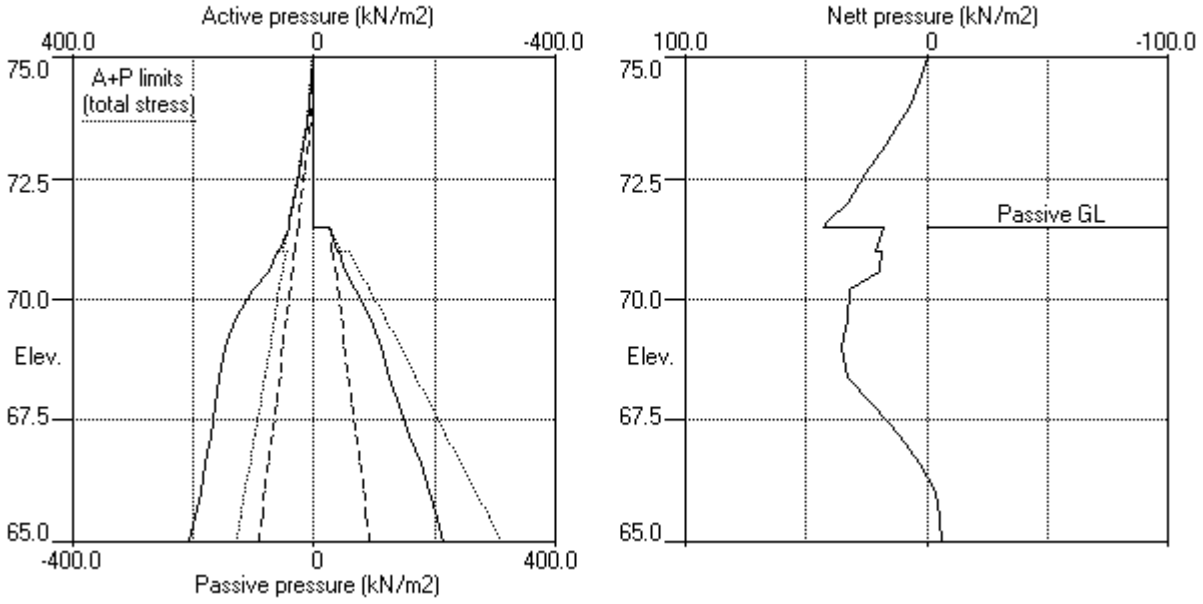
Stage No.9 Apply load no.1 at elevation 75.00
Note: 42.70a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.9 Apply load no.1 at elev. 75.00



Stage No.9 Apply load no.1 at elev. 75.00



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00		No analysis at this stage			
3	75.00	71.50	Cant.	2.126	65.84	68.77	2.73
4	75.00	71.50		No analysis at this stage			
5	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
6	75.00	71.50		No analysis at this stage			
7	75.00	71.50		No analysis at this stage			
8	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
9	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.067	0.000	0.0	-0.0	55.0	0.0
2	74.50	0.056	0.000	27.6	0.0	55.8	0.0
3	74.00	0.046	0.000	56.1	0.0	58.4	0.0
4	73.60	0.038	0.000	80.2	0.0	62.3	0.0
5	73.20	0.030	0.000	106.2	0.0	68.3	0.0
6	72.60	0.020	0.000	150.3	0.0	81.1	0.0
7	72.00	0.012	0.000	202.9	0.0	98.6	0.0
8	71.60	0.007	0.000	244.0	0.0	114.0	-118.4
9	71.50	0.006	0.000	233.5	0.0	45.5	-114.2
10	71.00	0.004	0.000	183.7	0.0	50.3	-104.4
11	70.60	0.003	0.000	147.7	0.0	9.9	-96.7
12	70.20	0.002	-0.000	112.9	0.0	0.0	-86.2
13	69.60	0.001	-0.001	63.5	0.0	0.0	-66.6
14	69.00	0.001	-0.001	36.6	0.0	0.0	-45.9
15	68.40	0.001	-0.000	15.9	0.0	0.0	-27.7
16	67.80	0.001	-0.000	4.6	-7.9	0.0	-15.0
17	67.20	0.001	0.000	0.1	-9.7	1.0	-5.4
18	66.60	0.001	0.000	0.0	-7.0	5.2	-0.9
19	66.00	0.001	0.000	0.0	-3.2	5.0	0.0
20	65.50	0.001	0.000	0.0	-0.9	2.8	0.0
21	65.00	0.001	0.000	0.0	0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	No calculation at this stage							
3	85.2	70.60	-2.9	66.60	49.2	71.00	-40.9	69.60
4	No calculation at this stage							
5	89.5	70.60	-3.1	66.60	50.3	71.00	-42.7	69.60
6	No calculation at this stage							
7	No calculation at this stage							
8	66.2	70.60	-1.1	66.60	59.0	71.60	-23.9	69.00
9	244.0	71.60	-9.7	67.20	114.0	71.60	-118.4	71.60

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 75.00
3	0.023	75.00	0.000	75.00	Excav. to elev. 71.50 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 71.60
5	0.023	75.00	-0.000	68.40	Apply surcharge no.2 at elev. 71.50
6	No calculation at this stage				Apply water pressure profile no.1
7	No calculation at this stage				Change soil type 3 to soil type 2
8	0.027	75.00	0.000	75.00	Change EI of wall to 31986kN.m2/m run
9	0.067	75.00	-0.001	69.00	Apply load no.1 at elev. 75.00

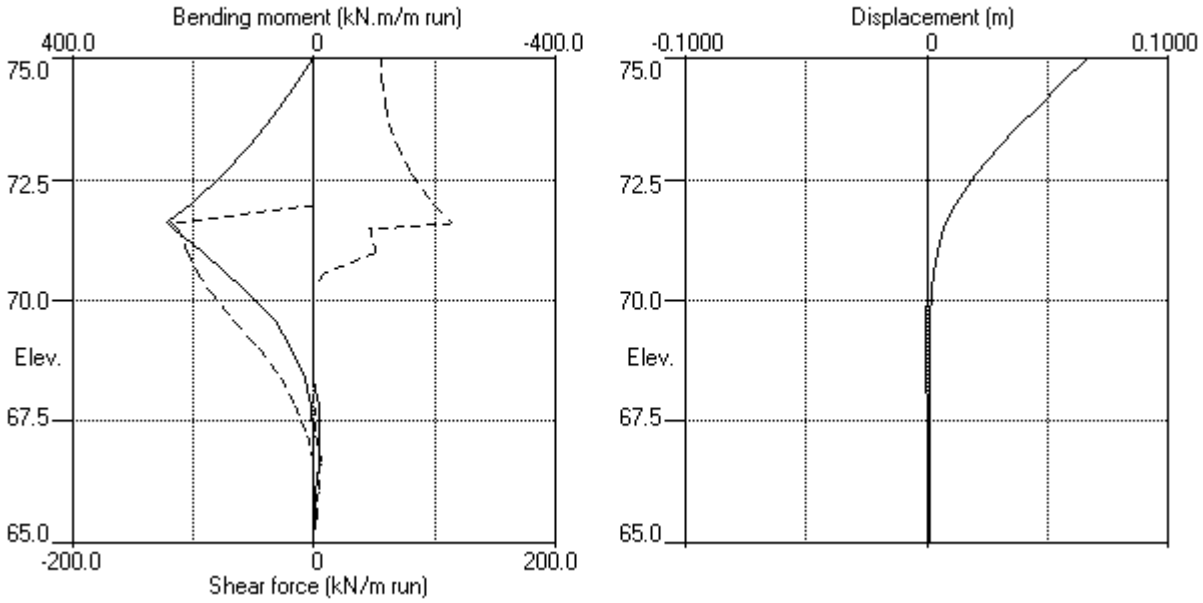
Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 71.60 kN/m run	kN/strut
5	slack	slack
8	67.76	67.76
9	232.38	232.38

