

Our ref.: 371654-L01 (00)

19<sup>th</sup> May 2020

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**For the attention of Rudy Djajasaputra**

Dear Sirs

**RE: RETAINING WALL ASSESSMENT – UGLY BROWN BUILDING**

**1 INTRODUCTION**

RSK Environment Ltd (RSK) were commissioned by GD Partnership on behalf of Reef Group c/o the Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Limited (the 'client'), to carry out an assessment into the reuse of the existing contiguous piled wall along the western elevation to the proposed development, in addition to the stability of the sheet piled wall, alongside Regent's Canal. This report is subject to the RSK service constraints given in **Appendix A**.

**2 APPROACH**

An initial assessment has been carried out concerning the reuse of the existing contiguous wall as the retaining wall within the northern elevation of Plot A. Additionally, an assessment on the stability of the existing sheet piled canal wall during temporary works has been assessed. As part of the assessment, we have considered five separate design cases as detailed below.

- **Design Case 01** – Section through the western section of Plot A where overburden removal is at its lowest;
- **Design Case 02** – Section through the proposed elevator shaft, capturing the deepest excavation and therefore the worst case;
- **Design Case 03** – Section through the eastern elevation of the Plot A;
- **Design Case 04** – Section through the canal wall at BH04 where the historic masonry wall is at a shallower depth;
- **Design Case 05** – Section the canal wall at BH15 where the historic masonry wall is at the maximum investigated depth.

The WALLAP computer package has been adopted to assess the stability and structural integrity for the existing contiguous and sheet piled wall. A surcharge loading of 100kN/m<sup>2</sup> has been applied to represent surface loads imposed by the existing building to Canal Side Studios.



The program allows any number of soil layers each with different soil parameters, including stiffness (Young's modulus), strength ( $c'$ ,  $c_u$ ,  $\phi'$ ) and unit weight ( $\gamma$ ) to be included along with appropriate partial safety factors.

For the purpose of this assessment we have carried out the above analyses adopting the Serviceability Limit State (SLS) and Ultimate Limit State (ULS) Design Approach 1 Combination 1 and 2 partial factors as defined in the National Annex to BS EN 1997-1:2004.

The section location plan is provided on **Figure 1** appended to this report.

### 3 RETAINING WALL GEOMETRY

The existing retaining wall geometry and stiffness values adopted for the purpose of these analyses are presented in Table 1 below. Information on the different retaining wall geometries and composition has been derived from RSK's geoenvironmental and geotechnical site investigation (ref 371654-01 (01) dated August 2019 and Arup's design calculations for piles subject to heave and lateral loads (ref 12727/BS/AT/KAH) dated August 1983. Arup's report states a contiguous pile spacing of 1.0m, however, during RSK's investigation, a maximum pile spacing of 1.1m was recorded and therefore used as the worst case when calculating moments of inertia.

**Table 1: Wall Properties**

Structures Member	Material	Moment of Inertia (m <sup>4</sup> /m run)	Young's Modulus (kPa)	Maximum Excavation Depth (m)	Wall Depth (m)
Contiguous piles	RC concrete	$5.78 \times 10^{-3}$	$2.80 \times 10^7$ <sup>1)</sup>	7.0 <sup>2)</sup>	21.70
Sheet pile	Welded steel (Arcelor AZ18) <sup>3)</sup>	$3.42 \times 10^{-4}$ <sup>4)</sup>	$2.05 \times 10^8$ <sup>4)</sup>	5.50 <sup>5)</sup>	7.50

1) Young's modulus for concrete  
 2) Maximum excavation depth taken from elevator shaft construction in Design Case 02  
 3) Dimensions of wall recorded during investigation similar to AZ18 provided in Arcelor Mittal piling handbook 9<sup>th</sup> edition  
 4) Values taken from Arcelor Mittal piling handbook  
 5) Maximum depth of historic masonry wall with an over dig of 0.50m (Design Case 05)

**Table 2: Single pile properties**

Diameter (mm)	Vertical reinforcing bars		Minimum cover (mm)	Concrete strength (N/mm <sup>2</sup> )	
	No.	Diameter (mm)		Design <sup>1)</sup>	Tested <sup>2)</sup>
600	6	32	70	25	40

1) Design value taken from Arup's report  
 2) Concrete samples tested during RSK's investigation  
 3) Tested values meet with design value. There is insufficient testing to assume a higher design strength

## 4 GEOTECHNICAL PARAMETERS

The soil parameters used for the analyses are summarised in Table 3. These have been assessed from the borehole *in-situ* testing results. All the WALLAP analyses performed have adopted total stress soil parameters as undrained conditions are considered critical during the initial stages of construction.

**Table 3: Soil Parameters for Analyses**

Material	Ground Level at Surface (mOD)	Bulk Unit weight (kN/m <sup>3</sup> )	cu (kN/m <sup>2</sup> )	Horizontal Earth pressure Coefficients K <sub>o</sub> , K <sub>ac</sub> , K <sub>pc</sub>	Eu (kN/m <sup>2</sup> )
Made Ground (Granular)	23.70 to 22.02	18.5	30	1.00, 2.47, 2.47 <sup>2)</sup>	15,000
London Clay	23.25 to 21.32	20	80 + 4.39 x z <sup>1)</sup>	1.00, 2.47, 2.47 <sup>2)</sup>	47,000 + 3130 x z
Lambeth Group	-3.75 to -3.48	20	180 + 13.08 x z	1.00, 2.47, 2.47 <sup>2)</sup>	72,000 + 5231 x z

1) Rate of increase of cohesion with depth from 20.00m AOD  
2) Critical values of the active and passive earth pressure coefficients have been adopted in the analysis.

## 5 CONTIGUOUS PILED WALL

The results of the analyses of Design Case's 01, 02 and 03 are presented in Table 4 below and reported as worst case values. Software outputs are presented in **Appendix B**.

**Table 4: Results of WALLAP Analyses for Contiguous Piled Wall**

Wall Condition	Factor of Safety		Maximum Bending Moment (kNm/m)		Maximum Shear Force (kN/m)		Maximum displacement (mm)		Acceptable/ Unacceptable
	SLS	ULS <sup>1)</sup>	SLS	ULS <sup>1)</sup>	SLS	ULS	SLS	ULS <sup>1)</sup>	
Cantilever	2.82	1.89	590 <sup>2)</sup>	515	325 <sup>2)</sup>	254	74	118	Unacceptable
Single Prop Level	4.29	2.83	195	163	250 <sup>2)</sup>	209	13	14	Unacceptable

1) ULS combination 2 has been reported as this is the worst case  
2) In this instance, the SLS values are the worst case. This is due to applying a factor of 1.35 to obtain values for design  
3) Bending moments and shear forces have been multiplied by 1.1 based on the maximum pile spacing recorded

### Cantilever

All three cases provide acceptable Factors of Safety against overturning failure in the short term (temporary case) without the need for propping. The most conservative analysis method (ULS

combination 2) calculated the lowest available FoS against overturning failure at 1.89 (during excavation of the elevator shaft) against an allowable FoS of 1.5.

However, the existing loads imposed by the neighbouring Canal Side Studios contribute to excessive bending moments (max 590kNm/m) acting on the existing pile wall at excavation level with a maximum shear force of some 325kN/m. Additionally, displacements of the wall due to the imposed load are too great with a maximum calculated at 118mm.

Therefore, the existing piled wall will be unacceptable if acting as a cantilever.

### Propping

Installing a single row of props during the temporary case has a notable effect on the bending moments exerted, with a significant decrease to 195kNm/m. The props modelled comprise 150mm diameter steel with a spacing of 6.0m and inclination of 45°.

In accordance with BS110-1 1997 and by consulting the British Concrete Association (BCA) curves, the reinforcement required for a pile of 600mm diameter at 25N/mm<sup>2</sup> strength to resist the maximum bending moment of 195kNm/m is calculated at six vertical 32mm steel bars at 184mm spacing with a cover of 70mm. The recommended reinforcing is similar to the reinforcing encountered during RSK's investigation and therefore considered sufficient to resist the new bending moments exerted in a single propped state.

It should be noted that to use a concrete strength higher than that of its design, 99% of concrete tests need to record above the design value. As only two piles were investigated during RSK's investigation, the higher concrete strength tested of 40N/mm<sup>2</sup> is not considered reliable

Shear links were not encountered within the top 1m of the piles tested. BS110 states that for shear links not to be necessary within a pile, the following has to comply:

$$0.5V_c < V < V_c$$

Where  $V_c$  = Shear strength of concrete

$V$  = Shear stress acting on the pile

The maximum shear force of 250 kN/m results in a shear stress of 1.03 N/mm<sup>2</sup>. When using the design concrete strength of 25N/mm<sup>2</sup>, a shear strength of 0.55N/mm<sup>2</sup> is available. When using the above equation, the calculated shear stress is neither less than the total shear strength of the concrete, nor is it less than half of the total shear strength. Therefore, the pile must have shear links in order to resist the shear forces acting on the pile.

As there were no shear links found within the top 1.0m of each pile (BH01 and BH02) and no reference is made to shear links in the Arup design document, it is not possible to assume that there are any present and therefore the existing contiguous piled wall is not considered suitable for reuse as a retaining wall.

Whilst the assessment of required reinforcement has been carried out using BS8110 it is not considered that an assessment based on EC7 Part 2 would make any significant difference.

## 6 SHEET PILED WALL

The results of the analyses of Design Case's 04 and 05 are presented in Table 5 below with their WALLAP outputs presented in **Appendix C**.

**Table 5: Results of WALLAP Analyses for Sheet Piled Wall**

Wall Condition	Factor of Safety		Maximum Bending Moment (kNm/m)		Maximum Shear Force (kN/m)		Maximum displacement (mm)		Acceptable/ Unacceptable
	SLS	ULS <sup>1)</sup>	SLS <sup>2)</sup>	ULS	SLS <sup>2)</sup>	ULS	SLS	ULS	
<b>Design Case 04</b>									
Cantilever	4.768	2.23	97	98	59	53	12	18	Acceptable
Single Prop Level	8.44	4.92	31	32	32	29	2	2	Acceptable
<b>Design Case 05</b>									
Cantilever	1.07	0.40	225	220	153	129	43	213	Unacceptable
Single Prop Level	4.86	2.94	64	60	59	52	4	5	Acceptable
1) ULS combination 2 has been reported as this is the worst case									
2) In this instance, the SLS values are the worst case. This is due to applying a factor of 1.35 to obtain values for design									

### Cantilever

The sheet pile dimensions recorded during RSK's investigation (ref 371654-01 (01)) indicate that the existing sheet piles are similar to the manufactured Arcelor AZ-18. The yield strength of the steel is unknown and therefore the most conservative steel grade of S 240 GP, manufactured in accordance to EN10248 Part 1, is assumed, exhibiting a yield strength of 240MPa (N/mm<sup>2</sup>).

The allowable bending stress of steel is generally considered to be 0.66 x yield strength which is calculated at 158N/mm<sup>2</sup> (158000kN/m<sup>2</sup>). The active earth pressures exerted by the canal and underlying London Clay contribute to a maximum bending moment of 225kN/m<sup>2</sup> and therefore well within the structural limits of the steel.

The cross-sectional area per metre run of Arcelor AZ-18 sheet piles is 150 cm<sup>2</sup> (0.015m<sup>2</sup>). The maximum shear force exerted through active earth pressures is recorded as 153kN/m which equates to a maximum shear stress of 10,200kN/m<sup>2</sup> (10.2N/mm<sup>2</sup>). It is generally accepted that the shear yield stress is 0.75 times its yield strength. Therefore, the maximum shear stress is within the structural limit of the steel at 180N/mm<sup>2</sup> (i.e. 0.75 x 240N/mm<sup>2</sup>).

Design Case 04 provides an acceptable Factor of Safety against overturning failure in the short term (temporary case) without the need for propping. However, Design Case 05 calculated unacceptable FoS with 1.07 and 0.40 for against an allowable FoS of 1.5 for both SLS and ULS combination 2 respectively.

Additionally, displacements of the wall during the temporary case are too great with a maximum calculated at 213mm. Therefore, the existing piled wall will be unacceptable if acting as a cantilever.

Although the sheet piled wall is considered stable during the excavation of the historic masonry wall in the northwest (Design Case 04), instability of the excavation is likely to still occur within the loose backfill material between the sheet pile and historic wall.

### Propping

Installing a single row of struts along the reinforced capping beam (23.50m AOD) during the temporary case has a notable effect on the displacements of the wall, with a maximum now recorded at 5mm. The struts modelled comprise 150mm diameter steel with a spacing of 5.0m.

## **7 CONCLUSION**

### Contiguous piled wall

The results of the analysis indicate that the existing piled wall will fail when utilised as a cantilever due to excessive bending moments and shear forces. The bending moments can be reduced to be within acceptable limits by propping the excavation in the temporary case, however, shear force values will remain unsatisfactory due to the apparent absence of shear link reinforcement within the piles.

The analysis has assumed the concrete piled wall to remain in good condition.

Therefore, the reuse of the existing contiguous piled walls is considered unfeasible unless further investigation below 1m depth confirms the presence of suitable shear link reinforcement in the piles.

### Sheet piled wall

The temporary excavation works of the masonry wall will induce excessive displacement along the existing canal wall and therefore struts are recommended along the capping beam to reduce the displacement to within acceptable values. Thrust struts, or something similar, are recommended at 5.0m spacing and at 150mm diameter. However, this should be designed by the specialist temporary works contractor.

Loose backfill material was encountered during RSK's previous investigation, in between the existing sheet piled wall and historic masonry wall. Should manned entry be required, the temporary support works should be designed by an appropriate temporary works contractor.

The results of the analysis indicate that the sheet piled wall will remain stable during the excavation of the masonry wall within the north-western area. However, the depth of the masonry wall was only recorded at one location during RSK's previous investigation and therefore its extent cannot be relied upon. Therefore propping/strutting is recommended across the entire length of the canal wall.

Where investigated, the sheet piled wall was found to be in good condition with little corrosion noted. The analysis has assumed the sheet piled wall to remain in good condition with fully welded joints throughout its embedded depth. Any localised imperfections have not been accounted for and if present, will reduce the stiffness of the wall. A qualified geotechnical engineer will need to inspect any localised corroded or

damaged areas that are uncovered during the temporary works and advise as necessary. The temporary works proposals will need to be discussed and approved by British Waterways in advance of any works.

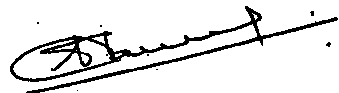
The preliminary analysis reported herein was undertaken to assess the feasibility of reusing the existing retaining structures and does not constitute a formal design. The Contractor undertaking the works will need to conduct their own formal design checks to satisfy themselves and any interested third parties.

Yours faithfully

For **RSK Environment Ltd**



**Michael McCann**  
Geotechnical Engineer



**Dr T Navaneethan**  
Associate Technical Director

Figures

Appendix A – Service Constraints

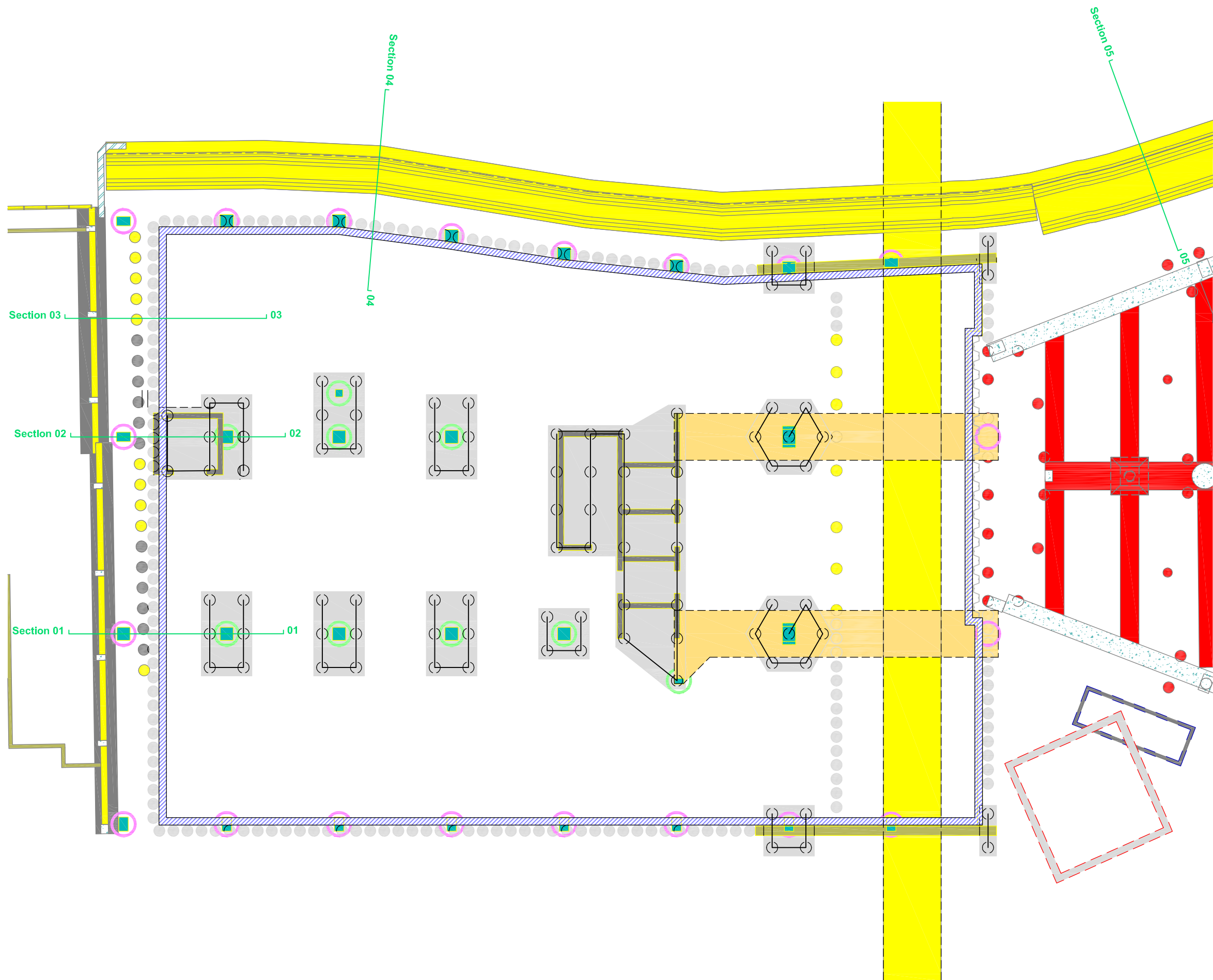
Appendix B – WALLAP Outputs – Contiguous piled wall

Appendix C – WALLAP Outputs – Sheet piled wall

## FIGURES

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Rev.	Date	Amendment	Drawn	Chkd.	Appd.



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Tel: +44 (0) 1442 437500  
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Client  
**THE TRUSTEES OF THE ST PANCRAS WAY  
BLOCK A UNIT TRUST & BIG LOBSTER**

Project Title  
**UGLY BROWN BUILDING  
RETAINING WALL ASSESSMENT**

Drawing Title  
**FIGURE 1: SECTION LOCATION PLAN**

Drawn	Date	Checked	Date	Approved	Date
AT	22-07-19	AT	22-07-19	MM	22-07-19

Scale	Orig Size	Dimensions
NTS	A3	M

Project No.	Drawing File
371654	371654_SLP

Drawing No.	Rev.
371654_01_SLP	R

## APPENDIX A

# SERVICE CONSTRAINTS

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1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for GD Partnership on behalf of Reef Group c/o The Trustees of the St Pancras Way Block A Unit Trust and Big Lobster Limited (the "Client") in accordance with the terms of a contract [RSK Environment Standard Terms and Conditions] between RSK and the Client. The Services were performed by RSK with the reasonable skill and care ordinarily exercised by an environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the Client.
2. Other than that, expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the Client. RSK is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the Client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the Client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, invasive plants, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials, unless specifically identified in the Services.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a visual inspection of the site together with RSK's interpretation of information, including documentation, obtained from third parties and from the Client on the history and usage of the site, unless specifically identified in the Services or accreditation system (such as UKAS ISO 17020:2012 clause 7.1.6):
  - a. The Services were based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely.
  - b. The Services were limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the visual inspection.
  - c. The Services did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services.

RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the Client and RSK.

8. The intrusive environmental site investigation aspects of the Services are a limited sampling of the site at pre-determined locations based on the known historic / operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the properties of the materials adjacent and local conditions, together with the position of any current structures and underground utilities and facilities, and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters (as stipulated in the scope between the client and RSK, based on an understanding of the available operational and historical information) and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.
10. The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater levels and ground gas concentrations and flows, may vary from those reported due to seasonal, or other, effects and the limitations stated in the data should be recognised.
11. Asbestos is often observed to be present in soils in discrete areas. Whilst asbestos-containing materials may have been locally encountered during the fieldworks or supporting laboratory analysis, the history of brownfield and demolition sites indicates that asbestos fibres may be present more widely in soils and aggregates, which could be encountered during more extensive ground works.
12. Unless stated otherwise, only preliminary geotechnical recommendations are presented in this report and these should be verified in a Geotechnical Design Report, once proposed construction and structural design proposals are confirmed.



**APPENDIX B**  
**WALLAP OUTPUTS: CONTIGUOUS PILED WALL**

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## DESIGN CASE 01

RSK ENVIRONMENT LTD  
 Program: WALLAP Version 6.06 Revision A52.B71.R55  
 Licensed from GEOSOLVE  
 Data filename/Run ID: Design\_Case\_01\_no\_prop\_SLS  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	22.02	1 Made Ground	1 Made Ground
2	21.32	2 London Clay	2 London Clay
3	-3.48	3 Lambeth Group	3 Lambeth Group

**SOIL PROPERTIES**

Soil type	Bulk density	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol. state. (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1 Made Ground	18.50	15000	1.000	NC (0.200)	0.353 (1.388)	3.412 (5.173)	0.0d
2 London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390)
3 Lambeth G.. ( -3.48 )	20.00	72000 ( 5231)	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08)
4 London Cl.. ( 20.00 )	20.00	28800 ( 2610)	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5 Lambeth G.. ( 8.75 )	20.00	57600 ( 4185)	1.000 ( 1.000)	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1 Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2 London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3 Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4 London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5 Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation  
 Left side: 20.59  
 Right side: 20.59  
 Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			Water press.
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0 MC+WC
2	1	22.02	22.02	0.0	1	15.55	15.55	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	20.02	6.00	0.017663	2.050E+08	1.65	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	21.80	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m <sup>2</sup>	-----	Equiv. soil type	Partial factor/ Category
1	20.02	1.20(L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.50	-0.00(R)	23.80	3.10	30.00	=	N/A	1.00 -
3	16.50	-5.80(R)	23.80	14.60	30.00	=	N/A	1.00 -
4	17.50	-0.00(R)	23.80	20.00	12.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 20.02 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Apply surcharge no.2 at elevation 16.50 No analysis at this stage
4	Apply surcharge no.3 at elevation 16.50 No analysis at this stage
5	Excavate to elevation 16.50 on RIGHT side
6	Remove surcharge no.2 at elevation 16.50 No analysis at this stage
7	Remove surcharge no.3 at elevation 16.50 No analysis at this stage
8	Fill to elevation 17.50 on RIGHT side with soil type 2
9	Install strut or anchor no.2 at elevation 18.00
10	Install strut or anchor no.3 at elevation 21.80
11	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
12	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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/m<sup>3</sup>  
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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m  
Distance to rigid boundary on Right side = 23.70 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 20.02	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Apply surcharge no.2 at elev. 16.50	No	No	No
4	Apply surcharge no.3 at elev. 16.50	No	No	No
5	Excav. to elev. 16.50 on RIGHT side	Yes	Yes	Yes
6	Remove surcharge no.2 at elev. 16.50	No	No	No
7	Remove surcharge no.3 at elev. 16.50	No	No	No
8	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.80	Yes	Yes	Yes
11	Change soil type 2 to soil type 4	Yes	Yes	Yes
12	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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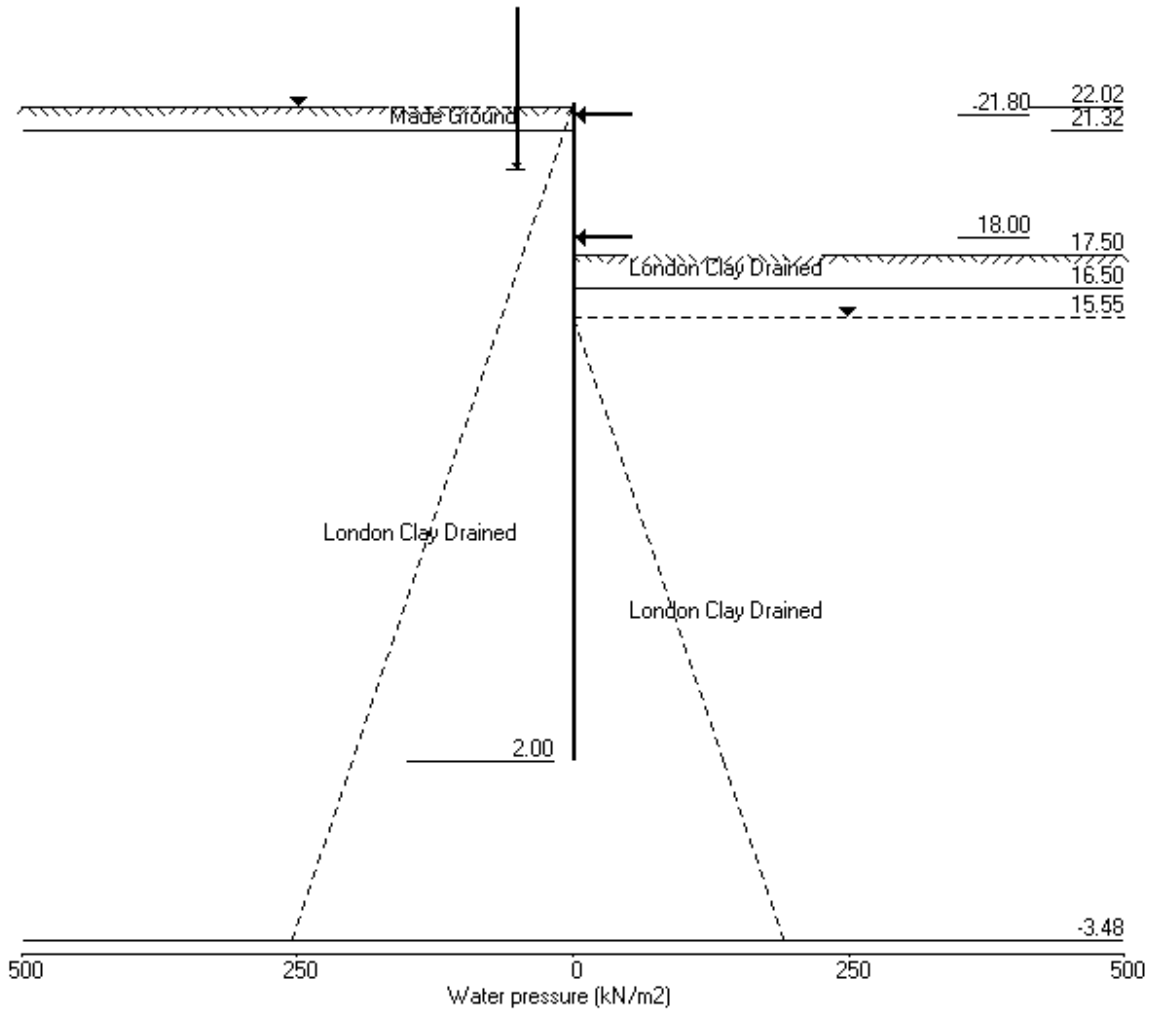


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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.12 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 16.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
5	22.02	16.50	Cant.	4.449	3.40	14.62	1.88	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.027	4.02E-03	0.0	0.0	
2	21.80	1.44	0.026	4.02E-03	0.2	-0.0	
3	21.32	4.57	0.024	4.02E-03	1.6	0.5	
		3.50	0.024	4.02E-03	1.6	0.5	
4	20.59	7.15	0.021	4.02E-03	5.5	3.1	
5	20.02	10.00	0.018	4.00E-03	10.4	7.7	
6	19.01	15.05	0.014	3.89E-03	23.0	25.0	
7	18.00	20.10	0.011	3.64E-03	40.8	57.6	
8	17.50	22.60	0.009	3.42E-03	51.4	80.7	
9	16.50	38.97	0.006	2.68E-03	82.2	160.4	
		-153.17	0.006	2.68E-03	82.2	160.4	
10	15.55	-60.63	0.004	1.71E-03	-19.3	169.2	
11	14.38	1.35	0.002	7.22E-04	-54.1	104.4	
12	13.20	19.95	0.002	1.92E-04	-41.6	41.7	
13	12.00	16.81	0.002	1.57E-05	-19.6	6.0	
14	10.80	8.29	0.002	1.38E-05	-4.5	-5.5	
15	9.60	2.08	0.002	5.36E-05	1.7	-5.2	
16	8.40	-0.60	0.002	8.03E-05	2.6	-2.0	
17	7.20	-1.03	0.001	8.61E-05	1.6	0.4	
18	6.00	-0.67	0.001	8.01E-05	0.6	1.2	
19	4.80	-0.30	0.001	7.15E-05	0.0	1.1	
20	3.60	-0.06	0.001	6.54E-05	-0.2	0.5	
21	2.80	0.10	0.001	6.35E-05	-0.2	0.2	
22	2.00	0.37	0.001	6.29E-05	-0.0	-0.0	

(continued)

Stage No.5 Excavate to elevation 16.50 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	3237
2	21.80	0.00	4.07	1.44	13.89	1.44	1.44a	3237
3	21.32	0.00	12.95	4.57	44.19	4.57	4.57a	3237
		Total>	12.95	3.50m	196.62	3.50	3.50a	12787
4	20.59	Total>	27.55	7.15m	219.15	7.15	7.15a	13469
5	20.02	Total>	38.95	10.00m	236.74	10.00	10.00a	14001
6	19.01	Total>	69.07	15.05m	277.83	15.05	15.05a	14944
7	18.00	Total>	101.69	20.10m	321.44	20.10	20.10a	15887
8	17.50	Total>	113.57	22.60m	338.74	22.60	22.60a	16354
9	16.50	Total>	133.14	27.60m	369.18	38.97	38.97	17288
10	15.55	Total>	150.00	32.35m	396.36	89.17	89.17	18175
11	14.38	Total>	170.66	38.22m	429.79	132.43	132.43	19272
12	13.20	Total>	191.69	44.10m	463.59	160.47	160.47	20369
13	12.00	Total>	213.61	50.10m	498.55	181.77	181.77	21489
14	10.80	Total>	235.90	56.10m	533.88	201.67	201.67	22610
15	9.60	Total>	258.49	62.10m	569.50	222.74	222.74	23730
16	8.40	Total>	281.30	68.10m	605.35	245.30	245.30	24850
17	7.20	Total>	304.28	74.10m	641.38	268.82	268.82	25971
18	6.00	Total>	327.41	80.10m	677.55	292.75	292.75	27091
19	4.80	Total>	350.66	86.10m	713.83	316.80	316.80	28212
20	3.60	Total>	374.00	92.10m	750.21	340.89	340.89	29332
21	2.80	Total>	389.61	96.10m	774.51	357.01	357.01	30079
22	2.00	Total>	405.24	100.10m	798.84	373.20	373.20	30826

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	16.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	30.00	0.00	266.04	192.14	192.14	31351
10	15.55	Total>	48.72	4.75m	295.09	149.80	149.80	32960
11	14.38	Total>	70.46	10.62m	329.59	131.08	131.08	34949
12	13.20	Total>	91.58	16.50m	363.48	140.51	140.51	36939
13	12.00	Total>	113.75	22.50m	398.69	164.96	164.96	38970
14	10.80	Total>	136.78	28.50m	434.75	193.38	193.38	41002
15	9.60	Total>	160.46	34.50m	471.47	220.66	220.66	43034
16	8.40	Total>	184.59	40.50m	508.65	245.90	245.90	45066
17	7.20	Total>	209.03	46.50m	546.12	269.85	269.85	47098
18	6.00	Total>	233.69	52.50m	583.82	293.43	293.43	49130
19	4.80	Total>	258.51	58.50m	621.69	317.10	317.10	51161
20	3.60	Total>	283.48	64.50m	659.69	340.96	340.96	53193
21	2.80	Total>	300.19	68.50m	685.09	356.91	356.91	54548
22	2.00	Total>	316.94	72.50m	710.54	372.83	372.83	55902

Run ID. Design\_Case\_01\_no\_prop\_SLS  
Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
Date:13-05-2020  
Checked :

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Stage No.5 Excavate to elevation 16.50 on RIGHT side  
Note: 22.60a Soil pressure at active limit  
123.45p Soil pressure at passive limit

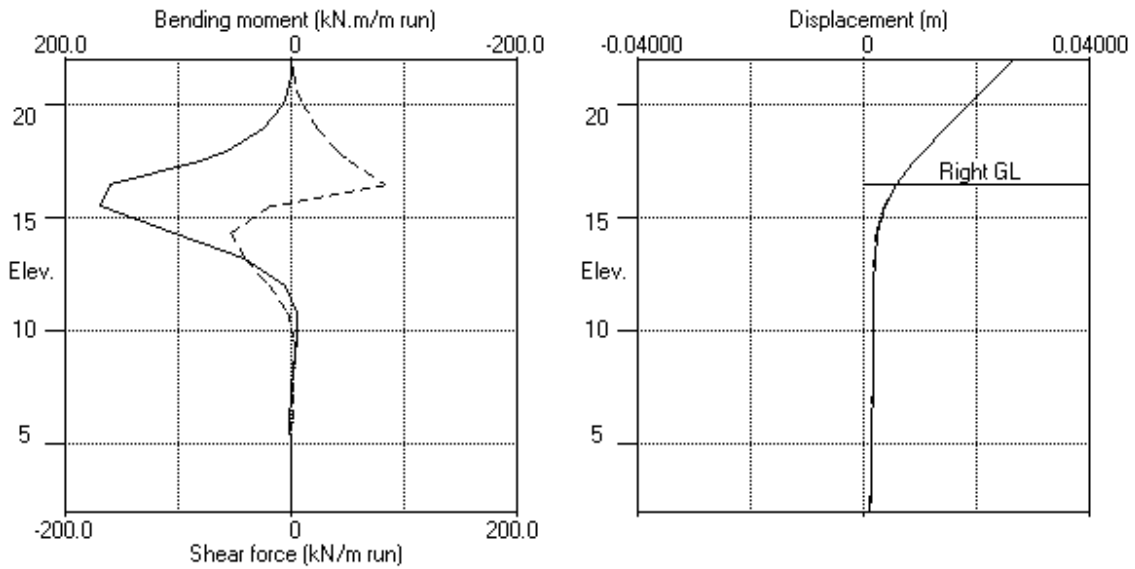
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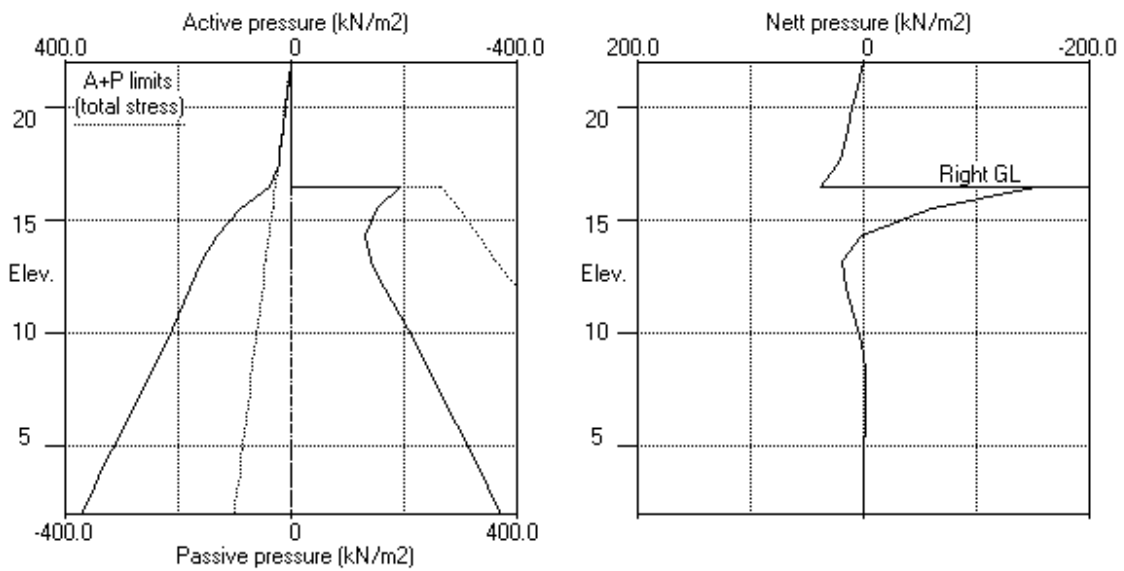
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
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Units: kN, m

Stage No.5 Excav. to elev. 16.50 on RIGHT side



Stage No.5 Excav. to elev. 16.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 8 Fill to elevation 17.50 on RIGHT side with soil type 2

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
8	22.02	17.50	Cant.	4.610	3.32	15.92	1.58	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.026	4.01E-03	0.0	0.0	
2	21.80	1.61	0.026	4.01E-03	0.2	-0.0	
3	21.32	4.72	0.024	4.01E-03	1.7	0.5	
		4.11	0.024	4.01E-03	1.7	0.5	
4	20.59	7.67	0.021	4.00E-03	6.0	3.4	
5	20.02	10.43	0.018	3.98E-03	11.2	8.4	
6	19.01	15.22	0.014	3.87E-03	24.1	26.6	
7	18.00	20.10	0.011	3.60E-03	41.9	60.4	
8	17.50	22.60	0.009	3.38E-03	52.6	84.1	
		22.16	0.009	3.38E-03	52.6	84.1	
9	16.50	17.49	0.006	2.62E-03	72.5	161.6	
		-145.83	0.006	2.62E-03	72.5	161.6	
10	15.55	-55.12	0.004	1.66E-03	-23.0	164.3	
11	14.38	3.90	0.002	7.15E-04	-53.1	98.6	
12	13.20	20.09	0.002	2.18E-04	-39.0	38.3	
13	12.00	15.92	0.002	5.58E-05	-17.4	5.4	
14	10.80	7.40	0.002	5.25E-05	-3.4	-4.5	
15	9.60	1.56	0.002	8.32E-05	2.0	-3.8	
16	8.40	-0.77	0.002	1.00E-04	2.4	-0.8	
17	7.20	-0.98	0.001	9.86E-05	1.4	1.1	
18	6.00	-0.57	0.001	8.83E-05	0.5	1.6	
19	4.80	-0.23	0.001	7.77E-05	-0.0	1.3	
20	3.60	-0.05	0.001	7.08E-05	-0.2	0.6	
21	2.80	0.10	0.001	6.88E-05	-0.2	0.3	
22	2.00	0.35	0.001	6.82E-05	-0.0	-0.0	

(continued)

Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	4156
2	21.80	0.00	4.07	1.44	13.89	1.61	1.61	4156
3	21.32	0.00	12.95	4.57	44.19	4.72	4.72	4156
		Total>	12.95	3.50m	196.62	4.11	4.11	16241
4	20.59	Total>	27.55	7.15m	219.15	7.67	7.67	17107
5	20.02	Total>	38.95	10.00m	236.74	10.43	10.43	17783
6	19.01	Total>	69.07	15.05m	277.83	15.22	15.22	18980
7	18.00	Total>	101.69	20.10m	321.44	20.10	20.10a	11972
8	17.50	Total>	113.57	22.60m	338.74	22.60	22.60a	12324
9	16.50	Total>	133.14	27.60m	369.18	37.84	37.84	13027
10	15.55	Total>	150.00	32.35m	396.36	87.27	87.27	13696
11	14.38	Total>	170.66	38.22m	429.79	129.95	129.95	14522
12	13.20	Total>	191.69	44.10m	463.59	158.03	158.03	15349
13	12.00	Total>	213.61	50.10m	498.55	179.87	179.87	16193
14	10.80	Total>	235.90	56.10m	533.88	200.49	200.49	17037
15	9.60	Total>	258.49	62.10m	569.50	222.24	222.24	17882
16	8.40	Total>	281.30	68.10m	605.35	245.33	245.33	20548
17	7.20	Total>	304.28	74.10m	641.38	269.26	269.26	21475
18	6.00	Total>	327.41	80.10m	677.55	293.48	293.48	22401
19	4.80	Total>	350.66	86.10m	713.83	317.76	317.76	23328
20	3.60	Total>	374.00	92.10m	750.21	342.06	342.06	24254
21	2.80	Total>	389.61	96.10m	774.51	358.32	358.32	24872
22	2.00	Total>	405.24	100.10m	798.84	374.64	374.64	25490

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	0.44	0.44	12324
9	16.50	Total>	20.00	5.00m	256.05	20.35	20.35	13027
		Total>	20.00	5.00m	256.05	183.67	183.67	13027
10	15.55	Total>	39.03	9.75m	285.40	142.39	142.39	13696
11	14.38	Total>	62.64	15.62m	321.77	126.05	126.05	14522
12	13.20	Total>	86.36	21.50m	358.26	137.94	137.94	15349
13	12.00	Total>	110.72	27.50m	395.66	163.95	163.95	16193
14	10.80	Total>	135.25	33.50m	433.23	193.10	193.10	17037
15	9.60	Total>	159.96	39.50m	470.98	220.68	220.68	17882
16	8.40	Total>	184.85	45.50m	508.90	246.11	246.11	20548
17	7.20	Total>	209.90	51.50m	546.99	270.25	270.25	21475
18	6.00	Total>	235.10	57.50m	585.24	294.06	294.06	22401
19	4.80	Total>	260.44	63.50m	623.61	317.99	317.99	23328
20	3.60	Total>	285.89	69.50m	662.10	342.11	342.11	24254
21	2.80	Total>	302.91	73.50m	687.81	358.22	358.22	24872
22	2.00	Total>	319.96	77.50m	713.56	374.29	374.29	25490

Run ID. Design\_Case\_01\_no\_prop\_SLS  
Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
Date:13-05-2020  
Checked :

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(continued)

Stage No.8    Fill to elevation 17.50 on RIGHT side with soil type 2  
Note:        22.60a    Soil pressure at active limit  
              123.45p    Soil pressure at passive limit

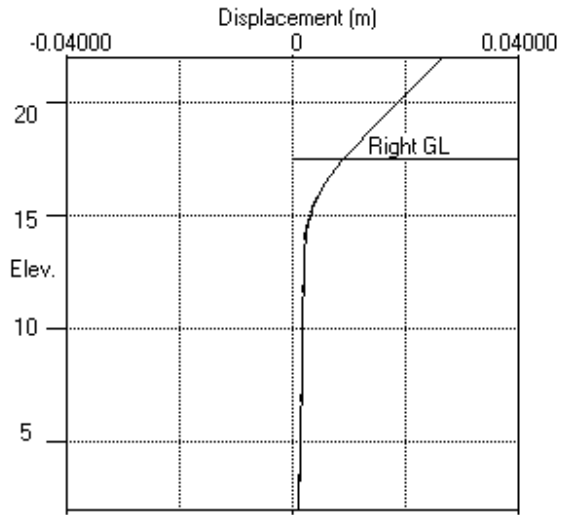
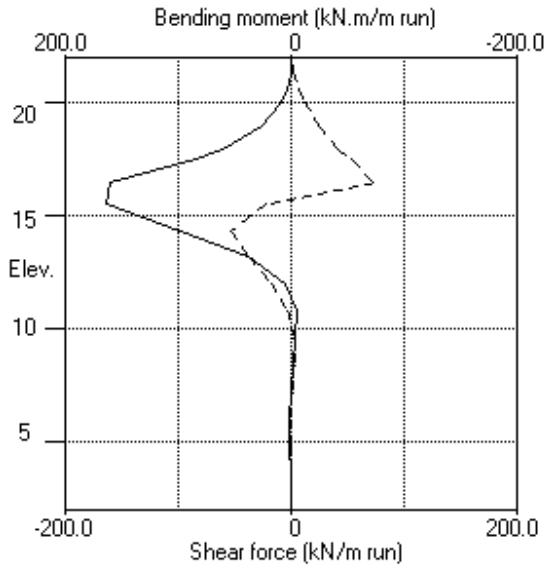


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 Ugly Brown Building  
 Existing contiguous wall stability assessment

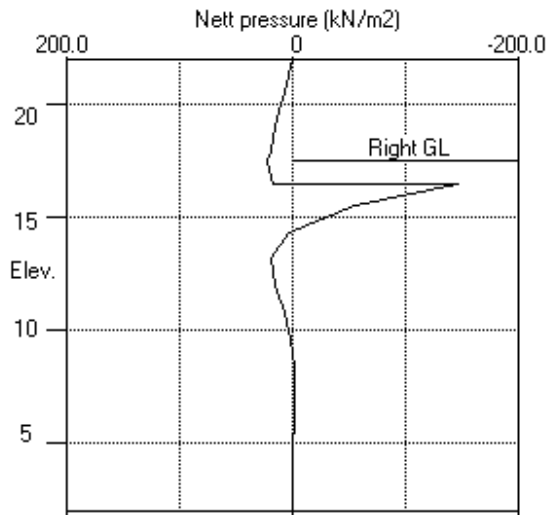
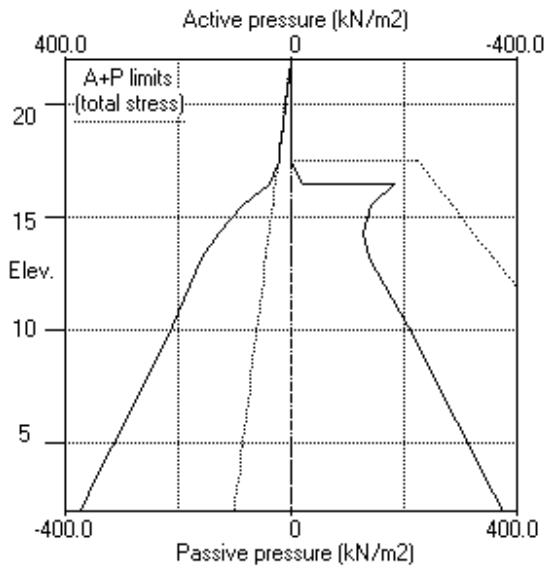
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.8 Fill to elev. 17.50 on RIGHT side



Stage No.8 Fill to elev. 17.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 11 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
11	22.02	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.026	3.90E-03	0.0	0.0	
2	21.80	3.58	0.025	3.90E-03	0.4	-0.0	0.0
3	21.32	6.44	0.023	3.89E-03	2.8	0.8	
		7.02	0.023	3.89E-03	2.8	0.8	
4	20.59	10.09	0.020	3.88E-03	9.0	5.3	
5	20.02	12.36	0.018	3.85E-03	15.4	12.4	
6	19.01	28.97	0.014	3.69E-03	36.3	38.3	
7	18.00	47.71	0.011	3.28E-03	75.0	93.8	-108.4
		47.71	0.011	3.28E-03	-33.4	93.8	
8	17.50	55.34	0.009	3.01E-03	-7.6	83.5	
		52.68	0.009	3.01E-03	-7.6	83.5	
9	16.50	44.07	0.007	2.39E-03	40.8	115.7	
		-15.94	0.007	2.39E-03	40.8	115.7	
10	15.55	-61.21	0.005	1.68E-03	4.1	127.4	
11	14.38	-6.13	0.003	8.94E-04	-35.5	89.4	
12	13.20	13.21	0.002	4.14E-04	-31.3	42.9	
13	12.00	12.28	0.002	2.02E-04	-16.0	14.3	
14	10.80	6.14	0.002	1.36E-04	-4.9	3.4	
15	9.60	1.62	0.002	1.18E-04	-0.3	1.4	
16	8.40	-0.16	0.002	1.06E-04	0.6	1.8	
17	7.20	-0.35	0.001	9.31E-05	0.3	1.9	
18	6.00	-0.13	0.001	8.05E-05	-0.0	1.5	
19	4.80	0.00	0.001	7.15E-05	-0.1	0.9	
20	3.60	0.02	0.001	6.68E-05	-0.1	0.3	
21	2.80	0.06	0.001	6.56E-05	-0.0	0.1	
22	2.00	0.01	0.001	6.53E-05	-0.0	-0.0	

At elev. 21.80 The prop is slack

At elev. 18.00 Prop force = 108.4 kN/m run

(continued)

Stage No.11 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	5719
2	21.80	0.00	4.07	1.44	13.89	3.58	3.58	4410
3	21.32	0.00	12.95	4.57	44.19	6.44	6.44	4410
		0.00	12.95	0.00	63.48	7.02	7.02	7454
4	20.59	0.00	27.55	3.30	107.92	10.09	10.09	8014
5	20.02	5.70	33.25	5.49	125.27	6.66	12.36	8451
6	19.01	15.80	53.27	13.17	186.18	13.17	28.97a	9226
7	18.00	25.90	75.79	21.81	254.75	21.81	47.71a	6082
8	17.50	30.90	82.67	24.44	275.66	24.44	55.34a	6315
9	16.50	40.90	92.24	28.11	304.79	28.11	69.01a	6782
10	15.55	50.40	99.60	30.93	327.19	31.26	81.66	7225
11	14.38	62.15	108.51	34.35	354.32	62.79	124.94	7774
12	13.20	73.90	117.79	37.91	382.57	80.69	154.59	8322
13	12.00	85.90	127.71	41.72	412.76	92.15	178.05	8882
14	10.80	97.90	138.00	45.66	444.08	101.96	199.86	9442
15	9.60	109.90	148.59	49.72	476.29	112.37	222.27	11075
16	8.40	121.90	159.40	53.87	509.19	123.74	245.64	11695
17	7.20	133.90	170.38	58.08	542.63	135.68	269.58	12316
18	6.00	145.90	181.51	62.35	576.50	147.81	293.71	12936
19	4.80	157.90	192.76	66.66	610.73	159.98	317.88	13556
20	3.60	169.90	204.10	71.01	645.25	172.20	342.10	14176
21	2.80	177.90	211.71	73.93	668.40	180.40	358.30	58223
22	2.00	185.90	219.34	76.86	691.64	188.57	374.47	63920

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.07	2.66	2.66	6315
9	16.50	0.00	20.00	0.41	84.95	24.94	24.94	6782
		0.00	20.00	0.41	84.95	84.95	84.95p	6782
10	15.55	0.00	39.03	7.71	142.87	142.87	142.87p	7225
11	14.38	11.75	50.89	12.26	178.95	119.31	131.06	7774
12	13.20	23.50	62.86	16.84	215.37	117.88	141.38	8322
13	12.00	35.50	75.22	21.59	253.01	130.27	165.77	8882
14	10.80	47.50	87.75	26.39	291.15	146.23	193.73	9442
15	9.60	59.50	100.46	31.27	329.83	161.15	220.65	11075
16	8.40	71.50	113.35	36.21	369.04	174.30	245.80	11695
17	7.20	83.50	126.40	41.21	408.76	186.43	269.93	12316
18	6.00	95.50	139.60	46.28	448.95	198.33	293.83	12936
19	4.80	107.50	152.94	51.39	489.54	210.37	317.87	13556
20	3.60	119.50	166.39	56.55	530.48	222.57	342.07	14176
21	2.80	127.50	175.41	60.01	557.92	230.73	358.23	58223
22	2.00	135.50	184.46	63.48	585.47	238.96	374.46	63920

Run ID. Design\_Case\_01\_no\_prop\_SLS  
Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
Date:13-05-2020  
Checked :

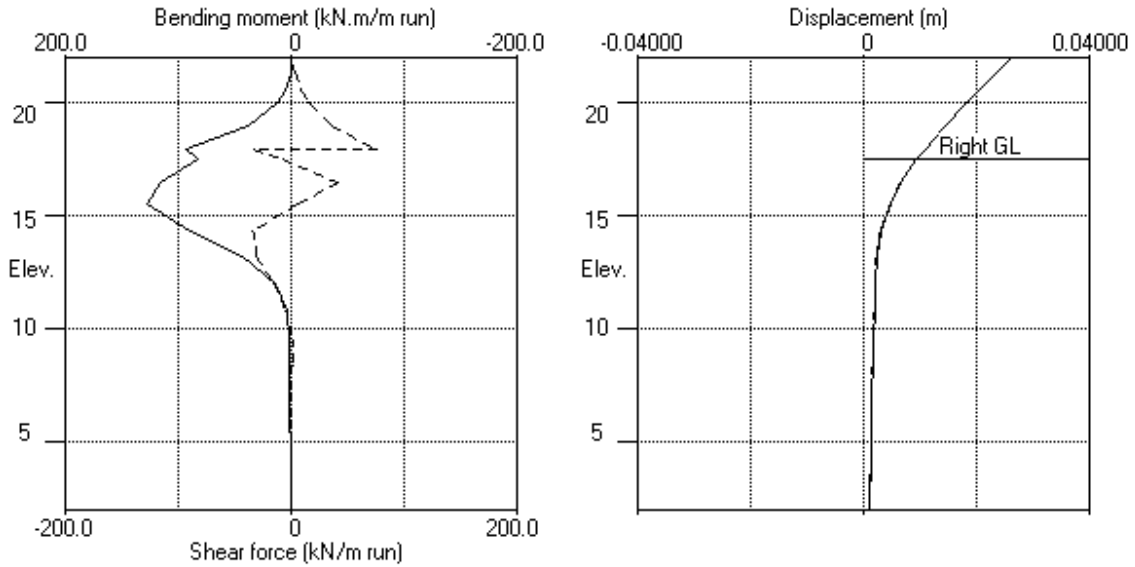
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(continued)

Stage No.11 Change properties of soil type 2 to soil type 4  
Ko pressures will not be reset

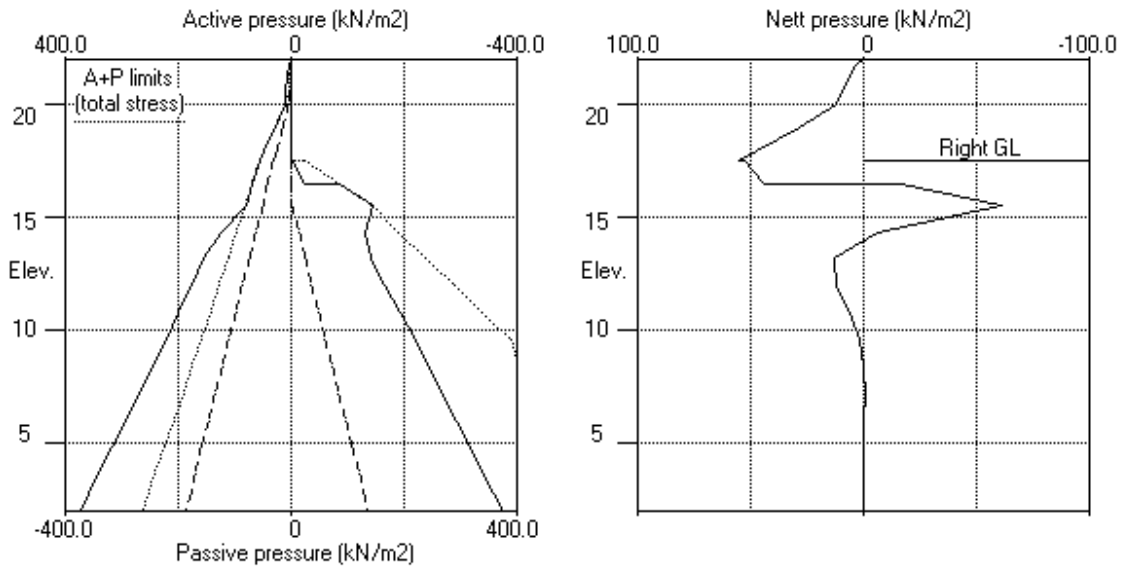
Note: 69.01a Soil pressure at active limit  
142.87p Soil pressure at passive limit

Units: kN, m

Stage No.11 Change soil type 2 to soil type 4



Stage No.11 Change soil type 2 to soil type 4



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 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	22.02	22.02		No analysis at this stage				
4	22.02	22.02		No analysis at this stage				
5	22.02	16.50	Cant.	4.449	3.40	14.62	1.88	L to R
6	22.02	16.50		No analysis at this stage				
7	22.02	16.50		No analysis at this stage				
8	22.02	17.50	Cant.	4.610	3.32	15.92	1.58	L to R
9	22.02	17.50		No analysis at this stage				

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

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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	22.02	0.027	-0.000	0	0	0	0	0	0	0	0
2	21.80	0.026	-0.000	0	-0	0	-0	0	-4	1	-5
3	21.32	0.024	0.000	1	-1	1	-1	3	-0	4	-0
4	20.59	0.021	0.000	5	0	7	0	11	-1	15	-2
5	20.02	0.018	0.000	13	-1	17	-1	23	-4	31	-6
6	19.01	0.015	0.000	52	-6	70	-9	54	-8	73	-11
7	18.00	0.011	0.000	131	-13	177	-18	104	-63	140	-86
8	17.50	0.009	0.000	107	-15	144	-21	53	-33	71	-44
9	16.50	0.007	0.000	162	-14	218	-20	82	0	111	0
10	15.55	0.005	0.000	169	-11	228	-14	5	-23	7	-31
11	14.38	0.004	0.000	104	-5	141	-6	5	-54	7	-73
12	13.20	0.003	0.000	43	-0	58	-0	3	-42	5	-56
13	12.00	0.003	0.000	14	0	19	0	2	-20	2	-26
14	10.80	0.003	0.000	3	-6	5	-7	0	-5	1	-7
15	9.60	0.003	0.000	3	-5	3	-7	2	-0	3	-0
16	8.40	0.002	0.000	2	-2	3	-3	3	-0	4	-0
17	7.20	0.002	0.000	3	0	4	0	2	-0	2	-0
18	6.00	0.002	0.000	2	0	3	0	1	-0	1	-0
19	4.80	0.002	0.000	2	0	2	0	0	-0	0	-0
20	3.60	0.002	0.000	1	0	1	0	0	-0	0	-0
21	2.80	0.002	0.000	0	0	0	0	0	-0	0	-0
22	2.00	0.002	0.000	0	-0	0	-0	0	-0	0	-0

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
	max. kN.m/m	elev.	min. kN.m/m	elev.	max. kN.m/m	min. kN.m/m	max. kN/m	elev.	min. kN/m	elev.	max. kN/m	min. kN/m
1	3	10.80	-15	17.50	4	-20	5	15.55	-8	19.01	7	-11
2	3	10.80	-15	17.50	4	-21	5	14.38	-8	19.01	7	-11
3	No calculation at this stage											
4	No calculation at this stage											
5	169	15.55	-6	10.80	228	-7	82	16.50	-54	14.38	111	-73
6	No calculation at this stage											
7	No calculation at this stage											
8	164	15.55	-5	10.80	222	-6	72	16.50	-53	14.38	98	-72
9	No calculation at this stage											
10	No calculation at this stage											
11	127	15.55	-0	21.80	172	-0	75	18.00	-35	14.38	101	-48
12	131	18.00	-1	21.32	177	-1	104	18.00	-63	18.00	140	-86

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.001	16.50	-0.000	22.02	Apply surcharge no.1 at elev. 20.02
2	0.001	16.50	-0.000	22.02	Apply water pressure profile no.1
3	No calculation at this stage				Apply surcharge no.2 at elev. 16.50
4	No calculation at this stage				Apply surcharge no.3 at elev. 16.50
5	0.027	22.02	0.000	22.02	Excav. to elev. 16.50 on RIGHT side
6	No calculation at this stage				Remove surcharge no.2 at elev. 16.50
7	No calculation at this stage				Remove surcharge no.3 at elev. 16.50
8	0.026	22.02	0.000	22.02	Fill to elev. 17.50 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 18.00
10	No calculation at this stage				Install prop no.3 at elev. 21.80
11	0.026	22.02	0.000	22.02	Change soil type 2 to soil type 4
12	0.027	22.02	0.000	22.02	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

Stage no.	Prop no. 2 at elev. 18.00			Prop no. 3 at elev. 21.80		
	Calculated kN per m run	Factored kN per prop	Factored kN per prop	Calculated kN per m run	Factored kN per slack	Factored kN per prop
11	108	108	146	slack	slack	slack
12	167	167	226	4	4	6

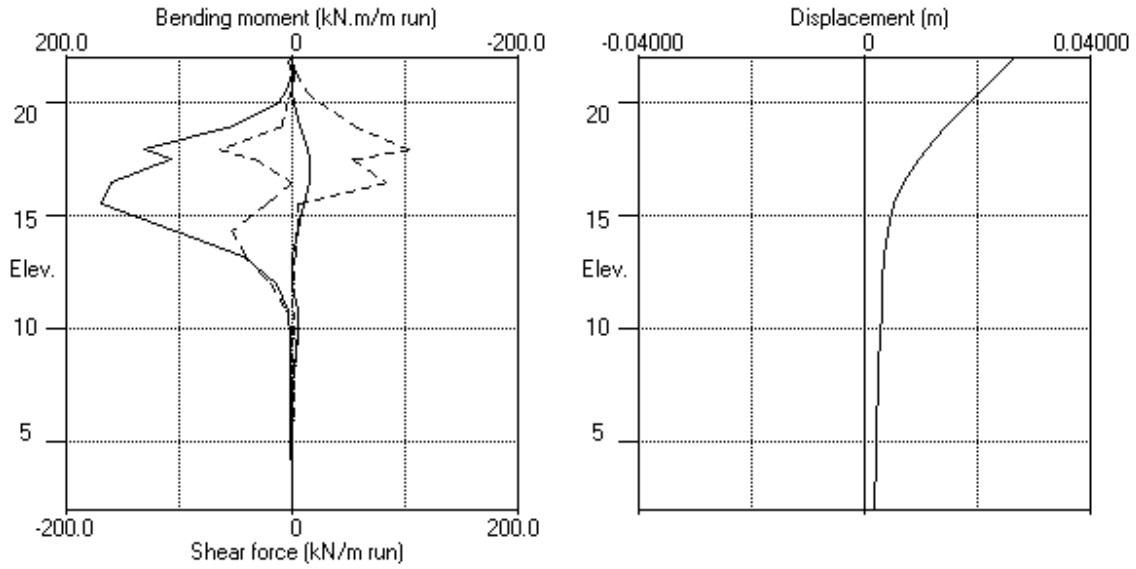


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Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	22.02	1 Made Ground		1 Made Ground
2	21.32	2 London Clay		2 London Clay
3	-3.48	3 Lambeth Group		3 Lambeth Group

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

Soil type	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh, kN/m2 (dEh/dy)	Ko (dKo/dy)	( Nu ) ( NC/OC )	( Ka ) ( Kac )	( Kpc ) ( Kpc )	( dc/dy ) ( kN/m2 )
1 Made Ground	18.50	15000	1.000	NC (0.200)	0.353 (1.388)	3.412 (5.173)	0.0d
2 London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390)
3 Lambeth G.. ( -3.48 )	20.00	72000 ( 5231)	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08)
4 London Cl.. ( 20.00 )	20.00	28800 ( 2610)	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5 Lambeth G.. ( 8.75 )	20.00	57600 ( 4185)	1.000 (1.000)	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1 Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2 London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3 Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4 London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5 Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation: Left side 20.59, Right side 20.59  
 Automatic water pressure balancing at toe of wall : No

Water press.		Left side			Right side			
profile no.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
	1	20.59	20.59	0.0	1	15.55	15.55	0.0
	2	22.02	22.02	0.0	1	15.55	15.55	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	20.02	6.00	0.017663	2.050E+08	1.65	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	21.80	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m2	-----	Surcharge Far edge	-----	Equiv. soil type	Partial factor/ Category
1	20.02	1.20(L)	32.15	1.00	100.00	=			N/A	1.00 -
2	16.00	-0.00(R)	23.80	3.10	30.00	=			N/A	1.00 -
3	16.00	-5.80(R)	23.80	14.60	30.00	=			N/A	1.00 -
4	17.50	-0.00(R)	23.80	20.00	12.00	=			N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 20.02 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Apply surcharge no.2 at elevation 16.00 No analysis at this stage
4	Apply surcharge no.3 at elevation 16.00 No analysis at this stage
5	Excavate to elevation 16.00 on RIGHT side
6	Remove surcharge no.2 at elevation 16.00 No analysis at this stage
7	Remove surcharge no.3 at elevation 16.00 No analysis at this stage
8	Fill to elevation 17.50 on RIGHT side with soil type 2
9	Install strut or anchor no.2 at elevation 18.00
10	Install strut or anchor no.3 at elevation 21.80
11	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
12	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall 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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m

## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 20.02	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Apply surcharge no.2 at elev. 16.00	No	No	No
4	Apply surcharge no.3 at elev. 16.00	No	No	No
5	Excav. to elev. 16.00 on RIGHT side	Yes	Yes	Yes
6	Remove surcharge no.2 at elev. 16.00	No	No	No
7	Remove surcharge no.3 at elev. 16.00	No	No	No
8	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.80	Yes	Yes	Yes
11	Change soil type 2 to soil type 4	Yes	Yes	Yes
12	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

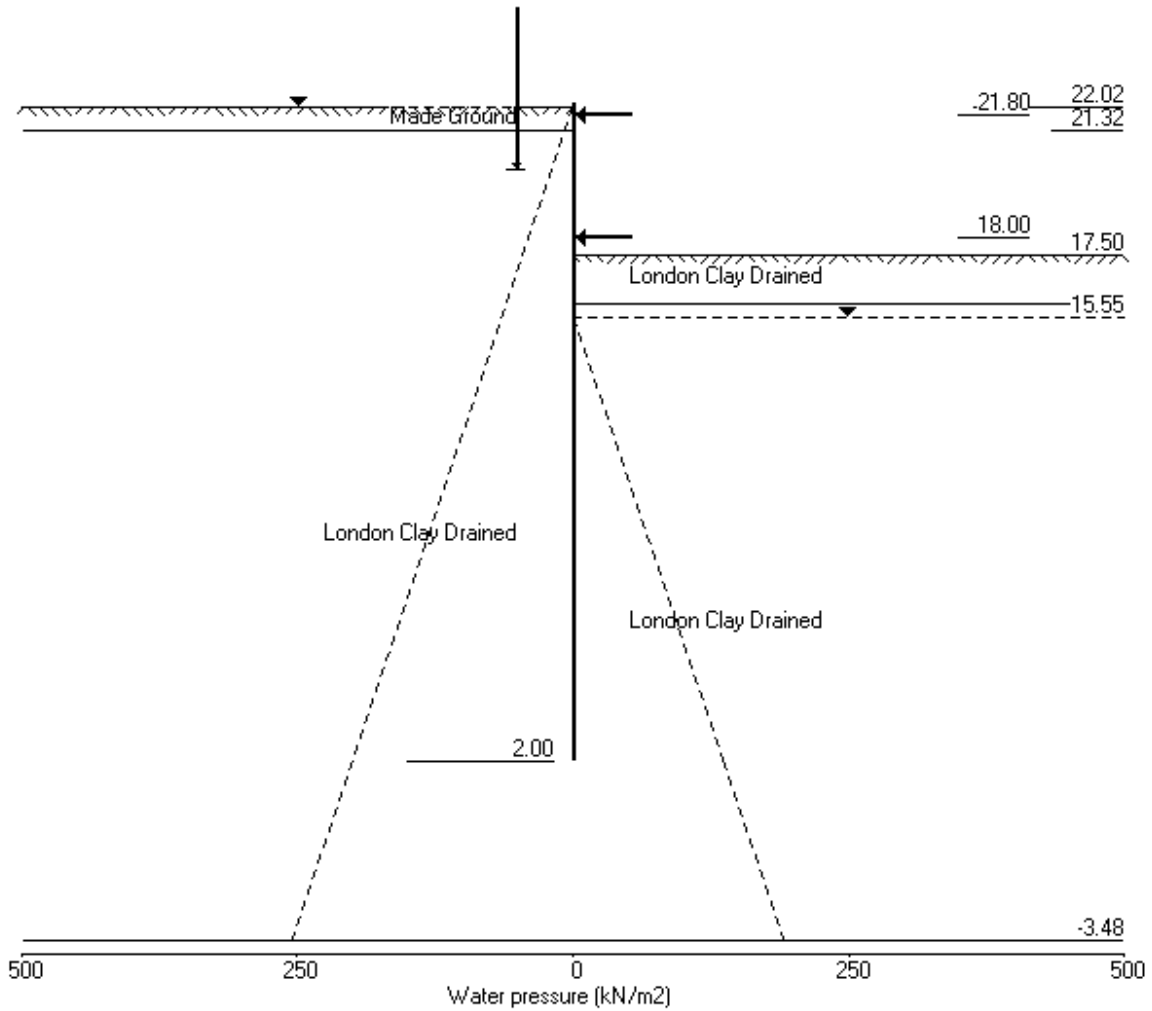
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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.12 Apply water pressure profile no.2 (Worst Cred.)