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	75.00	4 MG	4 MG
2	72.00	1 Head deposits	1 Head deposits
3	71.00	3 LC UN	3 LC UN

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Head deposits	20.00	9000	0.650	OC (0.200)	0.436 (0.000)	2.540 (0.000)	
2	LC DR (71.00)	20.00	17600 (1952)	1.000	OC (0.200)	0.422 (1.489)	2.648 (4.248)	2.100d
3	LC UN (71.00)	20.00	22000 (2440)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	29.30u (3.300)
4	MG	18.00	5000	0.590	OC (0.200)	0.368 (0.000)	3.060 (0.000)	

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Head deposits	20.40	0.500	0.00	20.40	0.500	0.00
2	LC DR	21.20	0.500	0.00	21.20	0.500	0.00
3	LC UN	0.00	0.500	0.00	0.00	0.500	0.00
4	MG	23.90	0.670	0.00	23.90	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	71.00	71.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	74.00	74.00	0.0	1	71.50	71.50	0.0
					2	71.50	74.00	25.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 65.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 2.2847E-03 m4/m run
E.I = 63972 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	71.60	1.00	0.400000	1.500E+07	20.00	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	75.00	55.00	0	0	N/A

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	75.00	0.50(A)	20.00	20.00	10.00	=	N/A	N/A
2	71.50	-0.00(P)	20.00	20.00	25.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Change EI of wall to 44780 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 75.00 No analysis at this stage
3	Excavate to elevation 71.15 on PASSIVE side
4	Fill to elevation 71.50 on PASSIVE side with soil type 1
5	Install strut or anchor no.1 at elevation 71.60
6	Apply surcharge no.2 at elevation 71.50
7	Apply water pressure profile no.1 No analysis at this stage
8	Change properties of soil type 3 to soil type 2 No analysis at this stage Ko pressures will not be reset
9	Change EI of wall to 31986 kN.m2/m run From elevation 75.00 to 65.00 Yield moment not defined Allow wall to relax with new modulus value
10	Apply load no.1 at elevation 75.00

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 44780kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 75.00	No	No	No
3	Excav. to elev. 71.15 on PASSIVE side	Yes	Yes	Yes
4	Fill to elev. 71.50 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 71.60	No	No	No
6	Apply surcharge no.2 at elev. 71.50	No	No	No
7	Apply water pressure profile no.1	No	No	No
8	Change soil type 3 to soil type 2	No	No	No
9	Change EI of wall to 31986kN.m2/m run	No	No	No
10	Apply load no.1 at elev. 75.00	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No. 10 Apply load no.1 at elevation 75.00

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
10	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m2/m
1	75.00	0.00	0.094	2.58E-02	55.0	-0.0	-55.0	31986
2	74.50	3.98	0.081	2.56E-02	56.0	27.6		31986
3	74.00	8.28	0.068	2.50E-02	59.1	56.4		31986
4	73.60	13.93	0.058	2.41E-02	63.5	80.9		31986
5	73.20	19.41	0.049	2.29E-02	70.2	107.5		31986
6	72.60	27.46	0.036	2.05E-02	84.2	153.5		31986
7	72.00	35.39	0.025	1.71E-02	103.1	208.5		31986
		38.24	0.025	1.71E-02	103.1	208.5		
8	71.60	46.44	0.018	1.42E-02	120.0	251.9	218.3	31986
		46.44	0.018	1.42E-02	-98.3	251.9		
9	71.50	50.14	0.017	1.34E-02	-93.4	243.5		31986
		25.14	0.017	1.34E-02	-93.4	243.5		
10	71.15	25.97	0.013	1.09E-02	-84.5	216.6		31986
11	71.00	25.98	0.011	9.96E-03	-80.6	206.1		31986
		16.12	0.011	9.96E-03	-80.6	206.1		
12	70.60	16.08	0.008	7.65E-03	-74.2	179.0		31986
13	70.20	11.50	0.005	5.71E-03	-68.7	152.6		31986
14	69.60	12.58	0.002	3.39E-03	-61.4	117.2		31986
15	69.00	17.37	0.001	1.71E-03	-52.4	82.9		31986
16	68.40	13.61	0.000	6.02E-04	-43.2	49.7		31986
17	67.80	22.90	-0.000	-1.38E-05	-32.2	23.5		31986
18	67.20	22.29	0.000	-2.67E-04	-18.6	6.7		31986
19	66.60	16.64	0.000	-3.11E-04	-7.0	-1.3		31986
20	66.00	9.05	0.000	-2.77E-04	0.7	-2.7		31986
21	65.50	-2.37	0.000	-2.51E-04	2.4	-1.1		31986
22	65.00	-7.27	0.001	-2.44E-04	0.0	0.0		---

At elev. 71.60 Strut force = 218.3 kN/strut = 218.3 kN/m run

(continued)

Stage No.10 Apply load no.1 at elevation 75.00

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	2189
2	74.50	0.00	10.82	3.98	33.10	3.98	3.98a	2189
3	74.00	0.00	22.50	8.28	68.85	8.28	8.28a	2189
4	73.60	4.00	26.99	9.93	82.59	9.93	13.93a	2189
5	73.20	8.00	31.01	11.41	94.89	11.41	19.41a	2189
6	72.60	14.00	36.57	13.46	111.90	13.46	27.46a	2189
7	72.00	20.00	41.81	15.39	127.95	15.39	35.39a	2189
		20.00	41.81	18.24	106.20	18.24	38.24a	3941
8	71.60	24.00	46.01	20.07	116.85	22.44	46.44	3941
9	71.50	25.00	47.05	20.53	119.49	25.14	50.14	2531
10	71.15	28.50	50.66	22.10	128.66	31.04	59.54	2531
11	71.00	30.00	52.20	22.77	132.57	33.08	63.08	2531
		30.00	52.20	18.91	147.12	28.59	58.59	4950
12	70.60	34.00	56.27	20.63	157.91	34.72	68.72	5170
13	70.20	38.00	60.31	22.34	168.61	38.57	76.57	5389
14	69.60	44.00	66.33	24.88	184.54	55.39	99.39	5719
15	69.00	50.00	72.30	27.40	200.35	78.21	128.21	6048
16	68.40	56.00	78.23	29.91	216.06	92.90	148.90	6377
17	67.80	62.00	84.13	32.40	231.69	101.64	163.64	6707
18	67.20	68.00	90.01	34.89	247.26	106.72	174.72	7036
19	66.60	74.00	95.88	37.36	262.78	110.02	184.02	7366
20	66.00	80.00	101.73	39.83	278.27	112.71	192.71	7695
21	65.50	85.00	106.59	41.89	291.15	112.49	197.49	26102
22	65.00	90.00	111.45	43.94	304.02	115.59	205.59	27001