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 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 16.00 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
5	22.02	16.00	Cant.	2.878	3.39	13.31	2.69	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.037	5.41E-03	0.0	-0.0	
2	21.80	3.00	0.036	5.41E-03	0.3	0.0	
3	21.32	9.54	0.033	5.41E-03	3.3	0.9	
		3.50	0.033	5.41E-03	3.3	0.9	
4	20.59	7.15	0.029	5.40E-03	7.2	4.8	
5	20.02	10.00	0.026	5.37E-03	12.1	10.4	
6	19.01	15.05	0.021	5.25E-03	24.8	29.3	
7	18.00	20.10	0.015	4.96E-03	42.5	63.6	
8	17.50	22.60	0.013	4.72E-03	53.2	87.6	
9	16.75	26.35	0.010	4.21E-03	71.5	134.4	
10	16.00	32.97	0.007	3.42E-03	93.8	205.3	
		-169.52	0.007	3.42E-03	93.8	205.3	
11	15.55	-133.42	0.005	2.81E-03	25.6	235.7	
12	14.38	-21.33	0.003	1.32E-03	-65.3	173.4	
13	13.20	22.15	0.002	4.00E-04	-64.8	81.9	
14	12.00	25.60	0.002	2.25E-05	-36.2	20.1	
15	10.80	15.02	0.002	-3.34E-05	-11.8	-5.0	
16	9.60	5.15	0.002	1.66E-05	0.3	-8.5	
17	8.40	0.05	0.002	6.57E-05	3.4	-4.7	
18	7.20	-1.35	0.002	8.66E-05	2.7	-0.9	
19	6.00	-1.10	0.002	8.64E-05	1.2	0.9	
20	4.80	-0.55	0.001	7.85E-05	0.2	1.2	
21	3.60	-0.14	0.001	7.17E-05	-0.2	0.6	
22	2.80	0.12	0.001	6.95E-05	-0.2	0.3	
23	2.00	0.48	0.001	6.88E-05	-0.0	0.0	

(continued)

Stage No.5 Excavate to elevation 16.00 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	3149
2	21.80	2.20	1.87	0.80	4.94	0.80	3.00a	3149
3	21.32	7.00	5.95	2.54	15.72	2.54	9.54a	3149
		Total>	12.95	3.50m	144.14	3.50	3.50a	12458
4	20.59	Total>	27.55	7.15m	164.41	7.15	7.15a	13122
5	20.02	Total>	38.95	10.00m	180.24	10.00	10.00a	13640
6	19.01	Total>	69.07	15.05m	218.19	15.05	15.05a	14559
7	18.00	Total>	101.69	20.10m	258.67	20.10	20.10a	15478
8	17.50	Total>	113.57	22.60m	274.42	22.60	22.60a	15933
9	16.75	Total>	128.53	26.35m	295.21	26.35	26.35a	16615
10	16.00	Total>	142.08	30.10m	314.58	32.97	32.97	17297
11	15.55	Total>	150.00	32.35m	325.99	63.19	63.19	17706
12	14.38	Total>	170.66	38.22m	355.78	122.99	122.99	18775
13	13.20	Total>	191.69	44.10m	385.93	159.33	159.33	19844
14	12.00	Total>	213.61	50.10m	417.17	182.86	182.86	20935
15	10.80	Total>	235.90	56.10m	448.77	202.08	202.08	22027
16	9.60	Total>	258.49	62.10m	480.67	221.92	221.92	23119
17	8.40	Total>	281.30	68.10m	512.80	243.66	243.66	24210
18	7.20	Total>	304.28	74.10m	545.10	266.85	266.85	25302
19	6.00	Total>	327.41	80.10m	577.55	290.74	290.74	26393
20	4.80	Total>	350.66	91.28	610.11	314.85	314.85	27485
21	3.60	Total>	374.00	105.31	642.77	339.02	339.02	28576
22	2.80	Total>	389.61	114.70	664.59	355.18	355.18	29304
23	2.00	Total>	405.24	124.13	686.44	371.42	371.42	30032

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	30.00	0.00	202.49	202.49	202.49p	33257
11	15.55	Total>	38.97	2.25m	214.95	196.61	196.61	34044
12	14.38	Total>	61.39	8.12m	246.49	144.32	144.32	36099
13	13.20	Total>	82.58	14.00m	276.80	137.19	137.19	38154
14	12.00	Total>	104.44	20.00m	307.98	157.26	157.26	40253
15	10.80	Total>	127.16	26.00m	340.02	187.06	187.06	42351
16	9.60	Total>	150.65	32.00m	372.83	216.77	216.77	44450
17	8.40	Total>	174.69	38.00m	406.18	243.61	243.61	46549
18	7.20	Total>	199.11	44.00m	439.92	268.20	268.20	48647
19	6.00	Total>	223.80	50.00m	473.92	291.84	291.84	50746
20	4.80	Total>	248.69	56.00m	508.13	315.40	315.40	52845
21	3.60	Total>	273.74	62.00m	542.50	339.16	339.16	54943
22	2.80	Total>	290.53	66.00m	565.50	355.06	355.06	56342
23	2.00	Total>	307.36	70.00m	588.55	370.94	370.94	57742



Run ID. Design\_Case\_01\_no\_prop\_ULS2  
Ugly Brown Building  
Existing contiguous wall stability assessment

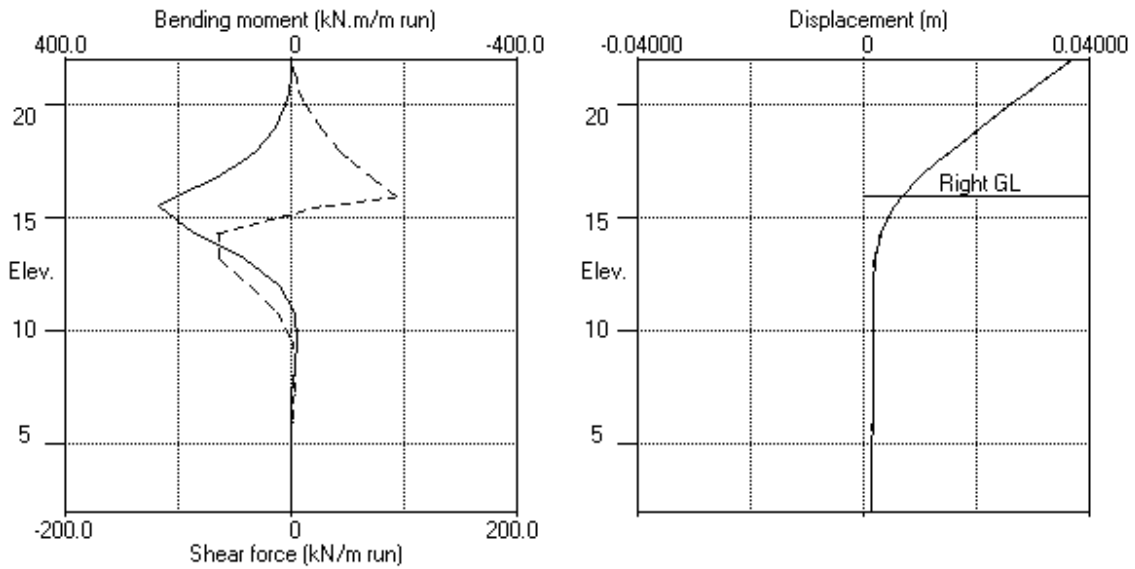
Sheet No.  
Date:13-05-2020  
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Stage No.5 Excavate to elevation 16.00 on RIGHT side  
Note: 26.35a Soil pressure at active limit  
202.49p Soil pressure at passive limit

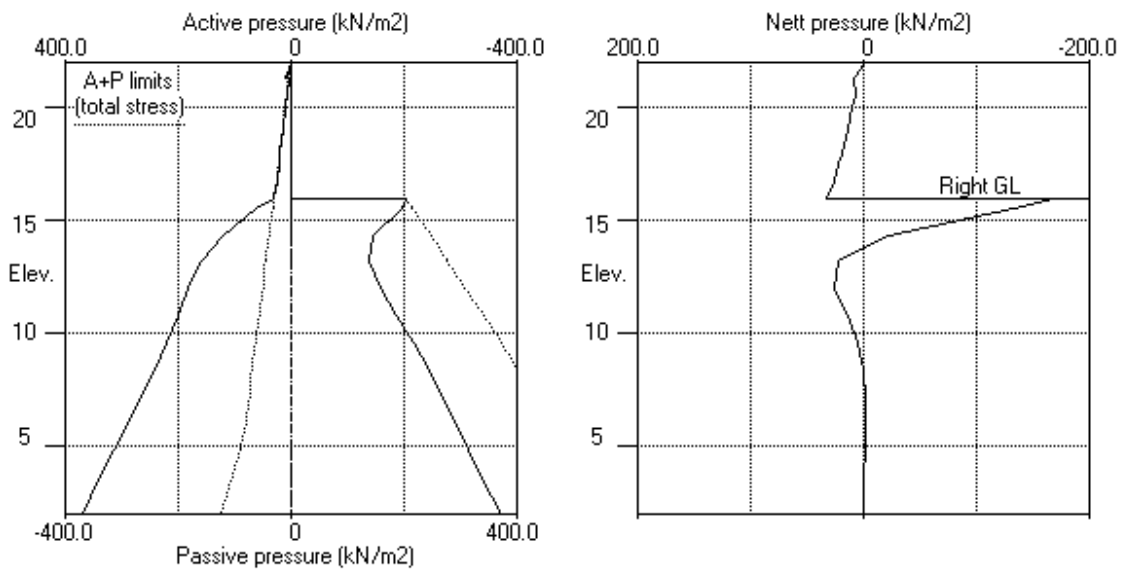
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Units: kN, m

Stage No.5 Excav. to elev. 16.00 on RIGHT side



Stage No.5 Excav. to elev. 16.00 on RIGHT side



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 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 8 Fill to elevation 17.50 on RIGHT side with soil type 2

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 2.00						
Stage	Ground level	Prop	Factor	Moment	Toe	Wall	Direction	
No.	Act.	Pass.	of	at elev.	elev.	Penetr	of	
			Safety			-ation	failure	
8	22.02	17.50	Cant.	3.290	3.33	15.47	2.03	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node	Y	Nett	Wall	Wall	Shear	Bending	Prop
no.	coord	pressure	disp.	rotation	force	moment	forces
		kN/m2	m	rad.	kN/m	kN.m/m	kN/m
1	22.02	0.00	0.037	5.49E-03	0.0	-0.0	
2	21.80	3.00	0.036	5.49E-03	0.3	0.0	
3	21.32	9.55	0.033	5.49E-03	3.3	0.9	
		3.56	0.033	5.49E-03	3.3	0.9	
4	20.59	7.60	0.029	5.48E-03	7.4	4.8	
5	20.02	10.79	0.026	5.45E-03	12.7	10.6	
6	19.01	16.48	0.020	5.32E-03	26.4	30.5	
7	18.00	22.18	0.015	5.02E-03	45.9	67.2	
8	17.50	24.96	0.013	4.77E-03	57.7	93.1	
9	16.75	17.31	0.009	4.22E-03	73.6	142.6	
10	16.00	9.69	0.006	3.40E-03	83.7	211.2	
		-163.98	0.006	3.40E-03	83.7	211.2	
11	15.55	-127.99	0.005	2.78E-03	18.0	237.7	
12	14.38	-17.38	0.003	1.30E-03	-67.4	169.8	
13	13.20	23.74	0.002	4.04E-04	-63.7	78.0	
14	12.00	25.49	0.001	4.81E-05	-34.1	18.2	
15	10.80	14.31	0.001	-1.07E-06	-10.2	-4.9	
16	9.60	4.50	0.001	4.45E-05	1.1	-7.4	
17	8.40	-0.32	0.001	8.44E-05	3.6	-3.4	
18	7.20	-1.47	0.001	9.61E-05	2.5	0.2	
19	6.00	-1.08	0.001	8.92E-05	1.0	1.7	
20	4.80	-0.49	0.001	7.73E-05	0.0	1.6	
21	3.60	-0.08	0.001	6.88E-05	-0.3	0.7	
22	2.80	0.18	0.001	6.61E-05	-0.3	0.3	
23	2.00	0.54	0.001	6.54E-05	-0.0	0.0	

(continued)

Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	17640
2	21.80	2.20	1.87	0.80	4.94	0.80	3.00a	17640
3	21.32	7.00	5.95	2.54	15.72	2.55	9.55	1477
		Total>	12.95	3.50m	144.14	3.56	3.56	6383
4	20.59	Total>	27.55	7.15m	164.41	7.60	7.60	6723
5	20.02	Total>	38.95	10.00m	180.24	10.79	10.79	6988
6	19.01	Total>	69.07	15.05m	218.19	16.48	16.48	7459
7	18.00	Total>	101.69	20.10m	258.67	22.18	22.18	7930
8	17.50	Total>	113.57	22.60m	274.42	24.96	24.96	8163
9	16.75	Total>	128.53	26.35m	295.21	29.01	29.01	8512
10	16.00	Total>	142.08	30.10m	314.58	35.72	35.72	8862
11	15.55	Total>	150.00	32.35m	325.99	65.91	65.91	9072
12	14.38	Total>	170.66	38.22m	355.78	125.55	125.55	9619
13	13.20	Total>	191.69	44.10m	385.93	161.92	161.92	10167
14	12.00	Total>	213.61	50.10m	417.17	185.79	185.79	10726
15	10.80	Total>	235.90	56.10m	448.77	205.58	205.58	11285
16	9.60	Total>	258.49	62.10m	480.67	226.04	226.04	11844
17	8.40	Total>	281.30	68.10m	512.80	248.31	248.31	12404
18	7.20	Total>	304.28	74.10m	545.10	271.93	271.93	12963
19	6.00	Total>	327.41	80.10m	577.55	296.13	296.13	13522
20	4.80	Total>	350.66	91.28	610.11	320.48	320.48	14081
21	3.60	Total>	374.00	105.31	642.77	344.83	344.83	14641
22	2.80	Total>	389.61	114.70	664.59	361.11	361.11	15013
23	2.00	Total>	405.24	124.13	686.44	377.45	377.45	15386

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	160.84	0.00	0.00a	8310
9	16.75	Total>	15.00	3.75m	181.67	11.70	11.70	8665
10	16.00	Total>	30.02	7.50m	202.50	26.03	26.03	9021
		Total>	30.02	7.50m	202.50	199.70	199.70	9021
11	15.55	Total>	39.03	9.75m	215.02	193.90	193.90	9235
12	14.38	Total>	62.64	15.62m	247.75	142.92	142.92	9792
13	13.20	Total>	86.36	21.50m	280.59	138.18	138.18	10350
14	12.00	Total>	110.72	27.50m	314.27	160.30	160.30	10919
15	10.80	Total>	135.25	33.50m	348.12	191.27	191.27	11488
16	9.60	Total>	159.96	39.50m	382.14	221.53	221.53	12057
17	8.40	Total>	184.85	45.50m	416.34	248.63	248.63	12627
18	7.20	Total>	209.90	51.50m	450.71	273.39	273.39	13196
19	6.00	Total>	235.10	57.50m	485.23	297.21	297.21	13765
20	4.80	Total>	260.44	63.50m	519.89	320.97	320.97	14335
21	3.60	Total>	285.89	69.50m	554.65	344.92	344.92	14904
22	2.80	Total>	302.91	73.50m	577.88	360.93	360.93	15283

Run ID. Design\_Case\_01\_no\_prop\_ULS2  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Date:13-05-2020  
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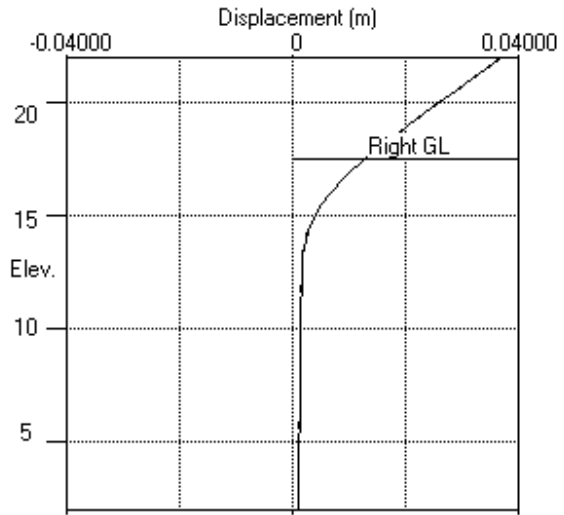
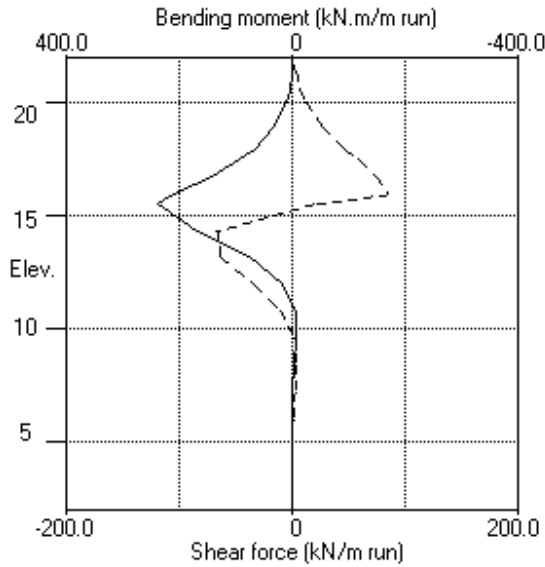
Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

RIGHT side								
<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m <sup>2</sup>	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u> kN/m <sup>2</sup>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m <sup>3</sup>
			<u>Vertic</u> <u>-al</u> kN/m <sup>2</sup>	<u>Active</u> <u>limit</u> kN/m <sup>2</sup>	<u>Passive</u> <u>limit</u> kN/m <sup>2</sup>	<u>Earth</u> <u>pressure</u> kN/m <sup>2</sup>		
23	2.00	Total>	319.96	77.50m	601.15	376.91	376.91	15663

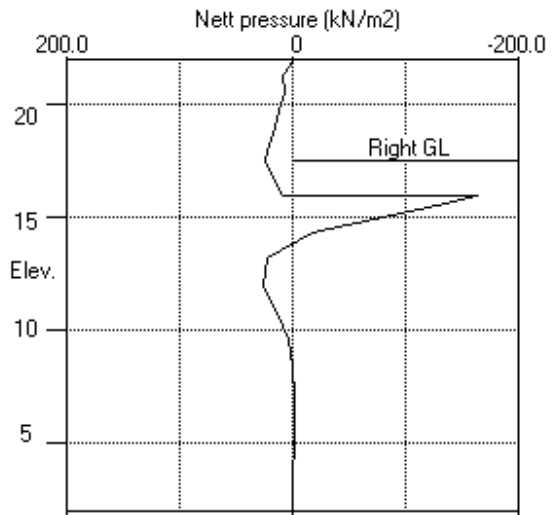
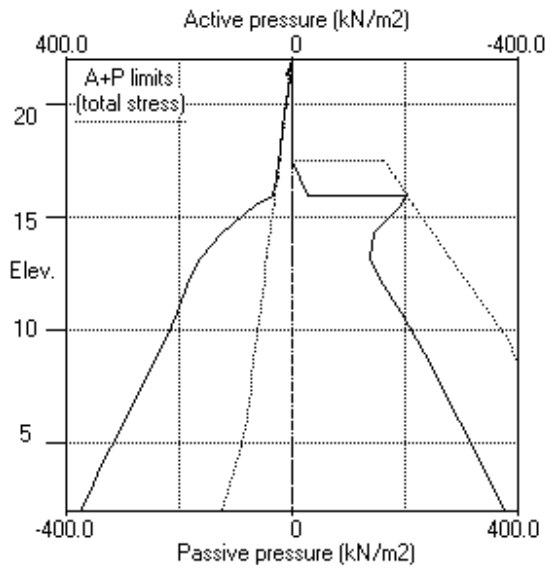
Note: 0.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN, m

Stage No.8 Fill to elev. 17.50 on RIGHT side



Stage No.8 Fill to elev. 17.50 on RIGHT side



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 Data filename/Run ID: Design\_Case\_01\_no\_prop\_ULS2  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 11 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>at</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
				<u>Safety</u>	<u>at</u>		<u>-ation</u>	<u>failure</u>	
				<u>More than one prop.</u>	<u>No</u>	<u>FoS</u>	<u>calc.</u>		
11	22.02	17.50							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	22.02	0.00	0.036	5.29E-03	0.0	-0.0			
2	21.80	6.73	0.035	5.29E-03	0.7	0.0	0.0		
3	21.32	12.90	0.032	5.29E-03	5.5	1.5			
		12.66	0.032	5.29E-03	5.5	1.5			
4	20.59	19.31	0.028	5.27E-03	17.1	9.7			
5	20.02	24.31	0.025	5.21E-03	29.6	23.0			
6	19.01	41.54	0.020	4.92E-03	62.8	69.6			
7	18.00	61.95	0.015	4.21E-03	115.1	158.3	-209.8		
		61.95	0.015	4.21E-03	-94.7	158.3			
8	17.50	70.10	0.013	3.78E-03	-61.7	119.1			
		65.29	0.013	3.78E-03	-61.7	119.1			
9	16.75	59.48	0.011	3.29E-03	-14.9	91.1			
10	16.00	51.01	0.009	2.84E-03	26.5	105.5			
		2.17	0.009	2.84E-03	26.5	105.5			
11	15.55	-13.54	0.007	2.52E-03	24.0	121.3			
12	14.38	-38.08	0.005	1.69E-03	-6.3	108.4			
13	13.20	-1.08	0.003	1.01E-03	-29.4	78.8			
14	12.00	10.83	0.002	5.64E-04	-23.5	42.3			
15	10.80	7.97	0.002	3.28E-04	-12.2	21.3			
16	9.60	3.35	0.002	2.05E-04	-5.4	11.9			
17	8.40	1.10	0.001	1.33E-04	-2.8	7.3			
18	7.20	0.57	0.001	9.07E-05	-1.8	4.3			
19	6.00	0.55	0.001	6.68E-05	-1.1	2.1			
20	4.80	0.47	0.001	5.62E-05	-0.5	0.7			
21	3.60	0.29	0.001	5.34E-05	-0.0	0.0			
22	2.80	0.23	0.001	5.36E-05	0.2	-0.1			
23	2.00	-0.67	0.001	5.38E-05	-0.0	0.0			

At elev. 21.80 The prop is slack

At elev. 18.00 Prop force = 209.8 kN/m run

(continued)

Stage No.11 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	4011
2	21.80	2.20	1.87	0.80	4.94	4.53	6.73	4011
3	21.32	7.00	5.95	2.54	15.72	5.90	12.90	4011
		7.00	5.95	0.00	31.02	5.66	12.66	6780
4	20.59	14.30	13.25	0.00	48.64	5.01	19.31	7290
5	20.02	20.00	18.95	2.28	62.40	4.31	24.31	7687
6	19.01	30.10	38.97	11.44	110.72	11.44	41.54a	8392
7	18.00	40.20	61.49	21.75	165.11	21.75	61.95a	5852
8	17.50	45.20	68.37	24.90	181.69	24.90	70.10a	6077
9	16.75	52.70	75.83	28.32	199.72	28.32	81.02a	6414
10	16.00	60.20	81.88	31.08	214.32	31.08	91.28a	6750
11	15.55	64.70	85.30	32.65	222.56	32.65	97.35a	6952
12	14.38	76.45	94.21	36.72	244.08	36.72	113.17a	7480
13	13.20	88.20	101.01	39.84	260.50	61.31	149.51	8008
14	12.00	100.20	113.41	45.51	290.44	78.26	178.46	8546
15	10.80	112.20	123.70	50.22	315.28	90.21	202.41	9085
16	9.60	124.20	134.29	55.06	340.83	101.26	225.46	9624
17	8.40	136.20	145.10	60.01	366.92	112.82	249.02	11908
18	7.20	148.20	156.08	65.04	393.45	124.74	272.94	12540
19	6.00	160.20	167.21	70.13	420.31	136.75	296.95	13171
20	4.80	172.20	178.46	75.28	447.46	148.76	320.96	13803
21	3.60	184.20	189.80	80.47	474.84	160.82	345.02	14434
22	2.80	192.20	197.41	83.95	493.20	168.93	361.13	14855
23	2.00	200.20	205.04	87.45	511.64	176.64	376.84	78474

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	16.66	4.81	4.81	6077
9	16.75	0.00	15.00	0.48	52.87	21.54	21.54	6414
10	16.00	0.00	30.02	7.35	89.12	40.27	40.27	6750
		0.00	30.02	7.35	89.12	89.12	89.12p	6750
11	15.55	0.00	39.03	11.47	110.89	110.89	110.89p	6952
12	14.38	11.75	50.89	16.90	139.51	139.51	151.26p	7480
13	13.20	23.50	62.86	22.38	168.40	127.09	150.59	8008
14	12.00	35.50	75.22	28.04	198.25	132.14	167.64	8546
15	10.80	47.50	87.75	33.77	228.50	146.94	194.44	9085
16	9.60	59.50	100.46	39.59	259.18	162.61	222.11	9624
17	8.40	71.50	113.35	45.48	290.28	176.42	247.92	11908
18	7.20	83.50	126.40	51.46	321.79	188.87	272.37	12540
19	6.00	95.50	139.60	57.50	353.66	200.90	296.40	13171
20	4.80	107.50	152.94	63.60	385.86	212.99	320.49	13803
21	3.60	119.50	166.39	69.76	418.33	225.23	344.73	14434



Run ID. Design\_Case\_01\_no\_prop\_ULS2  
Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
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(continued)

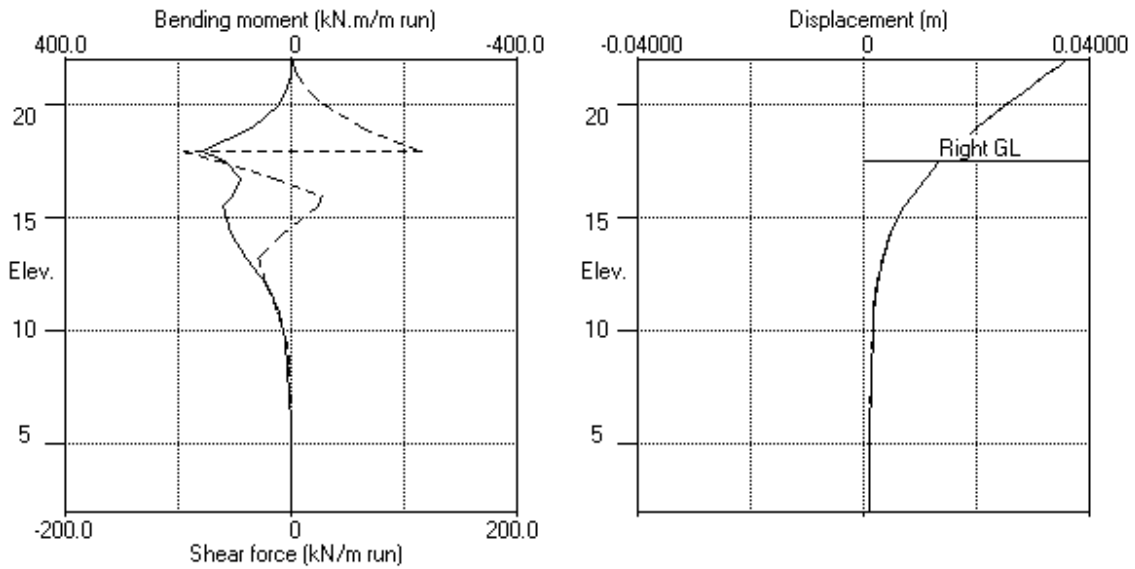
Stage No.11 Change properties of soil type 2 to soil type 4  
Ko pressures will not be reset

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>RIGHT side</u> <u>Effective stresses</u>					<u>Total</u> <u>earth</u> <u>pressure</u>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u>
		<u>Water</u> <u>press.</u>	<u>Vertic</u> <u>-al</u>	<u>Active</u> <u>limit</u>	<u>Passive</u> <u>limit</u>	<u>Earth</u> <u>pressure</u>		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
22	2.80	127.50	175.41	73.88	440.10	233.40	360.90	14855
23	2.00	135.50	184.46	78.03	461.95	242.02	377.52	78474

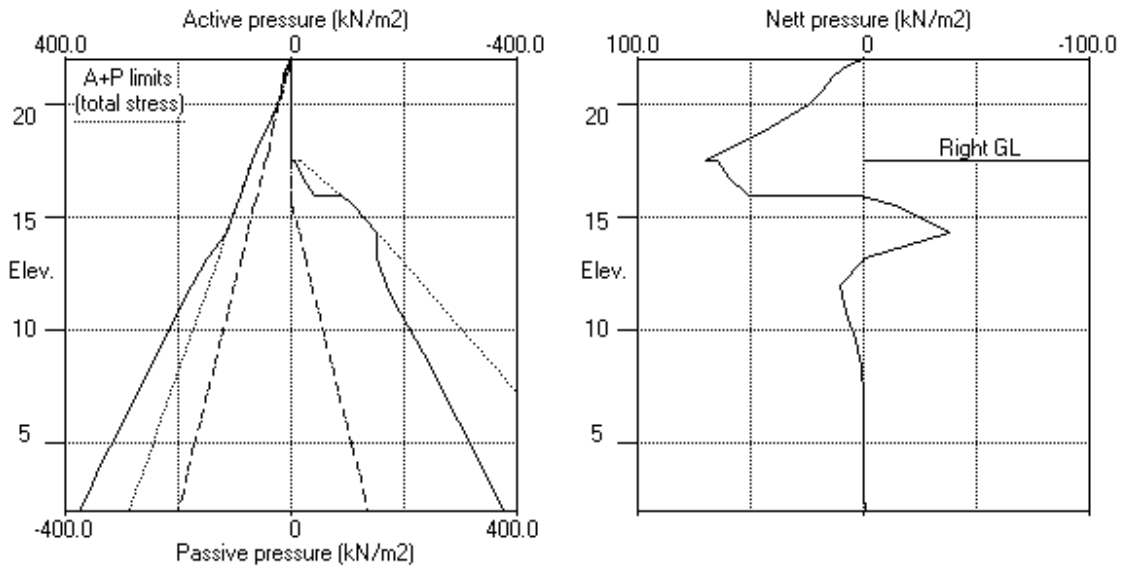
Note: 113.17a Soil pressure at active limit  
151.26p Soil pressure at passive limit

Units: kN, m

Stage No.11 Change soil type 2 to soil type 4



Stage No.11 Change soil type 2 to soil type 4



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 Existing contiguous wall stability assessment

Sheet No.  
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 Checked :

Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>Overall FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety at elev.</u>	<u>Moment of equilib.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	22.02	22.02		No analysis at this stage				
4	22.02	22.02		No analysis at this stage				
5	22.02	16.00	Cant.	2.878	3.39	13.31	2.69	L to R
6	22.02	16.00		No analysis at this stage				
7	22.02	16.00		No analysis at this stage				
8	22.02	17.50	Cant.	3.290	3.33	15.47	2.03	L to R
9	22.02	17.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	22.02	0.037	-0.000	0.0	-0.0	0.0	0.0
2	21.80	0.036	-0.000	0.0	-0.0	0.7	0.0
3	21.32	0.033	0.000	1.5	0.0	5.5	0.0
4	20.59	0.029	0.000	9.7	0.0	17.1	-1.1
5	20.02	0.026	0.000	23.0	-0.7	29.6	-4.0
6	19.01	0.021	0.000	69.6	-6.3	62.8	-8.2
7	18.00	0.015	0.000	158.3	-12.8	115.1	-94.7
8	17.50	0.013	0.000	119.1	-14.6	57.7	-61.7
9	16.75	0.011	0.000	142.6	-14.4	73.6	-14.9
10	16.00	0.009	0.000	211.2	-12.2	93.8	0.0
11	15.55	0.007	0.000	237.7	-10.2	25.6	0.0
12	14.38	0.005	0.000	173.4	-4.6	4.8	-67.4
13	13.20	0.003	0.000	81.9	-0.2	3.3	-64.8
14	12.00	0.002	0.000	42.3	0.0	1.6	-36.2
15	10.80	0.002	0.000	21.3	-5.0	0.4	-12.2
16	9.60	0.002	0.000	11.9	-8.5	1.1	-5.4
17	8.40	0.002	0.000	7.3	-4.7	3.6	-2.8
18	7.20	0.002	0.000	4.3	-0.9	2.7	-1.8
19	6.00	0.002	0.000	2.1	0.0	1.2	-1.1
20	4.80	0.001	0.000	1.6	0.0	0.2	-0.5
21	3.60	0.001	0.000	0.7	0.0	0.0	-0.3
22	2.80	0.001	0.000	0.3	-0.1	0.2	-0.3
23	2.00	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				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	2.9	10.80	-14.6	17.50	4.9	15.55	-7.8	19.01
2	2.8	10.80	-14.3	16.75	4.8	14.38	-8.2	19.01
3	No calculation at this stage							
4	No calculation at this stage							
5	235.7	15.55	-8.5	9.60	93.8	16.00	-65.3	14.38
6	No calculation at this stage							
7	No calculation at this stage							
8	237.7	15.55	-7.4	9.60	83.7	16.00	-67.4	14.38
9	No calculation at this stage							
10	No calculation at this stage							
11	158.3	18.00	-0.1	2.80	115.1	18.00	-94.7	18.00
12	158.3	18.00	-0.1	2.80	115.1	18.00	-94.7	18.00

Run ID. Design\_Case\_01\_no\_prop\_ULS2  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				Stage description
no.	maximum m	elev.	minimum m	elev.	
1	0.001	16.00	-0.000	22.02	Apply surcharge no.1 at elev. 20.02
2	0.001	16.00	0.000	22.02	Apply water pressure profile no.2
3	No calculation at this stage				Apply surcharge no.2 at elev. 16.00
4	No calculation at this stage				Apply surcharge no.3 at elev. 16.00
5	0.037	22.02	0.000	22.02	Excav. to elev. 16.00 on RIGHT side
6	No calculation at this stage				Remove surcharge no.2 at elev. 16.00
7	No calculation at this stage				Remove surcharge no.3 at elev. 16.00
8	0.037	22.02	0.000	22.02	Fill to elev. 17.50 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 18.00
10	No calculation at this stage				Install prop no.3 at elev. 21.80
11	0.036	22.02	0.000	22.02	Change soil type 2 to soil type 4
12	0.036	22.02	0.000	22.02	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

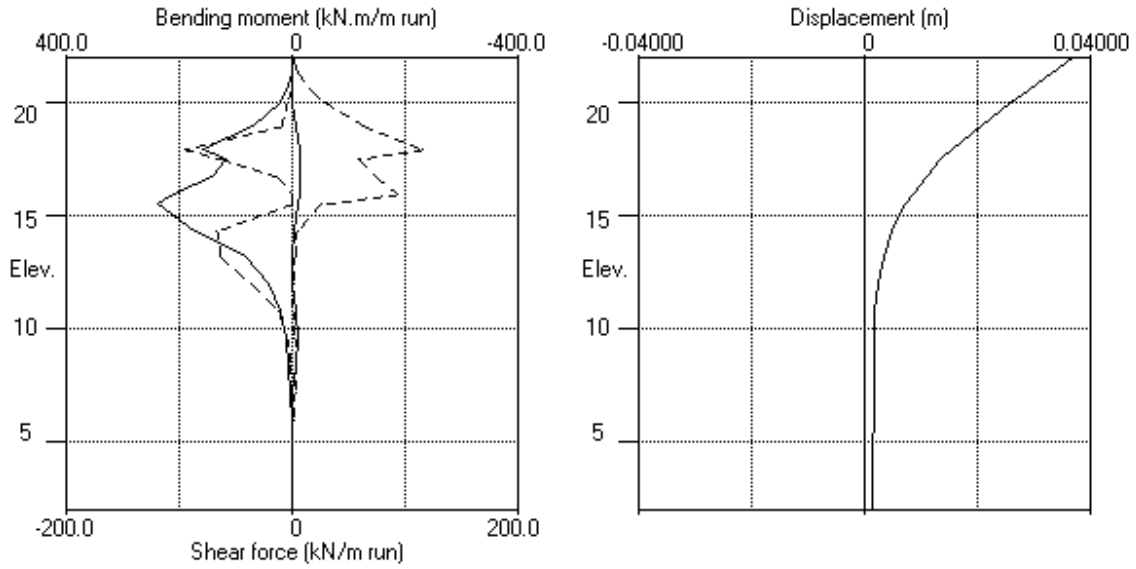
Stage	--- Strut no. 2 --- at elev. 18.00		--- Strut no. 3 --- at elev. 21.80	
no.	kN/m run	kN/prop	kN/m run	kN/prop
11	209.76	209.76	slack	slack
12	209.76	209.76	slack	slack

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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			
		Left side		Right side	
1	22.02	1	Made Ground	1	Made Ground
2	21.32	2	London Clay	2	London Clay
3	-3.48	3	Lambeth Group	3	Lambeth Group

**SOIL PROPERTIES**

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	Made Ground	18.50	15000	1.000	NC	1.000	1.000	0.0u
					(0.490)	(2.474)	(2.475)	
2	London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC	1.000	1.000	80.00u ( 4.390)
3	Lambeth G.. ( -3.48 )	20.00	72000 ( 5231)	1.000	OC	1.000	1.000	180.0u ( 13.08)
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610)	1.000	OC	0.384	3.043	5.000d ( 4.814)
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185)	1.000 ( 1.000)	OC ( 0.200)	0.384 ( 1.452)	3.043 ( 4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 20.59 Right side 20.59  
 Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0 MC+WC
2	1	22.02	22.02	0.0	1	15.55	15.55	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
   E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	20.02	6.00	0.017663	2.050E+08	1.65	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	21.80	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surchage kN/m <sup>2</sup>	-----	Equiv. soil type	Partial factor/ Category
1	20.02	1.20(L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.50	-0.00(R)	23.80	3.10	30.00	=	N/A	1.00 -
3	16.50	-5.80(R)	23.80	14.60	30.00	=	N/A	1.00 -
4	17.50	-0.00(R)	23.80	20.00	12.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 20.02 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 19.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 20.02
5	Apply surcharge no.2 at elevation 16.50 No analysis at this stage
6	Apply surcharge no.3 at elevation 16.50 No analysis at this stage
7	Excavate to elevation 16.50 on RIGHT side
8	Remove surcharge no.2 at elevation 16.50 No analysis at this stage
9	Remove surcharge no.3 at elevation 16.50 No analysis at this stage
10	Fill to elevation 17.50 on RIGHT side with soil type 2
11	Install strut or anchor no.2 at elevation 18.00
12	Install strut or anchor no.3 at elevation 21.80
13	Remove strut or anchor no.1 at elevation 20.02
14	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
15	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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/m<sup>3</sup>  
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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m  
Distance to rigid boundary on Right side = 23.70 m





## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 20.02	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 19.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 20.02	Yes	Yes	Yes
5	Apply surcharge no.2 at elev. 16.50	No	No	No
6	Apply surcharge no.3 at elev. 16.50	No	No	No
7	Excav. to elev. 16.50 on RIGHT side	Yes	Yes	Yes
8	Remove surcharge no.2 at elev. 16.50	No	No	No
9	Remove surcharge no.3 at elev. 16.50	No	No	No
10	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
11	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
12	Install prop no.3 at elev. 21.80	Yes	Yes	Yes
13	Remove prop no.1 at elev. 20.02	Yes	Yes	Yes
14	Change soil type 2 to soil type 4	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

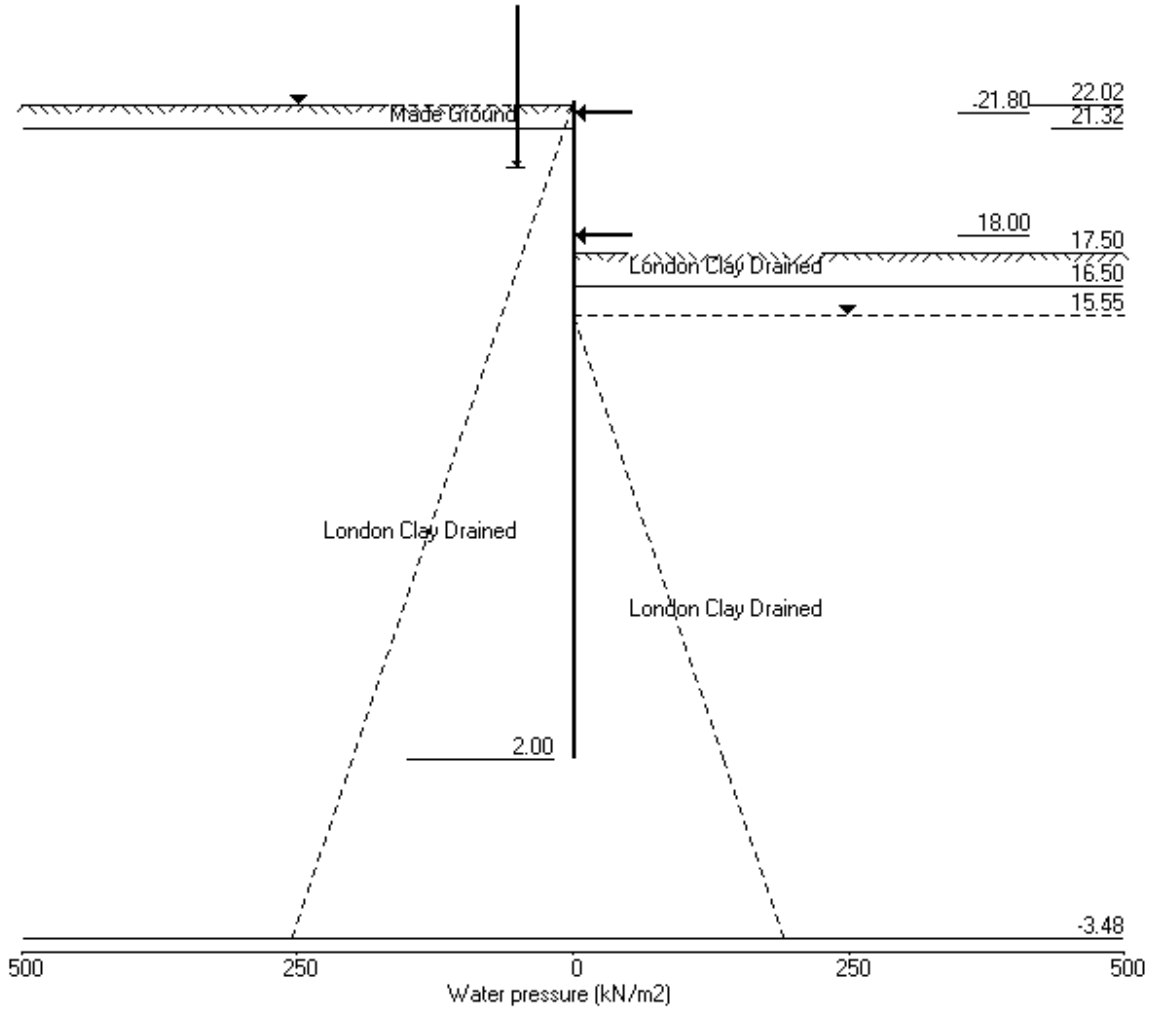
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 Ugly Brown Building  
 Existing contiguous wall stability assessment

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 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.15 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 19.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
3	22.02	19.50	Cant.	7.689	3.38	18.94	0.56	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.005	6.22E-04	0.0	0.0	
2	21.80	4.07	0.005	6.22E-04	0.4	0.0	
3	21.32	12.95	0.004	6.21E-04	4.5	1.1	
		3.50	0.004	6.21E-04	4.5	1.1	
4	20.59	7.15	0.004	6.05E-04	8.4	5.9	
5	20.02	10.00	0.003	5.73E-04	13.3	12.2	
6	19.50	12.60	0.003	5.20E-04	19.2	20.7	
		-35.47	0.003	5.20E-04	19.2	20.7	
7	18.75	-19.89	0.003	4.04E-04	-1.6	29.5	
8	18.00	-4.40	0.003	2.81E-04	-10.7	23.4	
9	17.50	1.04	0.002	2.18E-04	-11.5	17.6	
10	16.50	4.93	0.002	1.43E-04	-8.5	6.6	
11	15.55	4.58	0.002	1.22E-04	-4.0	0.5	
12	14.38	2.31	0.002	1.27E-04	0.0	-1.8	
13	13.20	0.45	0.002	1.36E-04	1.6	-0.8	
14	12.00	-0.47	0.002	1.35E-04	1.6	1.0	
15	10.80	-0.61	0.001	1.24E-04	1.0	2.1	
16	9.60	-0.41	0.001	1.07E-04	0.4	2.4	
17	8.40	-0.16	0.001	9.10E-05	0.0	2.1	
18	7.20	-0.01	0.001	7.69E-05	-0.1	1.7	
19	6.00	0.02	0.001	6.63E-05	-0.1	1.2	
20	4.80	-0.02	0.001	5.90E-05	-0.1	0.8	
21	3.60	-0.04	0.001	5.48E-05	-0.1	0.3	
22	2.80	0.03	0.001	5.35E-05	-0.1	0.2	
23	2.00	0.20	0.001	5.31E-05	-0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 19.50 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	4741
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	4741
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	4741
		Total>	12.95	3.50m	196.62	3.50	3.50a	13549
4	20.59	Total>	27.55	7.15m	219.15	7.15	7.15a	14271
5	20.02	Total>	38.95	10.00m	236.74	10.00	10.00a	14835
6	19.50	Total>	51.63	12.60m	255.07	12.60	12.60a	15349
7	18.75	Total>	78.61	16.35m	290.20	37.85	37.85	16091
8	18.00	Total>	101.69	20.10m	321.44	64.23	64.23	16833
9	17.50	Total>	113.57	22.60m	338.74	77.70	77.70	17327
10	16.50	Total>	133.14	27.60m	369.18	99.20	99.20	18317
11	15.55	Total>	150.00	32.35m	396.36	116.83	116.83	19256
12	14.38	Total>	170.66	38.22m	429.79	137.92	137.92	20419
13	13.20	Total>	191.69	44.10m	463.59	159.44	159.44	21581
14	12.00	Total>	213.61	50.10m	498.55	182.16	182.16	22768
15	10.80	Total>	235.90	56.10m	533.88	205.49	205.49	23955
16	9.60	Total>	258.49	62.10m	569.50	229.17	229.17	25142
17	8.40	Total>	281.30	68.10m	605.35	253.03	253.03	26329
18	7.20	Total>	304.28	74.10m	641.38	276.95	276.95	27516
19	6.00	Total>	327.41	80.10m	677.55	300.91	300.91	28704
20	4.80	Total>	350.66	86.10m	713.83	324.93	324.93	29891
21	3.60	Total>	374.00	92.10m	750.21	349.01	349.01	31078
22	2.80	Total>	389.61	96.10m	774.51	365.14	365.14	31869
23	2.00	Total>	405.24	100.10m	798.84	381.34	381.34	32660

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	203.44	48.07	48.07	15944
7	18.75	Total>	15.00	3.75m	226.59	57.73	57.73	16714
8	18.00	Total>	30.01	7.50m	249.75	68.63	68.63	17485
9	17.50	Total>	40.02	10.00m	265.20	76.66	76.66	17999
10	16.50	Total>	60.07	15.00m	296.11	94.27	94.27	19026
11	15.55	Total>	79.15	19.75m	325.52	112.25	112.25	20003
12	14.38	Total>	102.83	25.62m	361.96	135.61	135.61	21210
13	13.20	Total>	126.58	31.50m	398.48	158.99	158.99	22417
14	12.00	Total>	150.94	37.50m	435.88	182.63	182.63	23650
15	10.80	Total>	175.40	43.50m	473.38	206.10	206.10	24884
16	9.60	Total>	199.95	49.50m	510.97	229.58	229.58	26117
17	8.40	Total>	224.59	55.50m	548.64	253.18	253.18	27350
18	7.20	Total>	249.30	61.50m	586.40	276.96	276.96	28583
19	6.00	Total>	274.09	67.50m	624.22	300.89	300.89	29816
20	4.80	Total>	298.92	73.50m	662.09	324.95	324.95	31049
21	3.60	Total>	323.80	79.50m	700.01	349.05	349.05	32282
22	2.80	Total>	340.40	83.50m	725.30	365.11	365.11	33104
23	2.00	Total>	357.01	87.50m	750.61	381.14	381.14	33926

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Ugly Brown Building  
Existing contiguous wall stability assessment

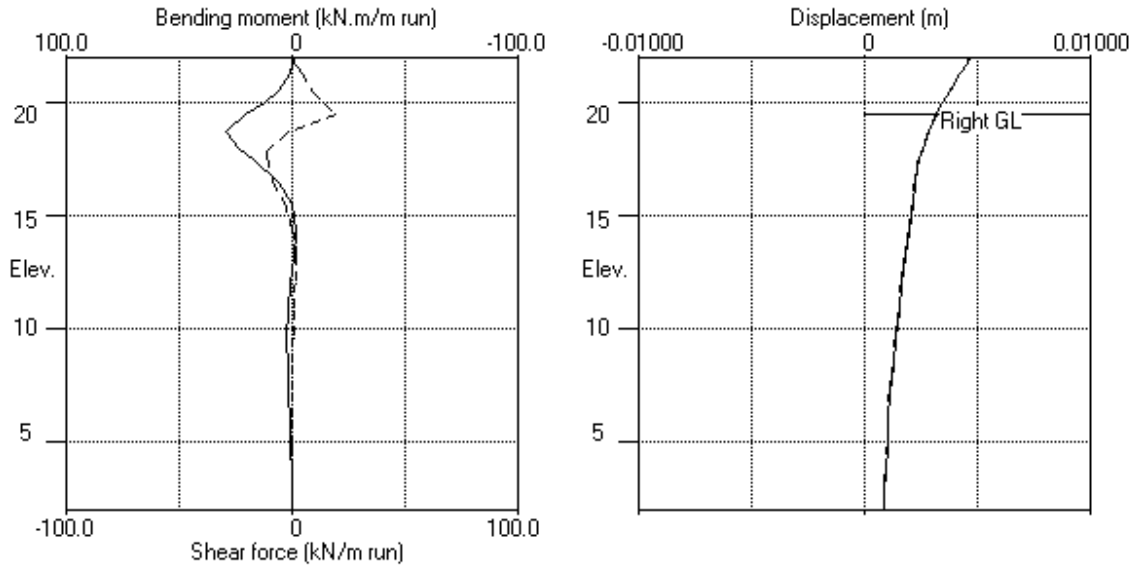
Sheet No.  
Date:13-05-2020  
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Stage No.3 Excavate to elevation 19.50 on RIGHT side  
Note: 12.60a Soil pressure at active limit  
123.45p Soil pressure at passive limit