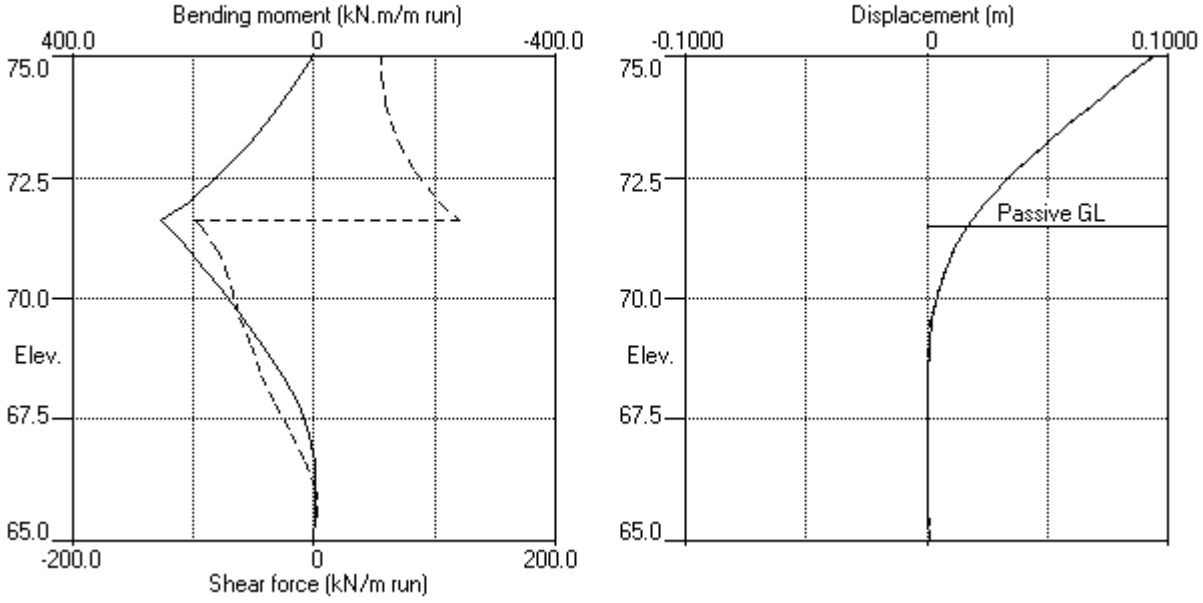
Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	74.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	74.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	73.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	73.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	72.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	72.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	71.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	71.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		25.00	0.00	0.00	0.00	0.00	25.00	2531
10	71.15	28.50	3.50	1.53	8.89	5.07	33.57	2531
11	71.00	30.00	5.00	2.18	12.69	7.10	37.10	2531
		30.00	5.00	0.00	22.16	12.48	42.48	4950
12	70.60	34.00	8.99	0.67	32.73	18.65	52.65	5170
13	70.20	38.00	12.98	2.35	43.30	27.07	65.07	5389
14	69.60	44.00	18.95	4.87	59.09	42.81	86.81	5719
15	69.00	50.00	24.89	7.38	74.82	60.84	110.84	6048
16	68.40	56.00	30.80	9.88	90.46	79.29	135.29	6377
17	67.80	62.00	36.67	12.36	106.02	78.74	140.74	6707
18	67.20	68.00	42.52	14.83	121.50	84.43	152.43	7036
19	66.60	74.00	48.34	17.29	136.91	93.39	167.39	7366
20	66.00	80.00	54.14	19.73	152.26	103.66	183.66	7695
21	65.50	85.00	58.96	21.77	165.03	114.86	199.86	26102
22	65.00	90.00	63.77	23.80	177.77	122.86	212.86	27001

(continued)

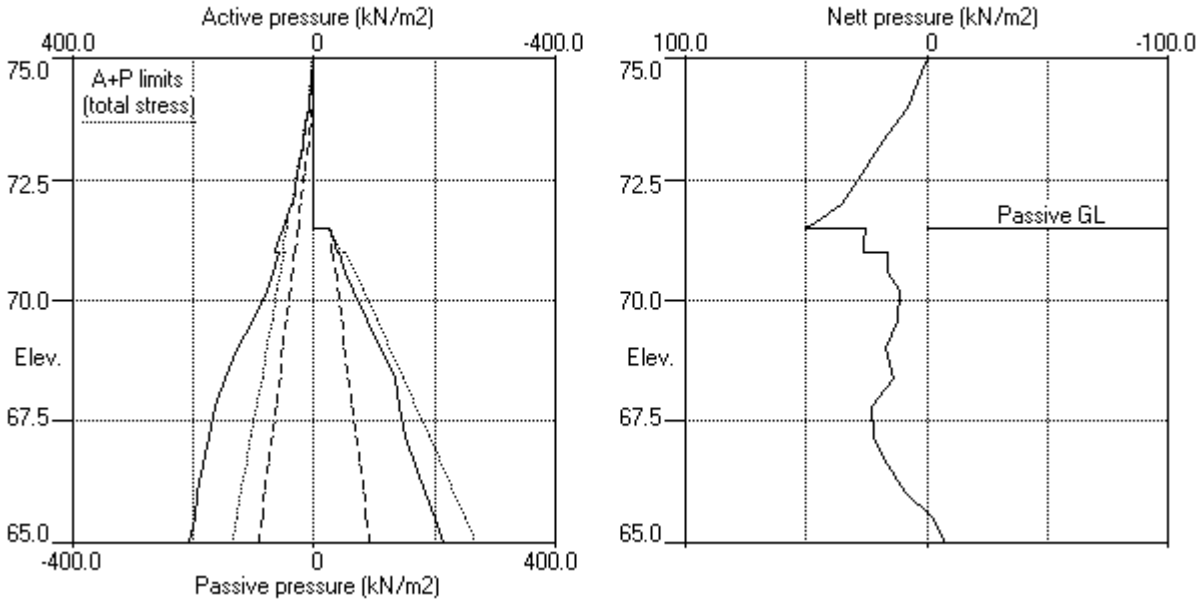
Stage No.10 Apply load no.1 at elevation 75.00
Note: 38.24a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.10 Apply load no.1 at elev. 75.00



Stage No.10 Apply load no.1 at elev. 75.00



Units: kN,m

Summary of results

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 65.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	75.00	75.00	Cant.	Conditions not suitable for FoS calc.			
2	75.00	75.00		No analysis at this stage			
3	75.00	71.15	Cant.	1.403	65.75	67.62	3.53
4	75.00	71.50	Cant.	1.485	65.79	67.88	3.62
5	75.00	71.50		No analysis at this stage			
6	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
7	75.00	71.50		No analysis at this stage			
8	75.00	71.50		No analysis at this stage			
9	75.00	71.50	71.60	Conditions not suitable for FoS calc.			
10	75.00	71.50	71.60	Conditions not suitable for FoS calc.			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	75.00	0.094	0.000	0.0	-0.0	55.0	0.0
2	74.50	0.081	0.000	27.6	0.0	56.0	0.0
3	74.00	0.068	0.000	56.4	0.0	59.1	0.0
4	73.60	0.058	0.000	80.9	0.0	63.5	0.0
5	73.20	0.049	0.000	107.5	0.0	70.2	0.0
6	72.60	0.036	0.000	153.5	0.0	84.2	0.0
7	72.00	0.025	0.000	208.5	0.0	103.1	0.0
8	71.60	0.018	0.000	251.9	0.0	120.0	-98.3
9	71.50	0.017	0.000	243.5	0.0	55.0	-93.4
10	71.15	0.014	0.000	216.6	0.0	63.3	-84.5
11	71.00	0.013	0.000	206.1	0.0	66.9	-80.6
12	70.60	0.010	0.000	179.0	0.0	43.3	-74.2
13	70.20	0.008	0.000	152.6	0.0	16.6	-68.7
14	69.60	0.005	0.000	127.0	0.0	0.0	-61.4
15	69.00	0.003	0.000	106.4	0.0	0.0	-52.4
16	68.40	0.002	0.000	73.4	0.0	0.0	-52.5
17	67.80	0.002	-0.000	43.4	0.0	0.0	-43.5
18	67.20	0.001	-0.000	21.2	0.0	0.0	-29.8
19	66.60	0.002	-0.000	8.0	-1.3	0.0	-16.5
20	66.00	0.002	-0.000	2.5	-2.7	0.7	-6.5
21	65.50	0.002	0.000	0.7	-1.1	2.4	-2.8
22	65.00	0.002	0.000	0.0	0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	75.00	0.0	75.00	0.0	75.00	0.0	75.00
2	No calculation at this stage							
3	121.8	69.60	-0.0	65.50	66.3	71.00	-50.3	68.40
4	123.1	69.60	-0.0	65.50	66.8	71.00	-50.8	68.40
5	No calculation at this stage							
6	127.3	70.20	-0.1	65.50	66.9	71.00	-52.5	68.40
7	No calculation at this stage							
8	No calculation at this stage							
9	86.4	70.20	0.0	75.00	67.3	71.60	-27.3	68.40
10	251.9	71.60	-2.7	66.00	120.0	71.60	-98.3	71.60