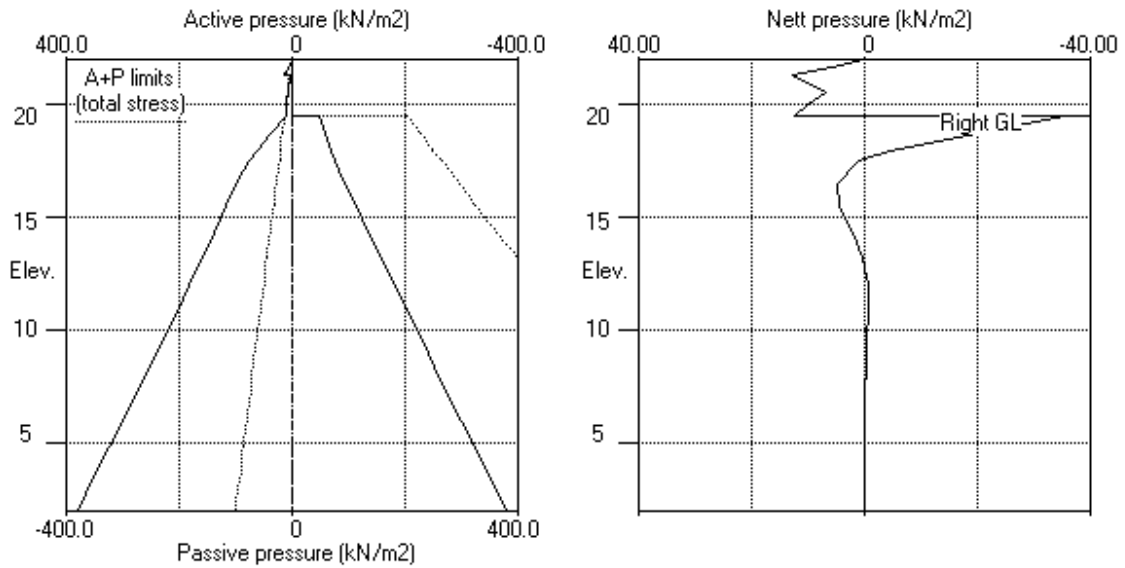
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Stage No.3 Excav. to elev. 19.50 on RIGHT side



Stage No.3 Excav. to elev. 19.50 on RIGHT side



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 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 7 Excavate to elevation 16.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
7	22.02	16.50	20.02	6.796	n/a	16.38	0.12	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.003	-3.84E-04	0.0	0.0	
2	21.80	4.07	0.003	-3.84E-04	0.4	0.0	
3	21.32	12.95	0.003	-3.85E-04	4.5	1.1	
		30.86	0.003	-3.85E-04	4.5	1.1	
4	20.59	10.78	0.004	-4.17E-04	19.7	13.2	
5	20.02	10.00	0.004	-4.87E-04	25.7	26.5	-89.0
		10.00	0.004	-4.87E-04	-63.3	26.5	
6	19.50	12.60	0.004	-5.22E-04	-57.4	-4.8	
7	18.75	19.34	0.005	-4.20E-04	-45.5	-39.1	
8	18.00	39.48	0.005	-1.77E-04	-23.4	-66.0	
9	17.50	50.41	0.005	3.64E-05	-0.9	-72.4	
10	16.50	71.03	0.005	3.99E-04	59.8	-45.2	
		-31.78	0.005	3.99E-04	59.8	-45.2	
11	15.55	-25.07	0.004	5.40E-04	32.8	-2.9	
12	14.38	-14.30	0.004	4.85E-04	9.7	18.1	
13	13.20	-5.29	0.003	3.49E-04	-1.9	19.5	
14	12.00	-0.14	0.003	2.27E-04	-5.1	13.4	
15	10.80	1.63	0.002	1.51E-04	-4.2	7.0	
16	9.60	1.60	0.002	1.14E-04	-2.3	2.9	
17	8.40	0.97	0.002	1.00E-04	-0.7	1.0	
18	7.20	0.38	0.002	9.47E-05	0.1	0.5	
19	6.00	0.01	0.002	9.10E-05	0.3	0.5	
20	4.80	-0.16	0.002	8.72E-05	0.2	0.5	
21	3.60	-0.17	0.002	8.40E-05	0.0	0.3	
22	2.80	-0.05	0.002	8.28E-05	-0.1	0.2	
23	2.00	0.19	0.002	8.24E-05	-0.0	0.0	

At elev. 20.02 Prop force = 89.0 kN/m run (horiz.)  
 = 125.8 kN/m run (inclined)



(continued)

Stage No.7 Excavate to elevation 16.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	11322
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	11322
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	11322
		Total>	12.95	3.50m	196.62	30.86	30.86	32356
4	20.59	Total>	27.55	7.15m	219.15	10.78	10.78	34080
5	20.02	Total>	38.95	10.00m	236.74	10.00	10.00a	9733
6	19.50	Total>	51.63	12.60m	255.07	12.60	12.60a	10070
7	18.75	Total>	78.61	16.35m	290.20	19.34	19.34	10557
8	18.00	Total>	101.69	20.10m	321.44	39.48	39.48	11044
9	17.50	Total>	113.57	22.60m	338.74	50.41	50.41	11368
10	16.50	Total>	133.14	27.60m	369.18	71.03	71.03	12017
11	15.55	Total>	150.00	32.35m	396.36	91.54	91.54	12634
12	14.38	Total>	170.66	38.22m	429.79	117.42	117.42	13397
13	13.20	Total>	191.69	44.10m	463.59	142.53	142.53	14159
14	12.00	Total>	213.61	50.10m	498.55	166.95	166.95	14938
15	10.80	Total>	235.90	56.10m	533.88	190.51	190.51	15717
16	9.60	Total>	258.49	62.10m	569.50	213.74	213.74	16496
17	8.40	Total>	281.30	68.10m	605.35	237.01	237.01	17275
18	7.20	Total>	304.28	74.10m	641.38	260.50	260.50	18053
19	6.00	Total>	327.41	80.10m	677.55	284.24	284.24	18832
20	4.80	Total>	350.66	86.10m	713.83	308.19	308.19	19611
21	3.60	Total>	374.00	92.10m	750.21	332.32	332.32	20390
22	2.80	Total>	389.61	96.10m	774.51	348.51	348.51	20909
23	2.00	Total>	405.24	100.10m	798.84	364.80	364.80	21428

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	16.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	30.00	0.00	266.04	102.80	102.80	15962
11	15.55	Total>	48.72	4.75m	295.09	116.61	116.61	16781
12	14.38	Total>	70.46	10.62m	329.59	131.73	131.73	17794
13	13.20	Total>	91.58	16.50m	363.48	147.81	147.81	18807
14	12.00	Total>	113.75	22.50m	398.69	167.09	167.09	19842
15	10.80	Total>	136.78	28.50m	434.75	188.88	188.88	20876
16	9.60	Total>	160.46	34.50m	471.47	212.14	212.14	21911
17	8.40	Total>	184.59	40.50m	508.65	236.03	236.03	22945
18	7.20	Total>	209.03	46.50m	546.12	260.12	260.12	23980
19	6.00	Total>	233.69	52.50m	583.82	284.23	284.23	25014
20	4.80	Total>	258.51	58.50m	621.69	308.35	308.35	26049
21	3.60	Total>	283.48	64.50m	659.69	332.49	332.49	27083
22	2.80	Total>	300.19	68.50m	685.09	348.56	348.56	27773
23	2.00	Total>	316.94	72.50m	710.54	364.61	364.61	28463

Run ID. Design\_Case\_01\_with\_prop\_SLS\_a  
Ugly Brown Building  
Existing contiguous wall stability assessment

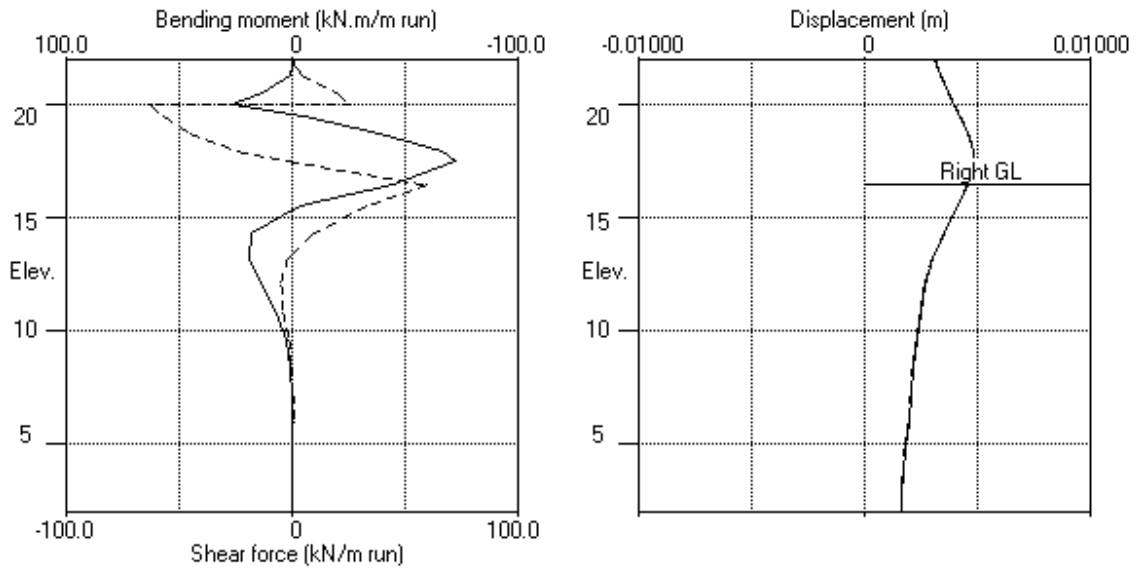
Sheet No.  
Date:13-05-2020  
Checked :

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Stage No.7 Excavate to elevation 16.50 on RIGHT side  
Note: 12.60a Soil pressure at active limit  
123.45p Soil pressure at passive limit

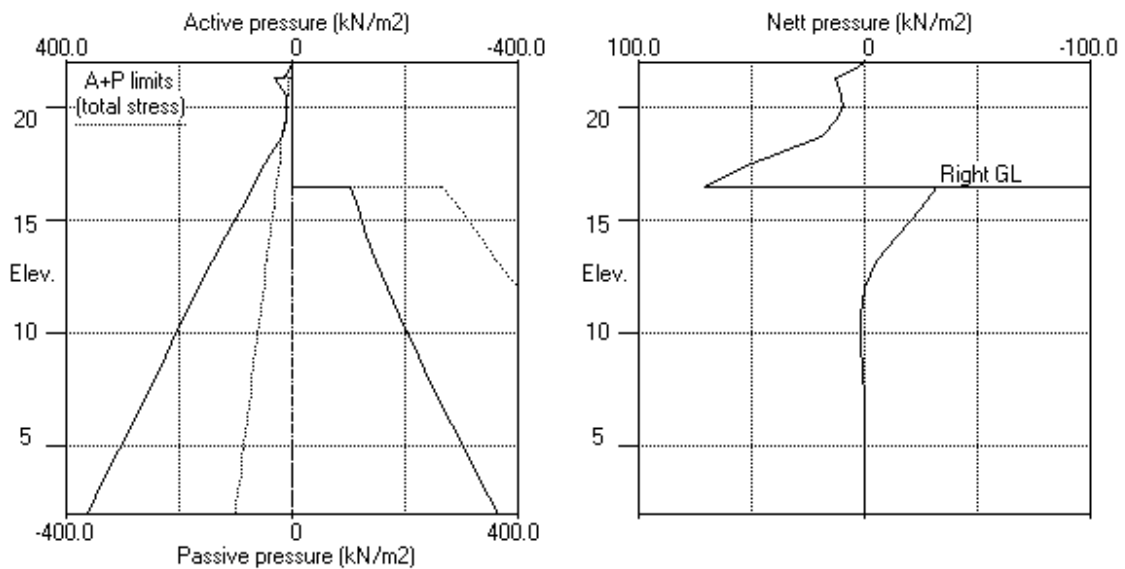
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(continued)

Units: kN,m

Stage No.7 Excav. to elev. 16.50 on RIGHT side



Stage No.7 Excav. to elev. 16.50 on RIGHT side



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 Data filename/Run ID: Design\_Case\_01\_with\_prop\_SLS\_a  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 10 Fill to elevation 17.50 on RIGHT side with soil type 2

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
10	22.02	17.50	20.02	6.839	n/a	17.43	0.07	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.003	-3.89E-04	0.0	0.0	
2	21.80	4.07	0.003	-3.89E-04	0.4	0.0	
3	21.32	12.95	0.003	-3.91E-04	4.5	1.1	
		31.12	0.003	-3.91E-04	4.5	1.1	
4	20.59	10.98	0.004	-4.23E-04	19.9	13.3	
5	20.02	10.14	0.004	-4.93E-04	25.9	26.7	-87.8
		10.14	0.004	-4.93E-04	-61.9	26.7	
6	19.50	12.67	0.004	-5.30E-04	-55.9	-3.9	
7	18.75	19.28	0.005	-4.35E-04	-43.9	-37.0	
8	18.00	39.23	0.005	-2.04E-04	-22.0	-62.7	
9	17.50	49.95	0.005	-2.24E-06	0.3	-68.4	
		49.49	0.005	-2.24E-06	0.3	-68.4	
10	16.50	49.58	0.005	3.44E-04	49.8	-43.7	
		-24.40	0.005	3.44E-04	49.8	-43.7	
11	15.55	-19.51	0.004	4.94E-04	29.0	-7.6	
12	14.38	-11.71	0.004	4.77E-04	10.6	12.3	
13	13.20	-5.12	0.003	3.74E-04	0.7	16.1	
14	12.00	-1.02	0.003	2.66E-04	-2.9	12.8	
15	10.80	0.75	0.003	1.89E-04	-3.1	8.0	
16	9.60	1.08	0.002	1.44E-04	-2.0	4.3	
17	8.40	0.79	0.002	1.19E-04	-0.9	2.2	
18	7.20	0.43	0.002	1.07E-04	-0.2	1.2	
19	6.00	0.11	0.002	9.92E-05	0.2	0.9	
20	4.80	-0.09	0.002	9.34E-05	0.2	0.7	
21	3.60	-0.15	0.002	8.95E-05	0.0	0.4	
22	2.80	-0.06	0.002	8.81E-05	-0.0	0.2	
23	2.00	0.17	0.002	8.76E-05	-0.0	0.0	

At elev. 20.02 Prop force = 87.8 kN/m run (horiz.)  
 = 124.1 kN/m run (inclined)

(continued)

Stage No.10 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	6779
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	6779
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	6779
		Total>	12.95	3.50m	196.62	31.12	31.12	19373
4	20.59	Total>	27.55	7.15m	219.15	10.98	10.98	20406
5	20.02	Total>	38.95	10.00m	236.74	10.14	10.14	21212
6	19.50	Total>	51.63	12.60m	255.07	12.67	12.67	21948
7	18.75	Total>	78.61	16.35m	290.20	19.28	19.28	11434
8	18.00	Total>	101.69	20.10m	321.44	39.23	39.23	11962
9	17.50	Total>	113.57	22.60m	338.74	49.95	49.95	12313
10	16.50	Total>	133.14	27.60m	369.18	69.91	69.91	13016
11	15.55	Total>	150.00	32.35m	396.36	89.67	89.67	13684
12	14.38	Total>	170.66	38.22m	429.79	114.97	114.97	14510
13	13.20	Total>	191.69	44.10m	463.59	140.10	140.10	15336
14	12.00	Total>	213.61	50.10m	498.55	165.06	165.06	16179
15	10.80	Total>	235.90	56.10m	533.88	189.34	189.34	17023
16	9.60	Total>	258.49	62.10m	569.50	213.24	213.24	17866
17	8.40	Total>	281.30	68.10m	605.35	237.04	237.04	20556
18	7.20	Total>	304.28	74.10m	641.38	260.94	260.94	21483
19	6.00	Total>	327.41	80.10m	677.55	284.97	284.97	22409
20	4.80	Total>	350.66	86.10m	713.83	309.15	309.15	23336
21	3.60	Total>	374.00	92.10m	750.21	333.49	333.49	24263
22	2.80	Total>	389.61	96.10m	774.51	349.82	349.82	24881
23	2.00	Total>	405.24	100.10m	798.84	366.24	366.24	25499

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02		0.00	0.00	0.00	0.00	0.00	0.0
2	21.80		0.00	0.00	0.00	0.00	0.00	0.0
3	21.32		0.00	0.00	0.00	0.00	0.00	0.0
4	20.59		0.00	0.00	0.00	0.00	0.00	0.0
5	20.02		0.00	0.00	0.00	0.00	0.00	0.0
6	19.50		0.00	0.00	0.00	0.00	0.00	0.0
7	18.75		0.00	0.00	0.00	0.00	0.00	0.0
8	18.00		0.00	0.00	0.00	0.00	0.00	0.0
9	17.50		0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	0.46	0.46	12313
10	16.50	Total>	20.00	5.00m	256.05	20.34	20.34	13016
		Total>	20.00	5.00m	256.05	94.32	94.32	13016
11	15.55	Total>	39.03	9.75m	285.40	109.17	109.17	13684
12	14.38	Total>	62.64	15.62m	321.77	126.68	126.68	14510
13	13.20	Total>	86.36	21.50m	358.26	145.22	145.22	15336
14	12.00	Total>	110.72	27.50m	395.66	166.08	166.08	16179
15	10.80	Total>	135.25	33.50m	433.23	188.59	188.59	17023
16	9.60	Total>	159.96	39.50m	470.98	212.16	212.16	17866
17	8.40	Total>	184.85	45.50m	508.90	236.25	236.25	20556
18	7.20	Total>	209.90	51.50m	546.99	260.51	260.51	21483
19	6.00	Total>	235.10	57.50m	585.24	284.86	284.86	22409
20	4.80	Total>	260.44	63.50m	623.61	309.24	309.24	23336
21	3.60	Total>	285.89	69.50m	662.10	333.64	333.64	24263
22	2.80	Total>	302.91	73.50m	687.81	349.88	349.88	24881

Run ID. Design\_Case\_01\_with\_prop\_SLS\_a  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

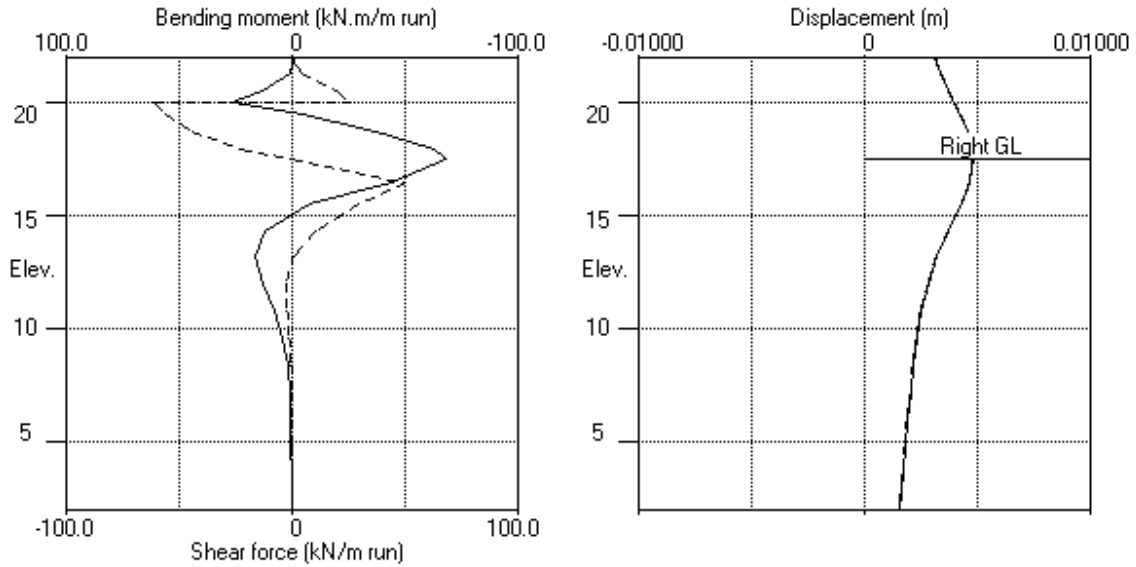
(continued)

Stage No.10 Fill to elevation 17.50 on RIGHT side with soil type 2

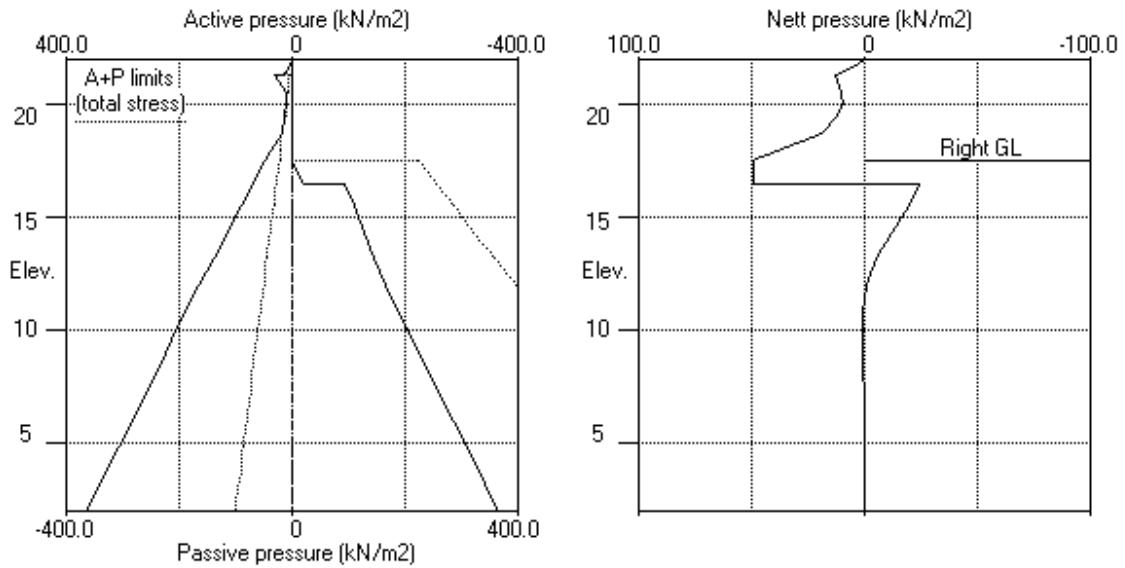
RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses			Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>	Earth pressure kN/m <sup>2</sup>		
23	2.00	Total>	319.96	77.50m	713.56	366.07	366.07	25499

Units: kN,m

Stage No.10 Fill to elev. 17.50 on RIGHT side



Stage No.10 Fill to elev. 17.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
14	22.02	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.003	-8.09E-04	0.0	0.0	
2	21.80	4.07	0.003	-8.09E-04	0.4	0.0	-38.9
3	21.32	4.07	0.003	-8.09E-04	-38.5	0.0	
		12.95	0.004	-7.83E-04	-34.4	-17.6	
4	20.59	27.68	0.004	-7.83E-04	-34.4	-17.6	
		6.82	0.004	-6.64E-04	-21.8	-35.1	
5	20.02	11.19	0.004	-5.22E-04	-16.7	-45.8	
6	19.50	19.26	0.005	-3.64E-04	-8.8	-52.5	
7	18.75	34.23	0.005	-1.31E-04	11.3	-47.6	
8	18.00	47.71	0.005	4.37E-05	42.0	-28.2	-83.2
		47.71	0.005	4.37E-05	-41.1	-28.2	
9	17.50	55.34	0.005	1.53E-04	-15.4	-42.6	
		54.66	0.005	1.53E-04	-15.4	-42.6	
10	16.50	52.10	0.005	3.82E-04	38.0	-31.8	
		-13.77	0.005	3.82E-04	38.0	-31.8	
11	15.55	-16.54	0.004	4.86E-04	23.6	-3.4	
12	14.38	-9.57	0.004	4.53E-04	8.3	12.3	
13	13.20	-4.07	0.003	3.55E-04	0.2	14.8	
14	12.00	-0.74	0.003	2.57E-04	-2.6	11.6	
15	10.80	0.66	0.003	1.87E-04	-2.7	7.4	
16	9.60	0.92	0.002	1.44E-04	-1.7	4.1	
17	8.40	0.68	0.002	1.21E-04	-0.8	2.2	
18	7.20	0.38	0.002	1.07E-04	-0.1	1.3	
19	6.00	0.11	0.002	9.95E-05	0.2	0.9	
20	4.80	-0.08	0.002	9.34E-05	0.2	0.7	
21	3.60	-0.14	0.002	8.94E-05	0.0	0.4	
22	2.80	-0.05	0.002	8.80E-05	-0.0	0.2	
23	2.00	0.17	0.002	8.75E-05	-0.0	0.0	
At elev. 21.80			Prop force =		38.9 kN/m run		
At elev. 18.00			Prop force =		83.2 kN/m run		



(continued)

Stage No.14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	85158
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	4312
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	4312
		0.00	12.95	0.00	63.48	27.68	27.68	5262
4	20.59	0.00	27.55	3.30	107.92	6.82	6.82	5658
5	20.02	5.70	33.25	5.49	125.27	5.49	11.19a	5967
6	19.50	10.90	40.73	8.36	148.03	8.36	19.26a	6248
7	18.75	18.40	60.21	15.83	207.31	15.83	34.23a	6655
8	18.00	25.90	75.79	21.81	254.75	21.81	47.71a	7061
9	17.50	30.90	82.67	24.44	275.66	24.44	55.34a	7332
10	16.50	40.90	92.24	28.11	304.79	30.28	71.18	7874
11	15.55	50.40	99.60	30.93	327.19	40.76	91.16	8388
12	14.38	62.15	108.51	34.35	354.32	53.89	116.04	9025
13	13.20	73.90	117.79	37.91	382.57	66.73	140.63	9661
14	12.00	85.90	127.71	41.72	412.76	79.30	165.20	10311
15	10.80	97.90	138.00	45.66	444.08	91.40	189.30	10961
16	9.60	109.90	148.59	49.72	476.29	103.26	213.16	11130
17	8.40	121.90	159.40	53.87	509.19	115.08	236.98	11753
18	7.20	133.90	170.38	58.08	542.63	127.02	260.92	12376
19	6.00	145.90	181.51	62.35	576.50	139.07	284.97	12999
20	4.80	157.90	192.76	66.66	610.73	151.26	309.16	13622
21	3.60	169.90	204.10	71.01	645.25	163.59	333.49	14245
22	2.80	177.90	211.71	73.93	668.40	171.92	349.82	38625
23	2.00	185.90	219.34	76.86	691.64	180.34	366.24	39720

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.07	0.68	0.68	7674
10	16.50	0.00	20.00	0.41	84.95	19.08	19.08	8241
		0.00	20.00	0.41	84.95	84.95	84.95p	8241
11	15.55	0.00	39.03	7.71	142.87	107.69	107.69	8779
12	14.38	11.75	50.89	12.26	178.95	113.86	125.61	9445
13	13.20	23.50	62.86	16.84	215.37	121.20	144.70	10112
14	12.00	35.50	75.22	21.59	253.01	130.44	165.94	10792
15	10.80	47.50	87.75	26.39	291.15	141.13	188.63	11472
16	9.60	59.50	100.46	31.27	329.83	152.74	212.24	11130
17	8.40	71.50	113.35	36.21	369.04	164.80	236.30	11753
18	7.20	83.50	126.40	41.21	408.76	177.03	260.53	12376
19	6.00	95.50	139.60	46.28	448.95	189.36	284.86	12999
20	4.80	107.50	152.94	51.39	489.54	201.74	309.24	13622
21	3.60	119.50	166.39	56.55	530.48	214.13	333.63	14245

Run ID. Design\_Case\_01\_with\_prop\_SLS\_a  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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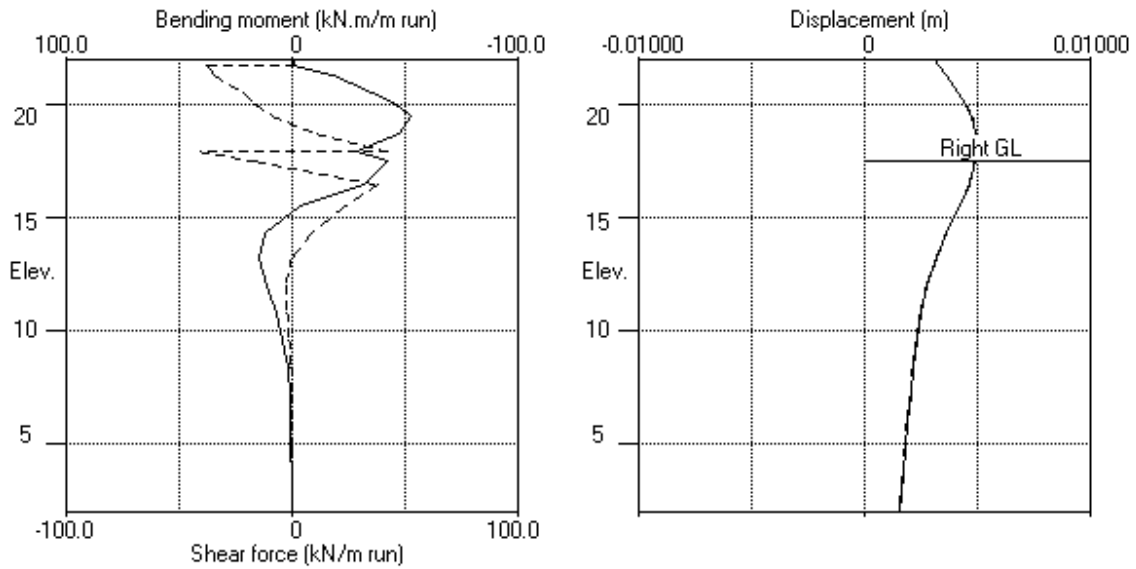
Stage No.14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u>	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u>
			<u>Vertic</u> <u>-al</u>	<u>Active</u> <u>limit</u>	<u>Passive</u> <u>limit</u>	<u>Earth</u> <u>pressure</u>		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
22	2.80	127.50	175.41	60.01	557.92	222.37	349.87	38625
23	2.00	135.50	184.46	63.48	585.47	230.57	366.07	39720

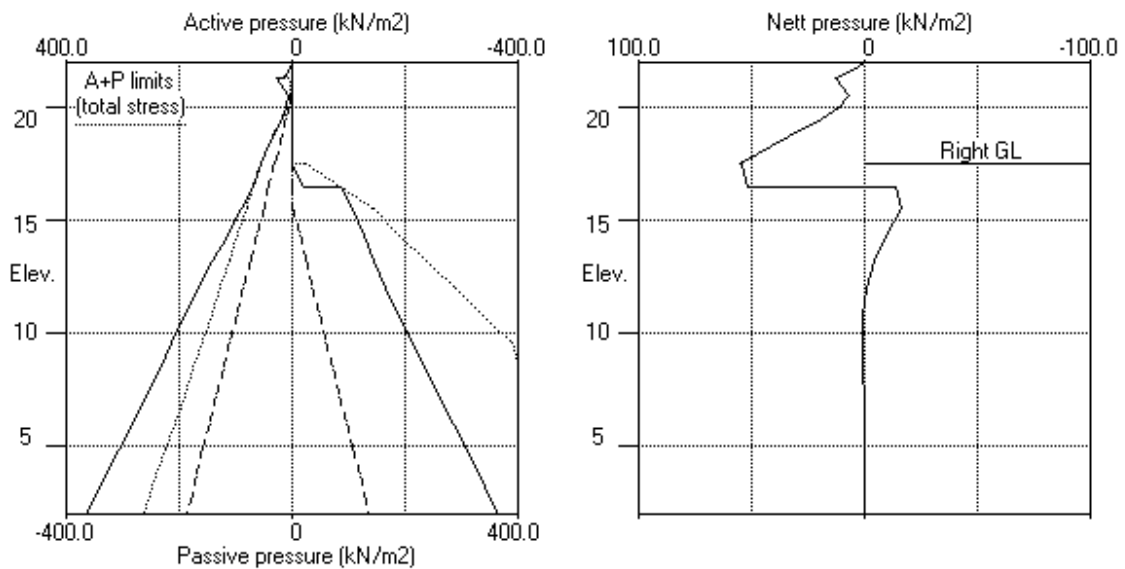
Note: 55.34a Soil pressure at active limit  
 84.95p Soil pressure at passive limit

Units: kN, m

Stage No.14 Change soil type 2 to soil type 4



Stage No.14 Change soil type 2 to soil type 4



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 Data filename/Run ID: Design\_Case\_01\_with\_prop\_SLS\_a  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	22.02	19.50	Cant.	7.689	3.38	18.94	0.56	L to R
4	22.02	19.50		No analysis at this stage				
5	22.02	19.50		No analysis at this stage				
6	22.02	19.50		No analysis at this stage				
7	22.02	16.50	20.02	6.796	n/a	16.38	0.12	L to R
8	22.02	16.50		No analysis at this stage				
9	22.02	16.50		No analysis at this stage				
10	22.02	17.50	20.02	6.839	n/a	17.43	0.07	L to R
11	22.02	17.50		No analysis at this stage				

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

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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	22.02	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	21.80	0.005	-0.000	0	-0	0	-0	0	-45	1	-60
3	21.32	0.004	-0.000	1	-21	1	-28	5	-40	6	-55
4	20.59	0.004	0.000	13	-41	18	-55	20	-22	27	-30
5	20.02	0.005	0.000	27	-50	36	-67	26	-63	35	-85
6	19.50	0.005	0.000	21	-53	28	-71	19	-57	26	-78
7	18.75	0.005	0.000	29	-48	40	-64	31	-45	41	-61
8	18.00	0.005	0.000	23	-66	32	-89	69	-68	93	-92
9	17.50	0.005	0.000	18	-72	24	-98	0	-37	0	-50
10	16.50	0.005	0.000	7	-45	9	-61	60	-9	81	-12
11	15.55	0.005	0.000	0	-11	1	-15	33	-4	44	-5
12	14.38	0.004	0.000	18	-5	24	-6	11	0	14	0
13	13.20	0.004	0.000	20	-1	26	-1	3	-2	5	-3
14	12.00	0.004	0.000	13	0	18	0	2	-5	2	-7
15	10.80	0.004	0.000	8	0	11	0	1	-4	1	-6
16	9.60	0.003	0.000	4	0	6	0	0	-2	1	-3
17	8.40	0.003	0.000	2	0	3	0	0	-1	0	-1
18	7.20	0.003	0.000	2	0	3	0	0	0	0	0
19	6.00	0.003	0.000	2	0	2	0	0	-0	0	-0
20	4.80	0.003	0.000	1	0	2	0	0	-0	0	-0
21	3.60	0.002	0.000	1	0	1	0	0	-0	0	-0
22	2.80	0.002	0.000	0	0	0	0	0	-0	0	-0
23	2.00	0.002	0.000	0	-0	0	-0	0	-0	0	-0

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. min.	
kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	
1	3	10.80	-16	17.50	4	-21	5	15.55	-8	18.75	7	-11
2	3	10.80	-16	17.50	4	-22	5	15.55	-8	18.75	7	-11
3	29	18.75	-2	14.38	40	-2	19	19.50	-12	17.50	26	-16
4	No calculation at this stage											
5	No calculation at this stage											
6	No calculation at this stage											
7	27	20.02	-72	17.50	36	-98	60	16.50	-63	20.02	81	-85
8	No calculation at this stage											
9	No calculation at this stage											
10	27	20.02	-68	17.50	36	-92	50	16.50	-62	20.02	67	-84
11	No calculation at this stage											
12	No calculation at this stage											
13	14	13.20	-46	19.50	20	-62	41	16.50	-35	21.80	55	-48
14	15	13.20	-53	19.50	20	-71	42	18.00	-41	18.00	57	-56
15	5	13.20	-52	19.50	7	-70	69	18.00	-68	18.00	93	-92

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.001	16.50	-0.000	22.02	Apply surcharge no.1 at elev. 20.02
2	0.001	16.50	-0.000	22.02	Apply water pressure profile no.1
3	0.005	22.02	0.000	22.02	Excav. to elev. 19.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 20.02
5	No calculation at this stage				Apply surcharge no.2 at elev. 16.50
6	No calculation at this stage				Apply surcharge no.3 at elev. 16.50
7	0.005	17.50	0.000	22.02	Excav. to elev. 16.50 on RIGHT side
8	No calculation at this stage				Remove surcharge no.2 at elev. 16.50
9	No calculation at this stage				Remove surcharge no.3 at elev. 16.50
10	0.005	17.50	0.000	22.02	Fill to elev. 17.50 on RIGHT side
11	No calculation at this stage				Install prop no.2 at elev. 18.00
12	No calculation at this stage				Install prop no.3 at elev. 21.80
13	0.005	18.00	0.000	22.02	Remove prop no.1 at elev. 20.02
14	0.005	18.00	0.000	22.02	Change soil type 2 to soil type 4
15	0.005	17.50	0.000	22.02	Apply water pressure profile no.2

Run ID. Design\_Case\_01\_with\_prop\_SIS\_a  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
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**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Prop forces at each stage (horizontal components)**

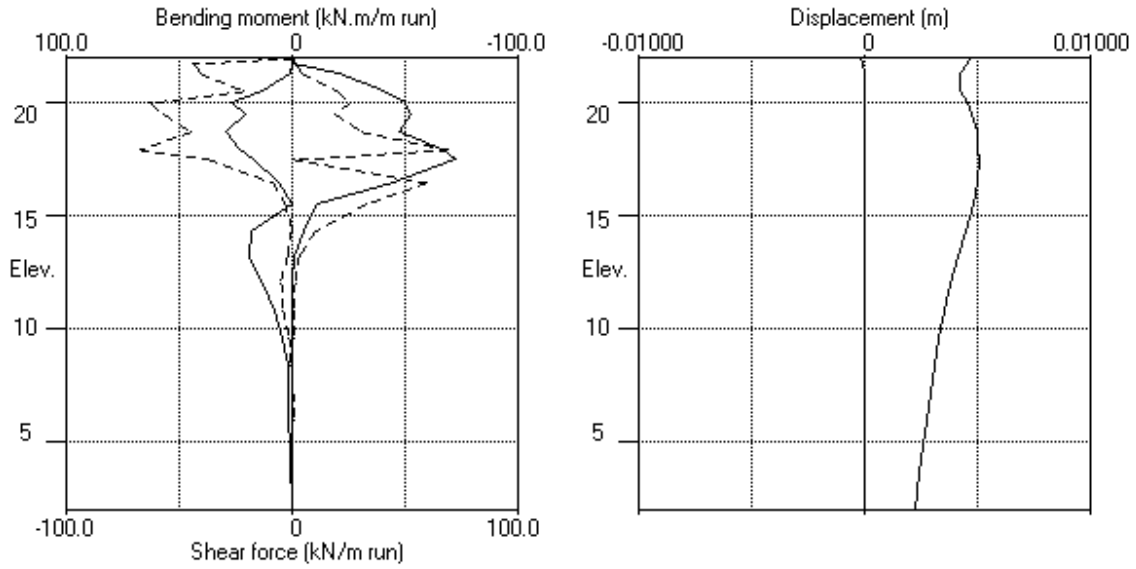
Stage no.	----- Prop no. 1 ----- at elev. 20.02			----- Prop no. 2 ----- at elev. 18.00			----- Prop no. 3 ----- at elev. 21.80		
	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop
7	89	534	721	---	---	---	---	---	---
10	88	527	711	---	---	---	---	---	---
13	---	---	---	56	56	75	36	36	48
14	---	---	---	83	83	112	39	39	53
15	---	---	---	137	137	185	45	45	61

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Bending moment, shear force, displacement envelopes





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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	22.02	1 Made Ground		1 Made Ground
2	21.32	2 London Clay		2 London Clay
3	-3.48	3 Lambeth Group		3 Lambeth Group

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. ( Nu ) ( NC/OC )	Active limit Ka ( Kac )	Passive limit Kp ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 (2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390 )
3	Lambeth G.. ( -3.48 )	20.00	72000 ( 5231 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08 )
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610 )	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185 )	1.000 ( 1.000 )	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	20.59	20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0
2	1	22.02	22.02	0.0	1	15.55	15.55	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	20.02	6.00	0.017663	2.050E+08	1.65	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	21.80	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m <sup>2</sup>	-----	Equiv. soil type	Partial factor/ Category
1	20.02	1.20(L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.50	-0.00(R)	23.80	3.10	30.00	=	N/A	1.00 -
3	16.50	-5.80(R)	23.80	14.60	30.00	=	N/A	1.00 -
4	17.50	-0.00(R)	23.80	20.00	12.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 20.02 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Excavate to elevation 19.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 20.02
5	Apply surcharge no.2 at elevation 16.50 No analysis at this stage
6	Apply surcharge no.3 at elevation 16.50 No analysis at this stage
7	Excavate to elevation 16.50 on RIGHT side
8	Remove surcharge no.2 at elevation 16.50 No analysis at this stage
9	Remove surcharge no.3 at elevation 16.50 No analysis at this stage
10	Fill to elevation 17.50 on RIGHT side with soil type 2
11	Install strut or anchor no.2 at elevation 18.00
12	Install strut or anchor no.3 at elevation 21.80
13	Remove strut or anchor no.1 at elevation 20.02
14	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
15	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m<sup>3</sup>

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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Output options		
		Displacement	Active, Passive	Graph. output
		Bending mom.	pressures	
		Shear force		
1	Apply surcharge no.1 at elev. 20.02	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Excav. to elev. 19.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 20.02	Yes	Yes	Yes
5	Apply surcharge no.2 at elev. 16.50	No	No	No
6	Apply surcharge no.3 at elev. 16.50	No	No	No
7	Excav. to elev. 16.50 on RIGHT side	Yes	Yes	Yes
8	Remove surcharge no.2 at elev. 16.50	No	No	No
9	Remove surcharge no.3 at elev. 16.50	No	No	No
10	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
11	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
12	Install prop no.3 at elev. 21.80	Yes	Yes	Yes
13	Remove prop no.1 at elev. 20.02	Yes	Yes	Yes
14	Change soil type 2 to soil type 4	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

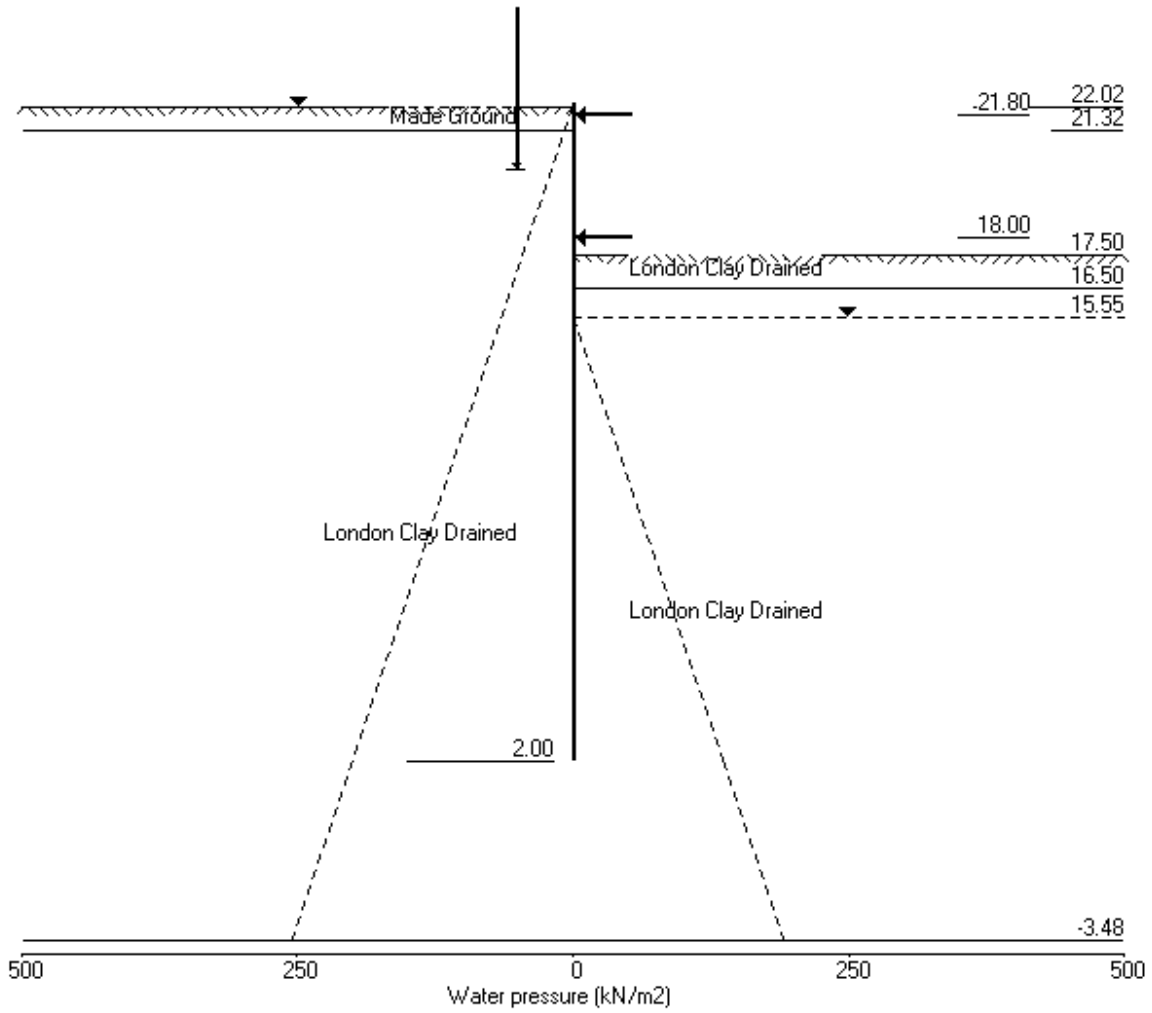
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Stage No.15 Apply water pressure profile no.2 (Worst Cred.)



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Stage No. 3 Excavate to elevation 19.50 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 2.00						
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
		<u>Elev.</u>	<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
3	22.02	19.50	Cant.	5.492	3.38	18.59	0.91	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	22.02	0.00	0.005	6.22E-04	0.0	0.0	
2	21.80	4.07	0.005	6.22E-04	0.4	0.0	
3	21.32	12.95	0.004	6.21E-04	4.5	1.1	
		3.50	0.004	6.21E-04	4.5	1.1	
4	20.59	7.15	0.004	6.05E-04	8.4	5.9	
5	20.02	10.00	0.003	5.73E-04	13.3	12.2	
6	19.50	12.60	0.003	5.20E-04	19.2	20.7	
		-35.69	0.003	5.20E-04	19.2	20.7	
7	18.75	-19.82	0.003	4.04E-04	-1.6	29.4	
8	18.00	-4.36	0.003	2.82E-04	-10.7	23.4	
9	17.50	1.07	0.002	2.19E-04	-11.5	17.6	
10	16.50	4.94	0.002	1.44E-04	-8.5	6.6	
11	15.55	4.58	0.002	1.24E-04	-4.0	0.4	
12	14.38	2.30	0.002	1.29E-04	0.0	-1.8	
13	13.20	0.44	0.002	1.38E-04	1.7	-0.7	
14	12.00	-0.47	0.002	1.37E-04	1.6	1.0	
15	10.80	-0.62	0.002	1.25E-04	1.0	2.1	
16	9.60	-0.41	0.001	1.08E-04	0.4	2.4	
17	8.40	-0.16	0.001	9.19E-05	0.0	2.1	
18	7.20	-0.01	0.001	7.78E-05	-0.1	1.7	
19	6.00	0.02	0.001	6.71E-05	-0.1	1.2	
20	4.80	-0.02	0.001	5.97E-05	-0.1	0.8	
21	3.60	-0.04	0.001	5.54E-05	-0.1	0.4	
22	2.80	0.03	0.001	5.42E-05	-0.1	0.2	
23	2.00	0.20	0.001	5.38E-05	-0.0	0.0	

(continued)

Stage No.3 Excavate to elevation 19.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	4742
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	4742
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	4742
		Total>	12.95	3.50m	144.14	3.50	3.50a	13553
4	20.59	Total>	27.55	7.15m	164.41	7.15	7.15a	14275
5	20.02	Total>	38.95	10.00m	180.24	10.00	10.00a	14839
6	19.50	Total>	51.63	12.60m	196.95	12.60	12.60a	15354
7	18.75	Total>	78.61	16.35m	229.76	38.15	38.15	16096
8	18.00	Total>	101.69	20.10m	258.67	64.52	64.52	16838
9	17.50	Total>	113.57	22.60m	274.42	77.99	77.99	17333
10	16.50	Total>	133.14	27.60m	301.76	99.48	99.48	18322
11	15.55	Total>	150.00	32.35m	325.99	117.10	117.10	19263
12	14.38	Total>	170.66	38.22m	355.78	138.19	138.19	20425
13	13.20	Total>	191.69	44.10m	385.93	159.71	159.71	21588
14	12.00	Total>	213.61	50.10m	417.17	182.43	182.43	22775
15	10.80	Total>	235.90	56.10m	448.77	205.76	205.76	23963
16	9.60	Total>	258.49	62.10m	480.67	229.45	229.45	25150
17	8.40	Total>	281.30	68.10m	512.80	253.30	253.30	26338
18	7.20	Total>	304.28	74.10m	545.10	277.22	277.22	27525
19	6.00	Total>	327.41	80.10m	577.55	301.19	301.19	28713
20	4.80	Total>	350.66	91.28	610.11	325.20	325.20	29900
21	3.60	Total>	374.00	105.31	642.77	349.29	349.29	31088
22	2.80	Total>	389.61	114.70	664.59	365.42	365.42	31879
23	2.00	Total>	405.24	124.13	686.44	381.62	381.62	32671

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	145.32	48.29	48.29	15940
7	18.75	Total>	15.00	3.75m	166.14	57.97	57.97	16711
8	18.00	Total>	30.01	7.50m	186.98	68.88	68.88	17481
9	17.50	Total>	40.02	10.00m	200.87	76.92	76.92	17995
10	16.50	Total>	60.07	15.00m	228.68	94.54	94.54	19022
11	15.55	Total>	79.15	19.75m	255.15	112.53	112.53	19998
12	14.38	Total>	102.83	25.62m	287.94	135.89	135.89	21205
13	13.20	Total>	126.58	31.50m	320.82	159.26	159.26	22412
14	12.00	Total>	150.94	37.50m	354.50	182.90	182.90	23645
15	10.80	Total>	175.40	43.50m	388.27	206.38	206.38	24878
16	9.60	Total>	199.95	49.50m	422.14	229.85	229.85	26111
17	8.40	Total>	224.59	55.50m	456.09	253.46	253.46	27344
18	7.20	Total>	249.30	61.50m	490.13	277.23	277.23	28577
19	6.00	Total>	274.09	67.50m	524.22	301.17	301.17	29809
20	4.80	Total>	298.92	73.50m	558.38	325.22	325.22	31042
21	3.60	Total>	323.80	79.50m	592.57	349.33	349.33	32275
22	2.80	Total>	340.40	83.50m	615.38	365.39	365.39	33097
23	2.00	Total>	357.01	87.50m	638.21	381.42	381.42	33919

Run ID. Design\_Case\_01\_with\_prop\_ULS2  
Ugly Brown Building  
Existing contiguous wall stability assessment

Sheet No.  
Date:13-05-2020  
Checked :

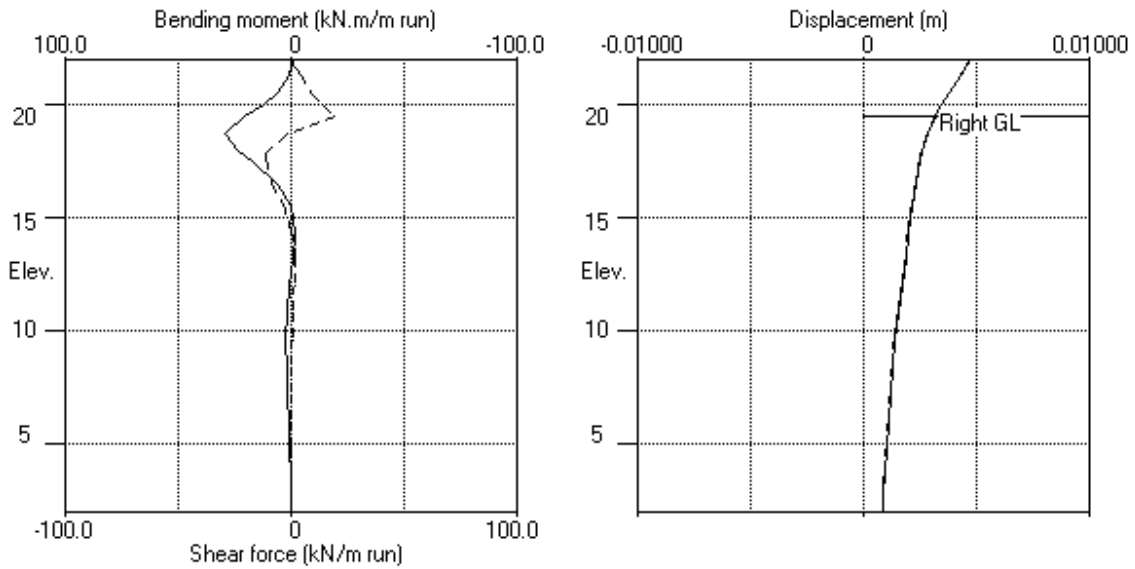
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Stage No.3 Excavate to elevation 19.50 on RIGHT side  
Note: 12.60a Soil pressure at active limit  
123.45p Soil pressure at passive limit

(continued)

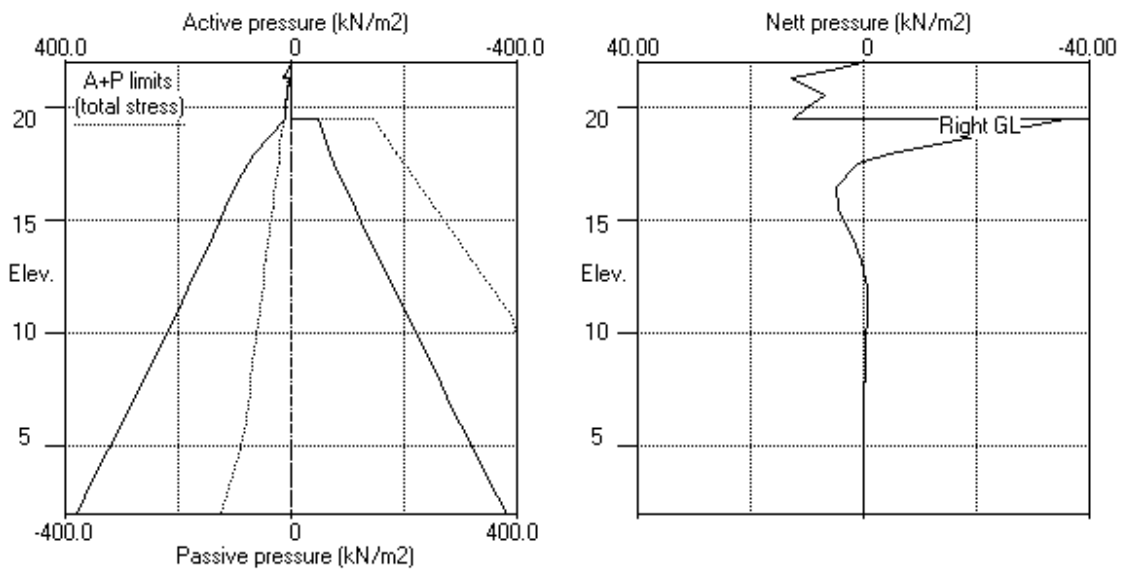


Units: kN, m

Stage No.3 Excav. to elev. 19.50 on RIGHT side



Stage No.3 Excav. to elev. 19.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 7 Excavate to elevation 16.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equil. at elev.	Toe elev.	Wall Penetr-ation	
7	22.02	16.50	20.02	4.854	n/a	16.33	0.17	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.003	-3.85E-04	0.0	-0.0	
2	21.80	4.07	0.003	-3.85E-04	0.4	0.0	
3	21.32	12.95	0.003	-3.87E-04	4.5	1.1	
		30.89	0.003	-3.87E-04	4.5	1.1	
4	20.59	10.76	0.004	-4.19E-04	19.7	13.2	
5	20.02	10.00	0.004	-4.89E-04	25.7	26.5	-89.2
		10.00	0.004	-4.89E-04	-63.6	26.5	
6	19.50	12.60	0.004	-5.23E-04	-57.7	-5.0	
7	18.75	19.57	0.005	-4.21E-04	-45.6	-39.4	
8	18.00	39.69	0.005	-1.76E-04	-23.4	-66.3	
9	17.50	50.61	0.005	3.84E-05	-0.8	-72.7	
10	16.50	71.24	0.005	4.02E-04	60.1	-45.3	
		-32.00	0.005	4.02E-04	60.1	-45.3	
11	15.55	-25.22	0.004	5.43E-04	32.9	-2.8	
12	14.38	-14.37	0.004	4.88E-04	9.7	18.2	
13	13.20	-5.29	0.003	3.50E-04	-1.9	19.6	
14	12.00	-0.12	0.003	2.28E-04	-5.1	13.5	
15	10.80	1.65	0.002	1.52E-04	-4.2	7.0	
16	9.60	1.60	0.002	1.15E-04	-2.3	2.9	
17	8.40	0.97	0.002	1.01E-04	-0.7	1.0	
18	7.20	0.38	0.002	9.54E-05	0.1	0.5	
19	6.00	0.01	0.002	9.17E-05	0.3	0.5	
20	4.80	-0.16	0.002	8.78E-05	0.2	0.5	
21	3.60	-0.17	0.002	8.46E-05	0.0	0.3	
22	2.80	-0.05	0.002	8.34E-05	-0.1	0.2	
23	2.00	0.19	0.002	8.30E-05	-0.0	0.0	

At elev. 20.02 Prop force = 89.2 kN/m run (horiz.)  
 = 126.2 kN/m run (inclined)

(continued)

Stage No.7 Excavate to elevation 16.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	11324
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	11324
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	11324
		Total>	12.95	3.50m	144.14	30.89	30.89	32364
4	20.59	Total>	27.55	7.15m	164.41	10.76	10.76	34089
5	20.02	Total>	38.95	10.00m	180.24	10.00	10.00a	9754
6	19.50	Total>	51.63	12.60m	196.95	12.60	12.60a	10093
7	18.75	Total>	78.61	16.35m	229.76	19.57	19.57	10581
8	18.00	Total>	101.69	20.10m	258.67	39.69	39.69	11068
9	17.50	Total>	113.57	22.60m	274.42	50.61	50.61	11394
10	16.50	Total>	133.14	27.60m	301.76	71.24	71.24	12044
11	15.55	Total>	150.00	32.35m	325.99	91.77	91.77	12662
12	14.38	Total>	170.66	38.22m	355.78	117.69	117.69	13426
13	13.20	Total>	191.69	44.10m	385.93	142.82	142.82	14191
14	12.00	Total>	213.61	50.10m	417.17	167.25	167.25	14971
15	10.80	Total>	235.90	56.10m	448.77	190.81	190.81	15752
16	9.60	Total>	258.49	62.10m	480.67	214.03	214.03	16532
17	8.40	Total>	281.30	68.10m	512.80	237.30	237.30	17313
18	7.20	Total>	304.28	74.10m	545.10	260.79	260.79	18093
19	6.00	Total>	327.41	80.10m	577.55	284.53	284.53	18874
20	4.80	Total>	350.66	91.28	610.11	308.48	308.48	19655
21	3.60	Total>	374.00	105.31	642.77	332.61	332.61	20435
22	2.80	Total>	389.61	114.70	664.59	348.81	348.81	20956
23	2.00	Total>	405.24	124.13	686.44	365.09	365.09	21476

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	16.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	30.00	0.00	198.61	103.24	103.24	16027
11	15.55	Total>	48.72	4.75m	224.71	117.00	117.00	16849
12	14.38	Total>	70.46	10.62m	255.57	132.06	132.06	17866
13	13.20	Total>	91.58	16.50m	285.81	148.11	148.11	18883
14	12.00	Total>	113.75	22.50m	317.30	167.37	167.37	19922
15	10.80	Total>	136.78	28.50m	349.64	189.16	189.16	20960
16	9.60	Total>	160.46	34.50m	382.64	212.43	212.43	21999
17	8.40	Total>	184.59	40.50m	416.09	236.32	236.32	23038
18	7.20	Total>	209.03	46.50m	449.84	260.41	260.41	24076
19	6.00	Total>	233.69	52.50m	483.82	284.52	284.52	25115
20	4.80	Total>	258.51	58.50m	517.96	308.64	308.64	26154
21	3.60	Total>	283.48	64.50m	552.24	332.78	332.78	27192
22	2.80	Total>	300.19	68.50m	575.16	348.86	348.86	27885
23	2.00	Total>	316.94	72.50m	598.13	364.90	364.90	28577