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	75.00	0.000	75.00	Change EI of wall to 44780kN.m2/m run
2	No calculation at this stage				Apply surcharge no.1 at elev. 75.00
3	0.049	75.00	0.000	75.00	Excav. to elev. 71.15 on PASSIVE side
4	0.049	75.00	0.000	75.00	Fill to elev. 71.50 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 71.60
6	0.048	75.00	-0.000	67.20	Apply surcharge no.2 at elev. 71.50
7	No calculation at this stage				Apply water pressure profile no.1
8	No calculation at this stage				Change soil type 3 to soil type 2
9	0.052	75.00	0.000	75.00	Change EI of wall to 31986kN.m2/m run
10	0.094	75.00	-0.000	67.80	Apply load no.1 at elev. 75.00

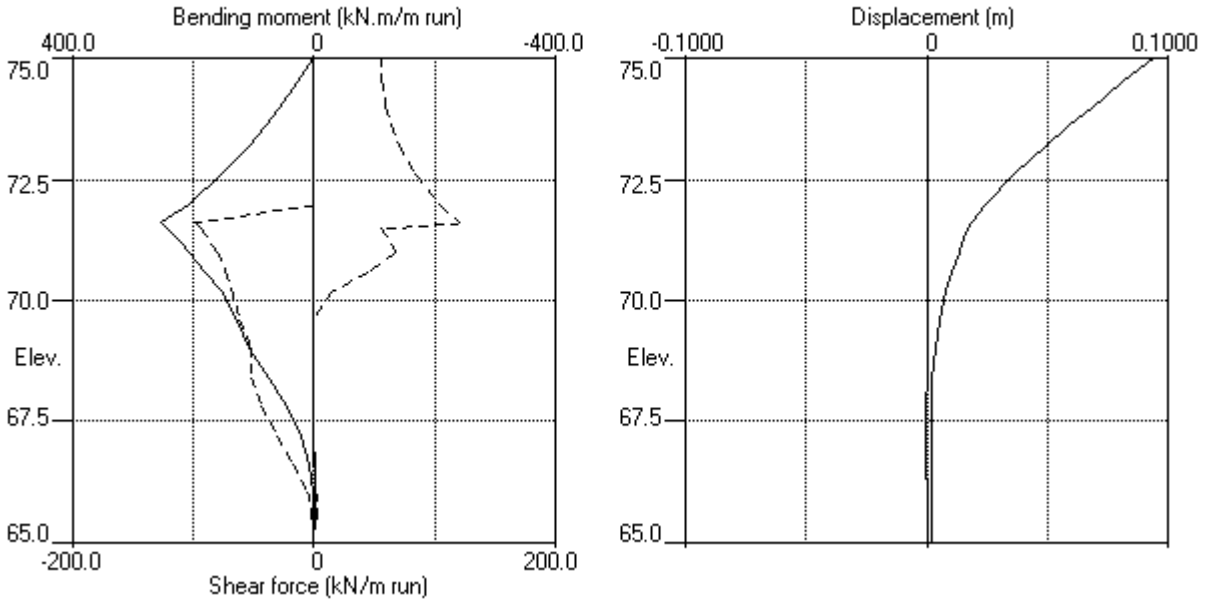
Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 71.60 kN/m run	kN/strut
6	slack	slack
9	73.06	73.06
10	218.29	218.29

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

Units: kN,m

Bending moment, shear force, displacement envelopes



Appendix D

Structural Analysis

PROJECT:	Hampstead Green	Rock & Alluvium				
						Ref: QR-32/01
TITLE or DESCRIPTION:		ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	Section 1	KK				16-0036	of

REFERENCE | Rev:

EC2

Bending and Axial Force to EN 1992-1-1:2004 (EC2) - Secant Wall Circular Sections (Cast In-situ)

Pile section

pile diameter	=	400	mm	
Pile spacing	=	550	mm	
design pile diameter h	=	380	mm	
Ac	=	113411	mm^2	
4.4.1.3(4) cover[1] c_{nom}	=	65	mm	k_2 = 75 mm
cage diameter d	=	214	mm	
ratio d/h	=	0.6		
f_{ck}	=	32	MPa	γ_c = 1.65 α_{cc} = 0.85 [NA 3.1.6 (1)]
f_{yk}	=	500	MPa	γ_s = 1.15

Design Actions on pile

Actions N	=	0	kN	
Factored Actions N	=	796	kN	
Wallap shear	=	81	kN/m	
Shear V_{Ed}	=	44.55	kN	BM/SF factor 1.0
Ult Shear V_{Ed}	=	44.55	kN	
Wallap moment	=	128	kNm/m	
Induced Moment M_i	=	70.4	kNm	
Applied Moment M_{Ed}	=		kNm	
Σ Moments M	=	70	kNm	
Factored Ult M	=	70	kNm	

Using IstructE design charts for circular columns:-

$M/h^3 f_{ck}$ = 0.047 (also checked for M/h3=0.0 for zero vertical load)

Actions N $N/h^2 f_{ck}$ = 0.00

Factored Actions N $N/h^2 f_{ck}$ = 0.20

therefore from charts;

$\rho f_{yk} / f_{ck}$ = 0.2 **From charts**

ρ = $4A_{st} / \pi.h^2$

therefore, adopt greater of:

Area of main steel Ast = 1234 mm^2

main bar dia	=	20	mm
no. main bars	=	6	no.
helical dia	=	8	mm

Area of main steel, A_{st} = 1885 mm^2.

Bar spacing (face to face) = 92 mm

PROJECT: **Hampstead Green**	Rock & Alluvium				
TITLE or DESCRIPTION: **Section 1**	ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	KK				16-0036	of

REFERENCE | Rev:

EC2 **Shear to EN 1992-1-1:2004 (EC2) - Secant Wall** Circular Sections (Cast In-situ) using helical reinforcement

Pile section

pile dia	=	400	mm
Pile spacing	=	550	mm
pile diameter dnom	=	380	mm
Ac	=	113411	mm^2
4.4.1.3(4) cover c_{nom}	=	65	mm
main bar dia	=	20	mm
no. main bars	=	6	no.
helical dia	=	8	mm
d	=	252	mm
f_{ck}	=	32	MPa
f_{yk}	=	500	MPa
Wallap shear	=	81	kN/m
	=	44.55	kN
Ult V_{Ed}	=	**44.55**	kN
Actions N	=		kN
factored actions N_{Ed}	=		kN

k_2 = 75 mm [NA.4.4.1.3 (4)]

γ_c = 1.5 (This is adjusted by K_f=1.1 [2.4.2.5 (2)] to give 1.65)

γ_c = 1.65 α_{cc} = 0.85 [NA. 3.1.6 (1)}

γ_s = 1.15

SF factor 1.0

6.2.2 Check requirement for shear reinforcement

$V_{Rd,c} = [C_{Rd,c}k(100\rho_1 f_{ck})^{1/3}+k_1\sigma_{cp}]b_w d$

with minimum $= (v_{min}+k_1\sigma_{cp})b_w d$

$v_{min} = 0.035k^{3/2}f_{ck}^{1/2}$ = 0.51497585

CRd,c = 0.18 / γc = 0.11

k = $1+(200/d)^{1/2}$ = 1.89 <=2.0

$\rho_1 = A_{sl}/b_w d$ = 0.01 <=0.02

$\sigma_{cp} = N_{ed}/A_c$ = 0 < 0.2f_{cd}

k_1 = 0.15 [NA.6.2.2(1)]

$V_{Rd,c}$ = **49** kN

Is $V_{Rd,c} > V_{Ed}$ => **YES** Action: ***No shear links needed - provide nominal links as req'd***

6.2.3 Design Shear Reinforcement

Check concrete strut capacity at Cot θ = 2.5 :-

6.2.3 (3) exp 6.9 $V_{Rd,max} = \alpha_{cw}.b_w.z.v_1.f_{cd} / (\cot\theta+\tan\theta)$ (6.9)

$V_{Rd,max}$ = **297** **kN**

cot θ = 2

tan θ = 0.5

α_{cw} = 1 [NA.6.2.3(3)]

z = 0.9d = 227 mm

v_1 = 0.6 (1-(fck/250) = 0.52 [6.6N]

Is $V_{Rd,max} > V_{Ed}$ => **NA** Action:

Calculation for strut inclination:-

θ = $0.5.\sin^{-1}[(6.54*V_{Ed})/(b_w.d.(1-f_{ck}/250).f_{ck})$

θ = NA rad

cot θ = 2.5 > 1.0

Calculate shear reinforcement spacing after Turmo et al (2008);-

$V_{Rd,s} = z.\cot\theta.(A_\Phi/0.5s).f_{ywd}.0.85$

$s = 2.([z.\cot\theta.A_\Phi.fywd.0.85]/V_{Rd,s})$

= **378** mm

A_{sw} = 50.3 mm^2

f_{ywd} = 435 MPa

Check maximum shear link spacing:-

is $s_{l,max}$ > 0.75d **YES**

Provide	**8**	mm helical at nominal pitch	**185**	mm

Turo, J, *et al*. Shear truss analogy for concrete members of solid and hollow circular cross section. **Eng. Struc.** (2008)

PROJECT:	Hampstead Green	Rock & Alluvium				
						Ref: QR-32/01
TITLE or DESCRIPTION:		ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	Section 2	KK				16-0036	of

REFERENCE | Rev:

EC2

Bending and Axial Force to EN 1992-1-1:2004 (EC2) - Secant Wall Circular Sections (Cast In-situ)

Pile section

	pile diameter	=	400	mm
	Pile spacing	=	550	mm
	design pile diameter h	=	380	mm
	Ac	=	113411	mm^2
4.4.1.3(4)	cover[1] c_{nom}	=	65	mm
	cage diameter d	=	209	mm
	ratio d/h	=	0.6	
	f_{ck}	=	32	MPa
	f_{yk}	=	500	MPa

k_2 = 75 mm

γ_c = 1.65 α_{cc} = 0.85 [NA 3.1.6 (1)}

γ_s = 1.15

Design Actions on pile

	Actions N	=	0	kN
	Factored Actions N	=	796	kN
	Wallap shear	=	124	kN/m
	Shear V_{Ed}	=	68.2	kN
	Ult Shear V_{Ed}	=	68.2	kN
	Wallap moment	=	239	kNm/m
	Induced Moment M_i	=	131.45	kNm
	Applied Moment M_{Ed}	=		kNm
	Σ Moments M	=	131	kNm
	Factored Ult M	=	131	kNm

BM/SF factor 1.0

Using IstructE design charts for circular columns:-

$M/h^3 f_{ck}$ = 0.088 (also checked for M/h3=0.0 for zero vertical load)

Actions N $N/h^2 f_{ck}$ = 0.00

Factored Actions N $N/h^2 f_{ck}$ = 0.20

therefore from charts;

$\rho f_{yk} / f_{ck}$ = 0.43 **From charts**

ρ = $4A_{st} / \pi.h^2$

therefore, adopt greater of:

Area of main steel Ast = 2653 mm^2

	main bar dia	=	25 mm
	no. main bars	=	6 no.
	helical dia	=	8 mm

Area of main steel, A_{st} = 2945 mm^2.

Bar spacing (face to face) = 84 mm

PROJECT: **Hampstead Green**	Rock & Alluvium				
TITLE or DESCRIPTION: **Section 2**	ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	KK				16-0036	of

REFERENCE | Rev:

EC2 **Shear to EN 1992-1-1:2004 (EC2) - Secant Wall** Circular Sections (Cast In-situ) using helical reinforcement

Pile section

pile dia	=	400	mm
Pile spacing	=	550	mm
pile diameter dnom	=	380	mm
Ac	=	113411	mm^2
4.4.1.3(4) cover c_{nom}	=	65	mm
main bar dia	=	25	mm
no. main bars	=	6	no.
helical dia	=	8	mm
d	=	249	mm
f_{ck}	=	32	MPa
f_{yk}	=	500	MPa
Wallap shear	=	124	kN/m
	=	68.2	kN
Ult V_{Ed}	=	68.2	kN
Actions N	=		kN
factored actions N_{Ed}	=		kN

k_2 = 75 mm [NA.4.4.1.3 (4)]

γ_c = 1.5 (This is adjusted by K_f=1.1 [2.4.2.5 (2)] to give 1.65)

γ_c = 1.65 α_{cc} = 0.85 [NA. 3.1.6 (1)}

γ_s = 1.15

SF factor 1.0

6.2.2 Check requirement for shear reinforcement

$V_{Rd,c} = [C_{Rd,c}k(100\rho_1 f_{ck})^{1/3}+k_1\sigma_{cp}]b_w d$

with minimum $= (v_{min}+k_1\sigma_{cp})b_w d$

$v_{min} = 0.035k^{3/2}f_{ck}^{1/2}$

0.51730105

CRd,c	=	0.18 / γc	0.11
k	=	$1+(200/d)^{1/2}$	1.90 <=2.0
ρ_1	=	$A_{sl}/b_w d$	0.02 <=0.02
σ_{cp}	=	N_{ed}/A_c	0 < 0.2f_{cd}
k_1	=	0.15	[NA.6.2.2(1)]

$V_{Rd,c}$ = 49 kN

Is $V_{Rd,c}$ > V_{Ed} => NO Action: ***Design of shear reinforcement required***

6.2.3 Design Shear Reinforcement

Check concrete strut capacity at Cot θ = 2.5 :-

6.2.3 (3) exp 6.9 $V_{Rd,max} = \alpha_{cw}.b_w.z.v_1.f_{cd} / (Cot\theta+tan\theta)$ (6.9)

$V_{Rd,max}$ = 293 kN

cot θ	=	2	
tan θ	=	0.5	
α_{cw}	=	1	[NA.6.2.3(3)]
z	=	0.9d	224 mm
v_1	=	0.6 (1-(fck/250)	0.52 [6.6N]

Is $V_{Rd,max}$ > V_{Ed} => YES Action: ***Calculate link spacing***

Calculation for strut inclination:-

θ = $0.5.\sin^{-1}[(6.54*V_{Ed})/(b_w.d.(1-f_{ck}/250).f_{ck})$

θ = NA rad cot θ = 2.5 > 1.0

Calculate shear reinforcement spacing after Turmo et al (2008);-

$V_{Rd,s} = z.\cot\theta.(A_\Phi/0.5s).f_{ywd}.0.85$

$s = 2.([z.\cot\theta.A_\Phi.fywd.0.85]/V_{Rd,s})$

= 244 mm

A_{sw} = 50.3 mm^2

f_{ywd} = 435 MPa

Check maximum shear link spacing:-

is $s_{l,max}$ > 0.75d YES

Provide	8	mm helical at nominal pitch	185	mm

Turo, J, *et al*. Shear truss analogy for concrete members of solid and hollow circular cross section. **Eng. Struc.** (2008)

PROJECT:	Hampstead Green	Rock & Alluvium				
						Ref: QR-32/01
TITLE or DESCRIPTION:		ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	Section 3	KK				16-0036	of