Run ID. Design\_Case\_01\_with\_prop\_ULS2  
Ugly Brown Building  
Existing contiguous wall stability assessment

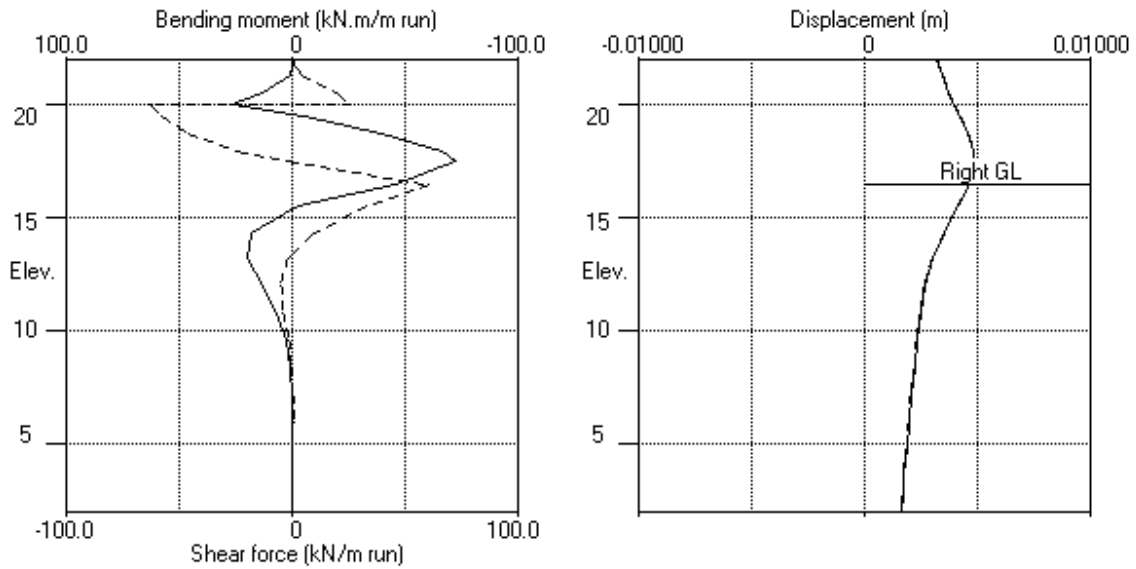
Sheet No.  
Date:13-05-2020  
Checked :

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Stage No.7 Excavate to elevation 16.50 on RIGHT side  
Note: 12.60a Soil pressure at active limit  
123.45p Soil pressure at passive limit

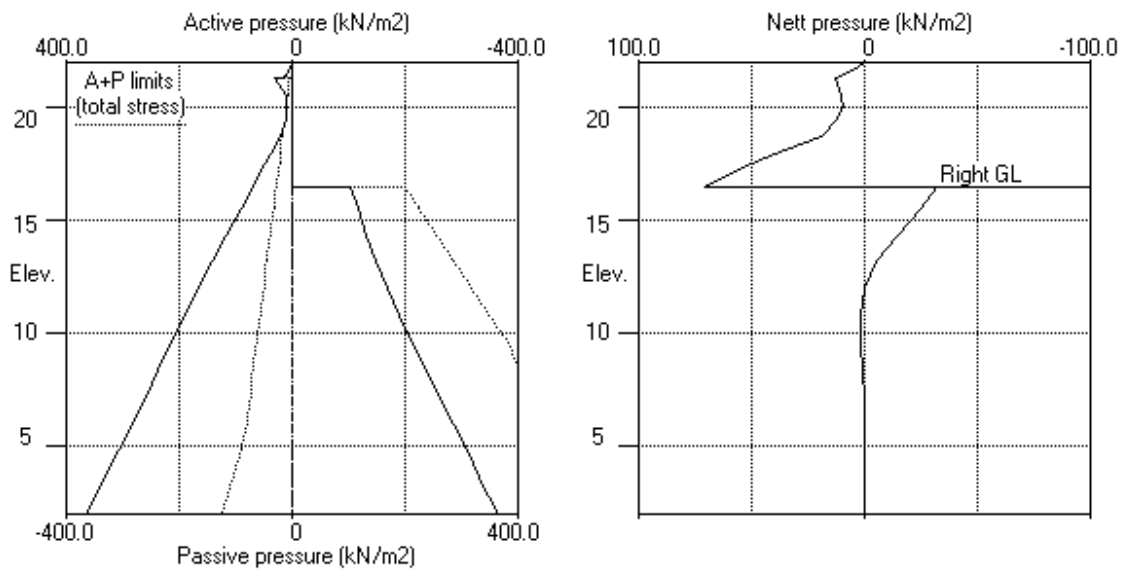
(continued)

Units: kN, m

Stage No.7 Excav. to elev. 16.50 on RIGHT side



Stage No.7 Excav. to elev. 16.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 10 Fill to elevation 17.50 on RIGHT side with soil type 2

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equil. at elev.	Toe elev.	Wall Penetr -ation	
10	22.02	17.50	20.02	4.885	n/a	17.40	0.10	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	22.02	0.00	0.003	-3.90E-04	0.0	-0.0	
2	21.80	4.07	0.003	-3.90E-04	0.4	0.0	
3	21.32	12.95	0.003	-3.92E-04	4.5	1.1	
		31.15	0.003	-3.92E-04	4.5	1.1	
4	20.59	10.96	0.004	-4.24E-04	19.9	13.3	
5	20.02	10.14	0.004	-4.95E-04	25.9	26.7	-88.0
		10.14	0.004	-4.95E-04	-62.1	26.7	
6	19.50	12.67	0.004	-5.31E-04	-56.2	-4.0	
7	18.75	19.51	0.005	-4.36E-04	-44.1	-37.3	
8	18.00	39.44	0.005	-2.03E-04	-22.0	-63.1	
9	17.50	50.15	0.005	-2.18E-07	0.4	-68.7	
		49.69	0.005	-2.18E-07	0.4	-68.7	
10	16.50	49.79	0.005	3.47E-04	50.1	-43.8	
		-24.63	0.005	3.47E-04	50.1	-43.8	
11	15.55	-19.66	0.004	4.97E-04	29.1	-7.5	
12	14.38	-11.77	0.004	4.79E-04	10.6	12.5	
13	13.20	-5.12	0.003	3.75E-04	0.7	16.2	
14	12.00	-1.00	0.003	2.67E-04	-3.0	12.8	
15	10.80	0.76	0.003	1.90E-04	-3.1	8.0	
16	9.60	1.09	0.002	1.45E-04	-2.0	4.3	
17	8.40	0.79	0.002	1.20E-04	-0.9	2.2	
18	7.20	0.43	0.002	1.07E-04	-0.2	1.2	
19	6.00	0.11	0.002	9.99E-05	0.2	0.9	
20	4.80	-0.09	0.002	9.40E-05	0.2	0.7	
21	3.60	-0.15	0.002	9.01E-05	0.0	0.4	
22	2.80	-0.06	0.002	8.87E-05	-0.0	0.2	
23	2.00	0.17	0.002	8.82E-05	-0.0	0.0	

At elev. 20.02 Prop force = 88.0 kN/m run (horiz.)  
 = 124.5 kN/m run (inclined)

(continued)

Stage No.10 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	6779
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	6779
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	6779
		Total>	12.95	3.50m	144.14	31.15	31.15	19373
4	20.59	Total>	27.55	7.15m	164.41	10.96	10.96	20406
5	20.02	Total>	38.95	10.00m	180.24	10.14	10.14	21212
6	19.50	Total>	51.63	12.60m	196.95	12.67	12.67	21948
7	18.75	Total>	78.61	16.35m	229.76	19.51	19.51	11434
8	18.00	Total>	101.69	20.10m	258.67	39.44	39.44	11962
9	17.50	Total>	113.57	22.60m	274.42	50.15	50.15	12313
10	16.50	Total>	133.14	27.60m	301.76	70.12	70.12	13016
11	15.55	Total>	150.00	32.35m	325.99	89.90	89.90	13684
12	14.38	Total>	170.66	38.22m	355.78	115.23	115.23	14510
13	13.20	Total>	191.69	44.10m	385.93	140.39	140.39	15336
14	12.00	Total>	213.61	50.10m	417.17	165.35	165.35	16179
15	10.80	Total>	235.90	56.10m	448.77	189.63	189.63	17023
16	9.60	Total>	258.49	62.10m	480.67	213.53	213.53	17866
17	8.40	Total>	281.30	68.10m	512.80	237.33	237.33	20556
18	7.20	Total>	304.28	74.10m	545.10	261.23	261.23	21483
19	6.00	Total>	327.41	80.10m	577.55	285.26	285.26	22409
20	4.80	Total>	350.66	91.28	610.11	309.44	309.44	23336
21	3.60	Total>	374.00	105.31	642.77	333.78	333.78	24263
22	2.80	Total>	389.61	114.70	664.59	350.11	350.11	24881
23	2.00	Total>	405.24	124.13	686.44	366.54	366.54	25499

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	160.84	0.46	0.46	12313
10	16.50	Total>	20.00	5.00m	188.61	20.34	20.34	13016
		Total>	20.00	5.00m	188.61	94.75	94.75	13016
11	15.55	Total>	39.03	9.75m	215.02	109.56	109.56	13684
12	14.38	Total>	62.64	15.62m	247.75	127.01	127.01	14510
13	13.20	Total>	86.36	21.50m	280.59	145.52	145.52	15336
14	12.00	Total>	110.72	27.50m	314.27	166.36	166.36	16179
15	10.80	Total>	135.25	33.50m	348.12	188.88	188.88	17023
16	9.60	Total>	159.96	39.50m	382.14	212.45	212.45	17866
17	8.40	Total>	184.85	45.50m	416.34	236.54	236.54	20556
18	7.20	Total>	209.90	51.50m	450.71	260.80	260.80	21483
19	6.00	Total>	235.10	57.50m	485.23	285.15	285.15	22409
20	4.80	Total>	260.44	63.50m	519.89	309.54	309.54	23336
21	3.60	Total>	285.89	69.50m	554.65	333.93	333.93	24263
22	2.80	Total>	302.91	73.50m	577.88	350.17	350.17	24881

Run ID. Design\_Case\_01\_with\_prop\_ULS2  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

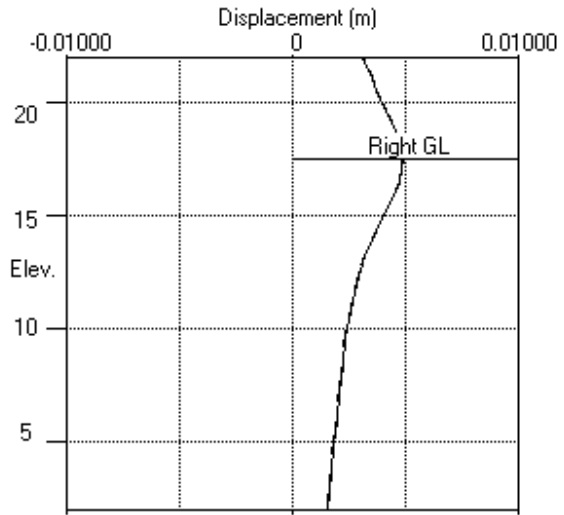
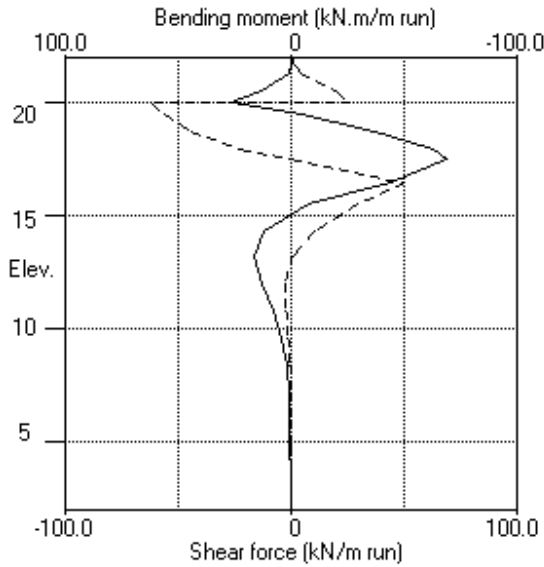
Stage No.10 Fill to elevation 17.50 on RIGHT side with soil type 2

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
23	2.00	Total>	319.96	77.50m	601.15	366.36	366.36	25499

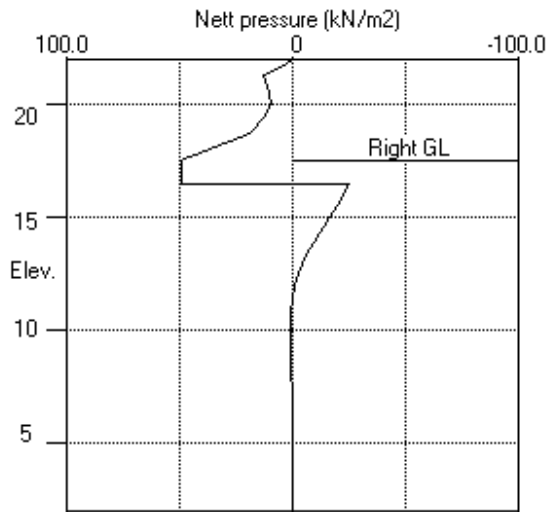
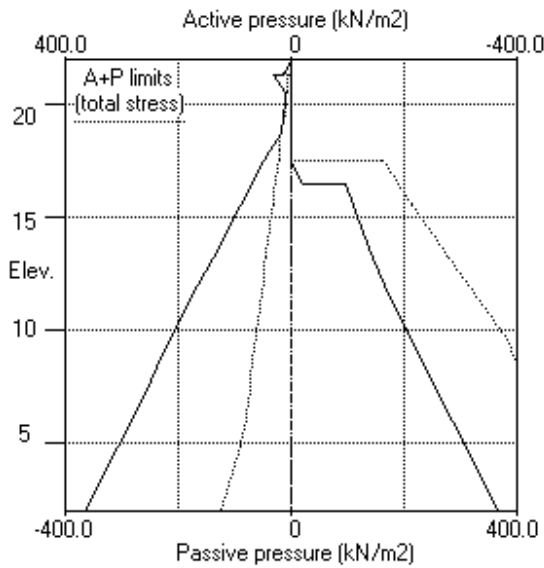


Units: kN,m

Stage No.10 Fill to elev. 17.50 on RIGHT side



Stage No.10 Fill to elev. 17.50 on RIGHT side



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No. 14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>at</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
				<u>Safety</u>	<u>at</u>		<u>-ation</u>	<u>failure</u>	
				<u>More than one prop.</u>	<u>No</u>	<u>FoS calc.</u>			
14	22.02	17.50							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	22.02	0.00	0.003	-8.75E-04	0.0	-0.0			
2	21.80	4.07	0.003	-8.75E-04	0.4	0.0	-45.1		
		4.07	0.003	-8.75E-04	-44.7	0.0			
3	21.32	12.95	0.004	-8.44E-04	-40.6	-20.6			
		27.62	0.004	-8.44E-04	-40.6	-20.6			
4	20.59	14.30	0.004	-7.03E-04	-25.3	-42.0			
5	20.02	22.28	0.005	-5.35E-04	-14.9	-53.3			
6	19.50	30.91	0.005	-3.57E-04	-1.0	-57.5			
7	18.75	47.32	0.005	-1.24E-04	28.3	-43.4			
8	18.00	61.95	0.005	-6.30E-06	69.3	-7.4	-142.7		
		61.95	0.005	-6.30E-06	-73.4	-7.4			
9	17.50	70.10	0.005	6.10E-05	-40.4	-36.1			
		68.67	0.005	6.10E-05	-40.4	-36.1			
10	16.50	63.97	0.005	3.07E-04	26.0	-43.6			
		19.53	0.005	3.07E-04	26.0	-43.6			
11	15.55	-12.56	0.004	4.81E-04	29.3	-15.7			
12	14.38	-12.70	0.004	5.09E-04	14.4	8.0			
13	13.20	-6.35	0.003	4.24E-04	3.2	15.6			
14	12.00	-2.06	0.003	3.13E-04	-1.8	14.3			
15	10.80	0.10	0.003	2.22E-04	-3.0	10.2			
16	9.60	0.82	0.002	1.62E-04	-2.4	6.2			
17	8.40	0.83	0.002	1.26E-04	-1.4	3.3			
18	7.20	0.59	0.002	1.07E-04	-0.6	1.7			
19	6.00	0.27	0.002	9.78E-05	-0.1	1.0			
20	4.80	0.01	0.002	9.18E-05	0.1	0.6			
21	3.60	-0.10	0.002	8.84E-05	0.1	0.3			
22	2.80	-0.04	0.002	8.74E-05	0.0	0.2			
23	2.00	0.03	0.002	8.70E-05	-0.0	0.0			
At elev. 21.80					Prop force =	45.1 kN/m run			
At elev. 18.00					Prop force =	142.7 kN/m run			

(continued)

Stage No.14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
1	22.02	Total>	0.00	0.00	0.00	0.00	0.00	108378
2	21.80	Total>	4.07	4.07	4.07	4.07	4.07	2887
3	21.32	Total>	12.95	12.95	12.95	12.95	12.95	2887
		7.00	5.95	0.00	31.02	20.62	27.62	3411
4	20.59	14.30	13.25	0.00	48.64	0.00	14.30a	3667
5	20.02	20.00	18.95	2.28	62.40	2.28	22.28a	3867
6	19.50	25.20	26.43	5.71	80.46	5.71	30.91a	4050
7	18.75	32.70	45.91	14.62	127.48	14.62	47.32a	4313
8	18.00	40.20	61.49	21.75	165.11	21.75	61.95a	4576
9	17.50	45.20	68.37	24.90	181.69	24.90	70.10a	4752
10	16.50	55.20	77.94	29.28	204.80	29.28	84.48a	5103
11	15.55	64.70	85.30	32.65	222.56	32.65	97.35a	5436
12	14.38	76.45	94.21	36.72	244.08	38.52	114.97	5849
13	13.20	88.20	102.58	40.56	264.30	51.73	139.93	6262
14	12.00	100.20	113.41	45.51	290.44	64.71	164.91	6683
15	10.80	112.20	123.70	50.22	315.28	77.14	189.34	7104
16	9.60	124.20	134.29	55.06	340.83	89.20	213.40	7526
17	8.40	136.20	145.10	60.01	366.92	101.15	237.35	11863
18	7.20	148.20	156.08	65.04	393.45	113.11	261.31	12492
19	6.00	160.20	167.21	70.13	420.31	125.14	285.34	13121
20	4.80	172.20	178.46	75.28	447.46	137.30	309.50	13750
21	3.60	184.20	189.80	80.47	474.84	149.60	333.80	14379
22	2.80	192.20	197.41	83.95	493.20	157.92	350.12	14798
23	2.00	200.20	205.04	87.45	511.64	166.27	366.47	105204

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
1	22.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	21.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	21.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	20.02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	16.66	1.43	1.43	6057
10	16.50	0.00	20.00	2.77	64.95	20.51	20.51	6504
		0.00	20.00	2.77	64.95	64.95	64.95p	6504
11	15.55	0.00	39.03	11.47	110.89	109.90	109.90	6929
12	14.38	11.75	50.89	16.90	139.51	115.93	127.68	7455
13	13.20	23.50	62.86	22.38	168.40	122.78	146.28	7981
14	12.00	35.50	75.22	28.04	198.25	131.47	166.97	8518
15	10.80	47.50	87.75	33.77	228.50	141.74	189.24	9055
16	9.60	59.50	100.46	39.59	259.18	153.08	212.58	9592
17	8.40	71.50	113.35	45.48	290.28	165.02	236.52	11863
18	7.20	83.50	126.40	51.46	321.79	177.22	260.72	12492
19	6.00	95.50	139.60	57.50	353.66	189.57	285.07	13121
20	4.80	107.50	152.94	63.60	385.86	201.98	309.48	13750
21	3.60	119.50	166.39	69.76	418.33	214.40	333.90	14379

Run ID. Design\_Case\_01\_with\_prop\_ULS2  
 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
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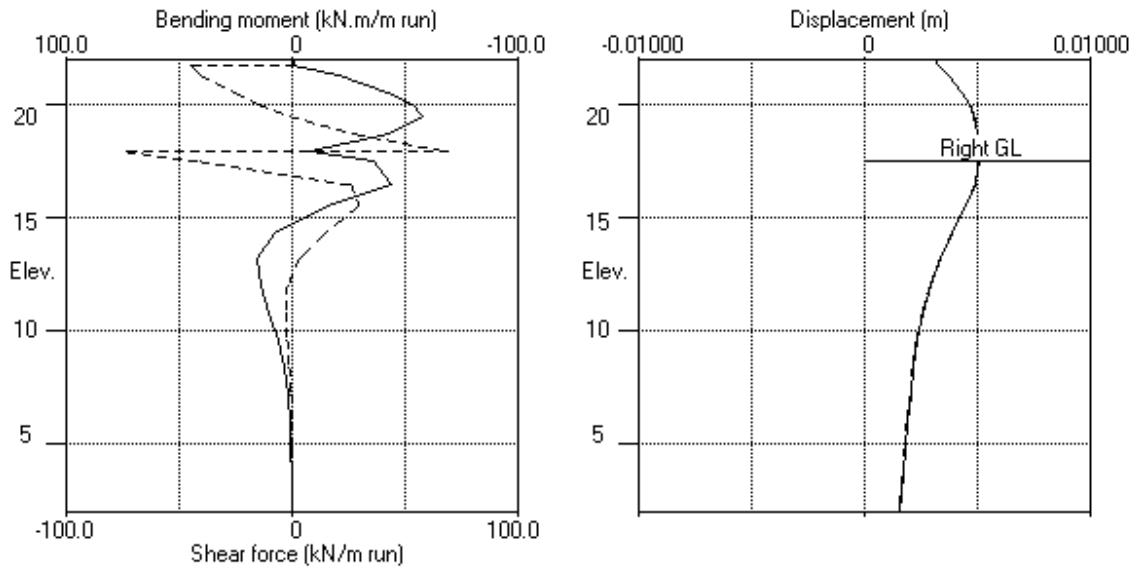
Stage No.14 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u>	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u>
			<u>Vertic</u> <u>-al</u>	<u>Active</u> <u>limit</u>	<u>Passive</u> <u>limit</u>	<u>Earth</u> <u>pressure</u>		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
22	2.80	127.50	175.41	73.88	440.10	222.66	350.16	14798
23	2.00	135.50	184.46	78.03	461.95	230.93	366.43	105204

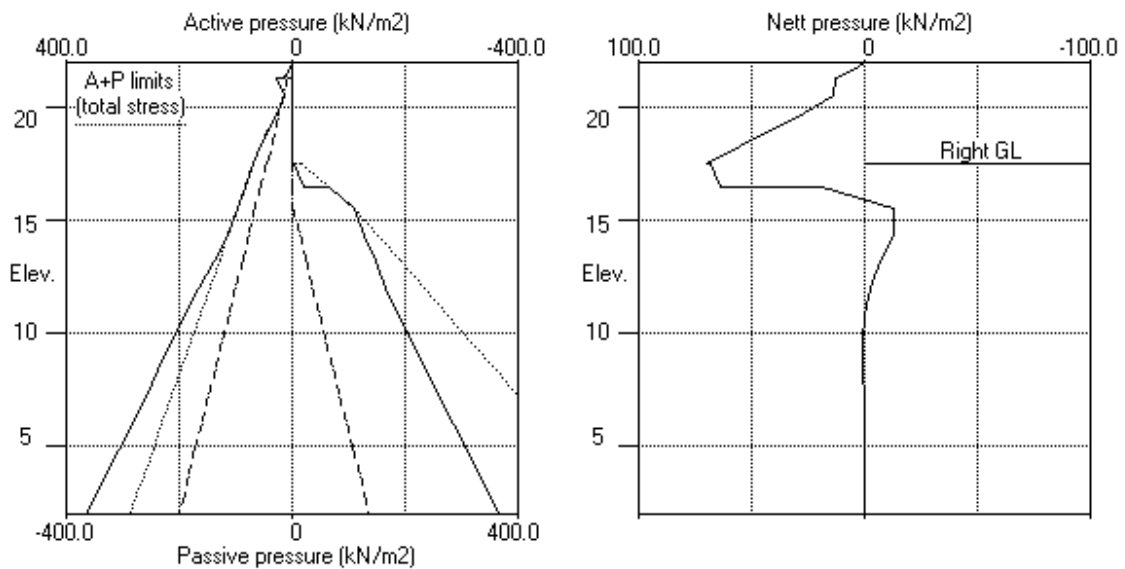
Note: 97.35a Soil pressure at active limit  
 64.95p Soil pressure at passive limit

Units: kN, m

Stage No.14 Change soil type 2 to soil type 4



Stage No.14 Change soil type 2 to soil type 4



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 Ugly Brown Building  
 Existing contiguous wall stability assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetration	
1	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	22.02	22.02	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	22.02	19.50	Cant.	5.492	3.38	18.59	0.91	L to R
4	22.02	19.50		No analysis at this stage				
5	22.02	19.50		No analysis at this stage				
6	22.02	19.50		No analysis at this stage				
7	22.02	16.50	20.02	4.854	n/a	16.33	0.17	L to R
8	22.02	16.50		No analysis at this stage				
9	22.02	16.50		No analysis at this stage				
10	22.02	17.50	20.02	4.885	n/a	17.40	0.10	L to R
11	22.02	17.50		No analysis at this stage				

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

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Sheet No.  
 Job No. 371654  
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 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	22.02	0.005	-0.000	0.0	-0.0	0.0	0.0
2	21.80	0.005	-0.000	0.0	-0.0	0.4	-44.7
3	21.32	0.004	-0.000	1.1	-20.6	4.5	-40.6
4	20.59	0.004	0.000	13.3	-42.0	19.9	-25.3
5	20.02	0.005	0.000	26.7	-53.3	25.9	-63.6
6	19.50	0.005	0.000	20.7	-57.5	19.2	-57.7
7	18.75	0.005	0.000	29.4	-43.4	28.3	-45.6
8	18.00	0.005	0.000	23.4	-66.3	69.3	-73.4
9	17.50	0.005	0.000	17.6	-72.7	0.4	-40.4
10	16.50	0.005	0.000	6.6	-45.3	60.1	-8.5
11	15.55	0.004	0.000	0.4	-15.7	32.9	-4.0
12	14.38	0.004	0.000	18.2	-4.7	14.4	0.0
13	13.20	0.003	0.000	19.6	-0.7	3.4	-1.9
14	12.00	0.003	0.000	14.3	0.0	1.6	-5.1
15	10.80	0.003	0.000	10.2	0.0	1.0	-4.2
16	9.60	0.002	0.000	6.2	0.0	0.4	-2.4
17	8.40	0.002	0.000	3.3	0.0	0.0	-1.4
18	7.20	0.002	0.000	1.7	0.0	0.1	-0.6
19	6.00	0.002	0.000	1.2	0.0	0.3	-0.2
20	4.80	0.002	0.000	0.8	0.0	0.2	-0.1
21	3.60	0.002	0.000	0.4	0.0	0.1	-0.1
22	2.80	0.002	0.000	0.2	0.0	0.0	-0.1
23	2.00	0.002	0.000	0.0	0.0	0.0	-0.0

**Summary of results (continued)**

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment				Shear force			
	<u>maximum</u> kN.m/m	<u>elev.</u>	<u>minimum</u> kN.m/m	<u>elev.</u>	<u>maximum</u> kN/m	<u>elev.</u>	<u>minimum</u> kN/m	<u>elev.</u>
1	2.9	10.80	-15.6	17.50	5.1	15.55	-8.1	18.75
2	2.9	10.80	-16.2	17.50	5.2	15.55	-8.3	18.75
3	29.4	18.75	-1.8	14.38	19.2	19.50	-11.5	17.50
4	No calculation at this stage							
5	No calculation at this stage							
6	No calculation at this stage							
7	26.5	20.02	-72.7	17.50	60.1	16.50	-63.6	20.02
8	No calculation at this stage							
9	No calculation at this stage							
10	26.7	20.02	-68.7	17.50	50.1	16.50	-62.1	20.02
11	No calculation at this stage							
12	No calculation at this stage							
13	14.5	13.20	-46.0	19.50	40.8	16.50	-35.5	21.80
14	15.6	13.20	-57.5	19.50	69.3	18.00	-73.4	18.00
15	15.6	13.20	-57.5	19.50	69.3	18.00	-73.4	18.00

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				<u>Stage description</u>
	<u>maximum</u> m	<u>elev.</u>	<u>minimum</u> m	<u>elev.</u>	
1	0.001	16.50	-0.000	22.02	Apply surcharge no.1 at elev. 20.02
2	0.001	16.50	-0.000	22.02	Apply water pressure profile no.2
3	0.005	22.02	0.000	22.02	Excav. to elev. 19.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 20.02
5	No calculation at this stage				Apply surcharge no.2 at elev. 16.50
6	No calculation at this stage				Apply surcharge no.3 at elev. 16.50
7	0.005	17.50	0.000	22.02	Excav. to elev. 16.50 on RIGHT side
8	No calculation at this stage				Remove surcharge no.2 at elev. 16.50
9	No calculation at this stage				Remove surcharge no.3 at elev. 16.50
10	0.005	17.50	0.000	22.02	Fill to elev. 17.50 on RIGHT side
11	No calculation at this stage				Install prop no.2 at elev. 18.00
12	No calculation at this stage				Install prop no.3 at elev. 21.80
13	0.005	18.00	0.000	22.02	Remove prop no.1 at elev. 20.02
14	0.005	18.00	0.000	22.02	Change soil type 2 to soil type 4
15	0.005	18.00	0.000	22.02	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

Stage no.	--- Strut no. 1 --- at elev. 20.02		--- Strut no. 2 --- at elev. 18.00		--- Strut no. 3 --- at elev. 21.80	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
7	89.22	535.34	---	---	---	---
10	88.03	528.16	---	---	---	---
13	---	---	55.77	55.77	35.97	35.97
14	---	---	142.65	142.65	45.13	45.13
15	---	---	142.65	142.65	45.13	45.13

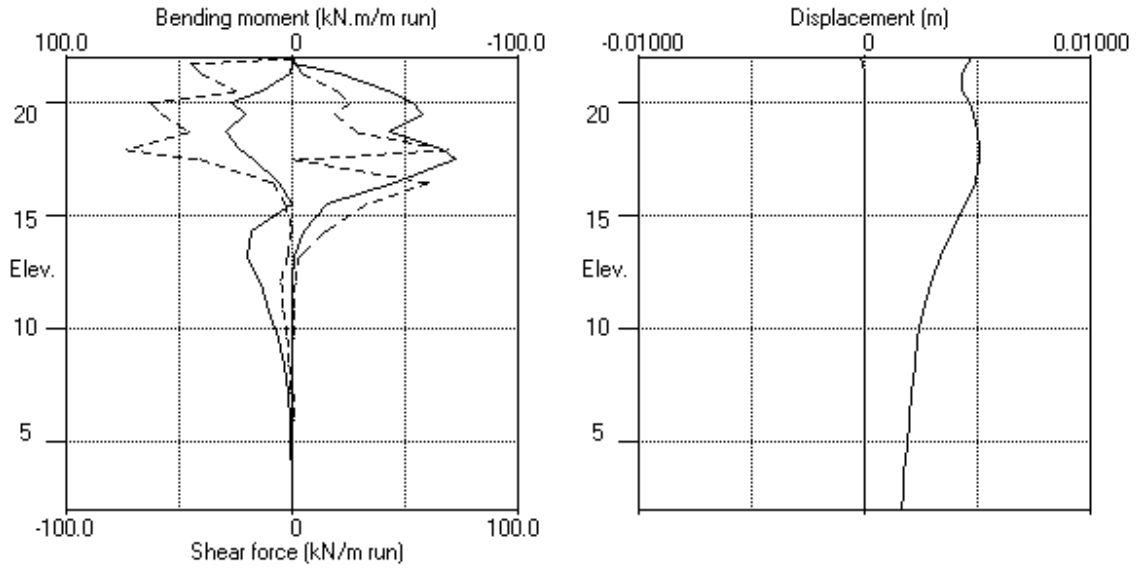


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Made by : MM  
Date: 13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes





## DESIGN CASE 02

RSK ENVIRONMENT LTD  
 Program: WALLAP Version 6.06 Revision A52.B71.R55  
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 Data filename/Run ID: Design\_Case\_02\_no\_prop\_SLS\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	23.70	1 Made Ground	1 Made Ground
2	23.25	2 London Clay	2 London Clay
3	8.75	3 Lambeth Group	3 Lambeth Group

**SOIL PROPERTIES**

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	Made Ground	18.50	15000	1.000	NC	0.353	3.412	0.0d
					(0.200)	(1.388)	(5.173)	
2	London Clay (20.00)	20.00	47000 (3130)	1.000	OC	1.000	1.000	80.00u
					(0.490)	(2.474)	(2.475)	(4.390)
3	Lambeth G.. (0.00)	20.00	72000 (5231)	1.000	OC	1.000	1.000	180.0u
					(0.490)	(2.474)	(2.475)	(13.08)
4	London Cl.. (20.00)	20.00	28800 (2610)	1.000	OC	0.384	3.043	5.000d
					(0.200)	(1.452)	(4.814)	
5	Lambeth G.. (8.75)	20.00	57600 (4185)	1.000	OC	0.384	3.043	0.0d
					(0.200)	(1.452)	(4.814)	

**Additional soil parameters associated with Ka and Kp**

No.	Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	28.59	0.000	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	20.59	20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0 MC+WC
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.90	6.00	0.017663	2.050E+08	4.00	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	23.50	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m <sup>2</sup>	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.90	1.20 (L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.55	-5.30 (R)	23.80	20.00	30.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Apply surcharge no.2 at elevation 16.55 No analysis at this stage
4	Excavate to elevation 16.55 on RIGHT side
5	Remove surcharge no.2 at elevation 16.55 No analysis at this stage
6	Fill to elevation 17.50 on RIGHT side with soil type 2
7	Install strut or anchor no.2 at elevation 18.00
8	Install strut or anchor no.3 at elevation 23.50
9	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
10	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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/m<sup>3</sup>  
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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m  
Distance to rigid boundary on Right side = 23.70 m

## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Apply surcharge no.2 at elev. 16.55	Yes	Yes	Yes
4	Excav. to elev. 16.55 on RIGHT side	Yes	Yes	Yes
5	Remove surcharge no.2 at elev. 16.55	Yes	Yes	Yes
6	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
7	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
8	Install prop no.3 at elev. 23.50	Yes	Yes	Yes
9	Change soil type 2 to soil type 4	Yes	Yes	Yes
10	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

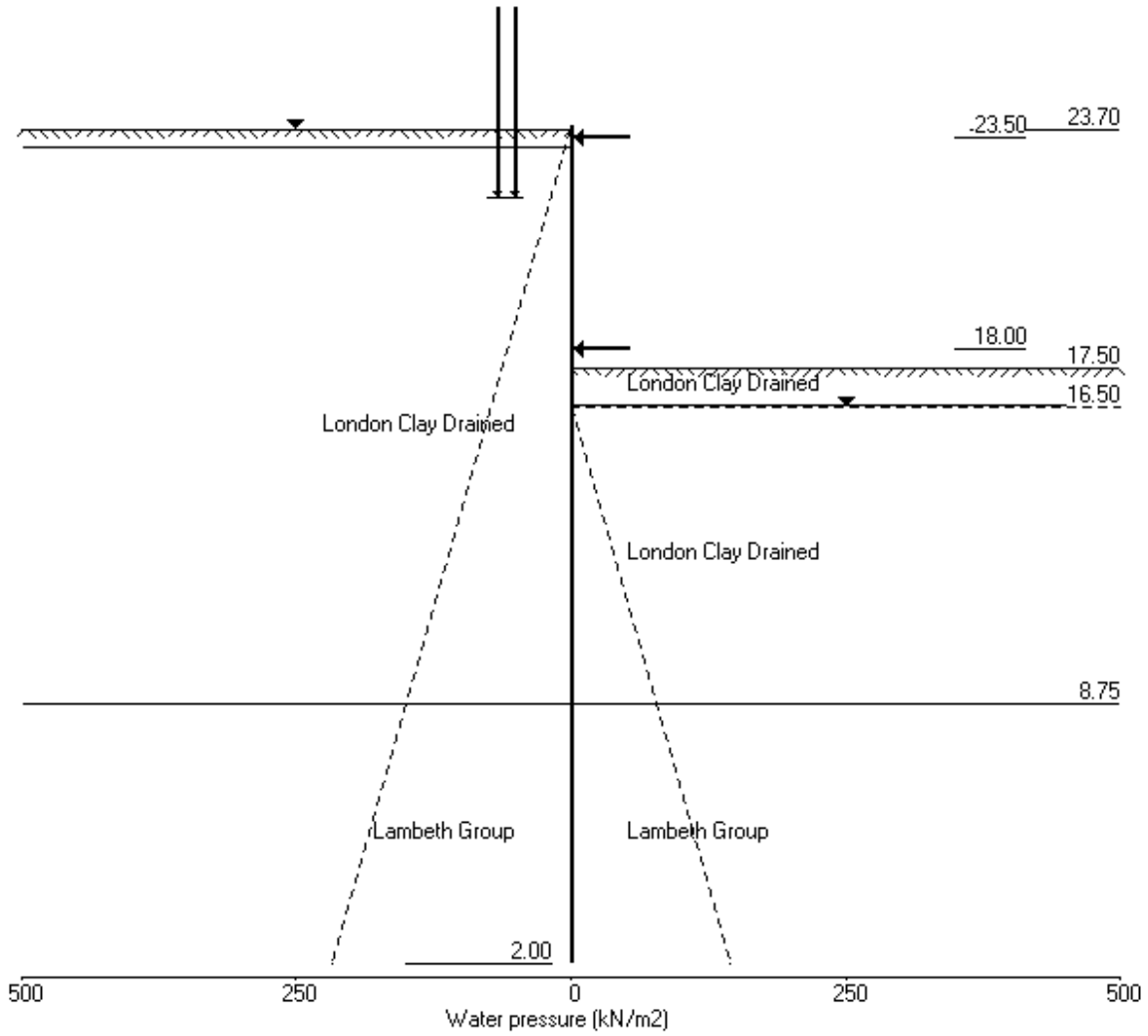
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 Design Case 3  
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 Checked :

Units: kN,m

Stage No.10 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 4 Excavate to elevation 16.55 on RIGHT side

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
4	23.70	16.55	Cant.	2.815	3.09	13.38	3.17	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.074	9.46E-03	0.0	0.0	
2	23.50	1.31	0.072	9.46E-03	0.1	0.0	
3	23.25	2.94	0.069	9.46E-03	0.7	0.1	
		2.25	0.069	9.46E-03	0.7	0.1	
4	22.58	5.63	0.063	9.45E-03	3.3	1.5	
5	21.90	9.00	0.057	9.44E-03	8.3	5.5	
6	21.24	12.28	0.050	9.40E-03	15.2	13.3	
7	20.59	15.55	0.044	9.32E-03	24.3	26.4	
8	19.90	19.02	0.038	9.16E-03	36.3	47.6	
9	19.20	22.50	0.032	8.89E-03	50.8	77.9	
10	18.00	28.50	0.021	8.02E-03	81.4	157.2	
11	17.50	31.00	0.018	7.47E-03	96.3	201.5	
12	16.55	35.75	0.011	5.97E-03	128.0	307.7	
		-199.75	0.011	5.97E-03	128.0	307.7	
13	16.50	-201.04	0.011	5.88E-03	117.9	313.8	
14	15.55	-138.06	0.006	3.82E-03	-43.1	385.6	
15	14.38	6.68	0.003	1.56E-03	-120.3	239.0	
16	13.20	50.13	0.002	3.25E-04	-86.9	101.5	
17	12.00	40.40	0.002	-1.70E-04	-32.6	32.4	
18	10.80	8.04	0.002	-3.70E-04	-3.6	21.5	
19	9.78	-30.98	0.003	-5.06E-04	-15.3	21.5	
20	8.75	-78.63	0.003	-5.40E-04	-71.5	-10.9	
		67.74	0.003	-5.40E-04	-71.5	-10.9	
21	7.98	45.64	0.004	-4.03E-04	-27.6	-46.2	
22	7.20	25.42	0.004	-1.63E-04	-0.0	-54.0	
23	6.00	3.20	0.004	1.71E-04	17.2	-36.5	
24	4.80	-6.85	0.004	3.60E-04	15.0	-14.3	
25	3.60	-7.56	0.003	4.20E-04	6.3	-2.0	
26	2.80	-4.51	0.003	4.24E-04	1.5	0.4	
27	2.00	0.78	0.002	4.23E-04	-0.0	-0.0	

(continued)

Stage No.4 Excavate to elevation 16.55 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	2881
2	23.50	0.00	3.70	1.31	12.63	1.31	1.31a	2881
3	23.25	0.00	8.33	2.94	28.41	2.94	2.94a	2881
		Total>	8.33	2.25m	171.02	2.25	2.25a	9841
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	10405
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	10970
6	21.24	Total>	52.45	12.28m	236.93	12.28	12.28a	11518
7	20.59	Total>	76.40	15.55m	268.00	15.55	15.55a	12065
8	19.90	Total>	97.68	19.02m	296.83	19.02	19.02a	12647
9	19.20	Total>	113.76	22.50m	320.46	22.50	22.50a	13228
10	18.00	Total>	136.33	28.50m	356.07	28.50	28.50a	14232
11	17.50	Total>	145.14	31.00m	370.32	31.00	31.00a	14650
12	16.55	Total>	161.82	35.75m	397.32	35.75	35.75a	15444
13	16.50	Total>	162.70	36.00m	398.74	36.00	36.00a	15486
14	15.55	Total>	179.60	40.75m	425.97	83.82	83.82	16281
15	14.38	Total>	200.90	46.63m	460.03	151.55	151.55	17263
16	13.20	Total>	222.58	52.50m	494.48	188.23	188.23	18246
17	12.00	Total>	245.04	58.50m	529.98	209.12	209.12	19250
18	10.80	Total>	267.76	64.50m	565.74	223.01	223.01	20253
19	9.78	Total>	287.32	69.63m	596.44	231.28	231.28	21111
20	8.75	Total>	307.01	74.75m	627.26	236.78	236.78	21968
		Total>	307.01	144.81	469.25	284.37	284.37	7009
21	7.98	Total>	321.95	134.67	509.29	292.91	292.91	8092
22	7.20	Total>	336.95	124.58	549.37	302.09	302.09	9175
23	6.00	Total>	360.25	109.05	611.53	319.25	319.25	10852
24	4.80	Total>	383.64	94.50m	673.76	340.37	340.37	12530
25	3.60	Total>	407.10	100.50m	736.08	364.56	364.56	14207
26	2.80	Total>	422.78	104.50m	777.65	381.85	381.85	15325
27	2.00	Total>	438.48	108.50m	819.25	399.89	399.89	16444

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	16.55	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	235.50	235.50	235.50p	34114
13	16.50	Total>	1.00	0.25m	237.04	237.04	237.04p	34206
14	15.55	Total>	20.09	5.00m	266.45	221.87	221.87	35961
15	14.38	Total>	44.26	10.87m	303.39	144.87	144.87	38132
16	13.20	Total>	69.26	16.75m	341.15	138.10	138.10	40303
17	12.00	Total>	95.40	22.75m	380.34	168.72	168.72	42520
18	10.80	Total>	121.85	28.75m	419.83	214.98	214.98	44736



Run ID. Design\_Case\_02\_no\_prop\_SLS\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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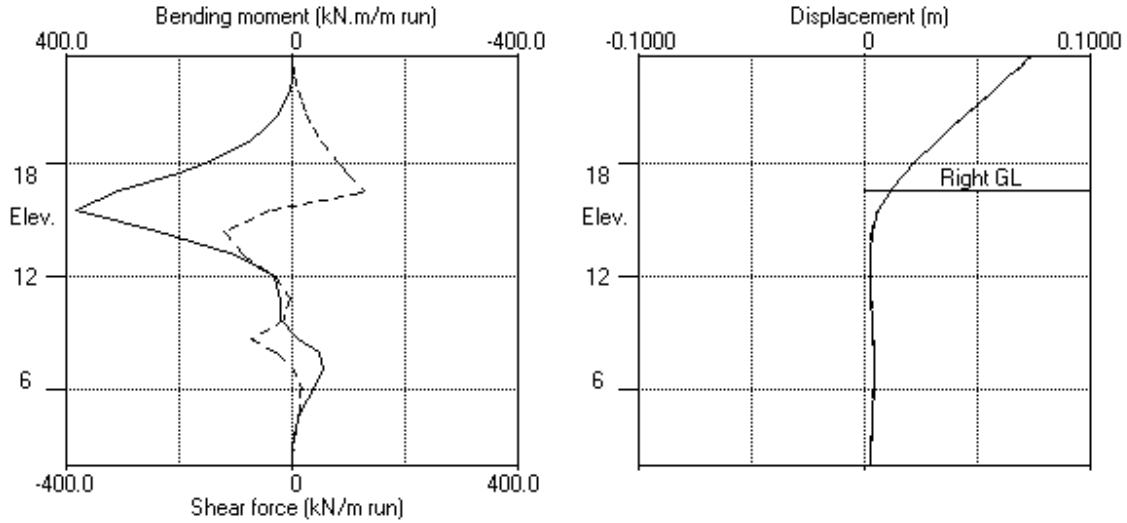
Stage No.4 Excavate to elevation 16.55 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
19	9.78	Total>	144.52	33.87m	453.63	262.25	262.25	46630
20	8.75	Total>	167.18	39.00m	487.43	315.41	315.41	48524
		Total>	167.18	39.00m	329.43	216.63	216.63	15481
21	7.98	Total>	184.31	42.87m	371.64	247.28	247.28	17874
22	7.20	Total>	201.42	46.75m	413.85	276.67	276.67	20266
23	6.00	Total>	227.90	52.75m	479.18	316.05	316.05	23971
24	4.80	Total>	254.37	58.75m	544.50	347.21	347.21	27676
25	3.60	Total>	280.84	64.75m	609.82	372.12	372.12	31381
26	2.80	Total>	298.50	68.75m	653.37	386.36	386.36	33851
27	2.00	Total>	316.15	72.75m	696.93	399.11	399.11	36321

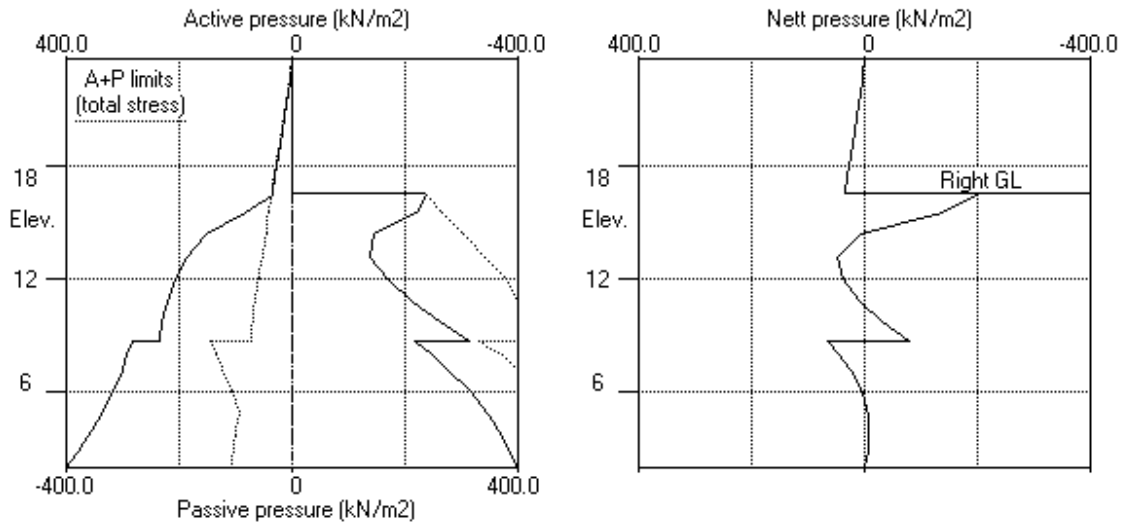
Note: 36.00a Soil pressure at active limit  
 237.04p Soil pressure at passive limit

Units: kN,m

Stage No.4 Excav. to elev. 16.55 on RIGHT side



Stage No.4 Excav. to elev. 16.55 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 6 Fill to elevation 17.50 on RIGHT side with soil type 2

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
6	23.70	17.50	Cant.	3.189	3.00	14.88	2.62	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.074	9.66E-03	0.0	0.0	
2	23.50	1.31	0.072	9.66E-03	0.1	0.0	
3	23.25	2.94	0.070	9.66E-03	0.7	0.1	
		2.25	0.070	9.66E-03	0.7	0.1	
4	22.58	5.63	0.064	9.65E-03	3.3	1.5	
5	21.90	9.00	0.057	9.64E-03	8.3	5.5	
6	21.24	12.28	0.051	9.60E-03	15.2	13.3	
7	20.59	15.55	0.044	9.52E-03	24.3	26.4	
8	19.90	19.49	0.038	9.36E-03	36.5	47.6	
9	19.20	24.01	0.031	9.09E-03	51.6	78.2	
10	18.00	32.00	0.021	8.21E-03	85.2	159.5	
11	17.50	35.36	0.017	7.65E-03	102.1	206.2	
12	16.55	29.36	0.010	6.11E-03	132.8	317.1	
		-206.13	0.010	6.11E-03	132.8	317.1	
13	16.50	-207.28	0.010	6.01E-03	122.5	323.5	
14	15.55	-141.82	0.005	3.90E-03	-43.3	396.8	
15	14.38	5.11	0.002	1.56E-03	-123.7	247.4	
16	13.20	50.06	0.001	2.83E-04	-91.3	105.1	
17	12.00	41.51	0.001	-2.22E-04	-36.3	31.2	
18	10.80	10.45	0.002	-4.01E-04	-5.1	17.0	
19	9.78	-27.01	0.002	-5.08E-04	-13.6	17.0	
20	8.75	-72.67	0.003	-5.26E-04	-64.7	-11.5	
		62.21	0.003	-5.26E-04	-64.7	-11.5	
21	7.98	41.75	0.003	-3.95E-04	-24.4	-43.1	
22	7.20	23.00	0.003	-1.73E-04	0.7	-49.7	
23	6.00	2.51	0.003	1.32E-04	16.0	-32.8	
24	4.80	-6.54	0.003	3.00E-04	13.6	-12.4	
25	3.60	-6.92	0.003	3.51E-04	5.5	-1.5	
26	2.80	-3.93	0.002	3.54E-04	1.1	0.5	
27	2.00	1.09	0.002	3.52E-04	-0.0	-0.0	

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Stage No.6 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	4746
2	23.50	0.00	3.70	1.31	12.63	1.31	1.31a	4746
3	23.25	0.00	8.33	2.94	28.41	2.94	2.94a	4746
		Total>	8.33	2.25m	171.02	2.25	2.25a	15857
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	16766
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	17676
6	21.24	Total>	52.45	12.28m	236.93	12.28	12.28a	18559
7	20.59	Total>	76.40	15.55m	268.00	15.55	15.55a	19442
8	19.90	Total>	97.68	19.02m	296.83	19.49	19.49	7119
9	19.20	Total>	113.76	22.50m	320.46	24.01	24.01	7446
10	18.00	Total>	136.33	28.50m	356.07	32.00	32.00	8011
11	17.50	Total>	145.14	31.00m	370.32	35.36	35.36	8246
12	16.55	Total>	161.82	35.75m	397.32	41.66	41.66	8693
13	16.50	Total>	162.70	36.00m	398.74	41.99	41.99	8717
14	15.55	Total>	179.60	40.75m	425.97	91.01	91.01	9164
15	14.38	Total>	200.90	46.63m	460.03	159.59	159.59	9717
16	13.20	Total>	222.58	52.50m	494.48	196.44	196.44	10271
17	12.00	Total>	245.04	58.50m	529.98	217.13	217.13	10835
18	10.80	Total>	267.76	64.50m	565.74	230.85	230.85	11400
19	9.78	Total>	287.32	69.63m	596.44	239.25	239.25	11883
20	8.75	Total>	307.01	74.75m	627.26	245.18	245.18	12365
		Total>	307.01	144.81	469.25	287.05	287.05	3945
21	7.98	Total>	321.95	134.67	509.29	296.05	296.05	4555
22	7.20	Total>	336.95	124.58	549.37	305.65	305.65	5165
23	6.00	Total>	360.25	109.05	611.53	323.28	323.28	6109
24	4.80	Total>	383.64	94.50m	673.76	344.60	344.60	7053
25	3.60	Total>	407.10	100.50m	736.08	368.72	368.72	7997
26	2.80	Total>	422.78	104.50m	777.65	385.87	385.87	8626
27	2.00	Total>	438.48	108.50m	819.25	403.68	403.68	9256

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	0.00	0.00a	8316
12	16.55	Total>	19.01	4.75m	254.50	12.30	12.30	8767
		Total>	19.01	4.75m	254.50	247.80	247.80	8767
13	16.50	Total>	20.01	5.00m	256.05	249.27	249.27	8791
14	15.55	Total>	39.05	9.75m	285.41	232.83	232.83	9242
15	14.38	Total>	62.69	15.62m	321.83	154.48	154.48	9800
16	13.20	Total>	86.49	21.50m	358.39	146.38	146.38	10358
17	12.00	Total>	111.00	27.50m	395.93	175.62	175.62	10928

Run ID. Design\_Case\_02\_no\_prop\_SLS\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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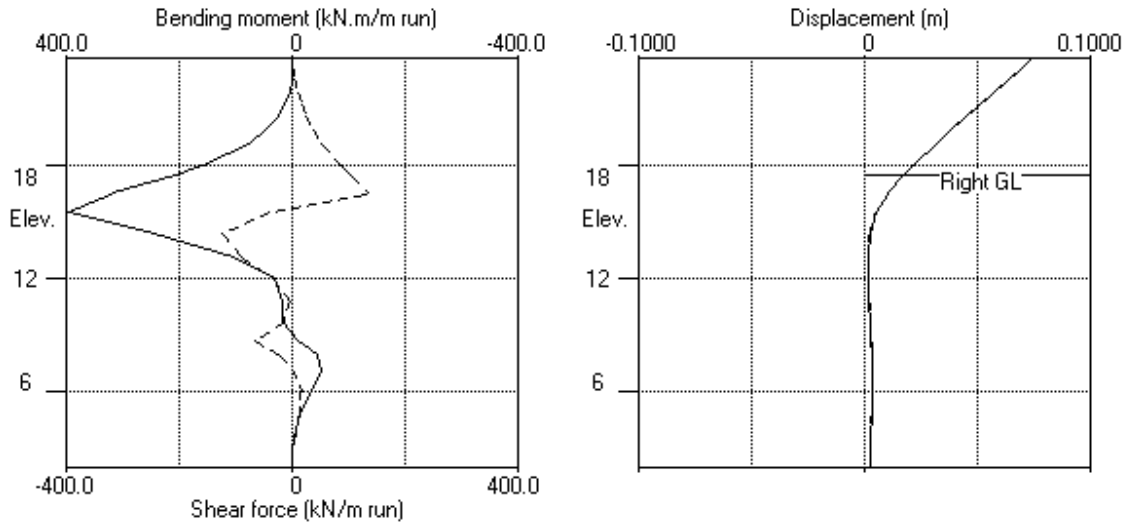
Stage No.6 Fill to elevation 17.50 on RIGHT side with soil type 2

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
18	10.80	Total>	135.73	33.50m	433.71	220.41	220.41	11497
19	9.78	Total>	157.05	38.62m	466.17	266.26	266.26	11984
20	8.75	Total>	178.55	43.75m	498.80	317.85	317.85	12471
		Total>	178.55	43.75m	340.79	224.84	224.84	3979
21	7.98	Total>	194.92	47.63m	382.25	254.30	254.30	4594
22	7.20	Total>	211.38	51.50m	423.81	282.65	282.65	5208
23	6.00	Total>	237.04	57.50m	488.32	320.76	320.76	6161
24	4.80	Total>	262.89	63.50m	553.02	351.14	351.14	7113
25	3.60	Total>	288.89	69.50m	617.87	375.64	375.64	8065
26	2.80	Total>	306.30	73.50m	661.17	389.80	389.80	8700
27	2.00	Total>	323.75	77.50m	704.52	402.59	402.59	9335

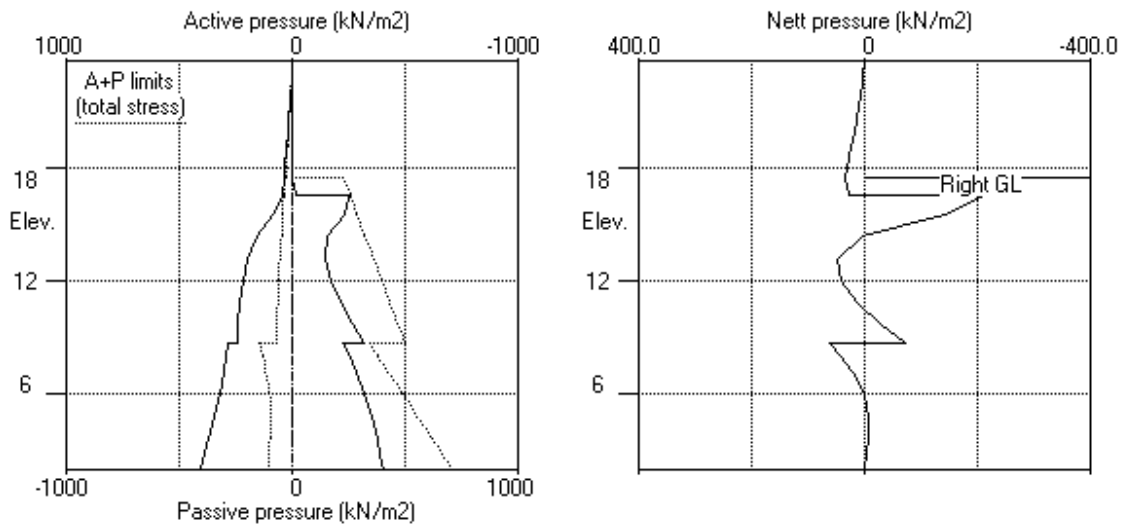
Note: 0.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.6 Fill to elev. 17.50 on RIGHT side



Stage No.6 Fill to elev. 17.50 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib. at elev.	Toe elev.	Wall Penetr -ation	
9	23.70	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.073	9.61E-03	0.0	0.0	
2	23.50	3.96	0.071	9.61E-03	0.4	0.0	0.0
3	23.25	5.55	0.069	9.60E-03	1.6	0.3	
		5.79	0.069	9.60E-03	1.6	0.3	
4	22.58	9.33	0.063	9.60E-03	6.7	3.1	
5	21.90	12.82	0.056	9.57E-03	14.2	10.2	
6	21.24	16.12	0.050	9.50E-03	23.6	22.7	
7	20.59	22.04	0.044	9.37E-03	36.1	42.6	
8	19.90	34.48	0.037	9.12E-03	55.8	74.3	
9	19.20	44.94	0.031	8.70E-03	83.4	122.3	
10	18.00	60.99	0.021	7.29E-03	146.9	258.7	-219.1
		60.99	0.021	7.29E-03	-72.2	258.7	
11	17.50	67.45	0.018	6.53E-03	-40.1	230.5	
		62.08	0.018	6.53E-03	-40.1	230.5	
12	16.55	54.94	0.012	5.21E-03	15.5	219.3	
		-2.21	0.012	5.21E-03	15.5	219.3	
13	16.50	-4.61	0.012	5.14E-03	15.3	220.1	
14	15.55	-50.22	0.008	3.71E-03	-10.7	266.4	
15	14.38	-28.59	0.004	2.03E-03	-57.0	197.5	
16	13.20	25.22	0.003	9.17E-04	-59.0	110.4	
17	12.00	27.31	0.002	2.95E-04	-27.5	57.3	
18	10.80	4.69	0.002	-7.81E-05	-8.3	43.5	
19	9.78	-28.15	0.002	-3.33E-04	-20.3	37.2	
20	8.75	-71.26	0.003	-4.56E-04	-71.2	1.4	
		63.09	0.003	-4.56E-04	-71.2	1.4	
21	7.98	43.31	0.003	-3.75E-04	-30.0	-35.0	
22	7.20	24.83	0.003	-1.82E-04	-3.6	-45.4	
23	6.00	4.13	0.003	1.05E-04	13.8	-32.4	
24	4.80	-5.48	0.003	2.75E-04	13.0	-13.4	
25	3.60	-6.44	0.003	3.34E-04	5.8	-2.4	