REFERENCE | Rev:

EC2

Bending and Axial Force to EN 1992-1-1:2004 (EC2) - Secant Wall Circular Sections (Cast In-situ)

Pile section

	pile diameter	=	400	mm
	Pile spacing	=	550	mm
	design pile diameter h	=	380	mm
	Ac	=	113411	mm^2
4.4.1.3(4)	cover[1] c_{nom}	=	65	mm
	cage diameter d	=	214	mm
	ratio d/h	=	0.6	
	f_{ck}	=	32	MPa
	f_{yk}	=	500	MPa

k_2 = 75 mm

γ_c = 1.65 α_{cc} = 0.85 [NA 3.1.6 (1)}

γ_s = 1.15

Design Actions on pile

	Actions N	=	0	kN
	Factored Actions N	=	796	kN
	Wallap shear	=	112	kN/m
	Shear V_{Ed}	=	61.6	kN
	Ult Shear V_{Ed}	=	61.6	kN
	Wallap moment	=	193	kNm/m
	Induced Moment M_i	=	106.15	kNm
	Applied Moment M_{Ed}	=		kNm
	Σ Moments M	=	106	kNm
	Factored Ult M	=	106	kNm

BM/SF factor 1.0

Using IstructE design charts for circular columns:-

$M/h^3 f_{ck}$ = 0.07 (also checked for M/h3=0.0 for zero vertical load)

Actions N $N/h^2 f_{ck}$ = 0.00

Factored Actions N $N/h^2 f_{ck}$ = 0.20

therefore from charts;

$\rho f_{yk} / f_{ck}$ = 0.3 **From charts**

ρ = $4A_{st} / \pi.h^2$

therefore, adopt greater of:

Area of main steel Ast = 1851 mm^2

	main bar dia	=	20 mm
	no. main bars	=	6 no.
	helical dia	=	8 mm

Area of main steel, A_{st} = 1885 mm^2.

Bar spacing (face to face) = 92 mm

PROJECT: **Hampstead Green**	Rock & Alluvium				
TITLE or DESCRIPTION: **Section 3**	ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	KK				16-0036	of

REFERENCE | Rev:

EC2 **Shear to EN 1992-1-1:2004 (EC2) - Secant Wall** Circular Sections (Cast In-situ) using helical reinforcement

Pile section

pile dia	=	400	mm
Pile spacing	=	550	mm
pile diameter dnom	=	380	mm
Ac	=	113411	mm^2
4.4.1.3(4) cover c_{nom}	=	65	mm
main bar dia	=	20	mm
no. main bars	=	6	no.
helical dia	=	8	mm
d	=	252	mm
f_{ck}	=	32	MPa
f_{yk}	=	500	MPa
Wallap shear	=	112	kN/m
	=	61.6	kN
Ult V_{Ed}	=	61.6	kN
Actions N	=		kN
factored actions N_{Ed}	=		kN

k_2 = 75 mm [NA.4.4.1.3 (4)]

γ_c = 1.5 (This is adjusted by K_f=1.1 [2.4.2.5 (2)] to give 1.65)

γ_c = 1.65 α_{cc} = 0.85 [NA. 3.1.6 (1)}

γ_s = 1.15

SF factor 1.0

6.2.2 Check requirement for shear reinforcement

$V_{Rd,c}$ = $[C_{Rd,c}k(100\rho_1 f_{ck})^{1/3}+k_1\sigma_{cp}]b_w d$

with minimum = $(v_{min}+k_1\sigma_{cp})b_w d$

v_{min} = $0.035k^{3/2}f_{ck}^{1/2}$ 0.51497585

CRd,c = $0.18/\gamma c$ 0.11

k = $1+(200/d)^{1/2}$ 1.89 <=2.0

ρ_1 = $A_{sl}/b_w d$ 0.01 <=0.02

σ_{cp} = N_{ed}/A_c 0 < $0.2f_{cd}$

k_1 = 0.15 [NA.6.2.2(1)]

$V_{Rd,c}$ = **49** kN

Is $V_{Rd,c} > V_{Ed}$ => **NO** Action: ***Design of shear reinforcement required***

6.2.3 Design Shear Reinforcement

Check concrete strut capacity at Cot θ = 2.5 :-

cot θ = 2

tan θ = 0.5

6.2.3 (3) exp 6.9 $V_{Rd,max}$ = $\alpha_{cw}.b_w.z.v_1.f_{cd}/(\cot\theta+\tan\theta)$ (6.9)

α_{cw} = 1 [NA.6.2.3(3)]

z = 0.9d 227 mm

v_1 = 0.6 (1-(fck/250) 0.52 [6.6N]

$V_{Rd,max}$ = **297** **kN**

Is $V_{Rd,max} > V_{Ed}$ => **YES** Action: ***Calculate link spacing***

Calculation for strut inclination:-

θ = $0.5.\sin^{-1}[(6.54*V_{Ed})/(b_w.d.(1-f_{ck}/250).f_{ck})$

θ = NA rad cot θ = 2.5 > 1.0

Calculate shear reinforcement spacing after Turmo et al (2008);-

$V_{Rd,s}$ = $z.\cot\theta.(A_\Phi/0.5s).f_{ywd}.0.85$

s = $2.([z.\cot\theta.A_\Phi.fywd.0.85]/V_{Rd,s})$

= **273** mm

A_{sw} = 50.3 mm^2

f_{ywd} = 435 MPa

Check maximum shear link spacing:-

is $s_{l,max}$ > 0.75d **YES**

Provide	**8**	mm helical at nominal pitch	**185**	mm

Turo, J, *et al*. Shear truss analogy for concrete members of solid and hollow circular cross section. **Eng. Struc.** (2008)

PROJECT:	Hampstead Green	Rock & Alluvium				
						Ref: QR-32/01
TITLE or DESCRIPTION:		ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	Section 4 (CP Piles 27-32)	KK				16-0036	of

REFERENCE		Rev:

EC2 — **Bending and Axial Force to EN 1992-1-1:2004 (EC2) - Secant Wall** — Circular Sections (Cast In-situ)

Pile section

	pile diameter	=	400	mm
	Pile spacing	=	550	mm
	design pile diameter h	=	380	mm
	Ac	=	113411	mm^2
4.4.1.3(4)	cover[1] c_{nom}	=	65	mm
	cage diameter d	=	205	mm
	ratio d/h	=	0.5	
	f_{ck}	=	32	MPa
	f_{yk}	=	500	MPa

k_2 = 75 mm

γ_c = 1.65 α_{cc} = 0.85 [NA 3.1.6 (1)}

γ_s = 1.15

Design Actions on pile

	Actions N	=	0	kN
	Factored Actions N	=	285	kN
	Wallap shear	=	224	kN/m
	Shear V_{Ed}	=	123.2	kN
	Ult Shear V_{Ed}	=	123.2	kN
	Wallap moment	=	223	kNm/m
	Induced Moment M_i	=	122.65	kNm
	Applied Moment M_{Ed}	=		kNm
	Σ Moments M	=	123	kNm
	Factored Ult M	=	123	kNm

BM/SF factor 1.0

Using IstructE design charts for circular columns:-

$M/h^3 f_{ck}$ = 0.082 (also checked for M/h3=0.0 for zero vertical load)

Actions N $N/h^2 f_{ck}$ = 0.00

Factored Actions N $N/h^2 f_{ck}$ = 0.07

therefore from charts;

$\rho f_{yk} / f_{ck}$ = 0.39 **From charts**

ρ = $4A_{st} / \pi.h^2$

therefore, adopt greater of:

Area of main steel Ast = 2406 mm^2

	main bar dia	=	25 mm
	no. main bars	=	6 no.
	helical dia	=	10 mm

Area of main steel, A_{st} = 2945 mm^2.