Run ID. Design\_Case\_02\_no\_prop\_SLS\_new  
 Design Case 3  
 New contig wall

Sheet No.  
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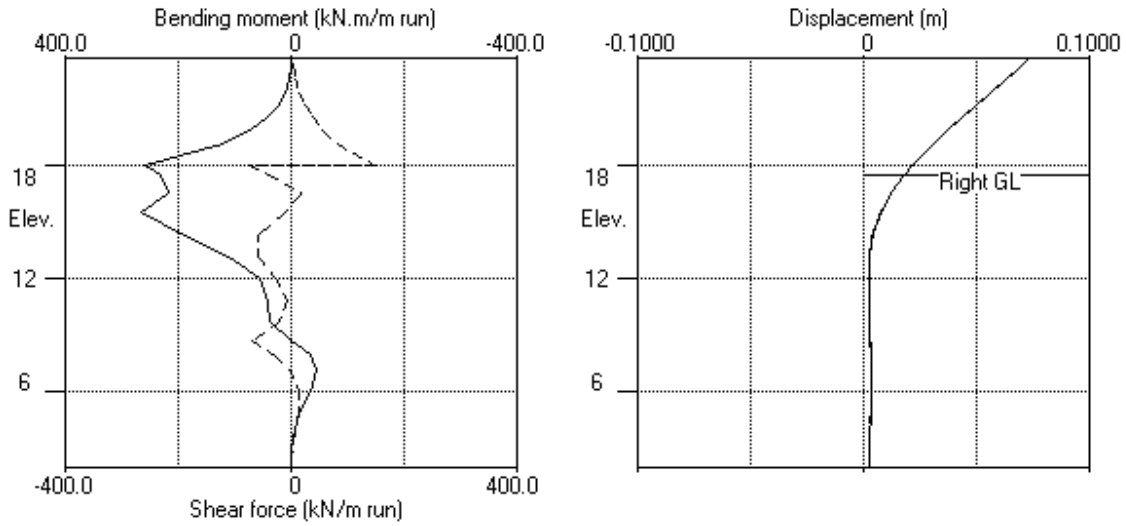
Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.07	5.37	5.37	6190
12	16.55	0.00	19.01	0.03	81.91	24.77	24.77	6624
		0.00	19.01	0.03	81.91	81.91	81.91p	6624
13	16.50	0.00	20.01	0.41	84.96	84.96	84.96p	6647
14	15.55	0.00	39.05	7.71	142.91	142.91	142.91p	7082
15	14.38	11.75	50.94	12.28	179.12	159.58	171.33	7619
16	13.20	23.50	62.99	16.90	215.79	135.30	158.80	8157
17	12.00	35.50	75.50	21.69	253.84	147.22	182.72	8705
18	10.80	47.50	88.23	26.58	292.60	175.79	223.29	9254
19	9.78	57.75	99.30	30.82	326.29	209.08	266.83	9723
20	8.75	68.00	110.55	35.14	360.52	249.15	317.15	11229
		Total>	178.55	43.75m	340.79	224.40	224.40	7042
21	7.98	Total>	194.92	47.63m	382.25	253.52	253.52	8130
22	7.20	Total>	211.38	51.50m	423.81	281.73	281.73	9219
23	6.00	Total>	237.04	57.50m	488.32	319.95	319.95	10904
24	4.80	Total>	262.89	63.50m	553.02	350.61	350.61	12590
25	3.60	Total>	288.89	69.50m	617.87	375.41	375.41	14275
26	2.80	Total>	306.30	73.50m	661.17	389.74	389.74	15398
27	2.00	Total>	323.75	77.50m	704.52	403.38	403.38	121112

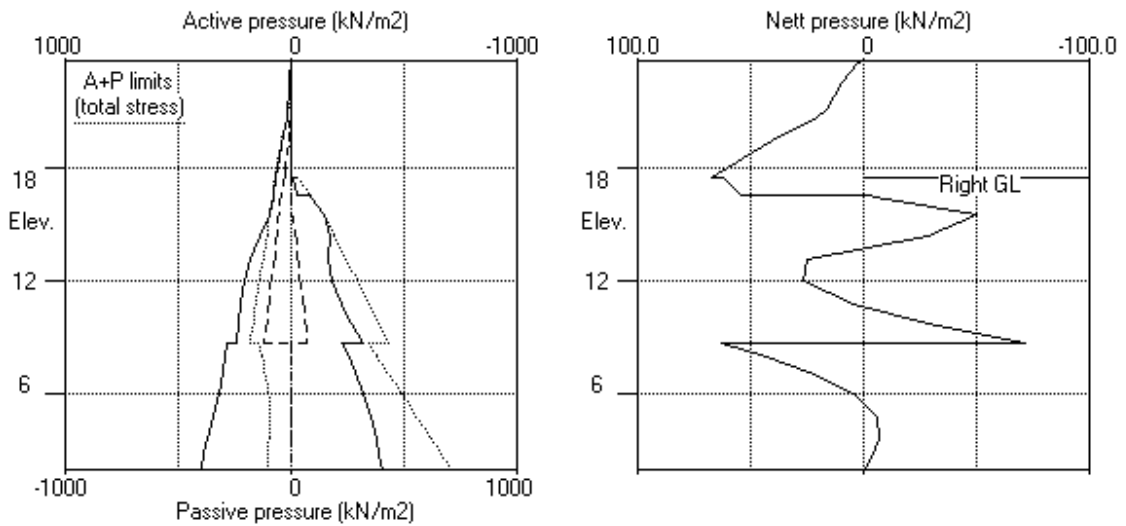
Note: 92.69a Soil pressure at active limit  
 142.91p Soil pressure at passive limit

Units: kN, m

Stage No.9 Change soil type 2 to soil type 4



Stage No.9 Change soil type 2 to soil type 4



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	23.70		No analysis at this stage				
4	23.70	16.55	Cant.	2.815	3.09	13.38	3.17	L to R
5	23.70	16.55		No analysis at this stage				
6	23.70	17.50	Cant.	3.189	3.00	14.88	2.62	L to R
7	23.70	17.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.074	-0.000	0	0	0	0	0	0	0	0
2	23.50	0.072	-0.000	0	0	0	0	0	-15	1	-20
3	23.25	0.070	0.000	0	-4	0	-5	2	-14	2	-18
4	22.58	0.064	0.000	3	-10	4	-14	7	-6	9	-8
5	21.90	0.057	0.000	10	-10	14	-13	14	-4	19	-5
6	21.24	0.051	0.000	23	-5	31	-7	26	-8	35	-10
7	20.59	0.044	0.000	43	-10	58	-14	51	-8	68	-11
8	19.90	0.038	0.000	74	-15	100	-20	85	-6	115	-7
9	19.20	0.032	0.000	147	-17	198	-23	128	-1	173	-2
10	18.00	0.022	0.000	353	-14	476	-19	219	-152	295	-205
11	17.50	0.018	0.000	288	-12	388	-16	102	-109	138	-147
12	16.55	0.013	0.000	317	-7	428	-9	133	-37	179	-49
13	16.50	0.013	0.000	323	-7	437	-9	122	-36	165	-48
14	15.55	0.009	0.000	397	-2	536	-3	4	-43	6	-59
15	14.38	0.006	0.000	247	0	334	0	3	-124	4	-167
16	13.20	0.005	0.000	110	0	149	0	2	-91	3	-123
17	12.00	0.004	0.000	57	0	77	0	1	-36	1	-49
18	10.80	0.003	0.000	44	0	59	0	0	-8	0	-11
19	9.78	0.003	0.000	37	0	50	0	0	-20	0	-27
20	8.75	0.003	0.000	6	-12	9	-16	0	-71	0	-97
21	7.98	0.004	0.000	0	-46	0	-62	0	-30	0	-40
22	7.20	0.004	0.000	0	-54	0	-73	1	-4	1	-5
23	6.00	0.004	0.000	0	-36	0	-49	17	0	23	0
24	4.80	0.004	0.000	0	-14	0	-19	15	0	20	0
25	3.60	0.003	0.000	1	-2	1	-3	6	0	9	0
26	2.80	0.003	0.000	1	-0	1	-0	2	-0	2	-0
27	2.00	0.002	0.000	0	-0	0	-0	0	-0	0	-0

Run ID. Design\_Case\_02\_no\_prop\_SLS\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. min.	
	kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m
1	5	12.00	-17	19.20	7	-23	5	16.55	-8	20.59	7	-11
2	6	10.80	-17	19.20	8	-23	5	16.55	-8	20.59	7	-11
3	No calculation at this stage											
4	386	15.55	-54	7.20	521	-73	128	16.55	-120	14.38	173	-162
5	No calculation at this stage											
6	397	15.55	-50	7.20	536	-67	133	16.55	-124	14.38	179	-167
7	No calculation at this stage											
8	No calculation at this stage											
9	266	15.55	-45	7.20	360	-61	147	18.00	-72	18.00	198	-97
10	353	18.00	-34	7.20	476	-45	219	18.00	-152	18.00	295	-205

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum elev.	minimum elev.	maximum elev.	minimum elev.	
	m	m	m	m	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.1
3	No calculation at this stage				Apply surcharge no.2 at elev. 16.55
4	0.074	23.70	0.000	23.70	Excav. to elev. 16.55 on RIGHT side
5	No calculation at this stage				Remove surcharge no.2 at elev. 16.55
6	0.074	23.70	0.000	23.70	Fill to elev. 17.50 on RIGHT side
7	No calculation at this stage				Install prop no.2 at elev. 18.00
8	No calculation at this stage				Install prop no.3 at elev. 23.50
9	0.073	23.70	0.000	23.70	Change soil type 2 to soil type 4
10	0.074	23.70	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

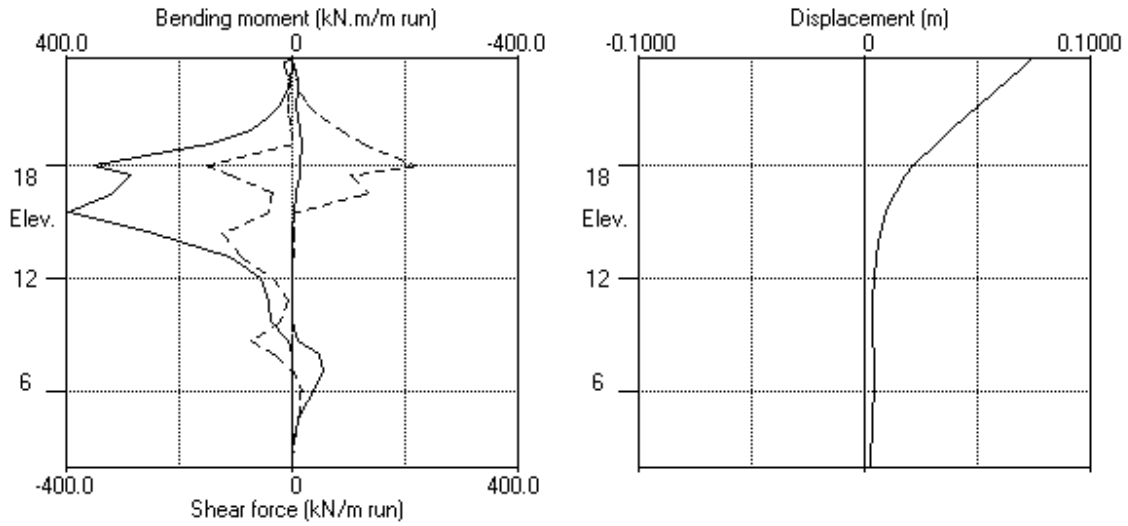
Stage no.	Prop no. 2 at elev. 18.00			Prop no. 3 at elev. 23.50		
	Calculated	Factored	Calculated	Factored	Calculated	Factored
	kN per m run	kN per prop	kN per m run	kN per prop	kN per slack	kN per slack
9	219	219	296	15	15	21
10	370	370	500	15	15	21

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Job No. 371654  
Made by : MM  
Date:13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes





**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.90	6.00	0.017663	2.050E+08	4.00	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	23.50	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m <sup>2</sup>	Equiv. soil type	Partial factor/ Category
1	21.90	1.20 (L)	32.15	1.00	100.00	=	N/A 1.00 -
2	16.05	-5.30 (R)	23.80	20.00	29.00	=	N/A 1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Apply surcharge no.2 at elevation 16.05 No analysis at this stage
4	Excavate to elevation 16.05 on RIGHT side
5	Remove surcharge no.2 at elevation 16.05 No analysis at this stage
6	Fill to elevation 17.50 on RIGHT side with soil type 2
7	Install strut or anchor no.2 at elevation 18.00
8	Install strut or anchor no.3 at elevation 23.50
9	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
10	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m<sup>3</sup>

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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m



## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Apply surcharge no.2 at elev. 16.05	Yes	Yes	Yes
4	Excav. to elev. 16.05 on RIGHT side	Yes	Yes	Yes
5	Remove surcharge no.2 at elev. 16.05	Yes	Yes	Yes
6	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
7	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
8	Install prop no.3 at elev. 23.50	Yes	Yes	Yes
9	Change soil type 2 to soil type 4	Yes	Yes	Yes
10	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

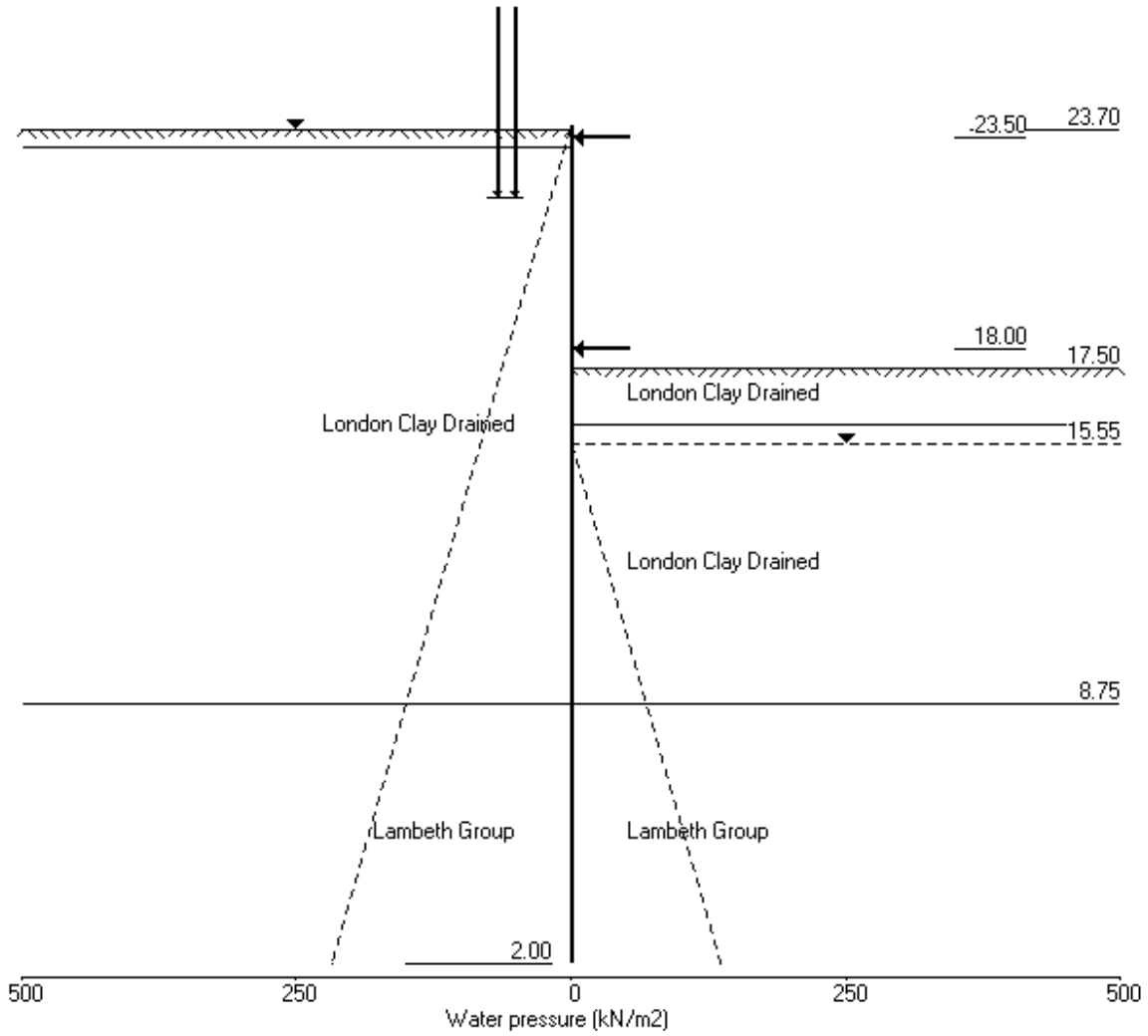
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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.10 Apply water pressure profile no.2 (Worst Cred.)



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 4 Excavate to elevation 16.05 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 2.00						
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>at elev.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
		<u>Elev.</u>	<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
4	23.70	16.05	Cant.	1.889	3.04	11.87	4.18	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.117	1.38E-02	0.0	-0.0	
2	23.50	2.73	0.114	1.38E-02	0.3	0.0	
3	23.25	6.13	0.111	1.38E-02	1.4	0.2	
		2.25	0.111	1.38E-02	1.4	0.2	
4	22.58	5.63	0.101	1.38E-02	4.0	2.1	
5	21.90	9.00	0.092	1.37E-02	9.0	6.6	
6	21.24	12.28	0.083	1.37E-02	15.9	14.9	
7	20.59	15.55	0.074	1.36E-02	25.1	28.4	
8	19.90	19.02	0.065	1.34E-02	37.1	50.1	
9	19.20	22.50	0.055	1.32E-02	51.5	81.0	
10	18.00	28.50	0.040	1.23E-02	82.1	161.1	
11	17.50	31.00	0.034	1.17E-02	97.0	205.8	
12	16.77	34.63	0.026	1.06E-02	120.8	284.6	
13	16.05	38.25	0.019	9.15E-03	147.2	381.5	
		-133.84	0.019	9.15E-03	147.2	381.5	
14	15.55	-145.24	0.014	7.89E-03	77.4	437.8	
15	14.38	-126.19	0.007	4.65E-03	-82.1	455.3	
16	13.20	11.29	0.003	1.86E-03	-149.6	310.6	
17	12.00	60.84	0.002	2.04E-04	-106.3	138.5	
18	10.80	36.24	0.002	-5.08E-04	-48.0	53.9	
19	9.78	-13.00	0.003	-7.53E-04	-36.1	23.2	
20	8.75	-73.34	0.004	-7.59E-04	-80.4	-21.1	
		77.54	0.004	-7.59E-04	-80.4	-21.1	
21	7.98	52.27	0.004	-5.64E-04	-30.1	-60.4	
22	7.20	29.16	0.005	-2.56E-04	1.5	-68.2	
23	6.00	3.64	0.005	1.67E-04	21.2	-46.1	
24	4.80	-8.07	0.004	4.08E-04	18.5	-18.9	
25	3.60	-9.10	0.004	4.89E-04	8.2	-3.2	
26	2.80	-5.75	0.003	4.97E-04	2.3	0.2	
27	2.00	0.09	0.003	4.96E-04	0.0	0.0	

(continued)

Stage No.4 Excavate to elevation 16.05 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	2734
2	23.50	2.00	1.70	0.73	4.49	0.73	2.73a	2734
3	23.25	4.50	3.83	1.63	10.10	1.63	6.13a	2734
		Total>	8.33	2.25m	124.54	2.25	2.25a	9366
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	9904
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	10441
6	21.24	Total>	52.45	12.28m	184.23	12.28	12.28a	10962
7	20.59	Total>	76.40	15.55m	213.27	15.55	15.55a	11484
8	19.90	Total>	97.68	19.02m	239.94	19.02	19.02a	12037
9	19.20	Total>	113.76	22.50m	261.42	22.50	22.50a	12590
10	18.00	Total>	136.33	28.50m	293.31	28.50	28.50a	13546
11	17.50	Total>	145.14	31.00m	306.00	31.00	31.00a	13944
12	16.77	Total>	142.60	34.63m	309.09	34.63	34.63a	14521
13	16.05	Total>	170.67	38.25m	342.79	38.25	38.25a	15098
14	15.55	Total>	179.60	40.75m	355.60	40.75	40.75a	15496
15	14.38	Total>	200.90	46.63m	386.02	92.77	92.77	16431
16	13.20	Total>	222.58	52.50m	416.82	172.42	172.42	17367
17	12.00	Total>	245.04	58.50m	448.60	212.12	212.12	18322
18	10.80	Total>	267.76	64.50m	480.64	228.20	228.20	19277
19	9.78	Total>	287.32	69.63m	508.16	232.85	232.85	20093
20	8.75	Total>	307.01	78.28	535.80	233.89	233.89	20909
		Total>	307.01	191.11	422.93	284.28	284.28	6671
21	7.98	Total>	321.95	188.14	455.80	291.64	291.64	7702
22	7.20	Total>	336.95	185.22	488.72	299.73	299.73	8733
23	6.00	Total>	360.25	180.77	539.78	315.67	315.67	10329
24	4.80	Total>	383.64	176.42	590.92	336.22	336.22	11926
25	3.60	Total>	407.10	172.13	642.13	360.35	360.35	13522
26	2.80	Total>	422.78	169.31	676.31	377.81	377.81	14587
27	2.00	Total>	438.48	166.52	710.51	396.11	396.11	15651

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	16.77	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	16.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	172.09	172.09	172.09p	32095
14	15.55	Total>	10.01	2.50m	185.99	185.99	185.99p	32941
15	14.38	Total>	33.86	8.37m	218.96	218.96	218.96p	34929
16	13.20	Total>	58.49	14.25m	252.72	161.13	161.13	36918
17	12.00	Total>	84.39	20.25m	287.93	151.28	151.28	38948
18	10.80	Total>	110.72	26.25m	323.58	191.95	191.95	40979

Run ID. Design\_Case\_02\_no\_prop\_ULS2\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.4 Excavate to elevation 16.05 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
19	9.78	Total>	133.36	31.37m	354.18	245.85	245.85	42713
20	8.75	Total>	156.05	36.50m	384.82	307.23	307.23	44448
		Total>	156.05	40.17	271.96	206.74	206.74	14181
21	7.98	Total>	173.21	40.37m	307.05	239.36	239.36	16372
22	7.20	Total>	190.37	44.25m	342.13	270.56	270.56	18564
23	6.00	Total>	216.94	50.25m	396.46	312.04	312.04	21958
24	4.80	Total>	243.53	56.25m	450.79	344.29	344.29	25352
25	3.60	Total>	270.13	62.25m	505.15	369.45	369.45	28745
26	2.80	Total>	287.88	66.25m	541.41	383.56	383.56	31008
27	2.00	Total>	305.65	70.25m	577.67	396.02	396.02	33270

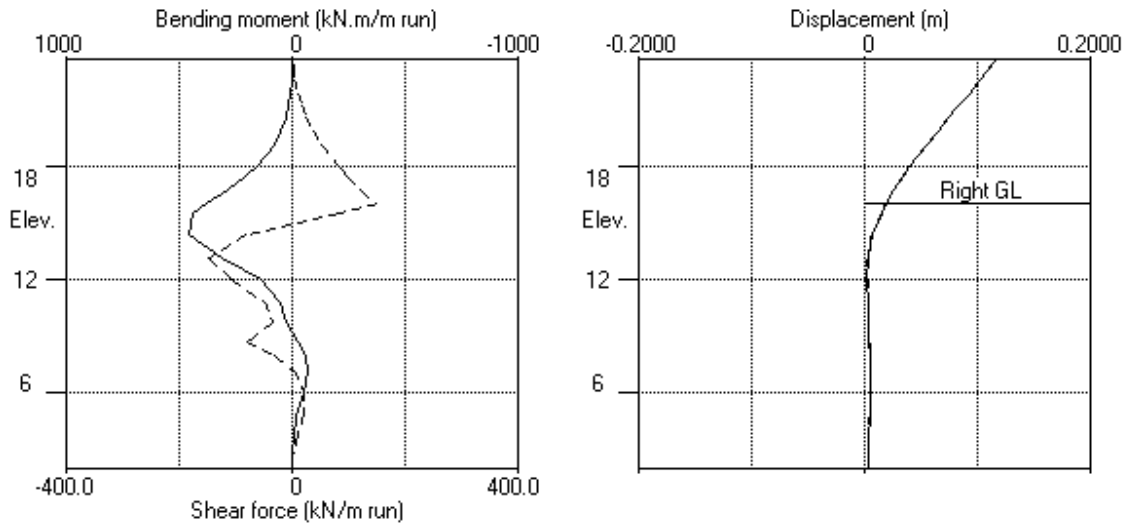
Note: 40.75a Soil pressure at active limit  
 218.96p Soil pressure at passive limit

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 Design Case 3  
 New contig wall

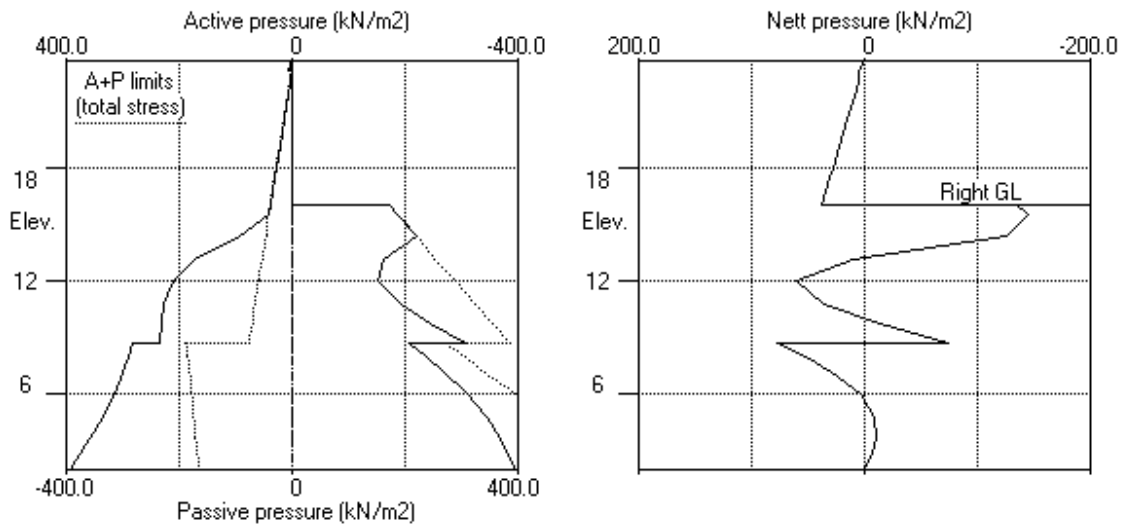
Sheet No.  
 Job No. 371654  
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Units: kN, m

Stage No.4 Excav. to elev. 16.05 on RIGHT side



Stage No.4 Excav. to elev. 16.05 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 6 Fill to elevation 17.50 on RIGHT side with soil type 2

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
6	23.70	17.50	Cant.	2.294	2.98	14.42	3.08	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.118	1.41E-02	0.0	-0.0	
2	23.50	2.73	0.115	1.41E-02	0.3	0.0	
3	23.25	6.13	0.112	1.41E-02	1.4	0.2	
		2.25	0.112	1.41E-02	1.4	0.2	
4	22.58	5.63	0.102	1.41E-02	4.0	2.1	
5	21.90	9.00	0.093	1.40E-02	9.0	6.6	
6	21.24	12.28	0.083	1.40E-02	15.9	14.9	
7	20.59	15.55	0.074	1.39E-02	25.1	28.4	
8	19.90	19.02	0.065	1.37E-02	37.1	50.1	
9	19.20	23.79	0.055	1.35E-02	51.9	81.0	
10	18.00	32.76	0.039	1.26E-02	85.9	162.5	
11	17.50	36.58	0.033	1.20E-02	103.2	209.7	
12	16.77	35.73	0.025	1.09E-02	129.4	293.2	
13	16.05	29.03	0.017	9.36E-03	152.9	395.5	
		-143.06	0.017	9.36E-03	152.9	395.5	
14	15.55	-152.29	0.013	8.05E-03	79.1	453.5	
15	14.38	-129.36	0.006	4.70E-03	-86.4	468.1	
16	13.20	10.72	0.002	1.85E-03	-156.1	316.3	
17	12.00	62.44	0.001	1.79E-04	-112.2	136.2	
18	10.80	40.53	0.001	-4.96E-04	-50.4	46.1	
19	9.78	-5.32	0.002	-6.90E-04	-32.4	15.4	
20	8.75	-61.27	0.002	-6.73E-04	-66.5	-20.9	
		66.67	0.002	-6.73E-04	-66.5	-20.9	
21	7.98	44.40	0.003	-4.97E-04	-23.5	-52.6	
22	7.20	24.07	0.003	-2.33E-04	3.1	-57.6	
23	6.00	1.97	0.003	1.17E-04	18.7	-37.2	
24	4.80	-7.62	0.003	3.07E-04	15.3	-13.9	
25	3.60	-7.75	0.003	3.64E-04	6.1	-1.6	
26	2.80	-4.33	0.002	3.67E-04	1.2	0.6	
27	2.00	1.25	0.002	3.65E-04	0.0	0.0	

(continued)

Stage No.6 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	4379
2	23.50	2.00	1.70	0.73	4.49	0.73	2.73a	4379
3	23.25	4.50	3.83	1.63	10.10	1.63	6.13a	4379
		Total>	8.33	2.25m	124.54	2.25	2.25a	14673
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	15514
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	16356
6	21.24	Total>	52.45	12.28m	184.23	12.28	12.28a	17173
7	20.59	Total>	76.40	15.55m	213.27	15.55	15.55a	17990
8	19.90	Total>	97.68	19.02m	239.94	19.02	19.02a	18857
9	19.20	Total>	113.76	22.50m	261.42	23.79	23.79	7524
10	18.00	Total>	136.33	28.50m	293.31	32.76	32.76	8095
11	17.50	Total>	145.14	31.00m	306.00	36.58	36.58	8333
12	16.77	Total>	142.60	34.63m	309.09	42.14	42.14	8678
13	16.05	Total>	170.67	38.25m	342.79	47.58	47.58	9023
14	15.55	Total>	179.60	40.75m	355.60	51.17	51.17	9261
15	14.38	Total>	200.90	46.63m	386.02	105.04	105.04	9820
16	13.20	Total>	222.58	52.50m	416.82	185.59	185.59	10379
17	12.00	Total>	245.04	58.50m	448.60	225.70	225.70	10950
18	10.80	Total>	267.76	64.50m	480.64	242.35	242.35	11521
19	9.78	Total>	287.32	69.63m	508.16	248.06	248.06	12008
20	8.75	Total>	307.01	78.28	535.80	250.73	250.73	12496
		Total>	307.01	191.11	422.93	289.65	289.65	3987
21	7.98	Total>	321.95	188.14	455.80	298.12	298.12	4603
22	7.20	Total>	336.95	185.22	488.72	307.27	307.27	5219
23	6.00	Total>	360.25	180.77	539.78	324.50	324.50	6173
24	4.80	Total>	383.64	176.42	590.92	345.75	345.75	7127
25	3.60	Total>	407.10	172.13	642.13	370.04	370.04	8081
26	2.80	Total>	422.78	169.31	676.31	387.36	387.36	8718
27	2.00	Total>	438.48	166.52	710.51	405.38	405.38	9354

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	160.84	0.00	0.00a	8333
12	16.77	Total>	14.50	3.63m	180.97	6.42	6.42	8678
13	16.05	Total>	29.02	7.25m	201.12	18.55	18.55	9023
		Total>	29.02	7.25m	201.12	190.64	190.64	9023
14	15.55	Total>	39.05	9.75m	215.03	203.46	203.46	9261
15	14.38	Total>	62.69	15.62m	247.80	234.40	234.40	9820
16	13.20	Total>	86.49	21.50m	280.72	174.87	174.87	10379
17	12.00	Total>	111.00	27.50m	314.54	163.26	163.26	10950



Run ID. Design\_Case\_02\_no\_prop\_ULS2\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.6 Fill to elevation 17.50 on RIGHT side with soil type 2

		RIGHT side						
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
18	10.80	Total>	135.73	33.50m	348.59	201.83	201.83	11521
19	9.78	Total>	157.05	38.62m	377.87	253.39	253.39	12008
20	8.75	Total>	178.55	43.75m	407.33	312.00	312.00	12496
		Total>	178.55	62.66	294.47	222.98	222.98	3987
21	7.98	Total>	194.92	61.11	328.76	253.73	253.73	4603
22	7.20	Total>	211.38	59.66	363.15	283.20	283.20	5219
23	6.00	Total>	237.04	57.58	416.56	322.52	322.52	6173
24	4.80	Total>	262.89	63.50m	470.16	353.37	353.37	7127
25	3.60	Total>	288.89	69.50m	523.92	377.79	377.79	8081
26	2.80	Total>	306.30	73.50m	559.82	391.69	391.69	8718
27	2.00	Total>	323.75	77.50m	595.78	404.13	404.13	9354

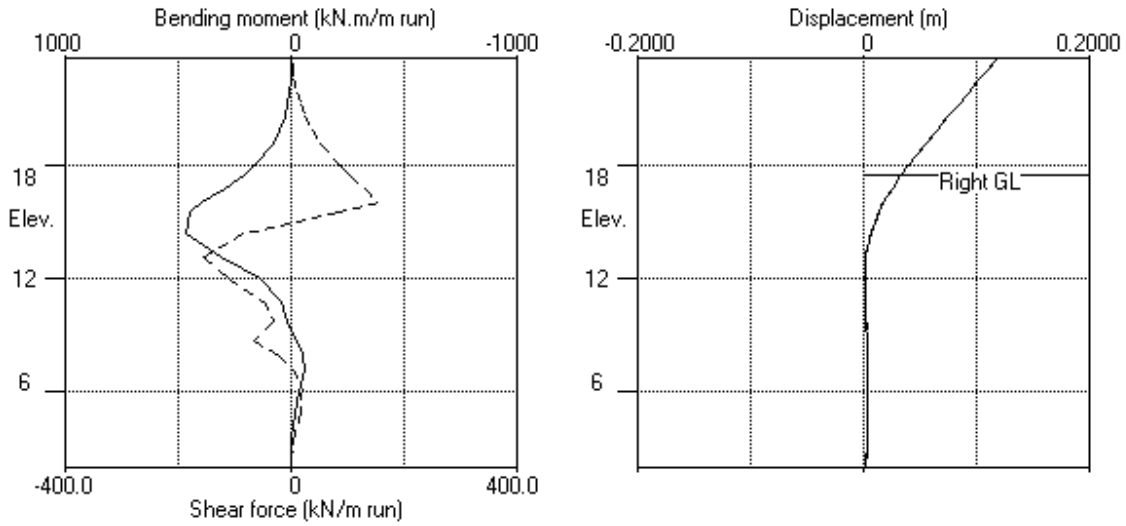
Note: 0.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Design Case 3  
 New contig wall

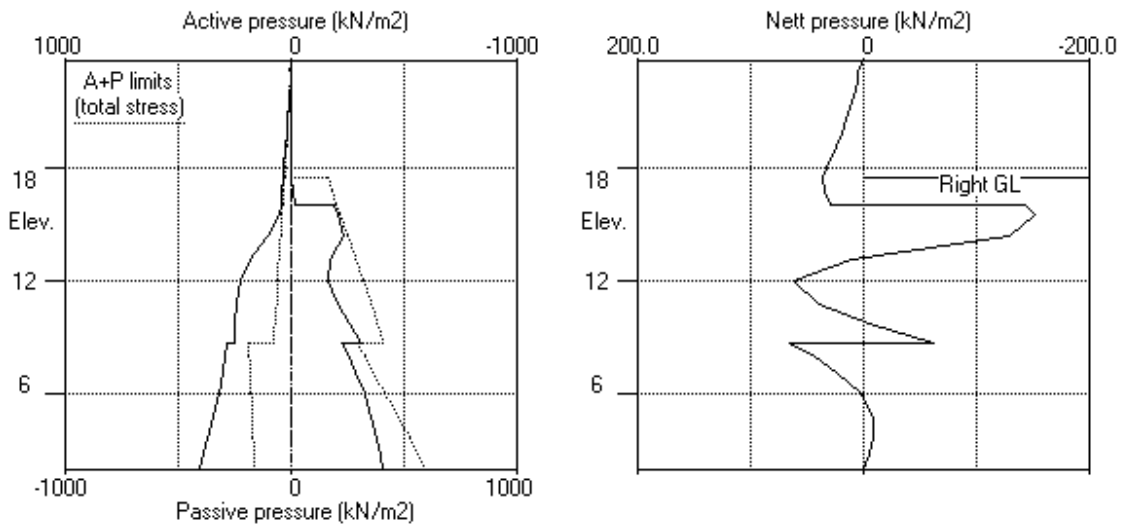
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.6 Fill to elev. 17.50 on RIGHT side



Stage No.6 Fill to elev. 17.50 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>at elev.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>		
			<u>Safety</u>	<u>More than one prop.</u>	<u>No FoS calc.</u>	<u>-ation</u>	<u>failure</u>		
9	23.70	17.50							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	23.70	0.00	0.118	1.42E-02	0.0	-0.0			
2	23.50	2.73	0.115	1.42E-02	0.3	0.0	-3.5		
		2.73	0.115	1.42E-02	-3.2	0.0			
3	23.25	6.26	0.112	1.42E-02	-2.1	-0.7			
		4.67	0.112	1.42E-02	-2.1	-0.7			
4	22.58	12.01	0.102	1.42E-02	3.5	-0.3			
5	21.90	19.54	0.092	1.42E-02	14.2	5.7			
6	21.24	30.93	0.083	1.42E-02	30.7	20.2			
7	20.59	45.44	0.074	1.40E-02	55.7	48.2			
8	19.90	58.95	0.064	1.37E-02	92.0	99.3			
9	19.20	70.08	0.055	1.31E-02	136.8	178.5			
10	18.00	86.92	0.040	1.10E-02	231.0	397.1	-396.4		
		86.92	0.040	1.10E-02	-165.4	397.1			
11	17.50	93.66	0.035	9.91E-03	-120.2	325.5			
		84.46	0.035	9.91E-03	-120.2	325.5			
12	16.77	77.17	0.028	8.60E-03	-61.6	260.0			
13	16.05	63.79	0.022	7.49E-03	-10.5	235.1			
		26.50	0.022	7.49E-03	-10.5	235.1			
14	15.55	9.09	0.019	6.77E-03	-1.6	232.2			
15	14.38	-15.26	0.012	5.01E-03	-5.3	252.5			
16	13.20	-39.80	0.007	3.23E-03	-37.6	237.0			
17	12.00	9.95	0.004	1.71E-03	-55.5	174.8			
18	10.80	13.22	0.003	6.38E-04	-41.6	114.9			
19	9.78	-16.57	0.002	2.52E-05	-43.4	78.8			
20	8.75	-62.49	0.002	-3.04E-04	-83.9	25.4			
		65.90	0.002	-3.04E-04	-83.9	25.4			
21	7.98	46.76	0.003	-3.17E-04	-40.2	-20.0			
22	7.20	28.34	0.003	-1.80E-04	-11.1	-37.2			
23	6.00	6.88	0.003	7.12E-05	10.0	-30.7			
24	4.80	-3.84	0.003	2.38E-04	11.8	-14.3			
25	3.60	-5.72	0.002	3.04E-04	6.1	-3.5			



Run ID. Design\_Case\_02\_no\_prop\_ULS2\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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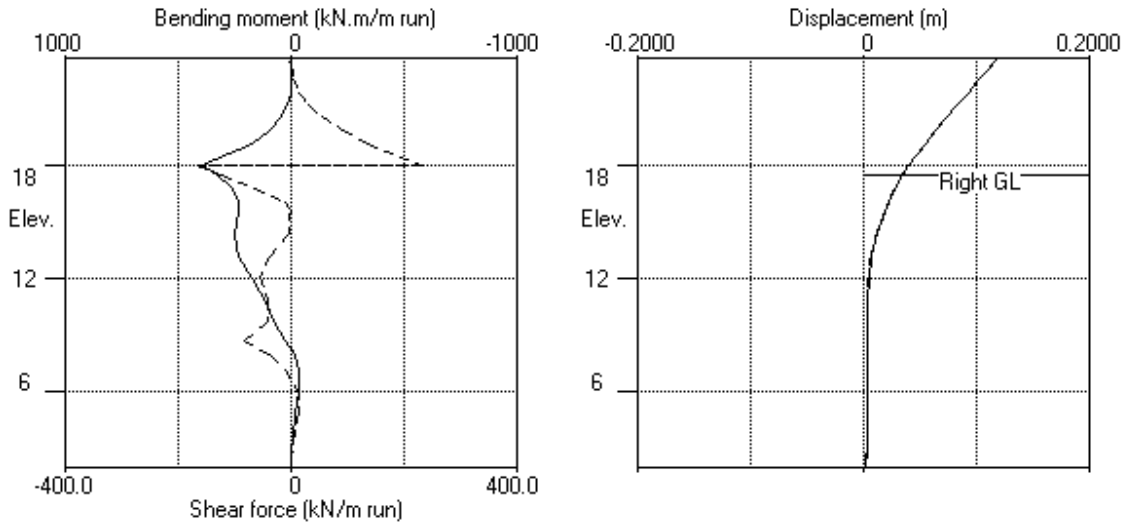
Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	16.66	9.20	9.20	5870
12	16.77	0.00	14.50	0.25	51.67	26.25	26.25	6185
13	16.05	0.00	29.02	6.89	86.71	49.42	49.42	6499
		0.00	29.02	6.89	86.71	86.71	86.71p	6499
14	15.55	0.00	39.05	11.48	110.92	110.92	110.92p	6716
15	14.38	11.75	50.94	16.92	139.64	139.64	151.39p	7226
16	13.20	23.50	62.99	22.44	168.72	168.72	192.22p	7735
17	12.00	35.50	75.50	28.16	198.91	154.01	189.51	8256
18	10.80	47.50	88.23	33.99	229.65	167.98	215.48	8776
19	9.78	57.75	99.30	39.05	256.37	201.26	259.01	9221
20	8.75	68.00	110.55	44.20	283.52	244.61	312.61	9666
		Total>	178.55	62.66	294.47	223.36	223.36	6121
21	7.98	Total>	194.92	61.11	328.76	252.55	252.55	8156
22	7.20	Total>	211.38	59.66	363.15	281.07	281.07	9248
23	6.00	Total>	237.04	57.58	416.56	320.07	320.07	10938
24	4.80	Total>	262.89	63.50m	470.16	351.48	351.48	12629
25	3.60	Total>	288.89	69.50m	523.92	376.77	376.77	14320
26	2.80	Total>	306.30	73.50m	559.82	391.30	391.30	15447
27	2.00	Total>	323.75	77.50m	595.78	405.97	405.97	119018

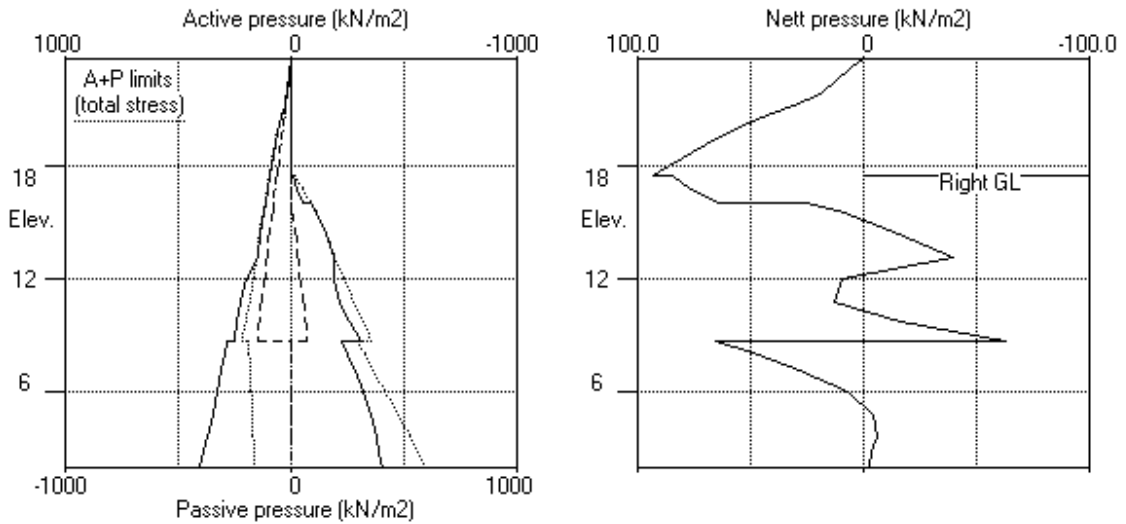
Note: 152.42a Soil pressure at active limit  
 192.22p Soil pressure at passive limit

Units: kN,m

Stage No.9 Change soil type 2 to soil type 4



Stage No.9 Change soil type 2 to soil type 4



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 2.00</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	23.70		No analysis at this stage				
4	23.70	16.05	Cant.	1.889	3.04	11.87	4.18	L to R
5	23.70	16.05		No analysis at this stage				
6	23.70	17.50	Cant.	2.294	2.98	14.42	3.08	L to R
7	23.70	17.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.118	-0.000	0.0	-0.0	0.0	0.0
2	23.50	0.115	-0.000	0.0	0.0	0.3	-3.2
3	23.25	0.112	0.000	0.2	-0.7	1.4	-2.1
4	22.58	0.102	0.000	2.1	-0.3	4.0	-1.0
5	21.90	0.093	0.000	6.6	-1.4	14.2	-4.0
6	21.24	0.083	0.000	20.2	-5.0	30.7	-7.7
7	20.59	0.074	0.000	48.2	-10.2	55.7	-8.7
8	19.90	0.065	0.000	99.3	-14.9	92.0	-5.7
9	19.20	0.055	0.000	178.5	-17.0	136.8	-1.2
10	18.00	0.040	0.000	397.1	-14.2	231.0	-165.4
11	17.50	0.035	0.000	325.5	-11.8	103.2	-120.2
12	16.77	0.028	0.000	293.2	-8.0	129.4	-61.6
13	16.05	0.022	0.000	395.5	-4.3	152.9	-10.5
14	15.55	0.019	0.000	453.5	-2.0	79.1	-1.6
15	14.38	0.012	0.000	468.1	0.0	3.1	-86.4
16	13.20	0.007	0.000	316.3	0.0	2.0	-156.1
17	12.00	0.004	0.000	174.8	0.0	1.1	-112.2
18	10.80	0.003	0.000	114.9	0.0	0.0	-50.4
19	9.78	0.003	0.000	78.8	0.0	0.0	-43.4
20	8.75	0.004	0.000	25.4	-21.1	0.0	-83.9
21	7.98	0.004	0.000	0.0	-60.4	0.0	-40.2
22	7.20	0.005	0.000	0.0	-68.2	3.1	-11.1
23	6.00	0.005	0.000	0.0	-46.1	21.2	0.0
24	4.80	0.004	0.000	0.0	-18.9	18.5	0.0
25	3.60	0.004	0.000	0.0	-3.5	8.2	0.0
26	2.80	0.003	0.000	0.6	-0.6	2.4	0.0
27	2.00	0.003	0.000	0.0	0.0	0.0	0.0



Run ID. Design\_Case\_02\_no\_prop\_ULS2\_new  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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**Summary of results (continued)**

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment				Shear force			
	<u>maximum</u> kN.m/m	<u>elev.</u>	<u>minimum</u> kN.m/m	<u>elev.</u>	<u>maximum</u> kN/m	<u>elev.</u>	<u>minimum</u> kN/m	<u>elev.</u>
1	5.1	12.00	-16.9	19.20	5.5	16.77	-8.4	20.59
2	6.4	10.80	-17.0	19.20	5.3	16.77	-8.7	20.59
3	No calculation at this stage							
4	455.3	14.38	-68.2	7.20	147.2	16.05	-149.6	13.20
5	No calculation at this stage							
6	468.1	14.38	-57.6	7.20	152.9	16.05	-156.1	13.20
7	No calculation at this stage							
8	No calculation at this stage							
9	397.1	18.00	-37.2	7.20	231.0	18.00	-165.4	18.00
10	397.1	18.00	-37.2	7.20	231.0	18.00	-165.4	18.00

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				<u>Stage description</u>
	<u>maximum</u> m	<u>elev.</u>	<u>minimum</u> m	<u>elev.</u>	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.2
3	No calculation at this stage				Apply surcharge no.2 at elev. 16.05
4	0.117	23.70	0.000	23.70	Excav. to elev. 16.05 on RIGHT side
5	No calculation at this stage				Remove surcharge no.2 at elev. 16.05
6	0.118	23.70	0.000	23.70	Fill to elev. 17.50 on RIGHT side
7	No calculation at this stage				Install prop no.2 at elev. 18.00
8	No calculation at this stage				Install prop no.3 at elev. 23.50
9	0.118	23.70	0.000	23.70	Change soil type 2 to soil type 4
10	0.118	23.70	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

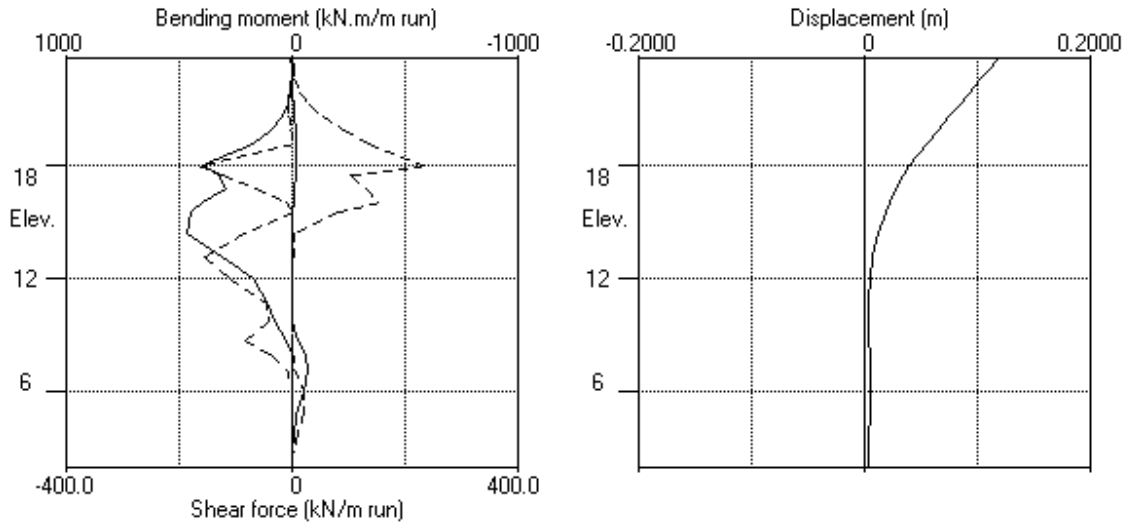
Stage no.	--- Strut no. 2 --- at elev. 18.00		--- Strut no. 3 --- at elev. 23.50	
	kN/m run	kN/prop	kN/m run	kN/prop
9	396.41	396.41	3.48	3.48
10	396.41	396.41	3.48	3.48

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Design Case 3  
New contig wall

Sheet No.  
Job No. 371654  
Made by : MM  
Date:13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	23.25	2 London Clay		2 London Clay
3	-3.75	3 Lambeth Group		3 Lambeth Group

**SOIL PROPERTIES**

No.	Description	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	Made Ground ( Datum elev. )	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 ( 2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	80.00u ( 4.390)
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	180.0u ( 13.08)
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610)	1.000	OC (0.200)	0.384 (1.452)	3.043 ( 4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185)	1.000 ( 1.000)	OC (0.200)	0.384 (1.452)	3.043 ( 4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	20.59	20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0 MC+WC
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.90	6.00	0.017663	2.050E+08	4.75	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	23.50	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
4	19.00	6.00	0.017663	2.050E+08	4.75	45.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width to wall	Surcharge Near edge kN/m <sup>2</sup>	Surcharge Far edge kN/m <sup>2</sup>	Equiv. soil type	Partial factor/ Category
1	21.90	1.20(L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.55	-5.30(R)	23.80	20.00	30.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 20.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 21.90
5	Apply surcharge no.2 at elevation 16.55 No analysis at this stage
6	Excavate to elevation 16.55 on RIGHT side
7	Remove surcharge no.2 at elevation 16.55 No analysis at this stage
8	Fill to elevation 17.50 on RIGHT side with soil type 2
9	Install strut or anchor no.2 at elevation 18.00
10	Install strut or anchor no.3 at elevation 23.50
11	Remove strut or anchor no.1 at elevation 21.90
12	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
13	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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/m<sup>3</sup>  
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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m

## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 21.90	Yes	Yes	Yes
5	Apply surcharge no.2 at elev. 16.55	Yes	Yes	Yes
6	Excav. to elev. 16.55 on RIGHT side	Yes	Yes	Yes
7	Remove surcharge no.2 at elev. 16.55	Yes	Yes	Yes
8	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
10	Install prop no.3 at elev. 23.50	Yes	Yes	Yes
11	Remove prop no.1 at elev. 21.90	Yes	Yes	Yes
12	Change soil type 2 to soil type 4	Yes	Yes	Yes
13	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

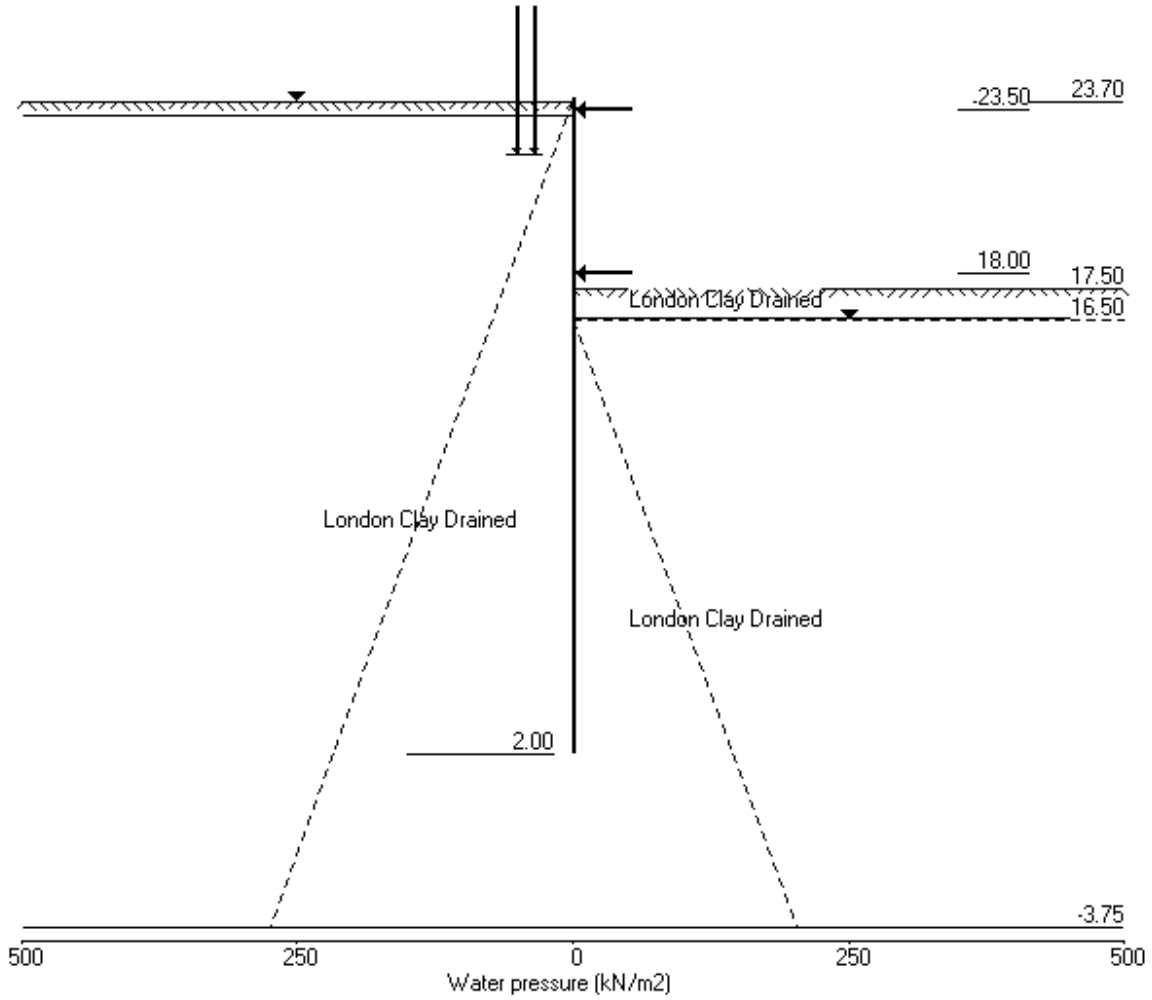
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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_SLS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.13 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 20.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
3	23.70	20.50	Cant.	6.013	3.61	19.44	1.06	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.008	1.13E-03	0.0	-0.0	
2	23.50	3.70	0.008	1.13E-03	0.4	0.0	
3	23.25	8.33	0.007	1.13E-03	1.9	0.3	
		2.25	0.007	1.13E-03	1.9	0.3	
4	22.58	5.63	0.007	1.12E-03	4.5	2.5	
5	21.90	9.00	0.006	1.10E-03	9.5	7.4	
6	21.24	12.28	0.005	1.05E-03	16.4	16.0	
7	20.59	17.01	0.004	9.59E-04	26.0	33.7	
8	20.50	21.06	0.004	9.39E-04	27.7	36.1	
		-45.77	0.004	9.39E-04	27.7	36.1	
9	19.85	-25.17	0.004	7.76E-04	4.7	44.9	
10	19.20	-11.43	0.003	6.00E-04	-7.2	42.8	
11	18.00	1.33	0.003	3.46E-04	-13.3	25.7	
12	17.50	3.51	0.003	2.77E-04	-12.1	19.2	
13	16.55	4.72	0.002	1.94E-04	-8.1	9.0	
14	16.50	4.72	0.002	1.92E-04	-7.9	8.6	
15	15.55	3.87	0.002	1.58E-04	-3.8	2.9	
16	14.38	1.84	0.002	1.45E-04	-0.5	0.6	
17	13.20	0.39	0.002	1.40E-04	0.8	0.8	
18	12.00	-0.26	0.002	1.31E-04	0.9	1.6	
19	10.80	-0.34	0.002	1.18E-04	0.5	2.0	
20	9.60	-0.19	0.001	1.03E-04	0.2	2.0	
21	8.40	-0.04	0.001	9.01E-05	0.1	1.7	
22	7.20	0.02	0.001	7.88E-05	0.1	1.3	
23	6.00	0.00	0.001	6.99E-05	0.1	1.0	
24	4.80	-0.06	0.001	6.34E-05	0.0	0.7	
25	3.60	-0.08	0.001	5.95E-05	-0.0	0.3	
26	2.80	-0.00	0.001	5.82E-05	-0.1	0.2	
27	2.00	0.18	0.001	5.78E-05	-0.0	0.0	

(continued)

Stage No.3 Excavate to elevation 20.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	4695
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4695
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	4695
		Total>	8.33	2.25m	171.02	2.25	2.25a	11527
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	12189
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	12850
6	21.24	Total>	52.45	12.28m	236.93	12.28	12.28a	13492
7	20.59	Total>	76.40	15.55m	268.00	17.01	17.01	14134
8	20.50	Total>	79.51	16.00m	272.09	21.06	21.06	14222
9	19.85	Total>	98.85	19.25m	298.49	46.76	46.76	14859
10	19.20	Total>	113.76	22.50m	320.46	67.00	67.00	15495
11	18.00	Total>	136.33	28.50m	356.07	95.99	95.99	16671
12	17.50	Total>	145.14	31.00m	370.32	106.32	106.32	17161
13	16.55	Total>	161.82	35.75m	397.32	124.59	124.59	18092
14	16.50	Total>	162.70	36.00m	398.74	125.52	125.52	18141
15	15.55	Total>	179.60	40.75m	425.97	142.99	142.99	19071
16	14.38	Total>	200.90	46.63m	460.03	164.61	164.61	20223
17	13.20	Total>	222.58	52.50m	494.48	186.76	186.76	21374
18	12.00	Total>	245.04	58.50m	529.98	209.99	209.99	22549
19	10.80	Total>	267.76	64.50m	565.74	233.66	233.66	23725
20	9.60	Total>	290.68	70.50m	601.69	257.57	257.57	24901
21	8.40	Total>	313.75	76.50m	637.80	281.61	281.61	26076
22	7.20	Total>	336.95	82.50m	674.04	305.70	305.70	27252
23	6.00	Total>	360.25	88.50m	710.38	329.83	329.83	28428
24	4.80	Total>	383.64	94.50m	746.81	354.02	354.02	29603
25	3.60	Total>	407.10	100.50m	783.31	378.27	378.27	30779
26	2.80	Total>	422.78	104.50m	807.68	394.51	394.51	31563
27	2.00	Total>	438.48	108.50m	832.07	410.81	410.81	32347

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	192.58	66.82	66.82	16031
9	19.85	Total>	13.00	3.25m	212.64	71.93	71.93	16749
10	19.20	Total>	26.01	6.50m	232.71	78.43	78.43	17467
11	18.00	Total>	50.05	12.50m	269.79	94.66	94.66	18792
12	17.50	Total>	60.09	15.00m	285.26	102.81	102.81	19345
13	16.55	Total>	79.20	19.75m	314.70	119.86	119.86	20394
14	16.50	Total>	80.21	20.00m	316.25	120.80	120.80	20449
15	15.55	Total>	99.38	24.75m	345.74	139.11	139.11	21498
16	14.38	Total>	123.19	30.62m	382.32	162.77	162.77	22796
17	13.20	Total>	147.12	36.50m	419.02	186.38	186.38	24093
18	12.00	Total>	171.69	42.50m	456.63	210.25	210.25	25419
19	10.80	Total>	196.38	48.50m	494.35	234.00	234.00	26744



Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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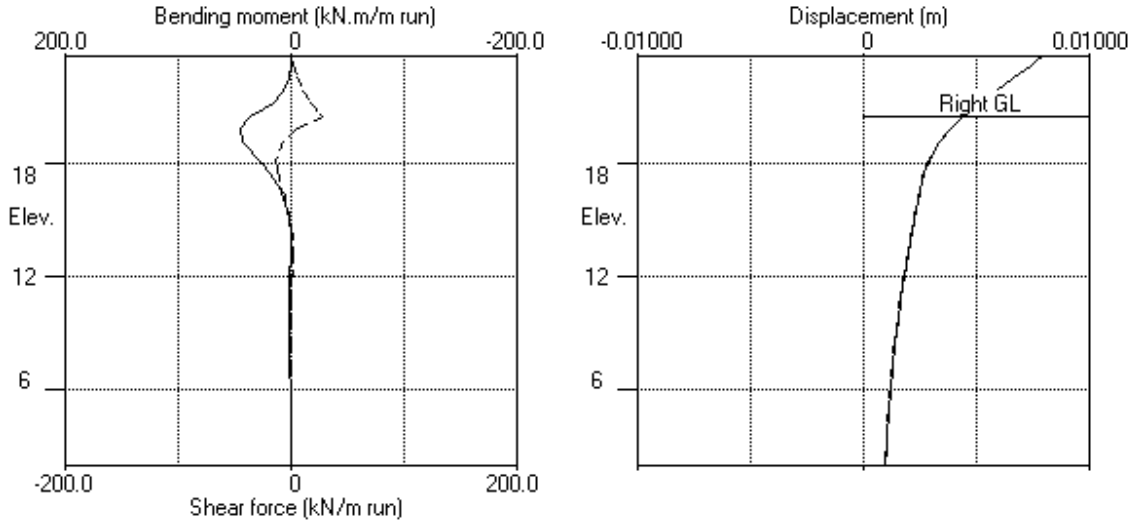
Stage No.3 Excavate to elevation 20.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m2	<u>Vertic</u> <u>-al</u> kN/m2	<u>Effective stresses</u>			<u>Total</u> <u>earth</u> <u>pressure</u> kN/m2	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m3
				<u>Active</u> <u>limit</u> kN/m2	<u>Passive</u> <u>limit</u> kN/m2	<u>Earth</u> <u>pressure</u> kN/m2		
20	9.60	Total> 221.18	54.50m	532.19	257.77	257.77	28069	
21	8.40	Total> 246.08	60.50m	570.13	281.65	281.65	29394	
22	7.20	Total> 271.07	66.50m	608.16	305.68	305.68	30720	
23	6.00	Total> 296.13	72.50m	646.26	329.83	329.83	32045	
24	4.80	Total> 321.25	78.50m	684.42	354.07	354.07	33370	
25	3.60	Total> 346.41	84.50m	722.62	378.35	378.35	34696	
26	2.80	Total> 363.20	88.50m	748.10	394.51	394.51	35579	
27	2.00	Total> 380.00	92.50m	773.59	410.63	410.63	36463	

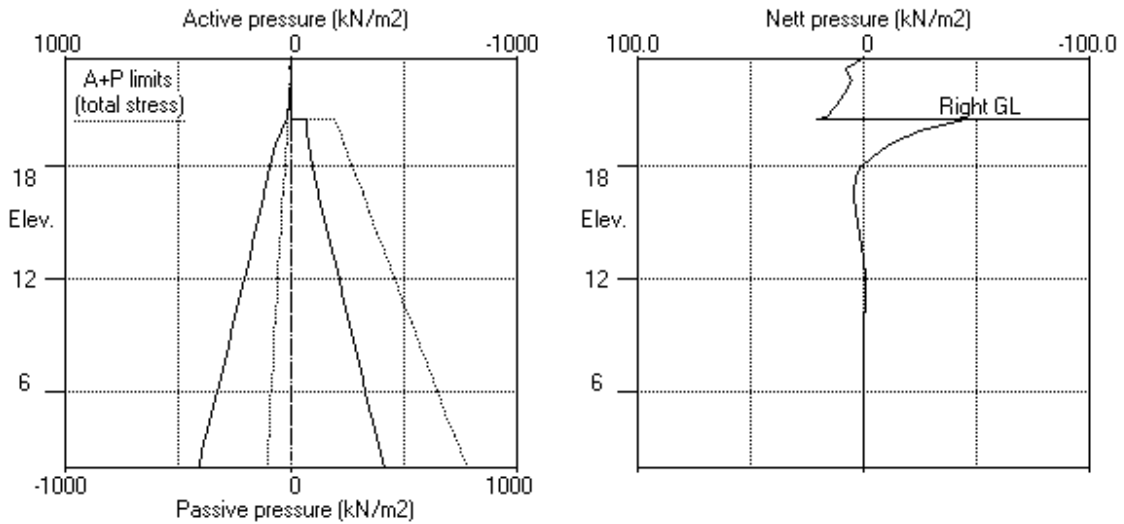
Note: 12.28a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 20.50 on RIGHT side



Stage No.3 Excav. to elev. 20.50 on RIGHT side



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 6 Excavate to elevation 16.55 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
6	23.70	16.55	21.90	4.576	n/a	16.24	0.31	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.006	-7.01E-04	0.0	-0.0	
2	23.50	3.70	0.006	-7.01E-04	0.4	0.0	
3	23.25	8.33	0.006	-7.01E-04	1.9	0.3	
		43.73	0.006	-7.01E-04	1.9	0.3	
4	22.58	5.63	0.007	-7.27E-04	18.5	12.0	
5	21.90	9.00	0.007	-8.07E-04	23.5	26.3	-87.2
		9.00	0.007	-8.07E-04	-63.7	26.3	
6	21.24	12.28	0.008	-8.33E-04	-56.7	-13.1	
7	20.59	15.55	0.008	-7.19E-04	-47.6	-43.3	
8	20.50	16.00	0.008	-6.94E-04	-46.2	-47.6	
9	19.85	19.25	0.009	-4.48E-04	-34.7	-75.0	
10	19.20	22.50	0.009	-1.08E-04	-21.2	-94.1	
11	18.00	33.93	0.009	5.69E-04	12.7	-89.0	
12	17.50	44.60	0.008	8.27E-04	32.3	-78.1	
13	16.55	68.04	0.007	1.13E-03	85.8	-25.0	
		-60.63	0.007	1.13E-03	85.8	-25.0	
14	16.50	-59.65	0.007	1.13E-03	82.8	-20.7	
15	15.55	-39.26	0.006	1.10E-03	35.8	30.8	
16	14.38	-17.27	0.005	8.32E-04	2.6	45.1	
17	13.20	-3.52	0.004	5.39E-04	-9.6	35.6	
18	12.00	2.54	0.004	3.31E-04	-10.2	20.7	
19	10.80	3.62	0.003	2.19E-04	-6.5	9.4	
20	9.60	2.61	0.003	1.71E-04	-2.7	3.4	
21	8.40	1.29	0.003	1.54E-04	-0.4	1.2	
22	7.20	0.34	0.003	1.46E-04	0.6	0.9	
23	6.00	-0.16	0.003	1.38E-04	0.7	1.1	
24	4.80	-0.35	0.002	1.30E-04	0.4	1.1	
25	3.60	-0.29	0.002	1.24E-04	-0.0	0.6	
26	2.80	-0.05	0.002	1.21E-04	-0.1	0.3	
27	2.00	0.39	0.002	1.21E-04	-0.0	0.0	

At elev. 21.90 Prop force = 87.2 kN/m run (horiz.)  
 = 123.3 kN/m run (inclined)

(continued)

Stage No.6 Excavate to elevation 16.55 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	14811
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	14811
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	14811
		Total>	8.33	2.25m	171.02	43.73	43.73	36364
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	7816
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	8240
6	21.24	Total>	52.45	12.28m	236.93	12.28	12.28a	8652
7	20.59	Total>	76.40	15.55m	268.00	15.55	15.55a	9064
8	20.50	Total>	79.51	16.00m	272.09	16.00	16.00a	9120
9	19.85	Total>	98.85	19.25m	298.49	19.25	19.25a	9528
10	19.20	Total>	113.76	22.50m	320.46	22.50	22.50a	9937
11	18.00	Total>	136.33	28.50m	356.07	33.93	33.93	10691
12	17.50	Total>	145.14	31.00m	370.32	44.60	44.60	11005
13	16.55	Total>	161.82	35.75m	397.32	68.04	68.04	11602
14	16.50	Total>	162.70	36.00m	398.74	69.37	69.37	11633
15	15.55	Total>	179.60	40.75m	425.97	95.29	95.29	12230
16	14.38	Total>	200.90	46.63m	460.03	126.66	126.66	12968
17	13.20	Total>	222.58	52.50m	494.48	155.29	155.29	13706
18	12.00	Total>	245.04	58.50m	529.98	181.81	181.81	14460
19	10.80	Total>	267.76	64.50m	565.74	206.62	206.62	15214
20	9.60	Total>	290.68	70.50m	601.69	230.74	230.74	15968
21	8.40	Total>	313.75	76.50m	637.80	254.81	254.81	16722
22	7.20	Total>	336.95	82.50m	674.04	279.08	279.08	17476
23	6.00	Total>	360.25	88.50m	710.38	303.56	303.56	18230
24	4.80	Total>	383.64	94.50m	746.81	328.21	328.21	18984
25	3.60	Total>	407.10	100.50m	783.31	353.01	353.01	19738
26	2.80	Total>	422.78	104.50m	807.68	369.64	369.64	20241
27	2.00	Total>	438.48	108.50m	832.07	386.38	386.38	20743

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	16.55	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	235.50	128.67	128.67	17420
14	16.50	Total>	1.00	0.25m	237.04	129.01	129.01	17467
15	15.55	Total>	20.09	5.00m	266.45	134.55	134.55	18363
16	14.38	Total>	44.26	10.87m	303.39	143.92	143.92	19472
17	13.20	Total>	69.26	16.75m	341.15	158.81	158.81	20580
18	12.00	Total>	95.40	22.75m	380.34	179.27	179.27	21712
19	10.80	Total>	121.85	28.75m	419.83	203.00	203.00	22844

Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.6 Excavate to elevation 16.55 on RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses				Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
			Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	9.60	Total>	148.39	34.75m	459.40	228.13	23976	
21	8.40	Total>	174.92	40.75m	498.97	253.52	25108	
22	7.20	Total>	201.42	46.75m	538.51	278.74	26240	
23	6.00	Total>	227.90	52.75m	578.03	303.72	27372	
24	4.80	Total>	254.37	58.75m	617.54	328.56	28504	
25	3.60	Total>	280.84	64.75m	657.05	353.29	29636	
26	2.80	Total>	298.50	68.75m	683.40	369.69	30391	
27	2.00	Total>	316.15	72.75m	709.75	385.98	31146	

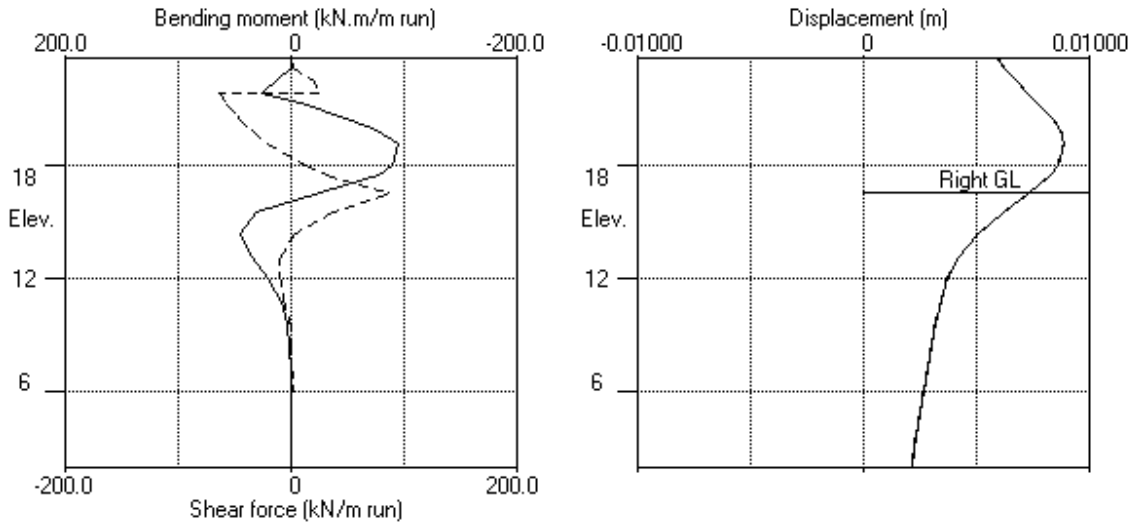
Note: 22.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_SLS\_new  
 Design Case 2  
 New contig wall

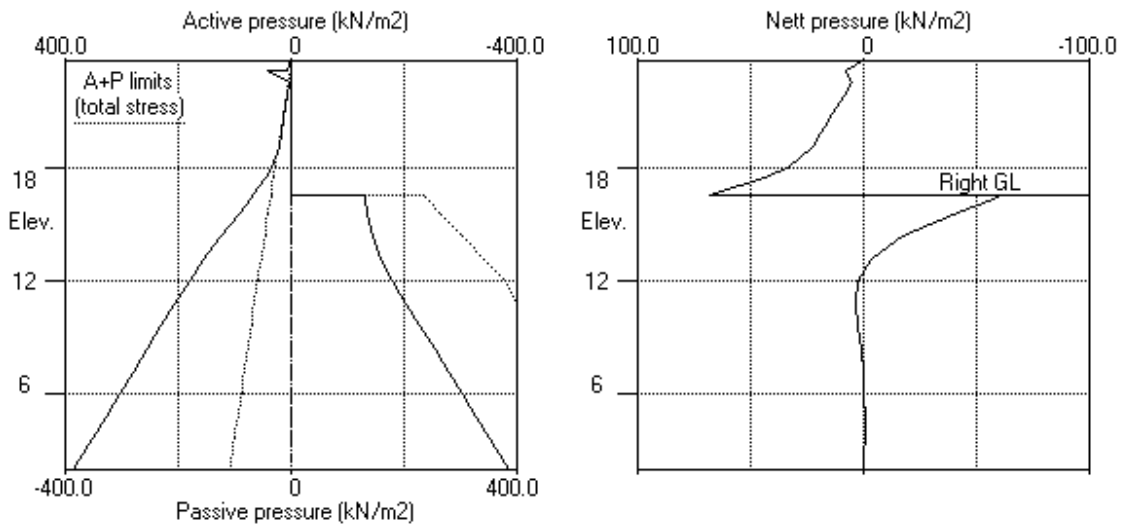
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.6 Excav. to elev. 16.55 on RIGHT side



Stage No.6 Excav. to elev. 16.55 on RIGHT side



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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_SLS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 8 Fill to elevation 17.50 on RIGHT side with soil type 2

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilb. at elev.	Toe elev.	Wall Penetr-ation	
8	23.70	17.50	21.90	5.013	n/a	17.28	0.22	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.006	-6.29E-04	0.0	-0.0	
2	23.50	3.70	0.006	-6.29E-04	0.4	0.0	
3	23.25	8.33	0.006	-6.30E-04	1.9	0.3	
		41.18	0.006	-6.30E-04	1.9	0.3	
4	22.58	5.63	0.007	-6.54E-04	17.7	11.4	
5	21.90	9.00	0.007	-7.30E-04	22.6	25.1	-87.9
		9.00	0.007	-7.30E-04	-65.2	25.1	
6	21.24	12.58	0.008	-7.50E-04	-58.2	-15.2	
7	20.59	16.31	0.008	-6.25E-04	-48.7	-46.4	
8	20.50	16.83	0.008	-5.98E-04	-47.2	-50.7	
9	19.85	20.66	0.009	-3.39E-04	-35.0	-78.7	
10	19.20	24.61	0.009	1.49E-05	-20.3	-97.7	
11	18.00	37.66	0.008	7.10E-04	17.0	-90.0	
12	17.50	49.09	0.008	9.67E-04	38.7	-76.5	
13	16.55	61.87	0.007	1.24E-03	91.4	-18.0	
		-66.80	0.007	1.24E-03	91.4	-18.0	
14	16.50	-65.67	0.007	1.24E-03	88.1	-13.5	
15	15.55	-42.83	0.005	1.17E-03	36.6	40.3	
16	14.38	-18.63	0.004	8.32E-04	0.5	53.2	
17	13.20	-3.51	0.004	4.92E-04	-12.5	40.4	
18	12.00	3.21	0.003	2.60E-04	-12.7	22.3	
19	10.80	4.41	0.003	1.44E-04	-8.2	8.9	
20	9.60	3.24	0.003	1.04E-04	-3.6	1.8	
21	8.40	1.66	0.003	1.00E-04	-0.6	-0.7	
22	7.20	0.52	0.002	1.05E-04	0.7	-0.7	
23	6.00	-0.10	0.002	1.08E-04	0.9	-0.1	
24	4.80	-0.35	0.002	1.07E-04	0.7	0.4	
25	3.60	-0.35	0.002	1.05E-04	0.2	0.3	
26	2.80	-0.19	0.002	1.04E-04	0.0	0.2	
27	2.00	0.13	0.002	1.03E-04	-0.0	-0.0	

At elev. 21.90 Prop force = 87.9 kN/m run (horiz.)  
 = 124.2 kN/m run (inclined)

(continued)

Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
		Total>	0.00	0.00	0.00	0.00	0.00	9491
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	9491
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	9491
		Total>	8.33	2.25m	171.02	41.18	41.18	23303
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	24640
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	25977
6	21.24	Total>	52.45	12.28m	236.93	12.58	12.58	7347
7	20.59	Total>	76.40	15.55m	268.00	16.31	16.31	7696
8	20.50	Total>	79.51	16.00m	272.09	16.83	16.83	7744
9	19.85	Total>	98.85	19.25m	298.49	20.66	20.66	8091
10	19.20	Total>	113.76	22.50m	320.46	24.61	24.61	8437
11	18.00	Total>	136.33	28.50m	356.07	37.66	37.66	9078
12	17.50	Total>	145.14	31.00m	370.32	49.09	49.09	9344
13	16.55	Total>	161.82	35.75m	397.32	74.00	74.00	9851
14	16.50	Total>	162.70	36.00m	398.74	75.39	75.39	9878
15	15.55	Total>	179.60	40.75m	425.97	102.50	102.50	10385
16	14.38	Total>	200.90	46.63m	460.03	134.71	134.71	11012
17	13.20	Total>	222.58	52.50m	494.48	163.45	163.45	11638
18	12.00	Total>	245.04	58.50m	529.98	189.52	189.52	12279
19	10.80	Total>	267.76	64.50m	565.74	213.57	213.57	12919
20	9.60	Total>	290.68	70.50m	601.69	236.87	236.87	13559
21	8.40	Total>	313.75	76.50m	637.80	260.20	260.20	14199
22	7.20	Total>	336.95	82.50m	674.04	283.88	283.88	14839
23	6.00	Total>	360.25	88.50m	710.38	307.92	307.92	15479
24	4.80	Total>	383.64	94.50m	746.81	332.24	332.24	16120
25	3.60	Total>	407.10	100.50m	783.31	356.78	356.78	16760
26	2.80	Total>	422.78	104.50m	807.68	373.26	373.26	17187
27	2.00	Total>	438.48	108.50m	832.07	389.84	389.84	17613

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
		0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	0.00	0.00a	9630
13	16.55	Total>	19.01	4.75m	254.50	12.12	12.12	10152
		Total>	19.01	4.75m	254.50	140.80	140.80	10152
14	16.50	Total>	20.01	5.00m	256.05	141.06	141.06	10180
15	15.55	Total>	39.05	9.75m	285.41	145.33	145.33	10702
16	14.38	Total>	62.69	15.62m	321.83	153.34	153.34	11348
17	13.20	Total>	86.49	21.50m	358.39	166.96	166.96	11994
18	12.00	Total>	111.00	27.50m	395.93	186.31	186.31	12654



Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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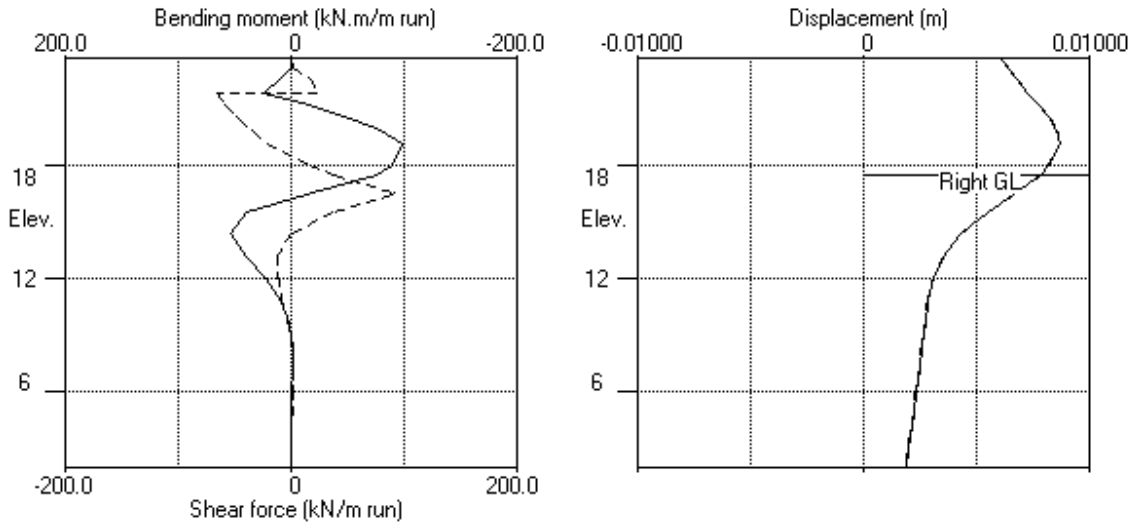
Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
19	10.80	Total>	135.73	33.50m	433.71	209.17	209.17	13314
20	9.60	Total>	160.71	39.50m	471.72	233.64	233.64	13973
21	8.40	Total>	185.93	45.50m	509.98	258.54	258.54	14633
22	7.20	Total>	211.38	51.50m	548.47	283.36	283.36	15293
23	6.00	Total>	237.04	57.50m	587.18	308.02	308.02	15953
24	4.80	Total>	262.89	63.50m	626.06	332.59	332.59	16612
25	3.60	Total>	288.89	69.50m	665.10	357.13	357.13	17272
26	2.80	Total>	306.30	73.50m	691.20	373.45	373.45	17712
27	2.00	Total>	323.75	77.50m	717.35	389.71	389.71	18152

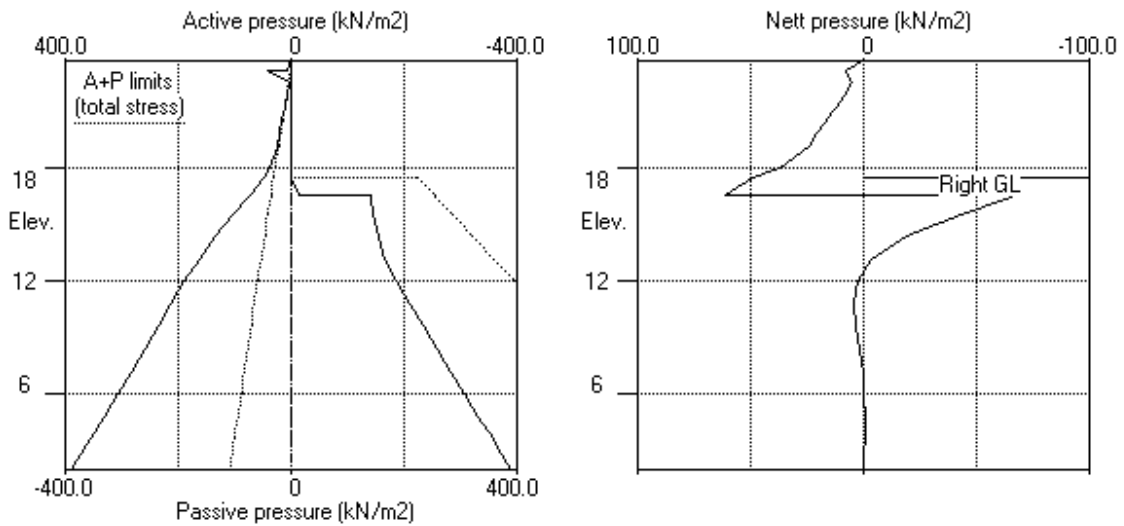
Note: 0.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.8 Fill to elev. 17.50 on RIGHT side



Stage No.8 Fill to elev. 17.50 on RIGHT side



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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_SLS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 12 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
12	23.70	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.006	-1.49E-03	0.0	-0.0	
2	23.50	3.70	0.006	-1.49E-03	0.4	0.0	-58.5
3	23.25	3.70	0.006	-1.49E-03	-58.1	0.0	
		8.33	0.007	-1.48E-03	-56.6	-14.3	
4	22.58	38.35	0.007	-1.48E-03	-56.6	-14.3	
		5.26	0.008	-1.36E-03	-41.9	-43.3	
5	21.90	8.37	0.008	-1.12E-03	-37.3	-69.9	
6	21.24	12.85	0.009	-7.99E-04	-30.3	-92.0	
7	20.59	22.04	0.009	-4.01E-04	-18.9	-104.5	
8	20.50	23.79	0.010	-3.42E-04	-16.8	-106.1	
9	19.85	35.21	0.010	9.56E-05	2.3	-112.3	
10	19.20	44.94	0.009	5.28E-04	28.4	-103.5	
11	18.00	60.99	0.008	9.93E-04	91.9	-21.7	-130.7
		60.99	0.008	9.93E-04	-38.7	-21.7	
12	17.50	67.45	0.008	1.07E-03	-6.6	-33.5	
		66.52	0.008	1.07E-03	-6.6	-33.5	
13	16.55	68.33	0.007	1.21E-03	57.4	-12.4	
		-2.21	0.007	1.21E-03	57.4	-12.4	
14	16.50	-4.61	0.007	1.21E-03	57.3	-9.5	
15	15.55	-39.35	0.006	1.14E-03	36.4	34.1	
16	14.38	-18.26	0.004	8.42E-04	2.5	49.1	
17	13.20	-4.02	0.004	5.23E-04	-10.6	39.0	
18	12.00	2.43	0.003	2.93E-04	-11.5	22.9	
19	10.80	3.79	0.003	1.70E-04	-7.8	10.4	
20	9.60	2.91	0.003	1.19E-04	-3.8	3.3	
21	8.40	1.64	0.003	1.06E-04	-1.0	0.3	
22	7.20	0.63	0.002	1.06E-04	0.3	-0.3	
23	6.00	0.03	0.002	1.07E-04	0.7	0.0	
24	4.80	-0.25	0.002	1.06E-04	0.6	0.3	
25	3.60	-0.30	0.002	1.03E-04	0.3	0.3	



Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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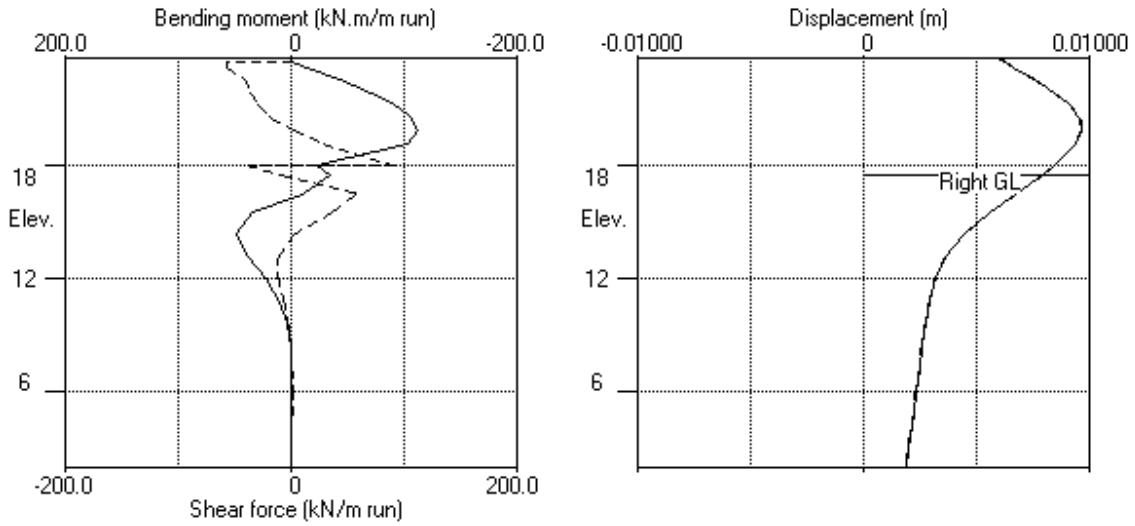
Stage No.12 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.07	0.93	0.93	6091
13	16.55	0.00	19.01	0.03	81.91	11.37	11.37	6519
		0.00	19.01	0.03	81.91	81.91	81.91p	6519
14	16.50	0.00	20.01	0.41	84.96	84.96	84.96p	6541
15	15.55	0.00	39.05	7.71	142.91	142.91	142.91p	6969
16	14.38	11.75	50.94	12.28	179.12	141.65	153.40	7498
17	13.20	23.50	62.99	16.90	215.79	143.89	167.39	8026
18	12.00	35.50	75.50	21.69	253.84	151.30	186.80	8567
19	10.80	47.50	88.23	26.58	292.60	162.02	209.52	9107
20	9.60	59.50	101.21	31.55	332.10	174.31	233.81	9647
21	8.40	71.50	114.43	36.62	372.33	187.05	258.55	11897
22	7.20	83.50	127.88	41.78	413.27	199.80	283.30	12528
23	6.00	95.50	141.54	47.02	454.85	212.45	307.95	13158
24	4.80	107.50	155.39	52.33	497.00	225.04	332.54	13789
25	3.60	119.50	169.39	57.70	539.61	237.61	357.11	14420
26	2.80	127.50	178.80	61.31	568.23	245.94	373.44	14840
27	2.00	135.50	188.25	64.93	597.00	254.27	389.77	81078

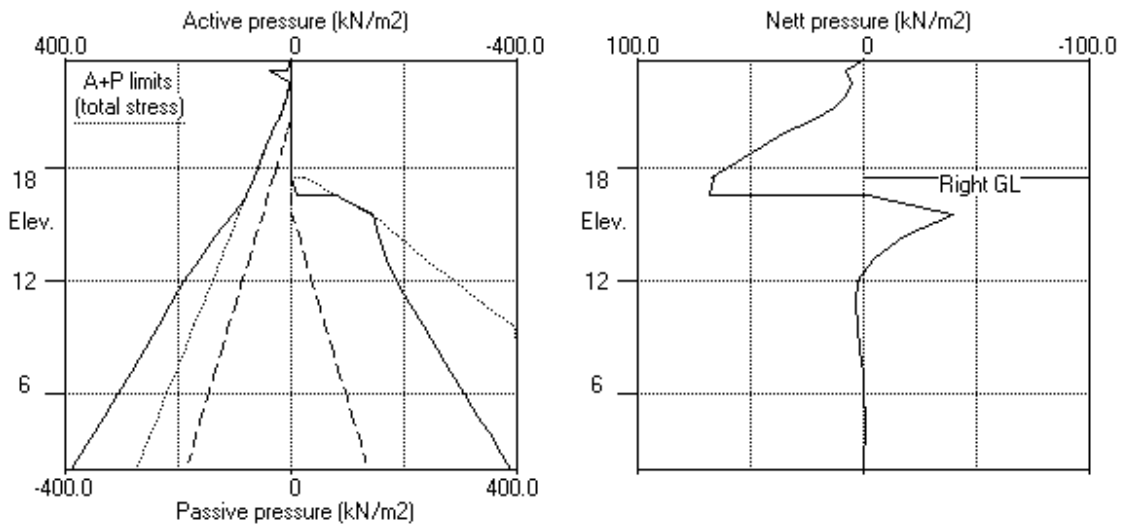
Note: 80.35a Soil pressure at active limit  
 142.91p Soil pressure at passive limit

Units: kN,m

Stage No.12 Change soil type 2 to soil type 4



Stage No.12 Change soil type 2 to soil type 4



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

-----  
 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	20.50	Cant.	6.013	3.61	19.44	1.06	L to R
4	23.70	20.50		No analysis at this stage				
5	23.70	20.50		No analysis at this stage				
6	23.70	16.55	21.90	4.576	n/a	16.24	0.31	L to R
7	23.70	16.55		No analysis at this stage				
8	23.70	17.50	21.90	5.013	n/a	17.28	0.22	L to R
9	23.70	17.50		No analysis at this stage				

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

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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.008	-0.000	0	-0	0	-0	0	0	0	0
2	23.50	0.008	-0.000	0	0	0	0	0	-78	0	-105
3	23.25	0.007	0.000	0	-19	0	-26	2	-77	3	-103
4	22.58	0.008	0.000	12	-61	16	-82	19	-59	25	-79
5	21.90	0.009	0.000	26	-97	35	-130	23	-65	32	-88
6	21.24	0.010	0.000	16	-122	22	-165	16	-58	22	-79
7	20.59	0.010	0.000	34	-131	45	-177	26	-49	35	-66
8	20.50	0.010	0.000	36	-131	49	-177	28	-47	37	-64
9	19.85	0.010	0.000	45	-123	61	-167	31	-35	42	-47
10	19.20	0.010	0.000	43	-103	58	-140	72	-21	97	-29
11	18.00	0.009	0.000	59	-90	79	-121	162	-111	219	-149
12	17.50	0.008	0.000	19	-78	26	-105	39	-67	52	-91
13	16.55	0.008	0.000	9	-25	12	-34	91	-8	123	-11
14	16.50	0.008	0.000	9	-21	12	-28	88	-8	119	-11
15	15.55	0.007	0.000	46	-2	62	-3	37	-4	49	-5
16	14.38	0.006	0.000	53	0	72	0	11	-3	14	-4
17	13.20	0.005	0.000	40	0	55	0	1	-13	1	-18
18	12.00	0.005	0.000	23	0	31	0	1	-13	1	-17
19	10.80	0.005	0.000	10	0	14	0	1	-8	1	-11
20	9.60	0.004	0.000	4	0	6	0	0	-4	0	-5
21	8.40	0.004	0.000	3	-1	4	-1	0	-1	0	-1
22	7.20	0.004	0.000	2	-1	3	-1	1	-0	1	-0
23	6.00	0.004	0.000	2	-0	3	-0	1	-0	1	-0
24	4.80	0.003	0.000	1	0	2	0	1	-0	1	-0
25	3.60	0.003	0.000	1	0	1	0	0	-0	0	-0
26	2.80	0.003	0.000	0	0	0	0	0	-0	0	-0
27	2.00	0.003	0.000	0	-0	0	-0	0	-0	0	-0



Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment				Shear force			
	Calculated		Factored		Calculated		Factored	
	max. elev.	min. elev.	max. elev.	min. elev.	max. elev.	min. elev.	max. elev.	min. elev.
	kN.m/m	kN.m/m	kN.m/m	kN.m/m	kN/m	kN/m	kN/m	kN/m
1	3 13.20	-17 19.20	4 -23	5 16.55	-8 20.59	7 -11		
2	3 12.00	-17 19.20	4 -23	5 16.55	-8 20.59	7 -11		
3	45 19.85	-0 23.70	61 -0	28 20.50	-13 18.00	37 -18		
4	No calculation at this stage							
5	No calculation at this stage							
6	45 14.38	-94 19.20	61 -127	86 16.55	-64 21.90	116 -86		
7	No calculation at this stage							
8	53 14.38	-98 19.20	72 -132	91 16.55	-65 21.90	123 -88		
9	No calculation at this stage							
10	No calculation at this stage							
11	52 14.38	-98 19.85	71 -132	79 16.55	-53 23.50	106 -72		
12	49 14.38	-112 19.85	66 -152	92 18.00	-58 23.50	124 -78		
13	59 18.00	-131 20.50	79 -177	162 18.00	-111 18.00	219 -149		

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.1
3	0.008	23.70	0.000	23.70	Excav. to elev. 20.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 21.90
5	No calculation at this stage				Apply surcharge no.2 at elev. 16.55
6	0.009	19.20	0.000	23.70	Excav. to elev. 16.55 on RIGHT side
7	No calculation at this stage				Remove surcharge no.2 at elev. 16.55
8	0.009	19.20	0.000	23.70	Fill to elev. 17.50 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 18.00
10	No calculation at this stage				Install prop no.3 at elev. 23.50
11	0.009	19.85	0.000	23.70	Remove prop no.1 at elev. 21.90
12	0.010	19.85	0.000	23.70	Change soil type 2 to soil type 4
13	0.010	20.50	0.000	23.70	Apply water pressure profile no.2

Run ID. Design\_Case\_02\_with\_prop\_SIS\_new  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Prop forces at each stage (horizontal components)**

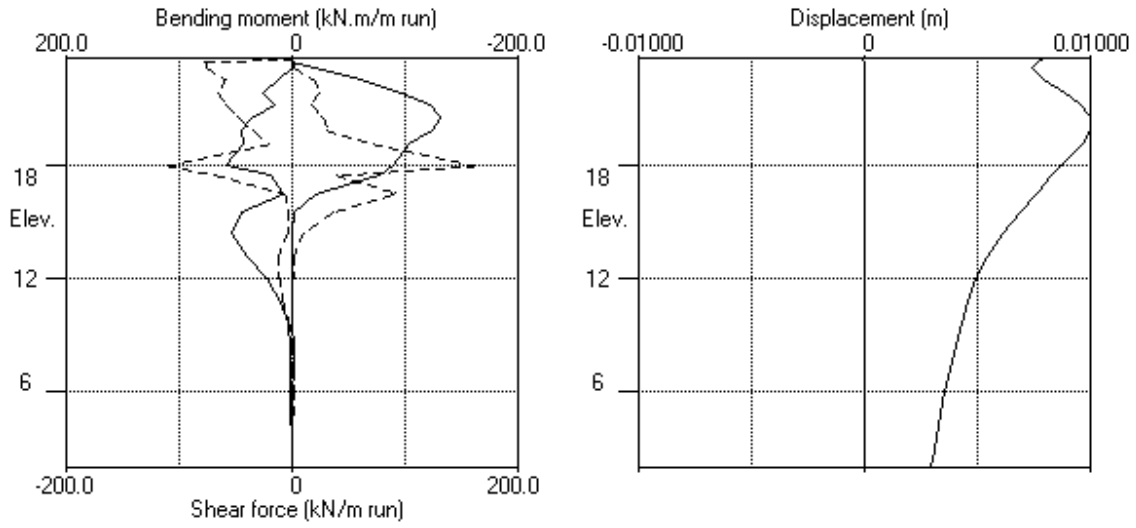
Stage no.	----- Prop no. 1 ----- at elev. 21.90			----- Prop no. 2 ----- at elev. 18.00			----- Prop no. 3 ----- at elev. 23.50		
	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop
6	87	523	706	---	---	---	---	---	---
8	88	527	712	---	---	---	---	---	---
11	---	---	---	44	44	59	54	54	72
12	---	---	---	131	131	176	58	58	79
13	---	---	---	273	273	368	78	78	106

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Design Case 2  
New contig wall

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Bending moment, shear force, displacement envelopes



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	23.25	2 London Clay		2 London Clay
3	-3.75	3 Lambeth Group		3 Lambeth Group

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. ( Nu ) ( NC/OC )	Active limit Ka ( Kac )	Passive limit Kp ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 (2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390 )
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08 )
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610 )	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185 )	1.000 ( 1.000 )	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

Initial water table elevation      Left side      Right side  
 20.59      20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	15.55	15.55	0.0
2	1	23.70	23.70	0.0	1	15.55	15.55	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.90	6.00	0.017663	2.050E+08	4.75	45.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
3	23.50	1.00	0.500000	2.800E+07	22.25	0.00	0	Strut	No	R
4	19.00	6.00	0.017663	2.050E+08	4.75	45.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpendicular to wall	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.90	1.20 (L)	32.15	1.00	100.00	=	N/A	1.00 -
2	16.05	-5.30 (R)	23.80	20.00	29.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Excavate to elevation 20.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 21.90
5	Apply surcharge no.2 at elevation 16.05 No analysis at this stage
6	Excavate to elevation 16.05 on RIGHT side
7	Remove surcharge no.2 at elevation 16.05 No analysis at this stage
8	Fill to elevation 17.50 on RIGHT side with soil type 2
9	Install strut or anchor no.2 at elevation 18.00
10	Install strut or anchor no.3 at elevation 23.50
11	Remove strut or anchor no.1 at elevation 21.90
12	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
13	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2  
Water pressures : Worst Credible  
Partial factor on C' = 1.250  
Partial factor on Phi' = 1.250  
Partial factor on Cu = 1.400  
Partial factor on Soil Modulus = 1.000  
Partial factor on Permanent Unfavourable loads = 1.000  
Partial factor on Permanent Favourable loads = 1.000  
Partial factor on Variable Unfavourable loads = 1.300

**Stability analysis:**

Method of analysis - Strength Factor method  
Overall 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) = 21.70 m

**Boundary conditions:**

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m  
Distance to rigid boundary on Right side = 23.70 m

## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 21.90	Yes	Yes	Yes
5	Apply surcharge no.2 at elev. 16.05	Yes	Yes	Yes
6	Excav. to elev. 16.05 on RIGHT side	Yes	Yes	Yes
7	Remove surcharge no.2 at elev. 16.05	Yes	Yes	Yes
8	Fill to elev. 17.50 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
10	Install prop no.3 at elev. 23.50	Yes	Yes	Yes
11	Remove prop no.1 at elev. 21.90	Yes	Yes	Yes
12	Change soil type 2 to soil type 4	Yes	Yes	Yes
13	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

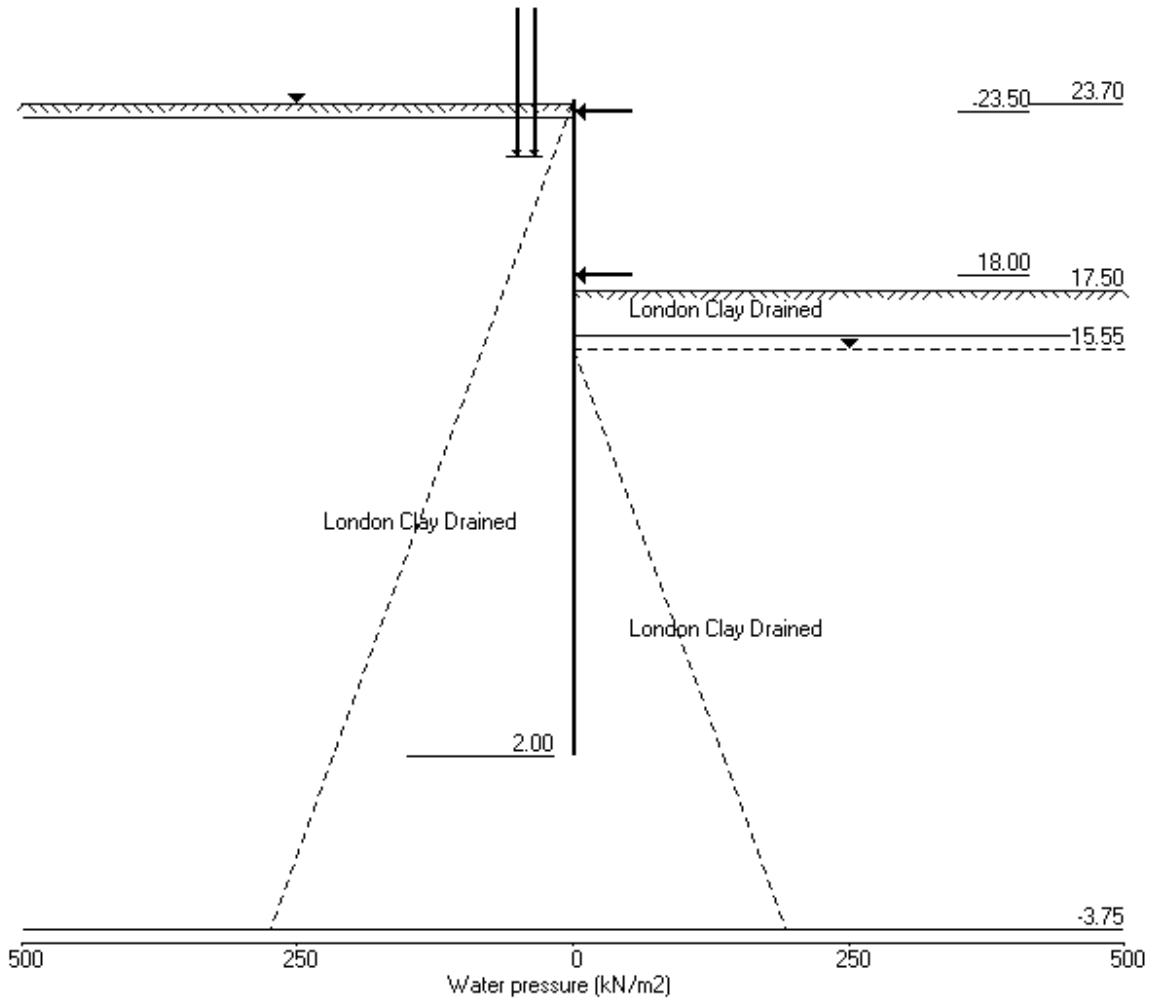
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 Design Case 2  
 New contig wall

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Stage No.13 Apply water pressure profile no.2 ( Worst Cred. )





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Stage No. 3 Excavate to elevation 20.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
3	23.70	20.50	Cant.	4.348	3.59	19.28	1.22	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.008	1.13E-03	0.0	-0.0	
2	23.50	3.70	0.008	1.13E-03	0.4	0.0	
3	23.25	8.32	0.007	1.13E-03	1.9	0.3	
		2.25	0.007	1.13E-03	1.9	0.3	
4	22.58	5.63	0.007	1.13E-03	4.5	2.5	
5	21.90	9.00	0.006	1.10E-03	9.5	7.4	
6	21.24	12.28	0.005	1.06E-03	16.4	16.0	
7	20.59	17.51	0.005	9.62E-04	26.2	33.8	
8	20.50	21.56	0.004	9.42E-04	27.9	36.2	
		-46.12	0.004	9.42E-04	27.9	36.2	
9	19.85	-25.37	0.004	7.79E-04	4.7	45.1	
10	19.20	-11.52	0.003	6.02E-04	-7.3	42.9	
11	18.00	1.32	0.003	3.48E-04	-13.4	25.7	
12	17.50	3.51	0.003	2.79E-04	-12.2	19.1	
13	16.77	4.69	0.003	2.12E-04	-9.2	11.0	
14	16.05	4.44	0.002	1.75E-04	-5.9	5.5	
15	15.55	3.87	0.002	1.62E-04	-3.8	3.0	
16	14.38	1.84	0.002	1.48E-04	-0.5	0.6	
17	13.20	0.39	0.002	1.43E-04	0.8	0.8	
18	12.00	-0.26	0.002	1.34E-04	0.9	1.6	
19	10.80	-0.34	0.002	1.20E-04	0.5	2.1	
20	9.60	-0.19	0.002	1.05E-04	0.2	2.0	
21	8.40	-0.04	0.001	9.18E-05	0.1	1.7	
22	7.20	0.02	0.001	8.03E-05	0.1	1.4	
23	6.00	0.00	0.001	7.14E-05	0.1	1.0	
24	4.80	-0.06	0.001	6.48E-05	0.0	0.7	
25	3.60	-0.08	0.001	6.08E-05	-0.0	0.3	
26	2.80	-0.00	0.001	5.95E-05	-0.1	0.2	
27	2.00	0.19	0.001	5.91E-05	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 20.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	4708
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4708
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	4708
		Total>	8.33	2.25m	124.54	2.25	2.25a	11559
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	12222
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	12885
6	21.24	Total>	52.45	12.28m	184.23	12.28	12.28a	13529
7	20.59	Total>	76.40	15.55m	213.27	17.51	17.51	14172
8	20.50	Total>	79.51	16.00m	217.08	21.56	21.56	14261
9	19.85	Total>	98.85	19.25m	241.46	47.32	47.32	14899
10	19.20	Total>	113.76	22.50m	261.42	67.61	67.61	15538
11	18.00	Total>	136.33	28.50m	293.31	96.62	96.62	16717
12	17.50	Total>	145.14	31.00m	306.00	106.96	106.96	17208
13	16.77	Total>	142.29	34.63m	308.77	121.00	121.00	17920
14	16.05	Total>	170.67	38.25m	342.79	134.46	134.46	18632
15	15.55	Total>	179.60	40.75m	355.60	143.62	143.62	19124
16	14.38	Total>	200.90	46.63m	386.02	165.25	165.25	20278
17	13.20	Total>	222.58	52.50m	416.82	187.40	187.40	21432
18	12.00	Total>	245.04	58.50m	448.60	210.63	210.63	22611
19	10.80	Total>	267.76	64.50m	480.64	234.30	234.30	23790
20	9.60	Total>	290.68	70.50m	512.87	258.21	258.21	24969
21	8.40	Total>	313.75	82.31	545.26	282.24	282.24	26148
22	7.20	Total>	336.95	96.19	577.77	306.34	306.34	27327
23	6.00	Total>	360.25	110.18	610.39	330.47	330.47	28506
24	4.80	Total>	383.64	124.26	643.10	354.65	354.65	29684
25	3.60	Total>	407.10	138.40	675.87	378.91	378.91	30863
26	2.80	Total>	422.78	147.87	697.76	395.14	395.14	31649
27	2.00	Total>	438.48	157.36	719.67	411.45	411.45	32435

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	137.56	67.68	67.68	16106
9	19.85	Total>	13.00	3.25m	155.60	72.70	72.70	16827
10	19.20	Total>	26.01	6.50m	173.66	79.13	79.13	17548
11	18.00	Total>	50.05	12.50m	207.02	95.30	95.30	18880
12	17.50	Total>	60.09	15.00m	220.94	103.45	103.45	19434
13	16.77	Total>	74.67	18.63m	241.15	116.32	116.32	20239
14	16.05	Total>	89.28	22.25m	261.39	130.02	130.02	21043
15	15.55	Total>	99.38	24.75m	275.38	139.75	139.75	21598
16	14.38	Total>	123.19	30.62m	308.31	163.40	163.40	22902
17	13.20	Total>	147.12	36.50m	341.37	187.01	187.01	24205
18	12.00	Total>	171.69	42.50m	375.25	210.89	210.89	25537
19	10.80	Total>	196.38	48.50m	409.25	234.64	234.64	26868

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 20.50 on RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	9.60	Total>	221.18	54.50m	443.37	258.40	258.40	28200
21	8.40	Total>	246.08	60.50m	477.59	282.29	282.29	29531
22	7.20	Total>	271.07	66.50m	511.90	306.32	306.32	30862
23	6.00	Total>	296.13	72.50m	546.28	330.47	330.47	32194
24	4.80	Total>	321.25	78.50m	580.71	354.71	354.71	33525
25	3.60	Total>	346.41	84.50m	615.19	378.98	378.98	34857
26	2.80	Total>	363.20	88.50m	638.19	395.14	395.14	35744
27	2.00	Total>	380.00	98.88	661.20	411.26	411.26	36632

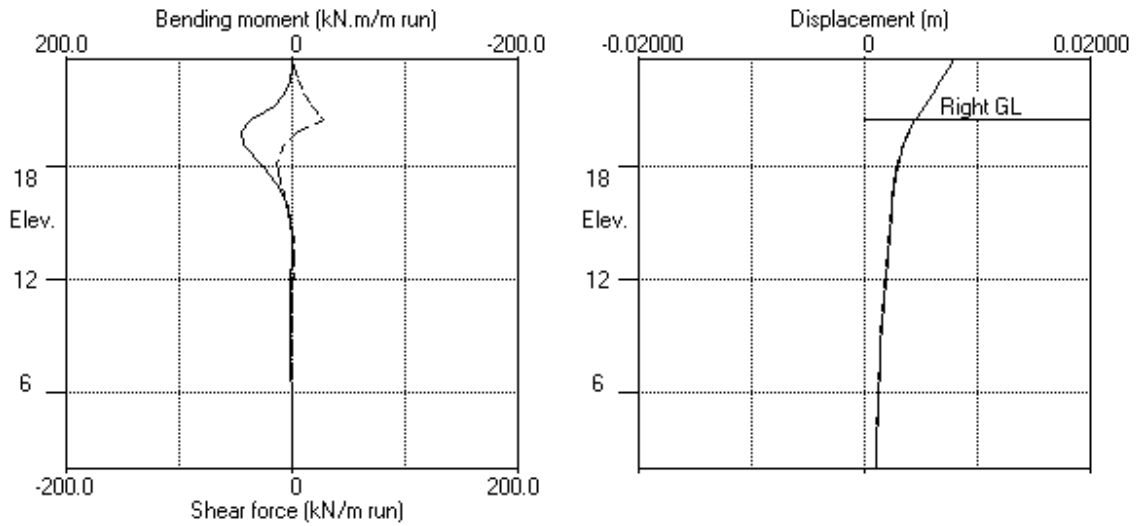
Note: 12.28a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Design Case 2  
 New contig wall

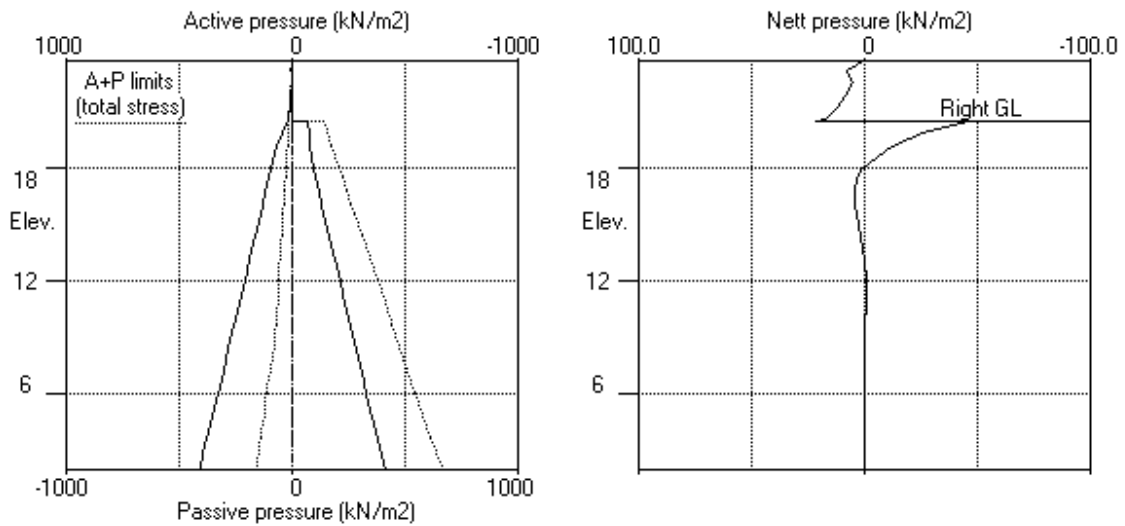
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN, m

Stage No.3 Excav. to elev. 20.50 on RIGHT side



Stage No.3 Excav. to elev. 20.50 on RIGHT side



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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 6 Excavate to elevation 16.05 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
6	23.70	16.05	21.90	3.036	n/a	15.50	0.55	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.006	-9.15E-04	0.0	-0.0	
2	23.50	3.70	0.006	-9.15E-04	0.4	0.0	
3	23.25	8.33	0.006	-9.15E-04	1.9	0.3	
		50.55	0.006	-9.15E-04	1.9	0.3	
4	22.58	5.63	0.007	-9.44E-04	20.8	13.5	
5	21.90	9.00	0.007	-1.03E-03	25.8	29.4	-91.5
		9.00	0.007	-1.03E-03	-65.7	29.4	
6	21.24	12.28	0.008	-1.07E-03	-58.7	-11.3	
7	20.59	15.55	0.009	-9.61E-04	-49.6	-42.8	
8	20.50	16.00	0.009	-9.35E-04	-48.2	-47.2	
9	19.85	19.25	0.009	-6.88E-04	-36.7	-76.0	
10	19.20	22.50	0.010	-3.42E-04	-23.2	-96.4	
11	18.00	28.50	0.010	4.22E-04	7.4	-109.9	
12	17.50	34.18	0.009	7.45E-04	23.1	-99.4	
13	16.77	51.06	0.009	1.13E-03	54.0	-72.7	
14	16.05	70.89	0.008	1.33E-03	98.2	-19.1	
		-73.79	0.008	1.33E-03	98.2	-19.1	
15	15.55	-60.07	0.007	1.33E-03	64.7	20.8	
16	14.38	-29.46	0.006	1.05E-03	12.1	54.8	
17	13.20	-8.30	0.005	6.86E-04	-10.0	48.1	
18	12.00	2.09	0.004	3.99E-04	-13.8	29.3	
19	10.80	4.75	0.004	2.40E-04	-9.7	13.5	
20	9.60	3.80	0.003	1.74E-04	-4.5	4.5	
21	8.40	2.02	0.003	1.54E-04	-1.0	1.0	
22	7.20	0.63	0.003	1.49E-04	0.6	0.4	
23	6.00	-0.13	0.003	1.44E-04	0.9	0.8	
24	4.80	-0.41	0.003	1.38E-04	0.5	1.0	
25	3.60	-0.36	0.003	1.32E-04	0.1	0.6	
26	2.80	-0.10	0.002	1.30E-04	-0.1	0.3	
27	2.00	0.37	0.002	1.29E-04	0.0	-0.0	
At elev. 21.90			Prop force =		91.5 kN/m run (horiz.)		
					= 129.3 kN/m run (inclined)		