Bar spacing (face to face) = 82 mm

PROJECT: **Hampstead Green**	Rock & Alluvium				
TITLE or DESCRIPTION: **Section 4 (CP Piles 27-32)**	ORIG by	Date	VERIF	Date	Ref. No / SHEET No
	KK				16-0036 / of

REFERENCE | Rev:

EC2 **Shear to EN 1992-1-1:2004 (EC2) - Secant Wall** Circular Sections (Cast In-situ) using helical reinforcement

Pile section

pile dia	=	400	mm
Pile spacing	=	550	mm
pile diameter dnom	=	380	mm
Ac	=	113411	mm^2
4.4.1.3(4) cover c_{nom}	=	65	mm
main bar dia	=	25	mm
no. main bars	=	6	no.
helical dia	=	10	mm
d	=	247	mm
f_{ck}	=	32	MPa
f_{yk}	=	500	MPa
Wallap shear	=	224	kN/m
	=	123.2	kN
Ult V_{Ed}	=	123.2	kN
Actions N	=		kN
factored actions N_{Ed}	=		kN

k_2 = 75 mm [NA.4.4.1.3 (4)]

γ_c = 1.5 (This is adjusted by K_f=1.1 [2.4.2.5 (2)] to give 1.65)

γ_c = 1.65 α_{cc} = 0.85 [NA. 3.1.6 (1)}

γ_s = 1.15

SF factor 1.0

6.2.2 Check requirement for shear reinforcement

$V_{Rd,c}$ = $[C_{Rd,c}k(100\rho_1 f_{ck})^{1/3}+k_1\sigma_{cp}]b_w d$

with minimum = $(v_{min}+k_1\sigma_{cp})b_w d$

v_{min} = $0.035k^{3/2}f_{ck}^{1/2}$ = 0.51824467

CRd,c	=	0.18 / γc	0.11
k	=	$1+(200/d)^{1/2}$	1.90 <=2.0
ρ_1	=	$A_{sl}/b_w d$	0.02 <=0.02
σ_{cp}	=	N_{ed}/A_c	0 < $0.2f_{cd}$
k_1	=	0.15	[NA.6.2.2(1)]

$V_{Rd,c}$ = 49 kN

Is $V_{Rd,c}$ > V_{Ed} => NO Action: ***Design of shear reinforcement required***

6.2.3 Design Shear Reinforcement

Check concrete strut capacity at Cot θ = 2.5 :-

6.2.3 (3) exp 6.9 $V_{Rd,max}$ = $\alpha_{cw}.b_w.z.v_1.f_{cd}$ / (Cotθ+tanθ) (6.9)

$V_{Rd,max}$ = 292 kN

cot θ	=	2	
tan θ	=	0.5	
α_{cw}	=	1	[NA.6.2.3(3)]
z	=	0.9d	223 mm
v_1	=	0.6 (1-(fck/250)	0.52 [6.6N]

Is $V_{Rd,max}$ > V_{Ed} => YES Action: ***Calculate link spacing***

Calculation for strut inclination:-

θ = $0.5.\sin^{-1}[(6.54*V_{Ed})/(b_w.d.(1-f_{ck}/250).f_{ck})$

θ = NA rad cot θ = 2.5 > 1.0

Calculate shear reinforcement spacing after Turmo et al (2008);-

$V_{Rd,s}$ = $z.\cot\theta.(A_\Phi/0.5s).f_{ywd}.0.85$

s = $2.([z.\cot\theta.A_\Phi.fywd.0.85]/V_{Rd,s})$ = 210 mm

A_{sw} = 78.5 mm^2

f_{ywd} = 435 MPa

Check maximum shear link spacing:-

is $s_{l,max}$ > 0.75d YES

Provide	10	mm helical at nominal pitch	185	mm

Turo, J, *et al*. Shear truss analogy for concrete members of solid and hollow circular cross section. **Eng. Struc.** (2008)

PROJECT:	Hampstead Green	Rock & Alluvium				
						Ref: QR-32/01
TITLE or DESCRIPTION:		ORIG by	Date	VERIF	Date	Ref. No	SHEET No
	Section 5 (CP Piles 321-352)	KK				16-0036	of

REFERENCE | Rev:

EC2

Bending and Axial Force to EN 1992-1-1:2004 (EC2) - Secant Wall Circular Sections (Cast In-situ)

Pile section

	pile diameter	=	400	mm
	Pile spacing	=	550	mm
	design pile diameter h	=	380	mm
	Ac	=	113411	mm^2
4.4.1.3(4)	cover[1] c_{nom}	=	65	mm
	cage diameter d	=	198	mm
	ratio d/h	=	0.5	
	f_{ck}	=	32	MPa
	f_{yk}	=	500	MPa

k_2 = 75 mm

γ_c = 1.65 α_{cc} = 0.85 [NA 3.1.6 (1)}

γ_s = 1.15

Design Actions on pile

	Actions N	=	0	kN
	Factored Actions N	=	285	kN
	Wallap shear	=	161	kN/m
	Shear V_{Ed}	=	88.55	kN
	Ult Shear V_{Ed}	=	88.55	kN
	Wallap moment	=	329	kNm/m
	Induced Moment M_i	=	180.95	kNm
	Applied Moment M_{Ed}	=		kNm
	Σ Moments M	=	181	kNm
	Factored Ult M	=	181	kNm

BM/SF factor 1.0

Using IstructE design charts for circular columns:-

$M/h^3 f_{ck}$ = 0.121 (also checked for M/h3=0.0 for zero vertical load)

Actions N $N/h^2 f_{ck}$ = 0.00

Factored Actions N $N/h^2 f_{ck}$ = 0.07

therefore from charts;

$\rho f_{yk} / f_{ck}$ = 0.64 **From charts**

ρ = $4A_{st} / \pi.h^2$

therefore, adopt greater of:

Area of main steel Ast = 3949 mm^2

	main bar dia	=	32 mm
	no. main bars	=	6 no.
	helical dia	=	10 mm

Area of main steel, A_{st} = 4825 mm^2.

Bar spacing (face to face) = 72 mm

PROJECT:	Hampstead Green	Rock & Alluvium				
TITLE or DESCRIPTION:	Section 5 (CP Piles 321-352)	ORIG by	Date	VERIF	Date	Ref. No	SHEET No
		KK				16-0036	of

REFERENCE | Rev:

EC2 **Shear to EN 1992-1-1:2004 (EC2) - Secant Wall** Circular Sections (Cast In-situ) using helical reinforcement

Pile section

pile dia	=	400	mm
Pile spacing	=	550	mm
pile diameter dnom	=	380	mm
Ac	=	113411	mm^2
4.4.1.3(4) cover c_{nom}	=	65	mm
main bar dia	=	32	mm
no. main bars	=	6	no.
helical dia	=	10	mm
d	=	243	mm
f_{ck}	=	32	MPa
f_{yk}	=	500	MPa
Wallap shear	=	161	kN/m
	=	88.55	kN
Ult V_{Ed}	=	88.55	kN
Actions N	=		kN
factored actions N_{Ed}	=		kN

k_2 = 75 mm [NA.4.4.1.3 (4)]

γ_c = 1.5 (This is adjusted by K_f=1.1 [2.4.2.5 (2)] to give 1.65)

γ_c = 1.65 α_{cc} = 0.85 [NA. 3.1.6 (1)}

γ_s = 1.15

SF factor 1.0

6.2.2 Check requirement for shear reinforcement

$V_{Rd,c}$ = $[C_{Rd,c}k(100\rho_1 f_{ck})^{1/3}+k_1\sigma_{cp}]b_w d$

with minimum = $(v_{min}+k_1\sigma_{cp})b_w d$

v_{min} = $0.035k^{3/2}f_{ck}^{1/2}$ 0.52161023

CRd,c = $0.18/\gamma c$ 0.11

k = $1+(200/d)^{1/2}$ 1.91 <=2.0

ρ_1 = $A_{sl}/b_w d$ 0.02 <=0.02

σ_{cp} = N_{ed}/A_c 0 < $0.2f_{cd}$

k_1 = 0.15 [NA.6.2.2(1)]