(continued)

Stage No.6 Excavate to elevation 16.05 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	14341
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	14341
3	23.25	Total>	8.33	8.32	8.33	8.33	8.33	14341
		Total>	8.33	2.25m	124.54	50.55	50.55	35211
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	9246
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	8221
6	21.24	Total>	52.45	12.28m	184.23	12.28	12.28a	8632
7	20.59	Total>	76.40	15.55m	213.27	15.55	15.55a	9042
8	20.50	Total>	79.51	16.00m	217.08	16.00	16.00a	9099
9	19.85	Total>	98.85	19.25m	241.46	19.25	19.25a	9506
10	19.20	Total>	113.76	22.50m	261.42	22.50	22.50a	9913
11	18.00	Total>	136.33	28.50m	293.31	28.50	28.50a	10666
12	17.50	Total>	145.14	31.00m	306.00	34.18	34.18	10979
13	16.77	Total>	142.29	34.63m	308.77	51.06	51.06	11433
14	16.05	Total>	170.67	38.25m	342.79	70.89	70.89	11888
15	15.55	Total>	179.60	40.75m	355.60	85.56	85.56	12201
16	14.38	Total>	200.90	46.63m	386.02	119.85	119.85	12938
17	13.20	Total>	222.58	52.50m	416.82	151.03	151.03	13674
18	12.00	Total>	245.04	58.50m	448.60	179.03	179.03	14426
19	10.80	Total>	267.76	64.50m	480.64	204.37	204.37	15179
20	9.60	Total>	290.68	70.50m	512.87	228.50	228.50	15931
21	8.40	Total>	313.75	82.31	545.26	252.40	252.40	16683
22	7.20	Total>	336.95	96.19	577.77	276.52	276.52	17435
23	6.00	Total>	360.25	110.18	610.39	300.93	300.93	18187
24	4.80	Total>	383.64	124.26	643.10	325.57	325.57	18939
25	3.60	Total>	407.10	138.40	675.87	350.39	350.39	19692
26	2.80	Total>	422.78	147.87	697.76	367.06	367.06	20193
27	2.00	Total>	438.48	157.36	719.67	383.84	383.84	20694

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	16.77	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	16.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	172.09	144.69	144.69	18783
15	15.55	Total>	10.01	2.50m	185.99	145.63	145.63	19278
16	14.38	Total>	33.86	8.37m	218.96	149.31	149.31	20442
17	13.20	Total>	58.49	14.25m	252.72	159.33	159.33	21606
18	12.00	Total>	84.39	20.25m	287.93	176.94	176.94	22794
19	10.80	Total>	110.72	26.25m	323.58	199.62	199.62	23983

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.6 Excavate to elevation 16.05 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
20	9.60	Total>	137.24	32.25m	359.41	224.70	224.70	25171
21	8.40	Total>	163.80	38.25m	395.29	250.39	250.39	26360
22	7.20	Total>	190.37	44.25m	431.18	275.89	275.89	27548
23	6.00	Total>	216.94	50.25m	467.07	301.06	301.06	28736
24	4.80	Total>	243.53	56.25m	502.97	325.98	325.98	29925
25	3.60	Total>	270.13	62.25m	538.89	350.75	350.75	31113
26	2.80	Total>	287.88	66.25m	562.86	367.16	367.16	31906
27	2.00	Total>	305.65	70.25m	586.83	383.46	383.46	32698

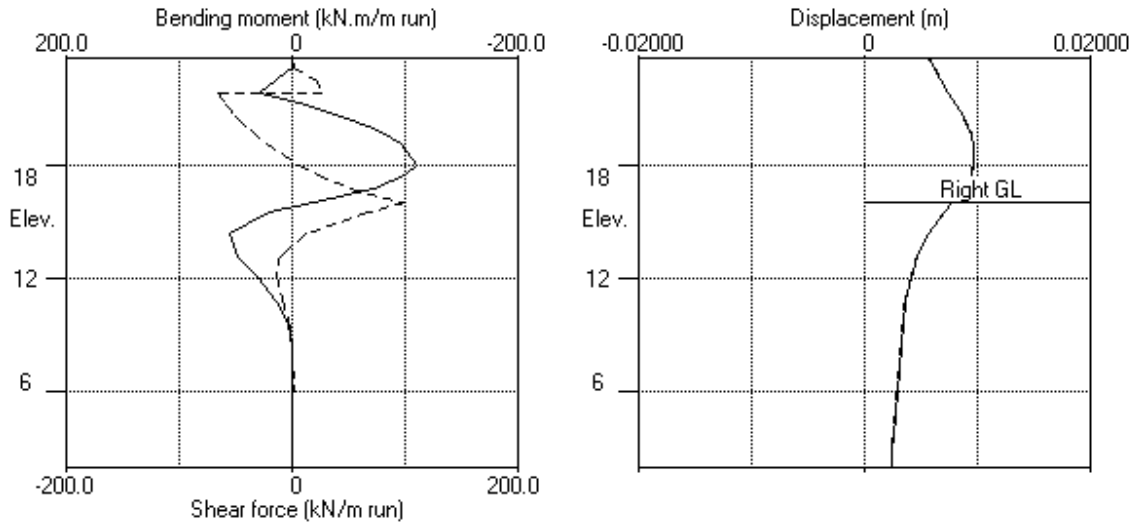
Note: 28.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Design Case 2  
 New contig wall

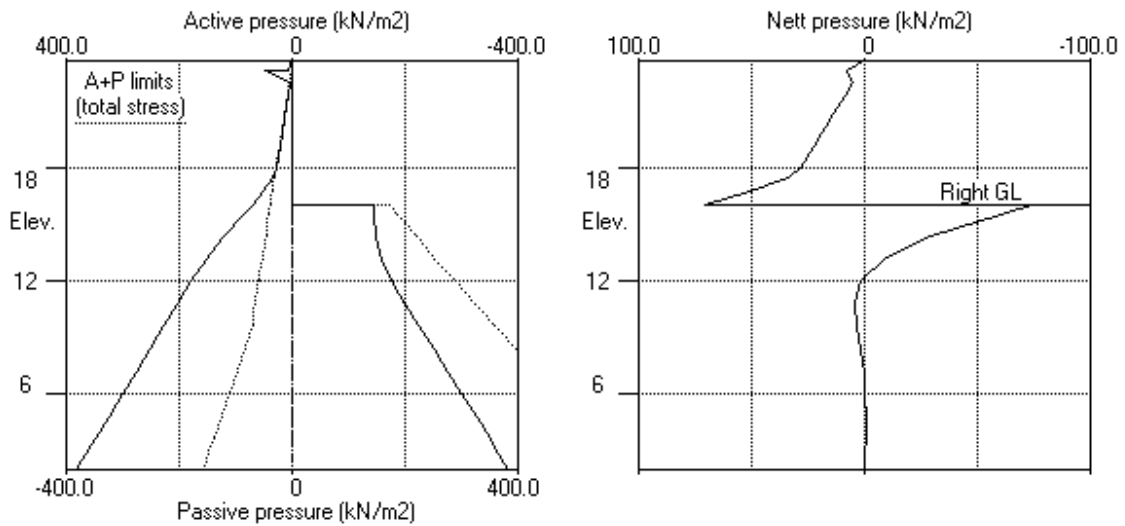
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 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.6 Excav. to elev. 16.05 on RIGHT side



Stage No.6 Excav. to elev. 16.05 on RIGHT side





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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 8 Fill to elevation 17.50 on RIGHT side with soil type 2

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
8	23.70	17.50	21.90	3.589	n/a	17.16	0.34	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m	
1	23.70	0.00	0.006	-8.19E-04	0.0	-0.0		
2	23.50	3.70	0.006	-8.19E-04	0.4	0.0		
3	23.25	8.32	0.006	-8.19E-04	1.9	0.3		
		47.04	0.006	-8.19E-04	1.9	0.3		
4	22.58	5.63	0.007	-8.46E-04	19.6	12.7		
5	21.90	9.00	0.007	-9.31E-04	24.6	27.8	-92.9	
		9.00	0.007	-9.31E-04	-68.3	27.8		
6	21.24	12.60	0.008	-9.58E-04	-61.2	-14.6		
7	20.59	16.45	0.009	-8.31E-04	-51.7	-47.7		
8	20.50	16.99	0.009	-8.04E-04	-50.2	-52.3		
9	19.85	20.97	0.009	-5.33E-04	-37.9	-82.2		
10	19.20	25.14	0.009	-1.62E-04	-22.9	-103.0		
11	18.00	33.37	0.009	6.43E-04	12.2	-114.2		
12	17.50	40.17	0.009	9.75E-04	30.6	-100.8		
13	16.77	52.64	0.008	1.35E-03	64.2	-68.3		
14	16.05	61.97	0.007	1.52E-03	105.8	-8.1		
		-82.71	0.007	1.52E-03	105.8	-8.1		
15	15.55	-66.86	0.006	1.48E-03	68.4	34.5		
16	14.38	-32.35	0.004	1.11E-03	10.1	68.1		
17	13.20	-8.76	0.003	6.57E-04	-14.1	57.2		
18	12.00	2.88	0.003	3.20E-04	-17.6	33.5		
19	10.80	5.87	0.003	1.44E-04	-12.3	14.0		
20	9.60	4.75	0.002	8.11E-05	-6.0	3.0		
21	8.40	2.63	0.002	7.45E-05	-1.5	-1.2		
22	7.20	0.94	0.002	8.53E-05	0.6	-1.7		
23	6.00	-0.02	0.002	9.46E-05	1.2	-0.8		
24	4.80	-0.41	0.002	9.78E-05	0.9	-0.0		
25	3.60	-0.44	0.002	9.71E-05	0.4	0.2		
26	2.80	-0.29	0.002	9.61E-05	0.1	0.2		
27	2.00	0.03	0.002	9.57E-05	0.0	-0.0		
At elev. 21.90			Prop force =		92.9 kN/m run (horiz.)			
					= 131.4 kN/m run (inclined)			

(continued)

Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	9213
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	9213
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	9213
		Total>	8.33	2.25m	124.54	47.04	47.04	22620
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	23918
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	25216
6	21.24	Total>	52.45	12.28m	184.23	12.60	12.60	6780
7	20.59	Total>	76.40	15.55m	213.27	16.45	16.45	7102
8	20.50	Total>	79.51	16.00m	217.08	16.99	16.99	7146
9	19.85	Total>	98.85	19.25m	241.46	20.97	20.97	7466
10	19.20	Total>	113.76	22.50m	261.42	25.14	25.14	7786
11	18.00	Total>	136.33	28.50m	293.31	33.37	33.37	8377
12	17.50	Total>	145.14	31.00m	306.00	40.17	40.17	8623
13	16.77	Total>	142.29	34.63m	308.77	58.79	58.79	8980
14	16.05	Total>	170.67	38.25m	342.79	80.34	80.34	9337
15	15.55	Total>	179.60	40.75m	355.60	96.07	96.07	9583
16	14.38	Total>	200.90	46.63m	386.02	132.21	132.21	10162
17	13.20	Total>	222.58	52.50m	416.82	164.20	164.20	10740
18	12.00	Total>	245.04	58.50m	448.60	192.16	192.16	11331
19	10.80	Total>	267.76	64.50m	480.64	216.90	216.90	11922
20	9.60	Total>	290.68	70.50m	512.87	240.21	240.21	12512
21	8.40	Total>	313.75	82.31	545.26	263.30	263.30	13103
22	7.20	Total>	336.95	96.19	577.77	286.73	286.73	13694
23	6.00	Total>	360.25	110.18	610.39	310.60	310.60	14285
24	4.80	Total>	383.64	124.26	643.10	334.84	334.84	14875
25	3.60	Total>	407.10	138.40	675.87	359.33	359.33	15466
26	2.80	Total>	422.78	147.87	697.76	375.78	375.78	15860
27	2.00	Total>	438.48	157.36	719.67	392.33	392.33	16254

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	160.84	0.00	0.00a	8688
13	16.77	Total>	14.50	3.63m	180.97	6.15	6.15	9047
14	16.05	Total>	29.02	7.25m	201.12	18.36	18.36	9407
		Total>	29.02	7.25m	201.12	163.05	163.05	9407
15	15.55	Total>	39.05	9.75m	215.03	162.93	162.93	9655
16	14.38	Total>	62.69	15.62m	247.80	164.56	164.56	10238
17	13.20	Total>	86.49	21.50m	280.72	172.96	172.96	10821
18	12.00	Total>	111.00	27.50m	314.54	189.28	189.28	11416

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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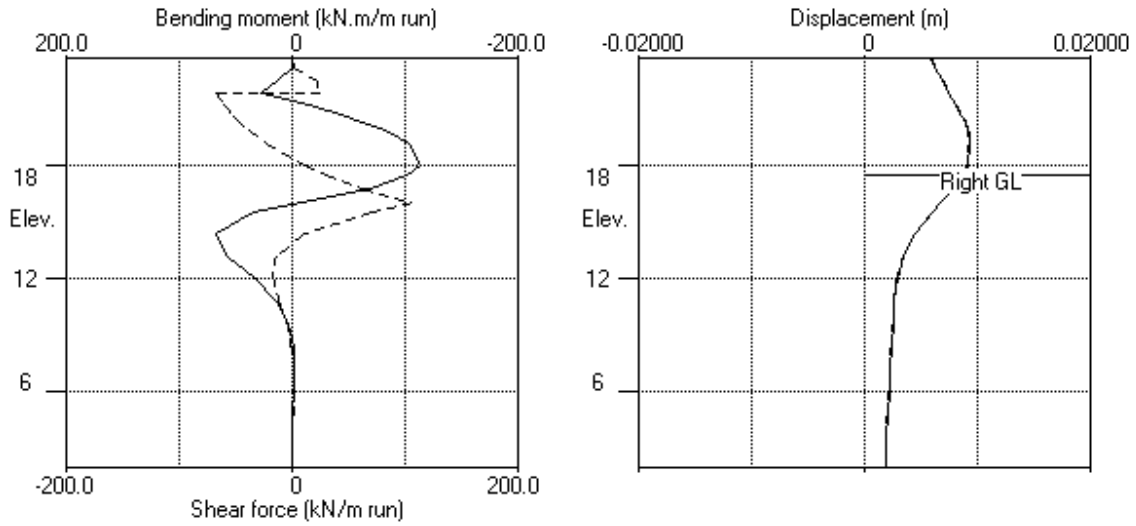
Stage No.8 Fill to elevation 17.50 on RIGHT side with soil type 2

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
19	10.80	Total>	135.73	33.50m	348.59	211.03	211.03	12011
20	9.60	Total>	160.71	39.50m	382.89	235.46	235.46	12606
21	8.40	Total>	185.93	45.50m	417.42	260.67	260.67	13201
22	7.20	Total>	211.38	51.50m	452.19	285.79	285.79	13797
23	6.00	Total>	237.04	57.50m	487.17	310.62	310.62	14392
24	4.80	Total>	262.89	63.50m	522.34	335.25	335.25	14987
25	3.60	Total>	288.89	69.50m	557.66	359.77	359.77	15582
26	2.80	Total>	306.30	73.50m	581.27	376.07	376.07	15979
27	2.00	Total>	323.75	77.50m	604.94	392.30	392.30	16376

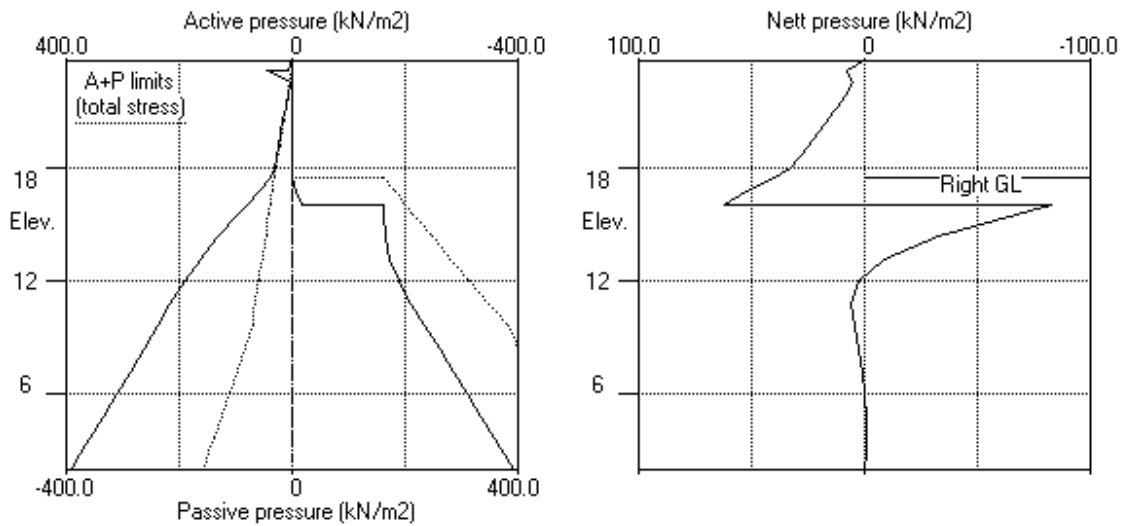
Note: 0.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.8 Fill to elev. 17.50 on RIGHT side



Stage No.8 Fill to elev. 17.50 on RIGHT side



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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 12 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>at elev.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>		
			<u>Safety</u>	<u>More than one prop.</u>	<u>No</u>	<u>FoS calc.</u>	<u>failure</u>		
12	23.70	17.50							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	23.70	0.00	0.006	-1.99E-03	0.0	-0.0			
2	23.50	3.70	0.006	-1.99E-03	0.4	0.0	-75.4		
		3.70	0.006	-1.99E-03	-75.1	0.0			
3	23.25	8.32	0.007	-1.97E-03	-73.6	-18.6			
		29.94	0.007	-1.97E-03	-73.6	-18.6			
4	22.58	11.25	0.008	-1.81E-03	-59.7	-59.5			
5	21.90	19.54	0.009	-1.49E-03	-49.3	-96.3			
6	21.24	30.93	0.010	-1.04E-03	-32.7	-123.4			
7	20.59	45.44	0.010	-5.27E-04	-7.7	-133.2			
8	20.50	47.35	0.010	-4.53E-04	-3.6	-133.7			
9	19.85	59.73	0.011	6.87E-05	31.2	-126.2			
10	19.20	70.08	0.010	5.09E-04	73.4	-93.4			
11	18.00	86.92	0.010	6.87E-04	167.6	45.6	-308.1		
		86.92	0.010	6.87E-04	-140.4	45.6			
12	17.50	93.66	0.009	6.33E-04	-95.3	-10.7			
		90.05	0.009	6.33E-04	-95.3	-10.7			
13	16.77	92.88	0.009	7.85E-04	-29.0	-57.2			
14	16.05	87.83	0.008	1.03E-03	36.5	-55.1			
		26.50	0.008	1.03E-03	36.5	-55.1			
15	15.55	9.09	0.008	1.17E-03	45.4	-34.9			
16	14.38	-15.26	0.006	1.26E-03	41.8	11.0			
17	13.20	-27.20	0.005	1.05E-03	16.8	46.0			
18	12.00	-9.46	0.004	7.14E-04	-5.2	46.1			
19	10.80	-0.44	0.003	4.22E-04	-11.1	32.7			
20	9.60	2.76	0.003	2.32E-04	-9.7	18.6			
21	8.40	3.07	0.002	1.32E-04	-6.2	8.4			
22	7.20	2.33	0.002	9.15E-05	-3.0	2.7			
23	6.00	1.30	0.002	8.06E-05	-0.8	0.3			
24	4.80	0.44	0.002	8.08E-05	0.3	-0.3			
25	3.60	-0.09	0.002	8.30E-05	0.5	-0.3			
26	2.80	-0.12	0.002	8.39E-05	0.4	-0.1			

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.12 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
27	2.00	-0.85	0.002	8.41E-05	0.0	-0.0	
					Prop force =		75.4 kN/m run
					Prop force =		308.1 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	80732
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	3502
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	3502
			4.50	3.83	0.00	25.89	25.44	3378
4	22.58	11.25	10.57	0.00	42.18	0.00	11.25a	3671
5	21.90	18.00	17.33	1.54	58.48	1.54	19.54a	3964
6	21.24	24.55	27.90	6.38	84.01	6.38	30.93a	4248
7	20.59	31.10	45.30	14.34	126.00	14.34	45.44a	4533
8	20.50	32.00	47.51	15.35	131.35	15.35	47.35a	4572
9	19.85	38.50	60.35	21.23	162.34	21.23	59.73a	4854
10	19.20	45.00	68.76	25.08	182.65	25.08	70.08a	5136
11	18.00	57.00	79.33	29.92	208.16	29.92	86.92a	5657
12	17.50	62.00	83.14	31.66	217.37	31.66	93.66a	5874
13	16.77	69.25	88.61	34.16	230.56	34.16	103.41a	6188
14	16.05	76.50	94.17	36.71	243.99	36.71	113.21a	6503
15	15.55	81.50	98.10	38.51	253.48	38.51	120.01a	6720
16	14.38	93.25	107.65	42.87	276.52	42.87	136.12a	7230
17	13.20	105.00	117.58	47.42	300.50	49.98	154.98	7740
18	12.00	117.00	128.04	52.21	325.76	68.99	185.99	8260
19	10.80	129.00	138.76	57.11	351.63	84.75	213.75	8781
20	9.60	141.00	149.68	62.11	377.98	98.21	239.21	9302
21	8.40	153.00	160.75	67.18	404.71	110.52	263.52	11839
22	7.20	165.00	171.95	72.30	431.75	122.42	287.42	12467
23	6.00	177.00	183.25	77.47	459.03	134.26	311.26	13094
24	4.80	189.00	194.64	82.68	486.52	146.27	335.27	13722
25	3.60	201.00	206.10	87.93	514.19	158.51	359.51	14350
26	2.80	209.00	213.78	91.44	532.72	166.86	375.86	54824
27	2.00	217.00	221.48	94.97	551.31	174.89	391.89	56377

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.85	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	16.66	3.61	3.61	5874

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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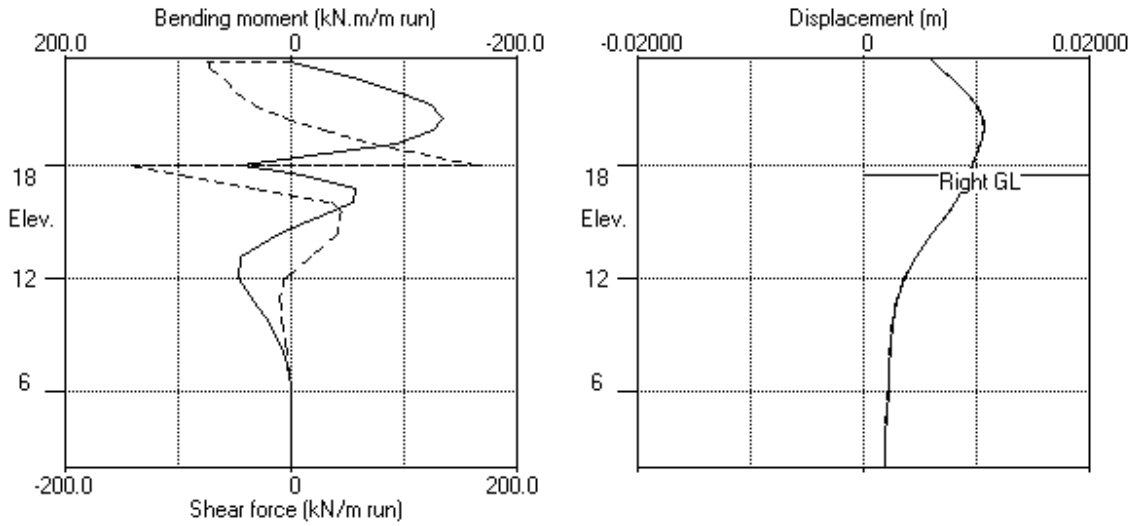
Stage No.12 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
13	16.77	0.00	14.50	0.25	51.67	10.54	10.54	6188
14	16.05	0.00	29.02	6.89	86.71	25.38	25.38	6503
		0.00	29.02	6.89	86.71	86.71	86.71p	6503
15	15.55	0.00	39.05	11.48	110.92	110.92	110.92p	6720
16	14.38	11.75	50.94	16.92	139.64	139.64	151.39p	7230
17	13.20	23.50	62.99	22.44	168.72	158.68	182.18	7740
18	12.00	35.50	75.50	28.16	198.91	159.95	195.45	8260
19	10.80	47.50	88.23	33.99	229.65	166.68	214.18	8781
20	9.60	59.50	101.21	39.93	260.98	176.95	236.45	9302
21	8.40	71.50	114.43	45.98	292.89	188.95	260.45	11839
22	7.20	83.50	127.88	52.13	325.36	201.60	285.10	12467
23	6.00	95.50	141.54	58.39	358.35	214.47	309.97	13094
24	4.80	107.50	155.39	64.72	391.77	227.32	334.82	13722
25	3.60	119.50	169.39	71.13	425.57	240.09	359.59	14350
26	2.80	127.50	178.80	75.43	448.28	248.48	375.98	54824
27	2.00	135.50	188.25	79.76	471.10	257.24	392.74	56377

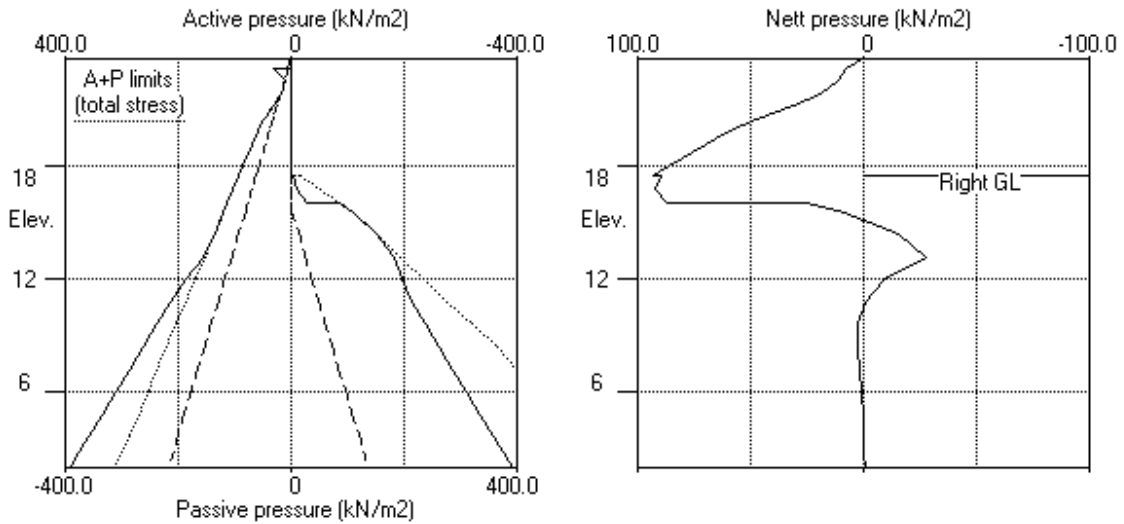
Note: 136.12a Soil pressure at active limit  
 151.39p Soil pressure at passive limit

Units: kN, m

Stage No.12 Change soil type 2 to soil type 4



Stage No.12 Change soil type 2 to soil type 4





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 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 2.00</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	20.50	Cant.	4.348	3.59	19.28	1.22	L to R
4	23.70	20.50		No analysis at this stage				
5	23.70	20.50		No analysis at this stage				
6	23.70	16.05	21.90	3.036	n/a	15.50	0.55	L to R
7	23.70	16.05		No analysis at this stage				
8	23.70	17.50	21.90	3.589	n/a	17.16	0.34	L to R
9	23.70	17.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Data filename/Run ID: Design\_Case\_02\_with\_prop\_ULS2  
 Design Case 2  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.008	-0.000	0.0	-0.0	0.0	0.0
2	23.50	0.008	-0.000	0.0	-0.0	0.4	-75.1
3	23.25	0.007	0.000	0.3	-18.6	1.9	-73.6
4	22.58	0.008	0.000	13.5	-59.5	20.8	-59.7
5	21.90	0.009	0.000	29.4	-96.3	25.8	-68.3
6	21.24	0.010	0.000	16.0	-123.4	16.4	-61.2
7	20.59	0.010	0.000	33.8	-133.2	26.2	-51.7
8	20.50	0.010	0.000	36.2	-133.7	27.9	-50.2
9	19.85	0.011	0.000	45.1	-126.2	31.2	-37.9
10	19.20	0.010	0.000	42.9	-103.0	73.4	-23.2
11	18.00	0.010	0.000	45.6	-114.2	167.6	-140.4
12	17.50	0.009	0.000	19.1	-100.8	30.6	-95.3
13	16.77	0.009	0.000	11.0	-72.7	64.2	-29.0
14	16.05	0.008	0.000	5.5	-55.1	105.8	-5.9
15	15.55	0.008	0.000	40.1	-34.9	68.4	-3.8
16	14.38	0.006	0.000	68.1	0.0	41.8	-0.5
17	13.20	0.005	0.000	57.2	0.0	16.8	-14.7
18	12.00	0.004	0.000	46.1	0.0	0.9	-17.6
19	10.80	0.004	0.000	32.7	0.0	0.5	-12.3
20	9.60	0.003	0.000	18.6	0.0	0.2	-9.7
21	8.40	0.003	0.000	8.4	-1.2	0.1	-6.2
22	7.20	0.003	0.000	2.7	-1.7	0.6	-3.0
23	6.00	0.003	0.000	1.0	-0.8	1.2	-0.8
24	4.80	0.003	0.000	1.0	-0.3	0.9	-0.0
25	3.60	0.003	0.000	0.6	-0.3	0.5	-0.1
26	2.80	0.002	0.000	0.3	-0.1	0.4	-0.1
27	2.00	0.002	0.000	0.0	-0.0	0.0	0.0

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 Design Case 2  
 New contig wall

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**Summary of results (continued)**

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment				Shear force			
	<u>maximum</u> kN.m/m	<u>elev.</u>	<u>minimum</u> kN.m/m	<u>elev.</u>	<u>maximum</u> kN/m	<u>elev.</u>	<u>minimum</u> kN/m	<u>elev.</u>
1	3.1	13.20	-16.9	19.20	5.5	16.77	-8.4	20.59
2	2.9	12.00	-17.4	19.20	5.3	16.77	-8.6	20.59
3	45.1	19.85	-0.0	23.70	27.9	20.50	-13.4	18.00
4	No calculation at this stage							
5	No calculation at this stage							
6	54.8	14.38	-109.9	18.00	98.2	16.05	-65.7	21.90
7	No calculation at this stage							
8	68.1	14.38	-114.2	18.00	105.8	16.05	-68.3	21.90
9	No calculation at this stage							
10	No calculation at this stage							
11	67.4	14.38	-102.3	19.85	94.9	16.05	-56.2	23.50
12	46.1	12.00	-133.7	20.50	167.6	18.00	-140.4	18.00
13	46.1	12.00	-133.7	20.50	167.6	18.00	-140.4	18.00

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				<u>Stage description</u>
	<u>maximum</u> m	<u>elev.</u>	<u>minimum</u> m	<u>elev.</u>	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.2
3	0.008	23.70	0.000	23.70	Excav. to elev. 20.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 21.90
5	No calculation at this stage				Apply surcharge no.2 at elev. 16.05
6	0.010	19.20	0.000	23.70	Excav. to elev. 16.05 on RIGHT side
7	No calculation at this stage				Remove surcharge no.2 at elev. 16.05
8	0.009	19.20	0.000	23.70	Fill to elev. 17.50 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 18.00
10	No calculation at this stage				Install prop no.3 at elev. 23.50
11	0.010	19.85	0.000	23.70	Remove prop no.1 at elev. 21.90
12	0.011	19.85	0.000	23.70	Change soil type 2 to soil type 4
13	0.011	19.85	0.000	23.70	Apply water pressure profile no.2

Run ID. Design\_Case\_02\_with\_prop\_ULS2  
Design Case 2  
New contig wall

Sheet No.  
Date:13-05-2020  
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**Summary of results (continued)**

**Prop forces at each stage (horizontal components)**

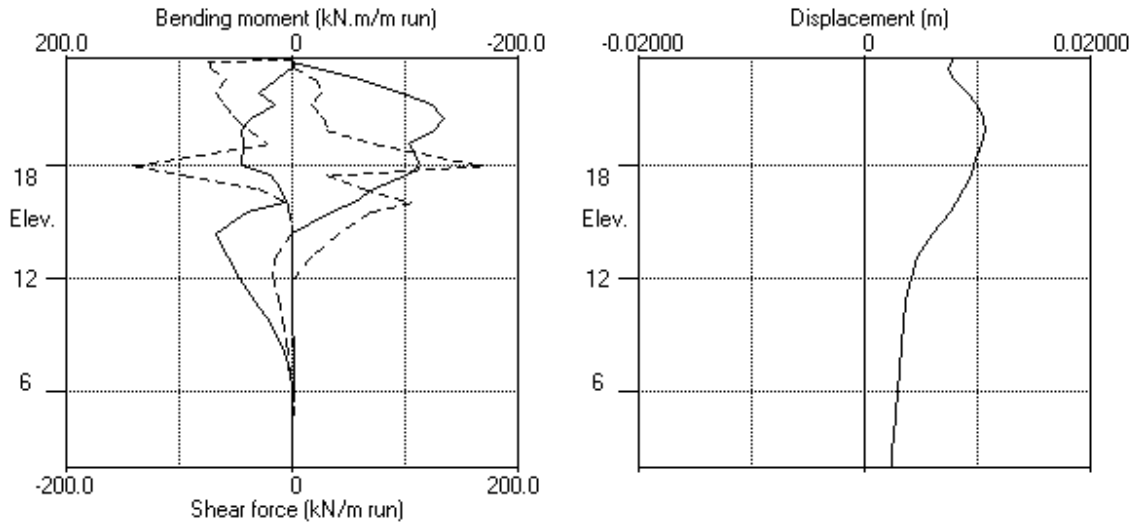
Stage no.	--- Strut no. 1 --- at elev. 21.90		--- Strut no. 2 --- at elev. 18.00		--- Strut no. 3 --- at elev. 23.50	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
6	91.46	548.76	---	---	---	---
8	92.90	557.41	---	---	---	---
11	---	---	46.15	46.15	56.55	56.55
12	---	---	308.06	308.06	75.44	75.44
13	---	---	308.06	308.06	75.44	75.44

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Bending moment, shear force, displacement envelopes



DESIGN CASE 03

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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	23.25	2 London Clay		2 London Clay
3	8.75	3 Lambeth Group		3 Lambeth Group

**SOIL PROPERTIES**

No.	Description	Bulk density kN/m3	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. ( Nu ) ( NC/OC )	Active limit Ka ( Kac )	Passive limit Kp ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 (2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390 )
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08 )
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610 )	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185 )	1.000 ( 1.000 )	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

Initial water table elevation      Left side      Right side  
 20.59      20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	16.50	16.50	0.0 MC+WC
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	23.50	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m <sup>2</sup>	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.90	1.20(L)	32.15	1.00	100.00	=	=	N/A	1.00 -
2	17.50	-0.00(R)	23.80	20.00	12.00	=	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable

P/F = Permanent Favourable

Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 17.50 on RIGHT side
4	Apply surcharge no.2 at elevation 17.50
5	Install strut or anchor no.2 at elevation 18.00
6	Install strut or anchor no.1 at elevation 23.50
7	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
8	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State

All loads and soil strengths are unfactored

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/m<sup>3</sup>

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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m



## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 17.50 on RIGHT side	Yes	Yes	Yes
4	Apply surcharge no.2 at elev. 17.50	Yes	Yes	Yes
5	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
6	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
7	Change soil type 2 to soil type 4	Yes	Yes	Yes
8	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

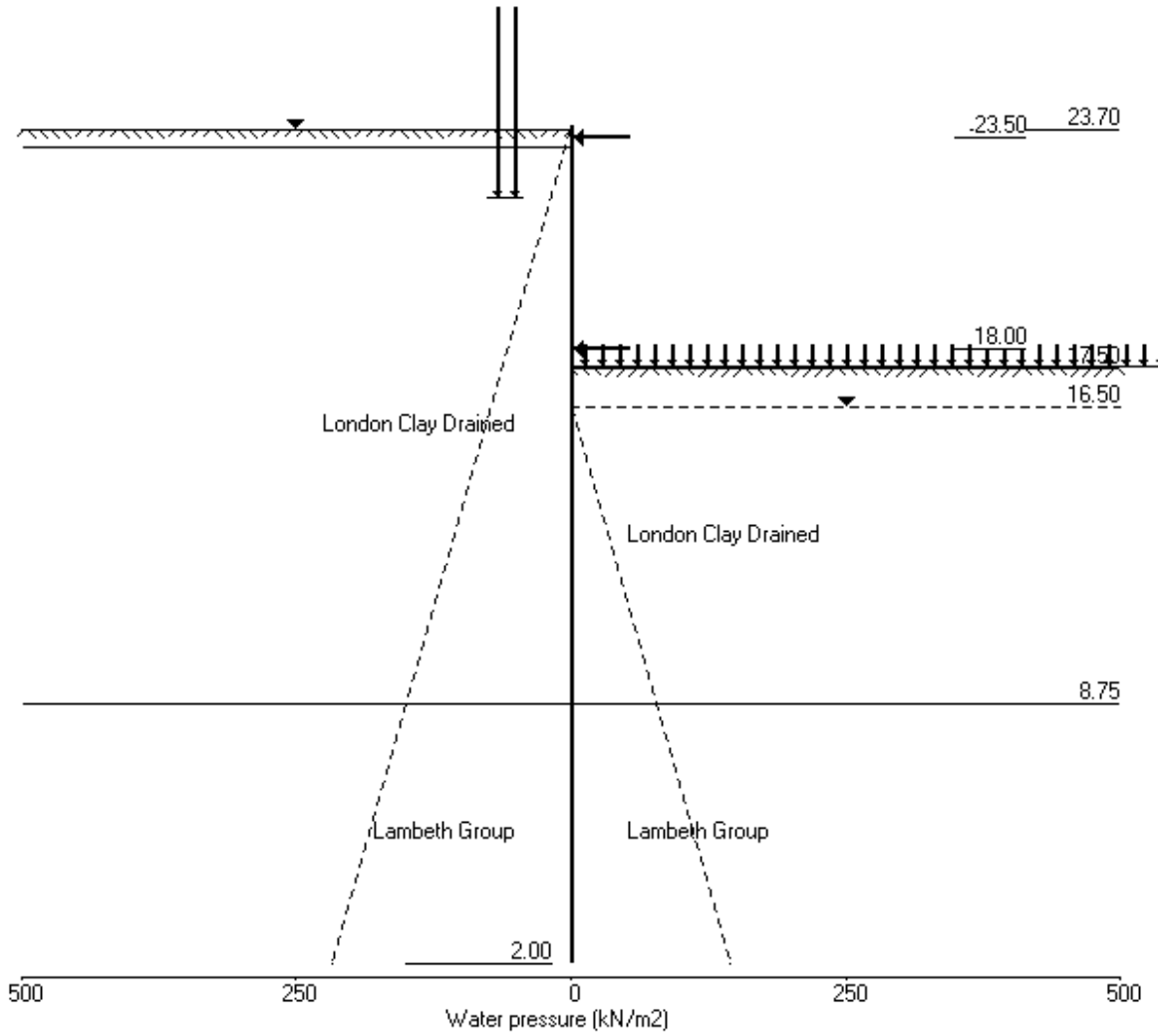
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Stage No.8 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Design Case 3  
 New contig wall

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Stage No. 3 Excavate to elevation 17.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr-ation	
3	23.70	17.50	Cant.	3.187	3.00	14.88	2.62	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.060	7.65E-03	0.0	0.0	
2	23.50	3.70	0.058	7.65E-03	0.4	0.0	
3	23.25	8.33	0.056	7.65E-03	1.9	0.3	
		2.25	0.056	7.65E-03	1.9	0.3	
4	22.58	5.63	0.051	7.64E-03	4.5	2.5	
5	21.90	9.00	0.046	7.62E-03	9.5	7.4	
6	21.24	12.28	0.041	7.58E-03	16.4	16.0	
7	20.59	15.55	0.036	7.48E-03	25.5	29.8	
8	19.90	19.02	0.031	7.31E-03	37.6	51.9	
9	19.20	22.50	0.026	7.02E-03	52.0	83.0	
10	18.00	28.50	0.018	6.10E-03	82.6	163.7	
11	17.50	31.00	0.015	5.53E-03	97.5	208.7	
		-102.60	0.015	5.53E-03	97.5	208.7	
12	16.50	-80.06	0.010	4.10E-03	6.1	252.4	
13	15.45	-33.90	0.007	2.52E-03	-53.7	235.5	
14	14.40	9.05	0.005	1.24E-03	-66.7	160.1	
15	13.20	25.54	0.004	3.28E-04	-46.0	86.1	
16	12.00	19.29	0.004	-1.71E-04	-19.1	48.8	
17	10.80	-2.28	0.004	-4.97E-04	-8.9	39.3	
18	9.78	-31.17	0.005	-7.13E-04	-26.0	28.7	
19	8.75	-67.15	0.005	-7.58E-04	-76.4	-14.6	
		63.71	0.005	-7.58E-04	-76.4	-14.6	
20	7.98	45.82	0.006	-5.92E-04	-34.0	-54.8	
21	7.20	28.77	0.006	-2.99E-04	-5.1	-67.5	
22	6.00	7.96	0.006	1.49E-04	17.0	-53.4	
23	4.80	-4.11	0.006	4.50E-04	19.3	-27.8	
24	3.60	-8.33	0.005	5.83E-04	11.8	-8.2	
25	2.80	-7.89	0.005	6.08E-04	5.4	-1.6	
26	2.00	-5.50	0.004	6.12E-04	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 17.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	4201
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4201
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	4201
		Total>	8.33	2.25m	171.02	2.25	2.25a	10314
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	10906
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	11497
6	21.24	Total>	52.45	12.28m	236.93	12.28	12.28a	12072
7	20.59	Total>	76.40	15.55m	268.00	15.55	15.55a	12646
8	19.90	Total>	97.68	19.02m	296.83	19.02	19.02a	13255
9	19.20	Total>	113.76	22.50m	320.46	22.50	22.50a	13864
10	18.00	Total>	136.33	28.50m	356.07	28.50	28.50a	14916
11	17.50	Total>	145.14	31.00m	370.32	31.00	31.00a	15354
12	16.50	Total>	162.70	36.00m	398.74	36.00	36.00a	16231
13	15.45	Total>	181.40	41.25m	428.85	74.62	74.62	17151
14	14.40	Total>	200.44	46.50m	459.30	122.18	122.18	18072
15	13.20	Total>	222.58	52.50m	494.48	155.95	155.95	19124
16	12.00	Total>	245.04	58.50m	529.98	175.51	175.51	20176
17	10.80	Total>	267.76	64.50m	565.74	185.67	185.67	21228
18	9.78	Total>	287.32	69.63m	596.44	187.96	187.96	22126
19	8.75	Total>	307.01	74.75m	627.26	185.98	185.98	23025
		Total>	307.01	144.81	469.25	268.16	268.16	7346
20	7.98	Total>	321.95	134.67	509.29	272.71	272.71	8481
21	7.20	Total>	336.95	124.58	549.37	277.86	277.86	9616
22	6.00	Total>	360.25	109.05	611.53	289.49	289.49	11374
23	4.80	Total>	383.64	94.50m	673.76	306.75	306.75	13132
24	3.60	Total>	407.10	100.50m	736.08	329.08	329.08	14890
25	2.80	Total>	422.78	104.50m	777.65	346.06	346.06	16063
26	2.00	Total>	438.48	108.50m	819.25	364.30	364.30	17235

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	133.60	133.60	8687
12	16.50	Total>	20.01	5.00m	256.05	116.06	116.06	9183
13	15.45	Total>	41.06	10.25m	288.51	108.51	108.51	9704
14	14.40	Total>	62.19	15.50m	321.05	113.13	113.13	10224
15	13.20	Total>	86.49	21.50m	358.39	130.41	130.41	10820
16	12.00	Total>	111.00	27.50m	395.93	156.22	156.22	11415
17	10.80	Total>	135.73	33.50m	433.71	187.94	187.94	12010
18	9.78	Total>	157.05	38.62m	466.17	219.13	219.13	12518
19	8.75	Total>	178.55	43.75m	498.80	253.13	253.13	13027
		Total>	178.55	43.75m	340.79	204.45	204.45	4156

Run ID. Design\_Case\_03\_no\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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(continued)

Stage No.3 Excavate to elevation 17.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m2	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u> kN/m2	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m3
			<u>Vertic</u> <u>-al</u> kN/m2	<u>Active</u> <u>limit</u> kN/m2	<u>Passive</u> <u>limit</u> kN/m2	<u>Earth</u> <u>pressure</u> kN/m2		
20	7.98	Total>	194.92	47.62m	382.25	226.89	226.89	4798
21	7.20	Total>	211.38	51.50m	423.81	249.09	249.09	5441
22	6.00	Total>	237.04	57.50m	488.32	281.52	281.52	6435
23	4.80	Total>	262.89	63.50m	553.02	310.86	310.86	7430
24	3.60	Total>	288.89	69.50m	617.87	337.40	337.40	8425
25	2.80	Total>	306.30	73.50m	661.17	353.95	353.95	9088
26	2.00	Total>	323.75	77.50m	704.52	369.80	369.80	9751

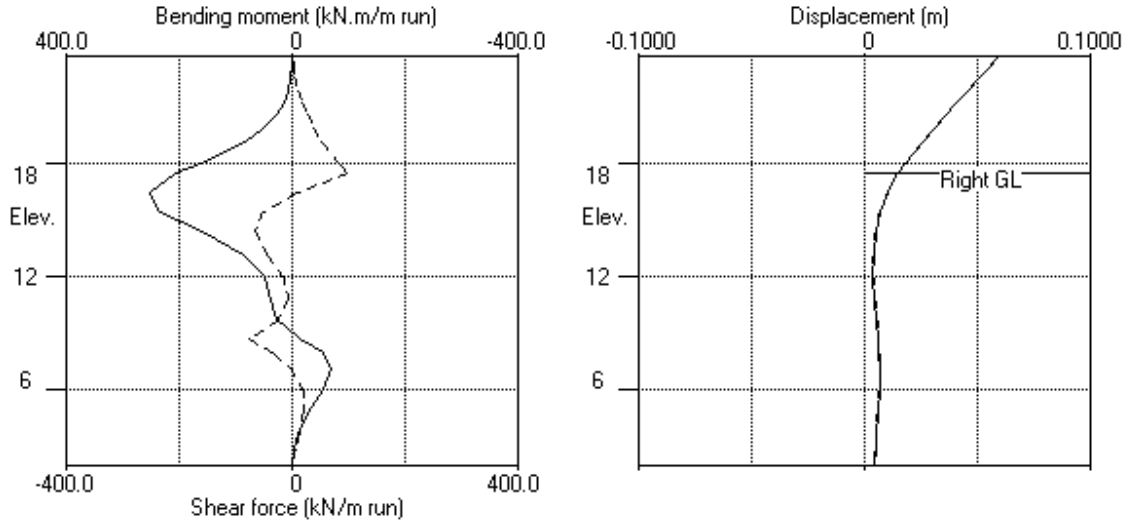
Note: 36.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Design Case 3  
 New contig wall

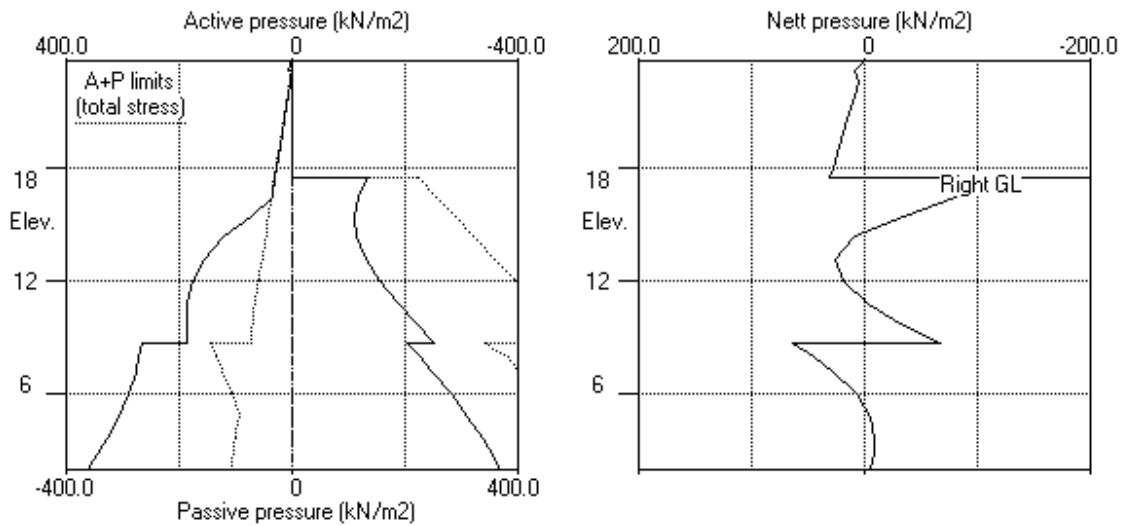
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 17.50 on RIGHT side



Stage No.3 Excav. to elev. 17.50 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
7	23.70	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.060	7.79E-03	0.0	0.0	
2	23.50	3.70	0.058	7.79E-03	0.4	0.0	-1.0
3	23.25	3.70	0.058	7.79E-03	-0.6	0.0	
		8.33	0.056	7.79E-03	0.9	0.0	
4	22.58	2.26	0.056	7.79E-03	0.9	0.0	
		5.68	0.051	7.79E-03	3.6	1.7	
5	21.90	9.12	0.046	7.77E-03	8.6	5.9	
6	21.24	12.85	0.041	7.73E-03	15.8	13.9	
7	20.59	22.04	0.036	7.65E-03	27.2	27.9	
8	19.90	34.48	0.031	7.47E-03	46.8	53.3	
9	19.20	44.94	0.025	7.15E-03	74.4	95.2	
10	18.00	60.99	0.017	5.98E-03	138.0	221.1	-157.1
		60.99	0.017	5.98E-03	-19.1	221.1	
11	17.50	67.45	0.015	5.30E-03	13.0	219.4	
		6.86	0.015	5.30E-03	13.0	219.4	
12	16.50	-41.12	0.010	3.94E-03	-4.1	221.3	
13	15.45	-25.49	0.007	2.54E-03	-39.1	210.1	
14	14.40	0.01	0.005	1.36E-03	-52.5	152.0	
15	13.20	19.53	0.004	4.77E-04	-40.7	88.6	
16	12.00	16.58	0.003	-4.88E-05	-19.1	53.3	
17	10.80	-1.83	0.004	-4.02E-04	-10.2	42.0	
18	9.78	-28.03	0.004	-6.30E-04	-25.5	30.3	
19	8.75	-61.30	0.005	-6.92E-04	-71.3	-10.9	
		58.76	0.005	-6.92E-04	-71.3	-10.9	
20	7.98	42.38	0.005	-5.49E-04	-32.1	-48.6	
21	7.20	26.70	0.006	-2.87E-04	-5.4	-60.9	
22	6.00	7.49	0.006	1.17E-04	15.2	-48.5	
23	4.80	-3.65	0.005	3.92E-04	17.5	-25.4	
24	3.60	-7.52	0.005	5.14E-04	10.8	-7.6	
25	2.80	-7.10	0.004	5.36E-04	4.9	-1.5	

Run ID. Design\_Case\_03\_no\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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(continued)

Stage No.7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
26	2.00	-5.19	0.004	5.40E-04	0.0	-0.0	
					Prop force =		1.0 kN/m run
					Prop force =		157.1 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	51904
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	51904
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	5813
			0.00	8.33	0.00	49.41	2.26	5764
4	22.58	0.00	21.82	1.11	90.49	5.68	5.68	6264
5	21.90	0.00	35.33	6.29	131.58	9.12	9.12	6763
6	21.24	0.00	52.45	12.85	183.70	12.85	12.85a	7248
7	20.59	0.00	76.40	22.04	256.58	22.04	22.04a	7733
8	19.90	6.95	90.73	27.53	300.19	27.53	34.48a	8248
9	19.20	13.90	99.86	31.04	327.99	31.04	44.94a	8763
10	18.00	25.90	110.43	35.09	360.16	35.09	60.99a	6116
11	17.50	30.90	114.24	36.55	371.77	36.55	67.45a	6351
12	16.50	40.90	121.80	39.45	394.78	39.45	80.35a	6820
13	15.45	51.40	130.00	42.59	419.71	42.59	93.99a	7312
14	14.40	61.90	134.13	44.18	432.29	61.46	123.36	7805
15	13.20	73.90	148.68	49.76	476.57	84.67	158.57	8368
16	12.00	85.90	159.14	53.77	508.42	93.78	179.68	8931
17	10.80	97.90	169.86	57.88	541.04	93.38	191.28	9494
18	9.78	108.15	179.17	61.45	569.39	86.62	194.77	9975
19	8.75	118.40	188.61	65.07	598.09	75.59	193.99	11231
		Total>	307.01	144.81	469.25	270.78	270.78	7043
20	7.98	Total>	321.95	134.67	509.29	275.95	275.95	8132
21	7.20	Total>	336.95	124.58	549.37	281.64	281.64	9220
22	6.00	Total>	360.25	109.05	611.53	293.85	293.85	10906
23	4.80	Total>	383.64	94.50m	673.76	311.35	311.35	12591
24	3.60	Total>	407.10	100.50m	736.08	333.63	333.63	14277
25	2.80	Total>	422.78	104.50m	777.65	350.45	350.45	15401
26	2.00	Total>	438.48	108.50m	819.25	368.31	368.31	95469

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	12.00	0.00	60.59	60.59	60.59p	6351



Run ID. Design\_Case\_03\_no\_prop\_SLS  
 Design Case 3  
 New contig wall

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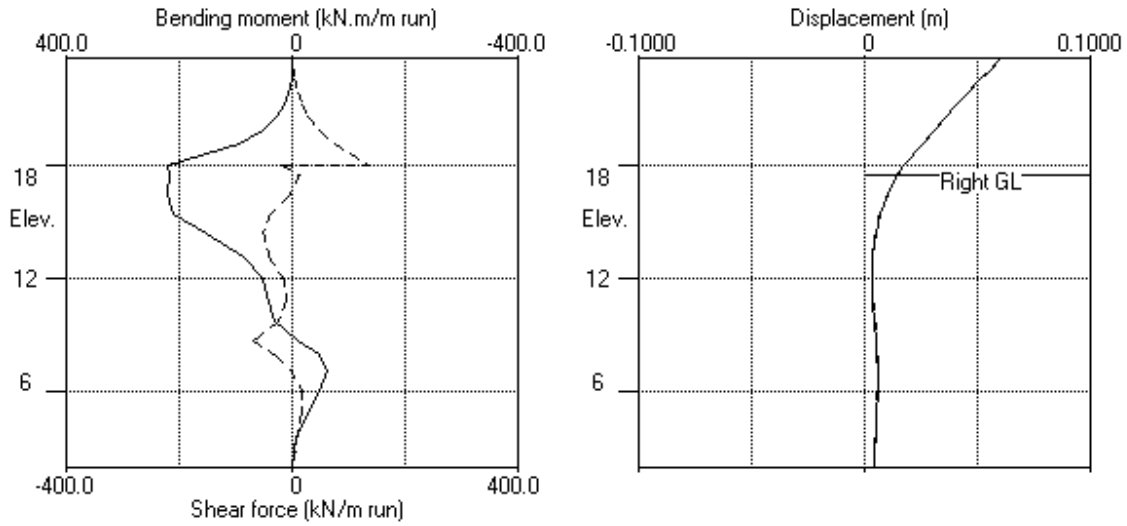
Stage No.7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
12	16.50	0.00	32.00	5.01	121.47	121.47	121.47p	6820
13	15.45	10.50	42.53	9.05	153.50	108.98	119.48	7312
14	14.40	21.00	53.10	13.10	185.67	102.36	123.36	7805
15	13.20	33.00	65.26	17.77	222.68	106.05	139.05	8368
16	12.00	45.00	77.55	22.48	260.08	118.11	163.11	8931
17	10.80	57.00	89.99	27.25	297.95	136.10	193.10	9494
18	9.78	67.25	100.76	31.38	330.72	155.56	222.81	9975
19	8.75	77.50	111.67	35.56	363.93	177.79	255.29	11231
		Total>	189.17	43.75m	351.41	212.02	212.02	7043
20	7.98	Total>	205.26	47.62m	392.60	233.57	233.57	8132
21	7.20	Total>	221.44	51.50m	433.86	254.95	254.95	9220
22	6.00	Total>	246.64	57.50m	497.91	286.35	286.35	10906
23	4.80	Total>	272.02	63.50m	562.14	315.00	315.00	12591
24	3.60	Total>	297.55	69.50m	626.53	341.15	341.15	14277
25	2.80	Total>	314.65	73.50m	669.52	357.55	357.55	15401
26	2.00	Total>	331.80	77.50m	712.57	373.50	373.50	95469

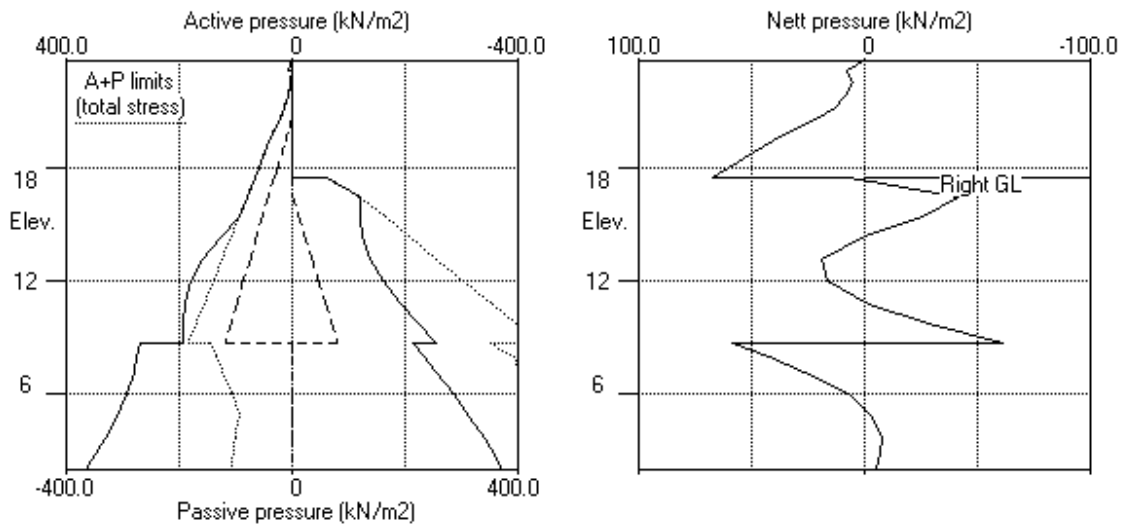
Note: 93.99a Soil pressure at active limit  
 121.47p Soil pressure at passive limit

Units: kN,m

Stage No.7 Change soil type 2 to soil type 4



Stage No.7 Change soil type 2 to soil type 4



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	17.50	Cant.	3.187	3.00	14.88	2.62	L to R
4	23.70	17.50	Cant.	3.379	3.07	14.96	2.54	L to R
5	23.70	17.50	No analysis at this stage					
All remaining stages have more than one prop - FoS calculation n/a								