$V_{Rd,c}$ = 48 kN

Is $V_{Rd,c}$ > V_{Ed} => NO Action: ***Design of shear reinforcement required***

6.2.3 Design Shear Reinforcement

Check concrete strut capacity at Cot θ = 2.5 :-

cot θ = 2

tan θ = 0.5

6.2.3 (3) exp 6.9 $V_{Rd,max}$ = $\alpha_{cw}.b_w.z.v_1.f_{cd}/(\cot\theta+\tan\theta)$ (6.9)

α_{cw} = 1 [NA.6.2.3(3)]

z = 0.9d 219 mm

v_1 = 0.6 (1-(fck/250) 0.52 [6.6N]

$V_{Rd,max}$ = 287 kN

Is $V_{Rd,max}$ > V_{Ed} => YES Action: ***Calculate link spacing***

Calculation for strut inclination:-

θ = $0.5.\sin^{-1}[(6.54*V_{Ed})/(b_w.d.(1-f_{ck}/250).f_{ck})$

θ = NA rad cot θ = 2.5 > 1.0

Calculate shear reinforcement spacing after Turmo et al (2008);-

$V_{Rd,s}$ = $z.\cot\theta.(A_\Phi/0.5s).f_{ywd}.0.85$

s = $2.([z.\cot\theta.A_\Phi.fywd.0.85]/V_{Rd,s})$

= 287 mm

A_{sw} = 78.5 mm^2

f_{ywd} = 435 MPa

Check maximum shear link spacing:-

is $s_{l,max}$ > 0.75d **YES**

Provide	10	mm helical at nominal pitch	180	mm

Turo, J, *et al*. Shear truss analogy for concrete members of solid and hollow circular cross section. **Eng. Struc.** (2008)

Appendix E

Concrete Stress Check

PROJECT	One Parkside	Rock & Alluvium					
TITLE	EC2 structural Capacity Check	Orig.	Date	Verif.	Date	Ref. No./rev.	Sheet
		KK				16-0036	
Section	Case 1 - 400mm					Date 21/04/2016	

Based on EC2 Design
Maximum Structural Capacity for 400 mm diameter pile

The Value of design compressive strength of concrete is defined as:

$f_{cd} = (\alpha_{cc} * f_{ck}) / (y_c * k_f)$ *Clauses 2.4.2.5 & 3.15*

Therefore for C 32/40 Concrete, characteristic cylinder strength = 32 N/mm^2

Where:

α_{cc} =	0.85	
f_{ck} =	32	N/mm^2
y_C =	1.50	
k_f =	1.10	

Therefore

f_{cd} = 16.48 N/mm^2

Design Axial Resistance of 400 **mm diameter pile**

$N_{rd} = A_c * f_{cd} + A_s * f_{yd}$

Where:

d_{nom}	380	mm^2
A_c =	113411	mm^2
f_{cd} =	16.48	N/mm^2
A_s	Ignore	
f_{yd}	Ignore	

Basing Design on Compressive Strength of Concrete Area alone

$N_{rd} = A_c * f_{cd}$

For a 400 mm diameter pile

A_c = 113411 mm^2

Therefore pile resistance is

N_{rd} = 1870 kN

Therefore max Com 1 action from schedule is

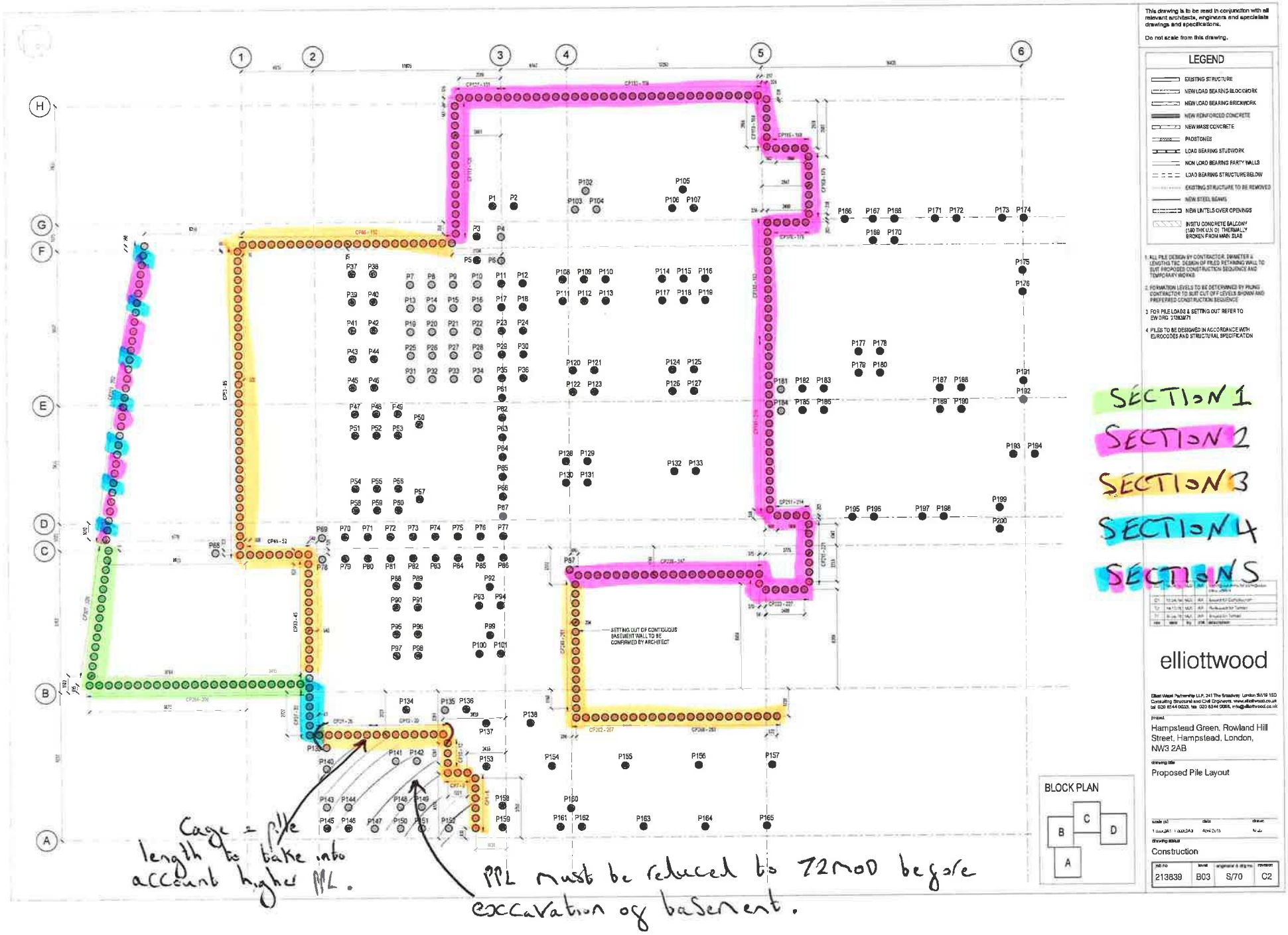
F_{cd} = 796 kN Total

Check Compressive Stress on Pile, $N_{rd} > F_{cd}$

Nrd > Fcd therefore no additional compression steel required

Appendix F

Section Location Plan



Cage = pile length to take into account higher PPL.

PPL must be reduced to 72mOD before excavation of basement.