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 New contig wall

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 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.060	-0.000	0	0	0	0	0	0	0	0
2	23.50	0.058	-0.000	0	0	0	0	0	-21	0	-29
3	23.25	0.056	0.000	0	-5	0	-7	2	-20	3	-27
4	22.58	0.051	0.000	3	-17	3	-22	5	-14	6	-18
5	21.90	0.046	0.000	7	-22	10	-29	9	-4	13	-5
6	21.24	0.041	0.000	16	-18	22	-24	16	-8	22	-10
7	20.59	0.036	0.000	30	-10	40	-14	39	-8	53	-11
8	19.90	0.031	0.000	53	-15	72	-20	74	-6	100	-7
9	19.20	0.026	0.000	105	-17	142	-23	117	-1	158	-2
10	18.00	0.018	0.000	299	-14	403	-19	209	-85	282	-114
11	17.50	0.015	0.000	267	-12	361	-16	102	-41	138	-55
12	16.50	0.011	0.000	259	-7	350	-9	7	-36	9	-49
13	15.45	0.008	0.000	242	-2	326	-2	4	-55	6	-74
14	14.40	0.006	0.000	164	0	221	0	3	-69	4	-93
15	13.20	0.005	0.000	89	0	120	0	2	-49	2	-65
16	12.00	0.005	0.000	53	0	72	0	1	-21	1	-28
17	10.80	0.005	0.000	42	0	57	0	0	-10	0	-14
18	9.78	0.005	0.000	30	0	41	0	0	-26	0	-35
19	8.75	0.006	0.000	0	-15	0	-20	0	-76	0	-103
20	7.98	0.006	0.000	0	-55	0	-74	0	-34	0	-46
21	7.20	0.006	0.000	0	-68	0	-91	0	-5	0	-7
22	6.00	0.006	0.000	0	-53	0	-72	17	0	23	0
23	4.80	0.006	0.000	0	-28	0	-38	19	0	26	0
24	3.60	0.005	0.000	0	-8	0	-11	12	0	16	0
25	2.80	0.005	0.000	0	-2	0	-2	5	0	7	0
26	2.00	0.004	0.000	0	-0	0	-0	0	-0	0	-0

Run ID. Design\_Case\_03\_no\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment						Shear force					
	Calculated		Factored		Calculated		Factored		Calculated		Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	
1	5	12.00	-17	19.20	7	-23	5	16.50	-8	20.59	7	-11
2	6	10.80	-17	19.20	8	-23	5	16.50	-8	20.59	7	-11
3	252	16.50	-68	7.20	341	-91	97	17.50	-76	8.75	132	-103
4	259	16.50	-62	7.20	350	-84	102	17.50	-70	8.75	138	-94
5	No calculation at this stage											
6	No calculation at this stage											
7	221	16.50	-61	7.20	299	-82	138	18.00	-71	8.75	186	-96
8	299	18.00	-49	7.20	403	-66	209	18.00	-85	18.00	282	-114

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.1
3	0.060	23.70	0.000	23.70	Excav. to elev. 17.50 on RIGHT side
4	0.060	23.70	0.000	23.70	Apply surcharge no.2 at elev. 17.50
5	No calculation at this stage				Install prop no.2 at elev. 18.00
6	No calculation at this stage				Install prop no.1 at elev. 23.50
7	0.060	23.70	0.000	23.70	Change soil type 2 to soil type 4
8	0.060	23.70	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

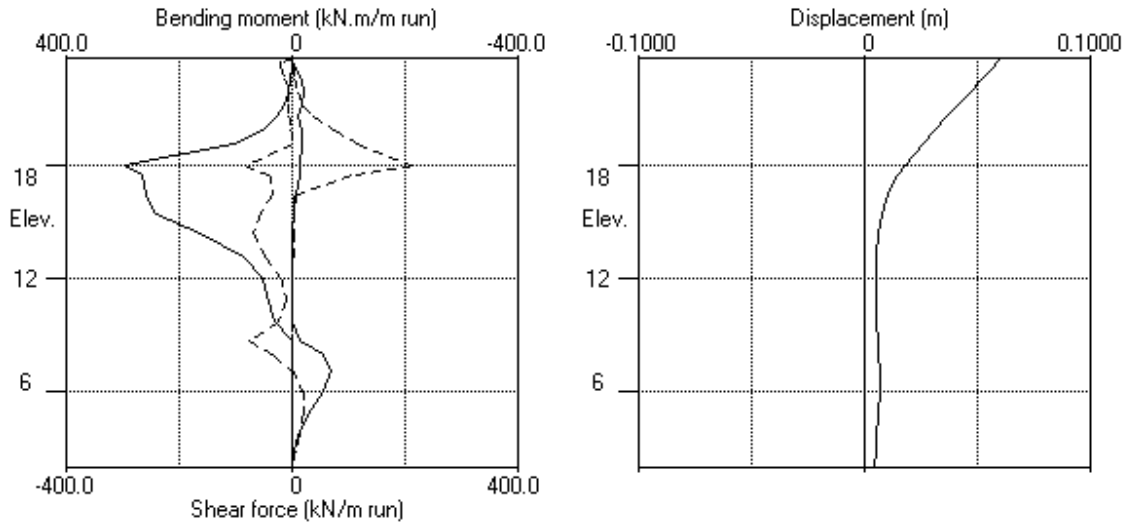
Stage no.	Prop no. 1			Prop no. 2		
	at elev. 23.50			at elev. 18.00		
	Calculated	Factored	Calculated	Factored	Calculated	Factored
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
7	1	1	1	157	157	212
8	22	22	29	293	293	396

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Design Case 3  
New contig wall

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Job No. 371654  
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Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



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 Program: WALLAP Version 6.06 Revision A52.B71.R55  
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 Data filename/Run ID: Design\_Case\_03\_no\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	23.70	1 Made Ground	1 Made Ground
2	23.25	2 London Clay	2 London Clay
3	8.75	3 Lambeth Group	3 Lambeth Group

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. ( Nu ) ( NC/OC )	Active limit Ka ( Kac )	Passive limit Kp ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 (2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390 )
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08 )
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610 )	1.000	OC (0.200)	0.384 (1.452)	3.043 (4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185 )	1.000 ( 1.000 )	OC (0.200)	0.384 (1.452)	3.043 (4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	20.59	20.59

Automatic water pressure balancing at toe of wall : No

Water press.		Left side			Right side			
profile no.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	16.50	16.50	0.0
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	23.50	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Distance from wall Elev.	Length parallel to wall	Width perpend. to wall	Surcharge kN/m <sup>2</sup>	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.90	1.20(L)	32.15	1.00	100.00	=	N/A	1.00 -
2	17.00	-0.00(R)	23.80	20.00	12.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable

P/F = Permanent Favourable

Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Excavate to elevation 17.00 on RIGHT side
4	Apply surcharge no.2 at elevation 17.00
5	Install strut or anchor no.2 at elevation 18.00
6	Install strut or anchor no.1 at elevation 23.50
7	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
8	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m<sup>3</sup>

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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m



## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Excav. to elev. 17.00 on RIGHT side	Yes	Yes	Yes
4	Apply surcharge no.2 at elev. 17.00	Yes	Yes	Yes
5	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
6	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
7	Change soil type 2 to soil type 4	Yes	Yes	Yes
8	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

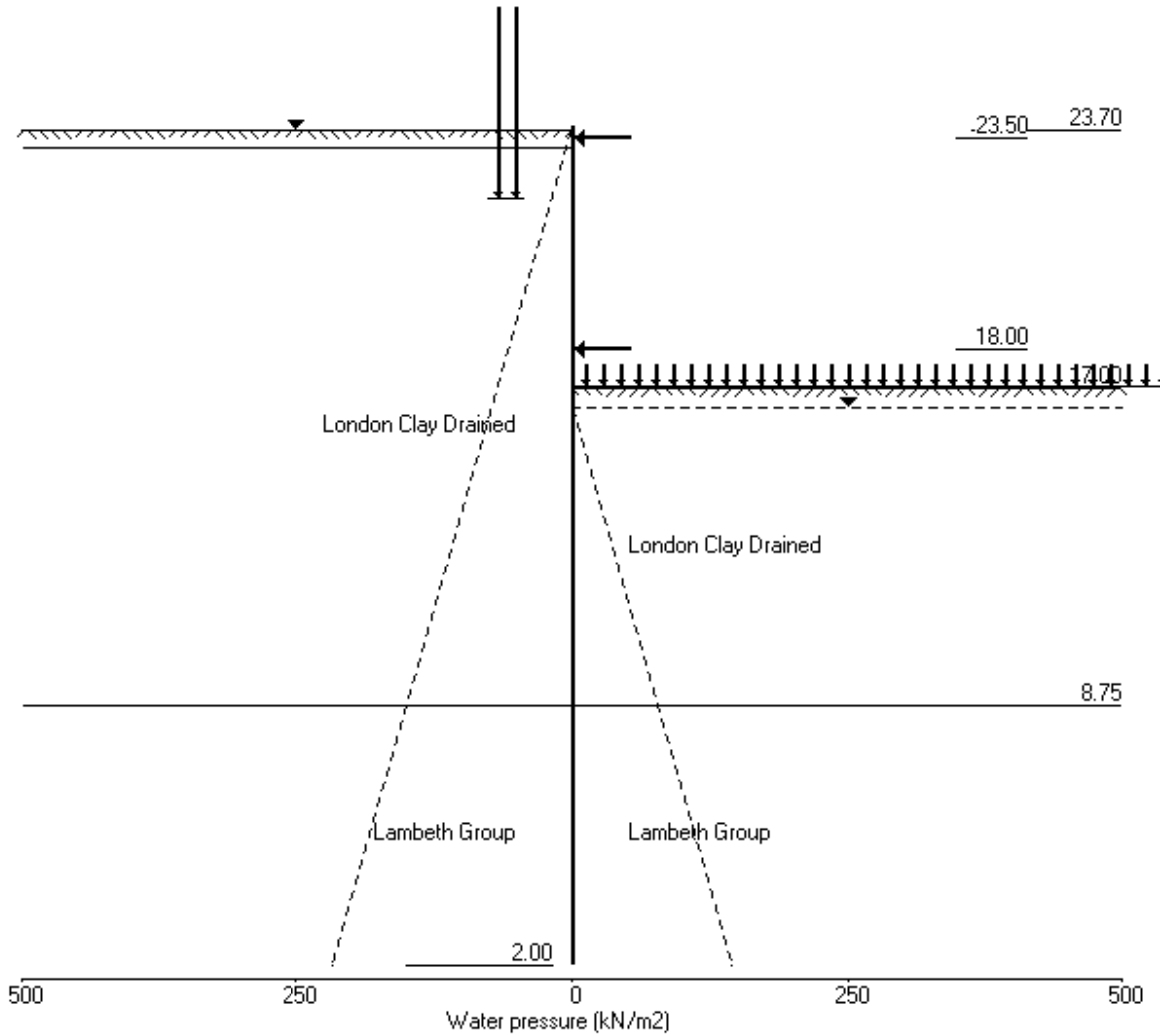
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Stage No.8 Apply water pressure profile no.2 (Worst Cred.)



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 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 17.00 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr -ation	
3	23.70	17.00	Cant.	2.112	2.98	13.45	3.55	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.066	8.68E-03	0.0	-0.0	
2	23.50	3.70	0.064	8.68E-03	0.4	0.0	
3	23.25	8.32	0.062	8.68E-03	1.9	0.3	
		2.25	0.062	8.68E-03	1.9	0.3	
4	22.58	5.63	0.056	8.67E-03	4.5	2.5	
5	21.90	9.00	0.050	8.65E-03	9.5	7.4	
6	21.24	12.28	0.045	8.61E-03	16.4	16.0	
7	20.59	15.55	0.039	8.51E-03	25.5	29.8	
8	19.90	19.02	0.033	8.34E-03	37.6	51.9	
9	19.20	22.50	0.028	8.05E-03	52.0	83.1	
10	18.00	28.50	0.018	7.13E-03	82.6	163.8	
11	17.00	33.50	0.012	5.82E-03	113.6	261.5	
		-131.22	0.012	5.82E-03	113.6	261.5	
12	16.50	-142.60	0.009	4.95E-03	45.1	301.4	
13	15.45	-80.44	0.005	2.94E-03	-72.0	319.4	
14	14.40	14.32	0.003	1.25E-03	-106.7	199.2	
15	13.20	45.17	0.002	2.20E-04	-71.0	81.0	
16	12.00	33.74	0.002	-1.83E-04	-23.6	27.9	
17	10.80	3.89	0.003	-3.72E-04	-1.1	23.3	
18	9.78	-32.87	0.003	-5.22E-04	-15.9	24.0	
19	8.75	-78.94	0.004	-5.67E-04	-73.2	-9.9	
		67.50	0.004	-5.67E-04	-73.2	-9.9	
20	7.98	46.07	0.004	-4.32E-04	-29.2	-46.5	
21	7.20	26.21	0.004	-1.88E-04	-1.2	-55.5	
22	6.00	3.99	0.004	1.60E-04	16.9	-38.6	
23	4.80	-6.45	0.004	3.62E-04	15.4	-16.0	
24	3.60	-7.64	0.003	4.32E-04	7.0	-2.8	
25	2.80	-4.91	0.003	4.38E-04	2.0	0.2	
26	2.00	0.02	0.003	4.38E-04	0.0	0.0	

(continued)

Stage No.3 Excavate to elevation 17.00 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	4067
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4067
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	4067
		Total>	8.33	2.25m	124.54	2.25	2.25a	9986
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	10559
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	11132
6	21.24	Total>	52.45	12.28m	184.23	12.28	12.28a	11688
7	20.59	Total>	76.40	15.55m	213.27	15.55	15.55a	12244
8	19.90	Total>	97.68	19.02m	239.94	19.02	19.02a	12834
9	19.20	Total>	113.76	22.50m	261.42	22.50	22.50a	13424
10	18.00	Total>	136.33	28.50m	293.31	28.50	28.50a	14442
11	17.00	Total>	153.03	33.50m	317.77	33.50	33.50a	15291
12	16.50	Total>	162.70	36.00m	331.33	36.00	36.00a	15715
13	15.45	Total>	181.40	41.25m	358.17	103.03	103.03	16606
14	14.40	Total>	200.44	46.50m	385.37	154.52	154.52	17498
15	13.20	Total>	222.58	52.50m	416.82	188.00	188.00	18516
16	12.00	Total>	245.04	58.50m	448.60	207.63	207.63	19535
17	10.80	Total>	267.76	64.50m	480.64	221.21	221.21	20553
18	9.78	Total>	287.32	69.63m	508.16	229.06	229.06	21423
19	8.75	Total>	307.01	78.28	535.80	233.82	233.82	22293
		Total>	307.01	191.11	422.93	284.25	284.25	7112
20	7.98	Total>	321.95	188.14	455.80	292.39	292.39	8212
21	7.20	Total>	336.95	185.22	488.72	301.12	301.12	9311
22	6.00	Total>	360.25	180.77	539.78	317.66	317.66	11013
23	4.80	Total>	383.64	176.42	590.92	338.32	338.32	12715
24	3.60	Total>	407.10	172.13	642.13	362.27	362.27	14417
25	2.80	Total>	422.78	169.31	676.31	379.49	379.49	15552
26	2.00	Total>	438.48	166.52	710.51	397.50	397.50	16687

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	164.72	164.72	164.72p	30858
12	16.50	Total>	10.00	2.50m	178.60	178.60	178.60p	31715
13	15.45	Total>	31.03	7.75m	207.78	183.46	183.46	33513
14	14.40	Total>	52.12	13.00m	237.03	140.21	140.21	35312
15	13.20	Total>	76.37	19.00m	270.60	142.83	142.83	37367
16	12.00	Total>	100.82	25.00m	304.36	173.89	173.89	39422
17	10.80	Total>	125.51	31.00m	338.37	217.32	217.32	41478
18	9.78	Total>	146.80	36.12m	367.62	261.92	261.92	43233
19	8.75	Total>	168.29	41.25m	397.06	312.76	312.76	44989
		Total>	168.29	52.41	284.20	216.76	216.76	14353

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 Design Case 3  
 New contig wall

Sheet No.  
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(continued)

Stage No.3 Excavate to elevation 17.00 on RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses				Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
			Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	7.98	Total>	184.66	50.86	318.49	246.32	16572	
21	7.20	Total>	201.13	49.42	352.89	274.91	18790	
22	6.00	Total>	226.84	55.00m	406.35	313.67	22225	
23	4.80	Total>	252.76	61.00m	460.02	344.78	25660	
24	3.60	Total>	278.85	67.00m	513.87	369.91	29095	
25	2.80	Total>	296.34	71.00m	549.86	384.40	31385	
26	2.00	Total>	313.88	75.00m	585.90	397.48	33675	

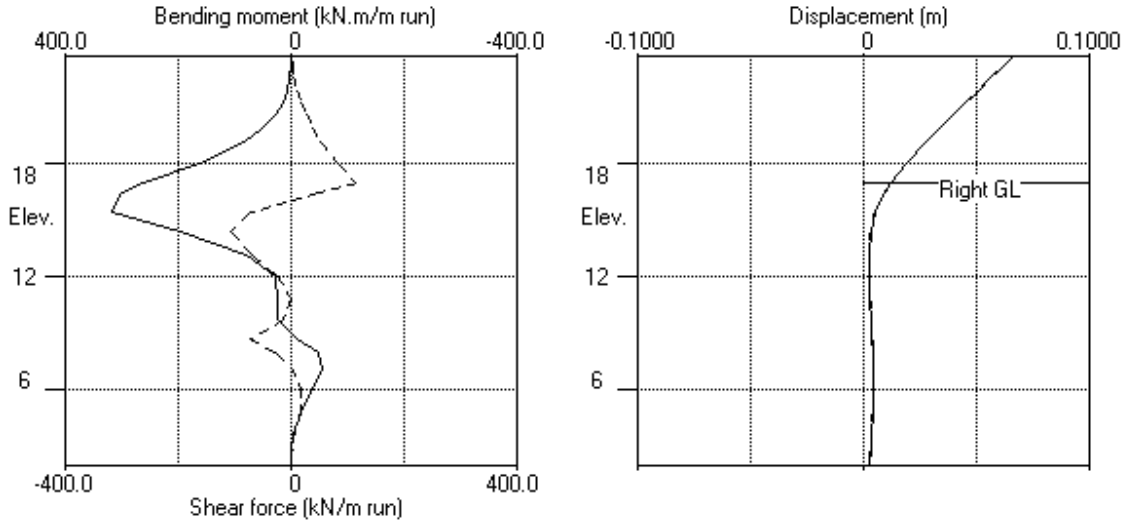
Note: 36.00a Soil pressure at active limit  
 178.60p Soil pressure at passive limit

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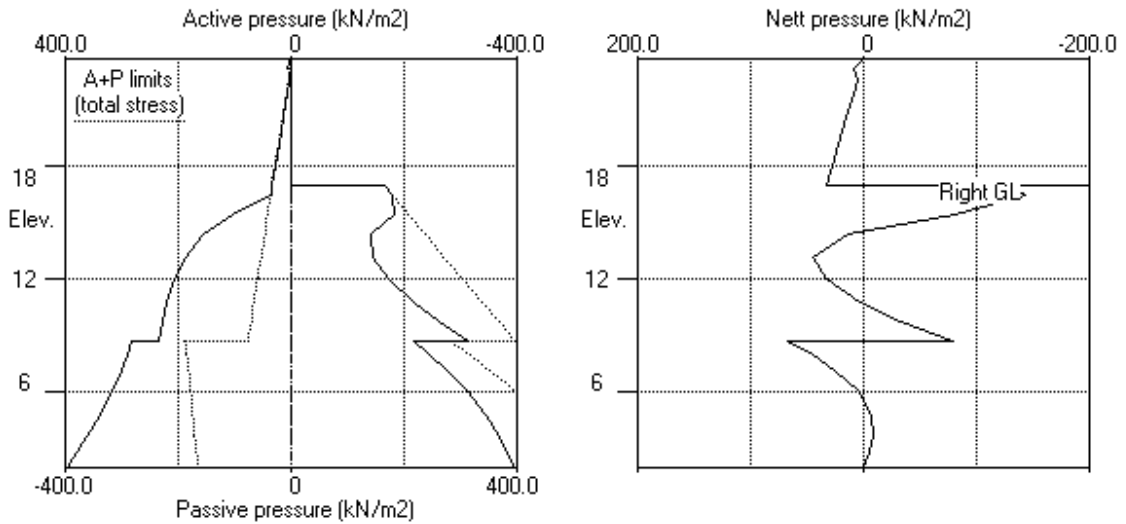
Sheet No.  
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Stage No.3 Excav. to elev. 17.00 on RIGHT side



Stage No.3 Excav. to elev. 17.00 on RIGHT side



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Sheet No.  
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 Checked :

Units: kN,m

Stage No. 7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>at</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
				<u>Safety</u>	<u>at</u>		<u>-ation</u>	<u>failure</u>	
				<u>More than one prop.</u>	<u>No</u>	<u>FoS calc.</u>			
7	23.70	17.00							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	23.70	0.00	0.067	8.85E-03	0.0	-0.0			
2	23.50	3.70	0.065	8.85E-03	0.4	0.0	-10.5		
		3.70	0.065	8.85E-03	-10.2	0.0			
3	23.25	8.33	0.063	8.86E-03	-8.6	-2.3			
		4.55	0.063	8.86E-03	-8.6	-2.3			
4	22.58	11.52	0.057	8.87E-03	-3.2	-6.4			
5	21.90	19.54	0.051	8.90E-03	7.3	-5.1			
6	21.24	30.93	0.045	8.90E-03	23.8	4.9			
7	20.59	45.44	0.039	8.83E-03	48.8	28.4			
8	19.90	58.95	0.033	8.61E-03	85.1	74.6			
9	19.20	70.08	0.027	8.13E-03	129.9	149.0			
10	18.00	86.92	0.018	6.24E-03	224.1	359.7	-406.6		
		86.92	0.018	6.24E-03	-182.5	359.7			
11	17.00	100.38	0.013	4.44E-03	-88.9	222.8			
		54.76	0.013	4.44E-03	-88.9	222.8			
12	16.50	37.35	0.011	3.81E-03	-65.9	184.4			
13	15.45	15.72	0.008	2.67E-03	-38.0	169.4			
14	14.40	-3.30	0.005	1.73E-03	-31.5	120.6			
15	13.20	11.96	0.004	9.92E-04	-26.3	78.9			
16	12.00	14.49	0.003	4.93E-04	-10.4	55.5			
17	10.80	-3.09	0.002	9.10E-05	-3.6	53.1			
18	9.78	-31.87	0.003	-2.27E-04	-21.5	47.6			
19	8.75	-72.14	0.003	-4.05E-04	-74.8	8.6			
		62.98	0.003	-4.05E-04	-74.8	8.6			
20	7.98	43.96	0.003	-3.53E-04	-33.3	-30.5			
21	7.20	25.91	0.003	-1.76E-04	-6.3	-43.3			
22	6.00	5.24	0.003	1.04E-04	12.4	-32.6			
23	4.80	-4.77	0.003	2.79E-04	12.7	-14.4			
24	3.60	-6.19	0.003	3.44E-04	6.1	-3.1			
25	2.80	-3.82	0.002	3.52E-04	2.1	-0.3			
26	2.00	-1.49	0.002	3.53E-04	0.0	0.0			

At elev. 23.50 Prop force = 10.5 kN/m run  
 At elev. 18.00 Prop force = 406.6 kN/m run

Run ID. Design\_Case\_03\_no\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
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 Checked :

(continued)

Stage No.7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	48263
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	48263
3	23.25	Total>	8.33	8.32	8.33	8.33	8.33	5333
			4.50	3.83	0.00	25.89	0.05	5270
4	22.58	11.25	10.57	0.00	42.18	0.27	11.52	5727
5	21.90	18.00	17.33	1.54	58.48	1.54	19.54a	6183
6	21.24	24.55	27.90	6.38	84.01	6.38	30.93a	6627
7	20.59	31.10	45.30	14.34	126.00	14.34	45.44a	7070
8	19.90	38.05	59.63	20.90	160.60	20.90	58.95a	7541
9	19.20	45.00	68.76	25.08	182.65	25.08	70.08a	8011
10	18.00	57.00	79.33	29.92	208.16	29.92	86.92a	5921
11	17.00	67.00	86.91	33.38	226.46	33.38	100.38a	6375
12	16.50	72.00	90.70	35.12	235.62	35.12	107.12a	6602
13	15.45	82.50	98.90	38.87	255.40	38.87	121.37a	7079
14	14.40	93.00	107.44	42.78	276.02	45.31	138.31	7556
15	13.20	105.00	117.58	47.42	300.50	72.07	177.07	8101
16	12.00	117.00	128.04	52.21	325.76	86.59	203.59	8646
17	10.80	129.00	138.76	57.11	351.63	94.18	223.18	9191
18	9.78	139.25	148.07	61.37	374.11	95.63	234.88	9657
19	8.75	149.50	157.51	65.69	396.88	92.89	242.39	11295
		Total>	307.01	191.11	422.93	287.17	287.17	7081
20	7.98	Total>	321.95	188.14	455.80	296.39	296.39	8175
21	7.20	Total>	336.95	185.22	488.72	305.88	305.88	9269
22	6.00	Total>	360.25	180.77	539.78	322.98	322.98	10964
23	4.80	Total>	383.64	176.42	590.92	343.63	343.63	12658
24	3.60	Total>	407.10	172.13	642.13	367.24	367.24	14353
25	2.80	Total>	422.78	169.31	676.31	384.13	384.13	15483
26	2.00	Total>	438.48	166.52	710.51	400.70	400.70	316207

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.24	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	12.00	0.00	45.62	45.62	45.62p	6375
12	16.50	0.00	22.00	3.68	69.77	69.77	69.77p	6602
13	15.45	10.50	32.51	8.49	95.15	95.15	105.65p	7079
14	14.40	21.00	43.07	13.32	120.62	120.62	141.62p	7556
15	13.20	33.00	55.21	18.88	149.92	132.11	165.11	8101
16	12.00	45.00	67.47	24.49	179.53	144.10	189.10	8646
17	10.80	57.00	79.90	30.17	209.53	169.26	226.26	9191
18	9.78	67.25	90.66	35.10	235.51	199.50	266.75	9657



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 Design Case 3  
 New contig wall

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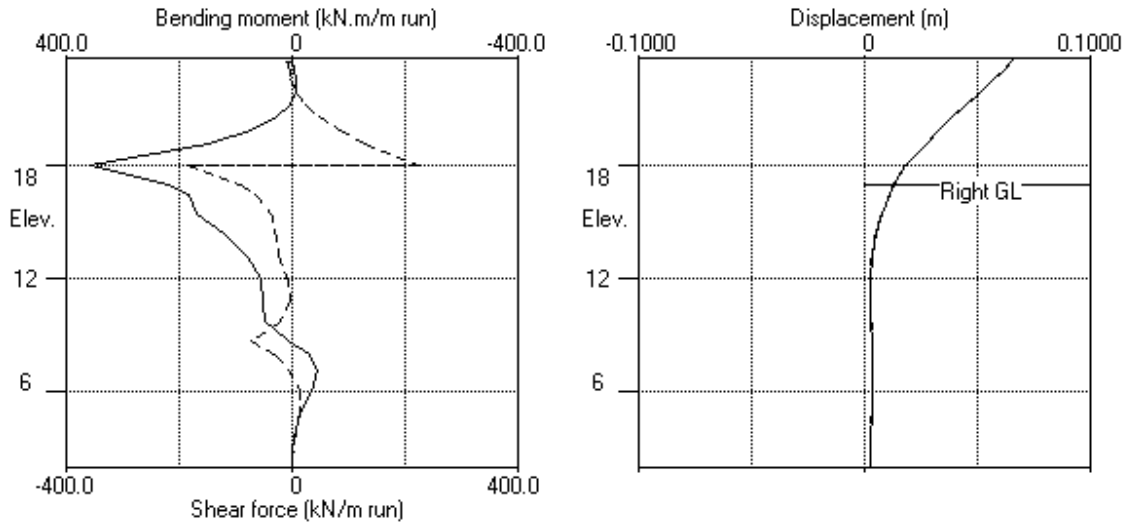
Stage No.7 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
19	8.75	77.50	101.57	40.09	261.86	237.02	314.52	11295
		Total>	179.07	63.19	294.99	224.19	224.19	7081
20	7.98	Total>	195.18	61.38	329.02	252.43	252.43	8175
21	7.20	Total>	211.38	59.66	363.14	279.98	279.98	9269
22	6.00	Total>	236.63	57.16	416.14	317.73	317.73	10964
23	4.80	Total>	262.08	61.00m	469.35	348.41	348.41	12658
24	3.60	Total>	287.71	67.00m	522.73	373.43	373.43	14353
25	2.80	Total>	296.37	71.00m	549.89	387.95	387.95	15483
26	2.00	Total>	322.12	75.00m	594.14	402.19	402.19	316207

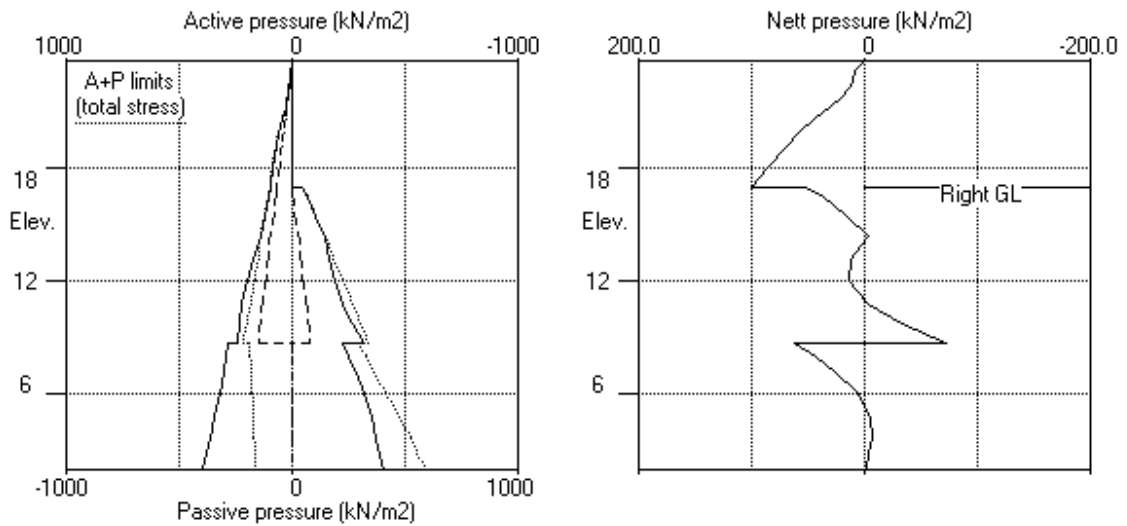
Note: 121.37a Soil pressure at active limit  
 141.62p Soil pressure at passive limit

Units: kN,m

Stage No.7 Change soil type 2 to soil type 4



Stage No.7 Change soil type 2 to soil type 4



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 New contig wall

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 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 2.00</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	17.00	Cant.	2.112	2.98	13.45	3.55	L to R
4	23.70	17.00	Cant.	2.229	3.03	13.52	3.48	L to R
5	23.70	17.00	No analysis at this stage					
All remaining stages have more than one prop - FoS calculation n/a								

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Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.067	-0.000	0.0	-0.0	0.0	0.0
2	23.50	0.065	-0.000	0.0	-0.0	0.4	-10.2
3	23.25	0.063	0.000	0.3	-2.3	1.9	-8.6
4	22.58	0.057	0.000	2.5	-6.4	4.5	-3.2
5	21.90	0.051	0.000	7.4	-5.1	9.5	-4.2
6	21.24	0.045	0.000	16.0	-5.3	23.8	-7.8
7	20.59	0.039	0.000	29.8	-10.7	48.8	-8.6
8	19.90	0.033	0.000	74.6	-15.5	85.1	-5.5
9	19.20	0.028	0.000	149.0	-17.6	129.9	-1.1
10	18.00	0.018	0.000	359.7	-14.6	224.1	-182.5
11	17.00	0.013	0.000	265.7	-9.5	118.3	-88.9
12	16.50	0.011	0.000	307.3	-6.7	47.6	-65.9
13	15.45	0.008	0.000	325.8	-1.6	4.6	-72.6
14	14.40	0.005	0.000	203.7	0.0	3.2	-108.9
15	13.20	0.004	0.000	82.3	0.0	1.9	-73.6
16	12.00	0.003	0.000	55.5	0.0	1.0	-25.8
17	10.80	0.003	0.000	53.1	0.0	0.0	-3.6
18	9.78	0.003	0.000	47.6	0.0	0.0	-21.5
19	8.75	0.004	0.000	8.6	-9.9	0.0	-74.8
20	7.98	0.004	0.000	0.0	-46.5	0.0	-33.3
21	7.20	0.004	0.000	0.0	-55.5	0.0	-6.3
22	6.00	0.004	0.000	0.0	-38.6	16.9	0.0
23	4.80	0.004	0.000	0.0	-16.0	15.4	0.0
24	3.60	0.003	0.000	0.0	-3.1	7.0	0.0
25	2.80	0.003	0.000	0.4	-0.3	2.1	0.0
26	2.00	0.003	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				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	5.1	12.00	-17.0	19.20	5.6	17.00	-8.4	20.59
2	6.4	10.80	-17.6	19.20	5.6	17.00	-8.6	20.59
3	319.4	15.45	-55.5	7.20	113.6	17.00	-106.7	14.40
4	325.8	15.45	-49.7	7.20	118.3	17.00	-108.9	14.40
5	No calculation at this stage							
6	No calculation at this stage							
7	359.7	18.00	-43.3	7.20	224.1	18.00	-182.5	18.00
8	359.7	18.00	-43.3	7.20	224.1	18.00	-182.5	18.00

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 Design Case 3  
 New contig wall

Sheet No.  
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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				Stage description
no.	maximum m	elev.	minimum m	elev.	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.2
3	0.066	23.70	0.000	23.70	Excav. to elev. 17.00 on RIGHT side
4	0.067	23.70	0.000	23.70	Apply surcharge no.2 at elev. 17.00
5	No calculation at this stage				Install prop no.2 at elev. 18.00
6	No calculation at this stage				Install prop no.1 at elev. 23.50
7	0.067	23.70	0.000	23.70	Change soil type 2 to soil type 4
8	0.067	23.70	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

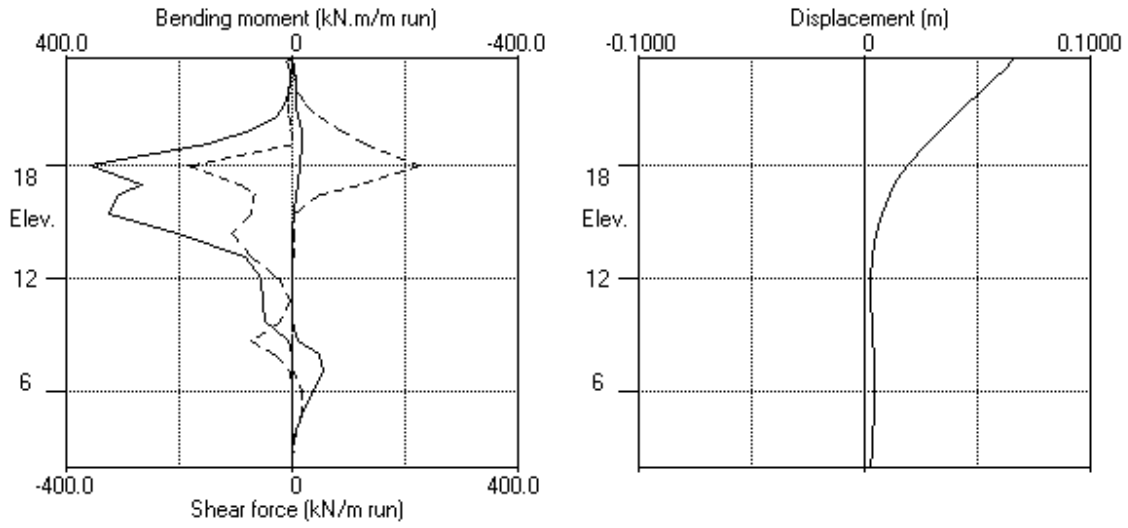
Stage	--- Strut no. 1 --- at elev. 23.50		--- Strut no. 2 --- at elev. 18.00	
no.	kN/m run	kN/prop	kN/m run	kN/prop
7	10.52	10.52	406.63	406.63
8	10.52	10.52	406.63	406.63

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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	23.70	1 Made Ground	1 Made Ground
2	23.25	2 London Clay	2 London Clay
3	8.75	3 Lambeth Group	3 Lambeth Group

**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. ( Nu ) ( NC/OC )	Active limit ( Ka ) ( Kac )	Passive limit ( Kp ) ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 (2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	80.00u ( 4.390 )
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231 )	1.000	OC (0.490)	1.000 (2.474)	1.000 (2.475)	180.0u ( 13.08 )
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610 )	1.000	OC (0.200)	0.384 (1.452)	3.043 ( 4.814 )	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185 )	1.000 ( 1.000 )	OC (0.200)	0.384 (1.452)	3.043 ( 4.814 )	0.0d

**Additional soil parameters associated with Ka and Kp**

Soil type No.	Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

Initial water table elevation      Left side      Right side  
 20.59      20.59

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	16.50	16.50	0.0 MC+WC
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
   E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	23.50	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
3	21.90	6.00	0.017663	2.050E+07	4.00	45.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpnd. to wall	Surcharge kN/m <sup>2</sup>	-----	-----	Equiv. soil type	Partial factor/ Category
1	21.90	1.20 (L)	32.15	1.00	100.00	=		N/A	1.00 -
2	17.50	-0.00 (R)	23.80	20.00	12.00	=		N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 21.50 on RIGHT side
4	Install strut or anchor no.3 at elevation 21.90
5	Excavate to elevation 17.50 on RIGHT side
6	Install strut or anchor no.2 at elevation 18.00
7	Install strut or anchor no.1 at elevation 23.50
8	Remove strut or anchor no.3 at elevation 21.90
9	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
10	Apply water pressure profile no.2 ( Mod. Conserv. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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/m<sup>3</sup>  
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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m  
Distance to rigid boundary on Right side = 23.70 m



## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 21.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.3 at elev. 21.90	Yes	Yes	Yes
5	Excav. to elev. 17.50 on RIGHT side	Yes	Yes	Yes
6	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
7	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
8	Remove prop no.3 at elev. 21.90	Yes	Yes	Yes
9	Change soil type 2 to soil type 4	Yes	Yes	Yes
10	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

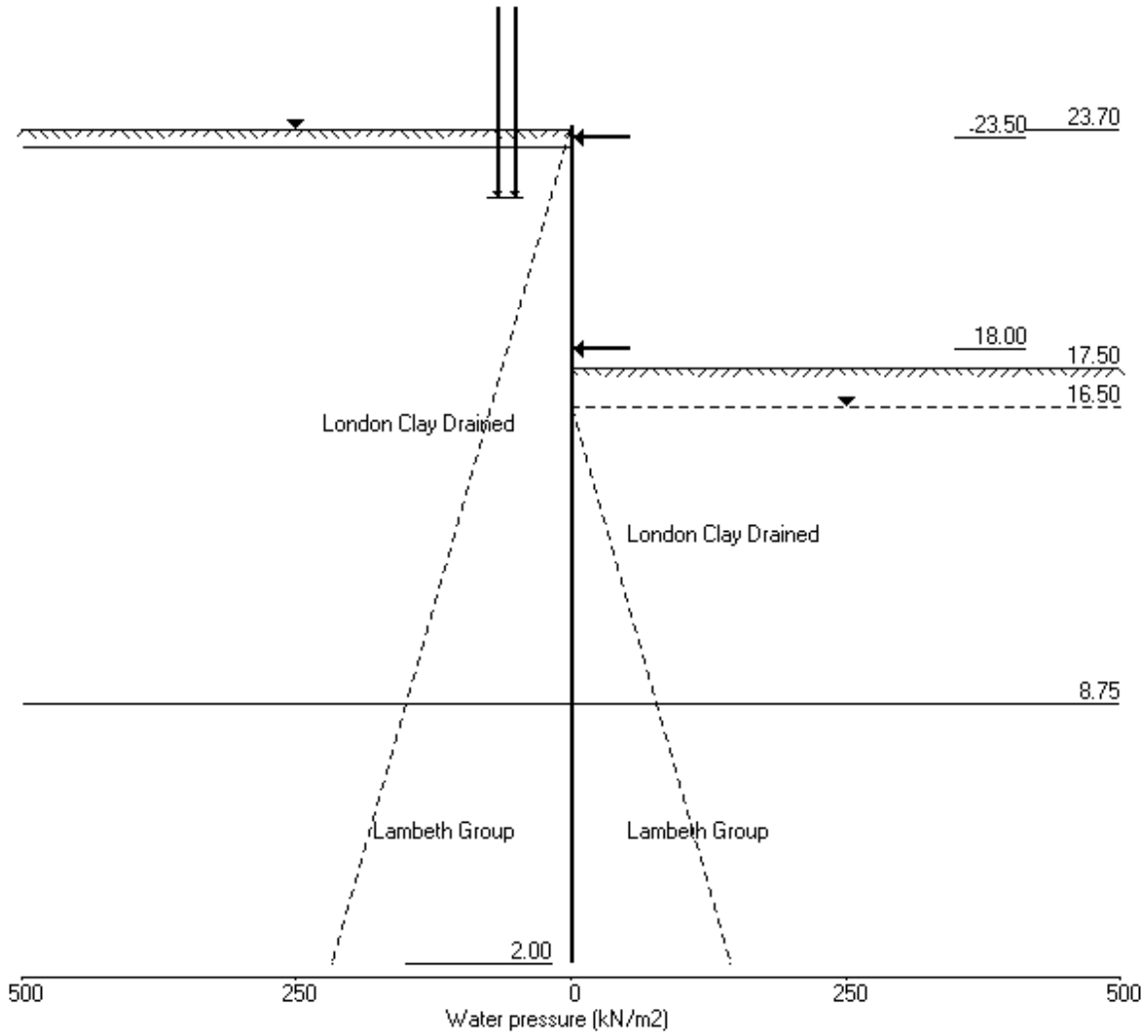
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Stage No.10 Apply water pressure profile no.2 ( Mod. Conserv. )



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 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 21.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
3	23.70	21.50	Cant.	7.915	3.18	21.26	0.24	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.005	6.14E-04	0.0	0.0	
2	23.50	3.70	0.005	6.14E-04	0.4	0.0	
3	23.25	8.33	0.005	6.13E-04	1.9	0.3	
		2.25	0.005	6.13E-04	1.9	0.3	
4	22.58	5.63	0.005	6.07E-04	4.5	2.5	
5	21.90	9.00	0.004	5.87E-04	9.5	7.4	
6	21.50	11.00	0.004	5.63E-04	13.5	12.0	
		-17.53	0.004	5.63E-04	13.5	12.0	
7	20.59	-14.02	0.004	4.65E-04	-0.9	22.9	
8	19.90	-3.43	0.003	3.74E-04	-6.9	19.5	
9	19.20	1.36	0.003	3.02E-04	-7.7	14.0	
10	18.00	3.17	0.003	2.30E-04	-4.9	5.6	
11	17.50	3.03	0.003	2.16E-04	-3.4	3.4	
12	16.50	2.49	0.003	2.01E-04	-0.6	1.2	
13	15.45	1.78	0.002	1.93E-04	1.6	1.5	
14	14.40	1.45	0.002	1.76E-04	3.3	3.7	
15	13.20	1.00	0.002	1.31E-04	4.8	8.2	
16	12.00	-0.84	0.002	4.87E-05	4.9	14.2	
17	10.80	-6.04	0.002	-7.44E-05	0.7	19.0	
18	9.78	-14.50	0.002	-1.86E-04	-9.8	16.4	
19	8.75	-26.32	0.002	-2.33E-04	-30.7	-1.5	
		24.66	0.002	-2.33E-04	-30.7	-1.5	
20	7.98	17.84	0.002	-1.87E-04	-14.2	-18.0	
21	7.20	11.34	0.002	-8.72E-05	-2.9	-23.7	
22	6.00	3.35	0.002	7.28E-05	5.9	-19.4	
23	4.80	-1.35	0.002	1.82E-04	7.1	-10.3	
24	3.60	-3.08	0.002	2.32E-04	4.4	-3.0	
25	2.80	-2.96	0.002	2.41E-04	2.0	-0.6	
26	2.00	-2.08	0.002	2.42E-04	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 21.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	4327
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4327
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	4327
		Total>	8.33	2.25m	171.02	2.25	2.25a	10624
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	11234
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	11843
6	21.50	Total>	44.46	11.00m	226.18	11.00	11.00a	12205
7	20.59	Total>	76.40	15.55m	268.00	31.65	31.65	13026
8	19.90	Total>	97.68	19.02m	296.83	55.27	55.27	13654
9	19.20	Total>	113.76	22.50m	320.46	73.29	73.29	14281
10	18.00	Total>	136.33	28.50m	356.07	98.17	98.17	15365
11	17.50	Total>	145.14	31.00m	370.32	107.65	107.65	15816
12	16.50	Total>	162.70	36.00m	398.74	126.28	126.28	16719
13	15.45	Total>	181.40	41.25m	428.85	145.95	145.95	17668
14	14.40	Total>	200.44	46.50m	459.30	165.95	165.95	18616
15	13.20	Total>	222.58	52.50m	494.48	188.93	188.93	19699
16	12.00	Total>	245.04	58.50m	529.98	211.25	211.25	20783
17	10.80	Total>	267.76	64.50m	565.74	231.66	231.66	21866
18	9.78	Total>	287.32	69.63m	596.44	246.68	246.68	22792
19	8.75	Total>	307.01	74.75m	627.26	259.67	259.67	23717
		Total>	307.01	144.81	469.25	291.67	291.67	7567
20	7.98	Total>	321.95	134.67	509.29	302.93	302.93	8736
21	7.20	Total>	336.95	124.58	549.37	314.42	314.42	9906
22	6.00	Total>	360.25	109.05	611.53	333.57	333.57	11717
23	4.80	Total>	383.64	94.50m	673.76	354.83	354.83	13528
24	3.60	Total>	407.10	100.50m	736.08	378.00	378.00	15339
25	2.80	Total>	422.78	104.50m	777.65	394.26	394.26	16546
26	2.00	Total>	438.48	108.50m	819.25	411.02	411.02	17753

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	181.71	28.53	28.53	6310
7	20.59	Total>	18.20	4.55m	209.80	45.67	45.67	6734
8	19.90	Total>	32.11	8.02m	231.26	58.70	58.70	7059
9	19.20	Total>	46.03	11.50m	252.73	71.92	71.92	7383
10	18.00	Total>	70.10	17.50m	289.84	95.00	95.00	7943
11	17.50	Total>	80.14	20.00m	305.32	104.62	104.62	8177
12	16.50	Total>	100.27	25.00m	336.31	123.79	123.79	8644
13	15.45	Total>	121.46	30.25m	368.91	144.18	144.18	9134
14	14.40	Total>	142.71	35.50m	401.57	164.50	164.50	9624
15	13.20	Total>	167.09	41.50m	438.98	187.93	187.93	10184
16	12.00	Total>	191.54	47.50m	476.48	212.09	212.09	10744
17	10.80	Total>	216.08	53.50m	514.05	237.69	237.69	11304
18	9.78	Total>	237.09	58.62m	546.21	261.18	261.18	11783
19	8.75	Total>	258.15	63.75m	578.40	285.99	285.99	12261
		Total>	258.15	95.95	420.40	267.01	267.01	3912

Run ID. Design\_Case\_03\_with\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 21.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m <sup>2</sup>	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u> kN/m <sup>2</sup>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m <sup>3</sup>
			<u>Vertic</u> <u>-al</u> kN/m <sup>2</sup>	<u>Active</u> <u>limit</u> kN/m <sup>2</sup>	<u>Passive</u> <u>limit</u> kN/m <sup>2</sup>	<u>Earth</u> <u>pressure</u> kN/m <sup>2</sup>		
20	7.98	Total>	274.10	86.82	461.44	285.09	285.09	4516
21	7.20	Total>	290.07	77.71	502.50	303.08	303.08	5121
22	6.00	Total>	314.83	77.50m	566.11	330.21	330.21	6057
23	4.80	Total>	339.62	83.50m	629.75	356.18	356.18	6994
24	3.60	Total>	364.43	89.50m	693.40	381.08	381.08	7930
25	2.80	Total>	380.98	93.50m	735.85	397.23	397.23	8554
26	2.00	Total>	397.53	97.50m	778.30	413.10	413.10	9178

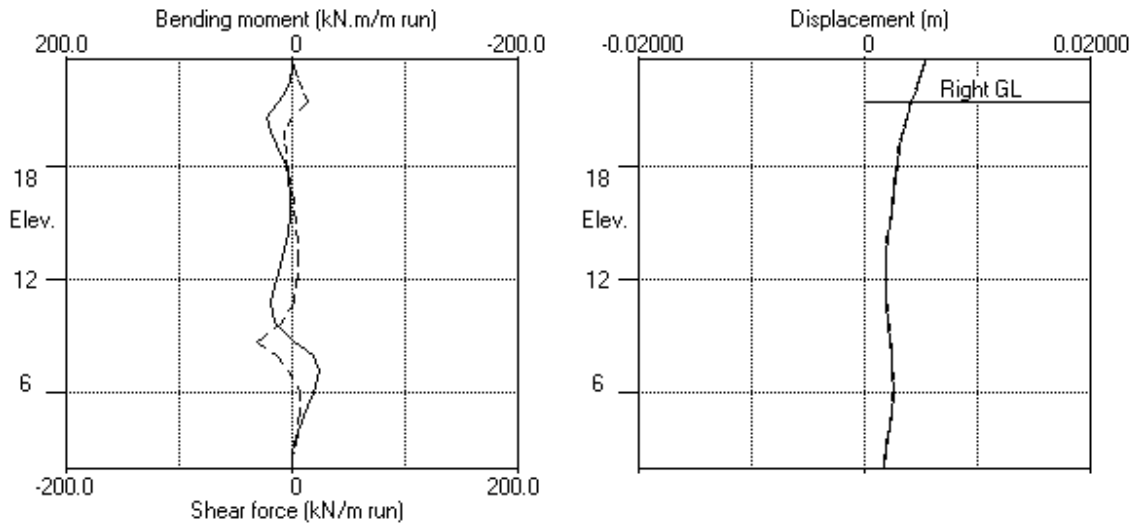
Note: 11.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Design Case 3  
 New contig wall

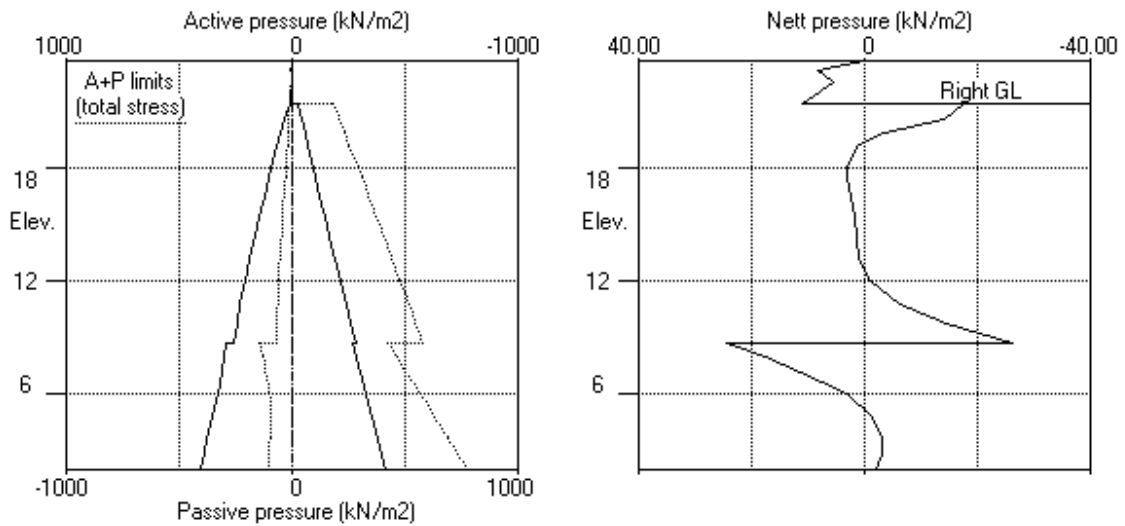
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 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 21.50 on RIGHT side



Stage No.3 Excav. to elev. 21.50 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 17.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilb. at elev.	Toe elev.	Wall Penetr-ation	
5	23.70	17.50	21.90	4.294	n/a	17.28	0.22	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.012	6.92E-05	0.0	0.0	
2	23.50	3.70	0.012	6.91E-05	0.4	0.0	
3	23.25	8.33	0.012	6.89E-05	1.9	0.3	
		2.25	0.012	6.89E-05	1.9	0.3	
4	22.58	5.63	0.012	6.30E-05	4.5	2.5	
5	21.90	9.00	0.012	4.23E-05	9.5	7.4	-57.7
		9.00	0.012	4.23E-05	-48.2	7.4	
6	21.50	11.00	0.012	4.69E-05	-44.2	-11.1	
7	20.59	15.55	0.012	1.92E-04	-32.1	-40.7	
8	19.90	19.02	0.012	4.07E-04	-20.1	-59.3	
9	19.20	22.50	0.011	6.82E-04	-5.7	-68.6	
10	18.00	41.60	0.010	1.09E-03	32.8	-41.8	
11	17.50	53.04	0.010	1.18E-03	56.4	-19.8	
		-32.35	0.010	1.18E-03	56.4	-19.8	
12	16.50	-22.11	0.008	1.18E-03	29.2	20.1	
13	15.45	-11.32	0.007	9.97E-04	11.6	38.1	
14	14.40	-2.76	0.006	7.31E-04	4.3	43.7	
15	13.20	2.01	0.006	3.97E-04	3.8	46.4	
16	12.00	-0.90	0.005	3.34E-05	4.5	51.9	
17	10.80	-14.47	0.006	-3.67E-04	-4.7	56.2	
18	9.78	-36.39	0.006	-6.82E-04	-30.8	43.4	
19	8.75	-66.22	0.007	-7.95E-04	-83.4	-7.6	
		64.01	0.007	-7.95E-04	-83.4	-7.6	
20	7.98	47.42	0.008	-6.50E-04	-40.2	-53.1	
21	7.20	31.32	0.008	-3.54E-04	-9.7	-70.2	
22	6.00	10.82	0.008	1.27E-04	15.6	-59.8	
23	4.80	-2.26	0.008	4.74E-04	20.7	-33.9	
24	3.60	-8.33	0.007	6.42E-04	14.4	-11.3	
25	2.80	-9.42	0.006	6.76E-04	7.3	-2.6	
26	2.00	-8.74	0.006	6.83E-04	0.0	0.0	
At elev. 21.90					Prop force =	57.7 kN/m run (horiz.)	
					=	81.6 kN/m run (inclined)	

(continued)

Stage No.5 Excavate to elevation 17.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	2149
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	2149
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	2149
		Total>	8.33	2.25m	171.02	2.25	2.25a	5277
4	22.58	Total>	21.82	5.63m	191.86	5.63	5.63a	5580
5	21.90	Total>	35.33	9.00m	212.69	9.00	9.00a	5883
6	21.50	Total>	44.46	11.00m	226.18	11.00	11.00a	6062
7	20.59	Total>	76.40	15.55m	268.00	15.55	15.55a	6470
8	19.90	Total>	97.68	19.02m	296.83	19.02	19.02a	6782
9	19.20	Total>	113.76	22.50m	320.46	22.50	22.50a	7094
10	18.00	Total>	136.33	28.50m	356.07	41.60	41.60	7632
11	17.50	Total>	145.14	31.00m	370.32	53.04	53.04	7856
12	16.50	Total>	162.70	36.00m	398.74	76.85	76.85	8305
13	15.45	Total>	181.40	41.25m	428.85	102.05	102.05	8775
14	14.40	Total>	200.44	46.50m	459.30	126.31	126.31	9246
15	13.20	Total>	222.58	52.50m	494.48	151.79	151.79	9785
16	12.00	Total>	245.04	58.50m	529.98	173.62	173.62	10323
17	10.80	Total>	267.76	64.50m	565.74	190.04	190.04	10861
18	9.78	Total>	287.32	69.63m	596.44	198.67	198.67	11321
19	8.75	Total>	307.01	74.75m	627.26	203.12	203.12	11780
		Total>	307.01	144.81	469.25	273.63	273.63	3758
20	7.98	Total>	321.95	134.67	509.29	280.34	280.34	4339
21	7.20	Total>	336.95	124.58	549.37	287.39	287.39	4920
22	6.00	Total>	360.25	109.05	611.53	300.87	300.87	5820
23	4.80	Total>	383.64	94.50m	673.76	318.56	318.56	6719
24	3.60	Total>	407.10	100.50m	736.08	340.18	340.18	7619
25	2.80	Total>	422.78	104.50m	777.65	356.26	356.26	8218
26	2.00	Total>	438.48	108.50m	819.25	373.34	373.34	8818

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	225.18	85.39	85.39	8310
12	16.50	Total>	20.01	5.00m	256.05	98.96	98.96	8784
13	15.45	Total>	41.06	10.25m	288.51	113.37	113.37	9282
14	14.40	Total>	62.19	15.50m	321.05	129.07	129.07	9780
15	13.20	Total>	86.49	21.50m	358.39	149.78	149.78	10350
16	12.00	Total>	111.00	27.50m	395.93	174.51	174.51	10919
17	10.80	Total>	135.73	33.50m	433.71	204.51	204.51	11488
18	9.78	Total>	157.05	38.62m	466.17	235.06	235.06	11974
19	8.75	Total>	178.55	43.75m	498.80	269.33	269.33	12461
		Total>	178.55	43.75m	340.79	209.62	209.62	3975



Run ID. Design\_Case\_03\_with\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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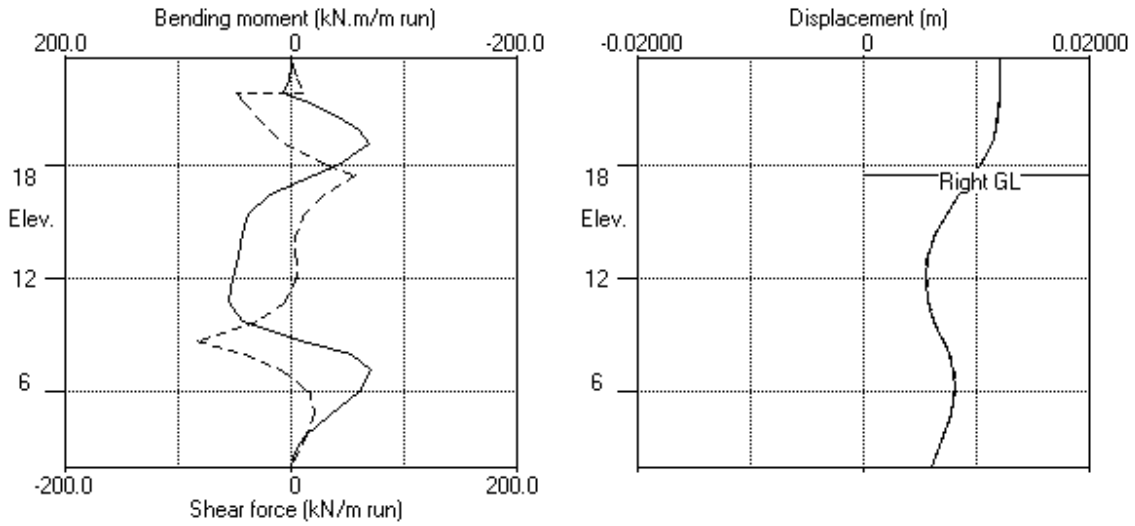
Stage No.5 Excavate to elevation 17.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m <sup>2</sup>	<u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u> kN/m <sup>2</sup>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m <sup>3</sup>
			<u>Vertic</u> <u>-al</u> kN/m <sup>2</sup>	<u>Active</u> <u>limit</u> kN/m <sup>2</sup>	<u>Passive</u> <u>limit</u> kN/m <sup>2</sup>	<u>Earth</u> <u>pressure</u> kN/m <sup>2</sup>		
20	7.98	Total>	194.92	47.62m	382.25	232.92	4590	
21	7.20	Total>	211.38	51.50m	423.81	256.07	5204	
22	6.00	Total>	237.04	57.50m	488.32	290.06	6156	
23	4.80	Total>	262.89	63.50m	553.02	320.82	7107	
24	3.60	Total>	288.89	69.50m	617.87	348.51	8059	
25	2.80	Total>	306.30	73.50m	661.17	365.68	8693	
26	2.00	Total>	323.75	77.50m	704.52	382.07	9327	

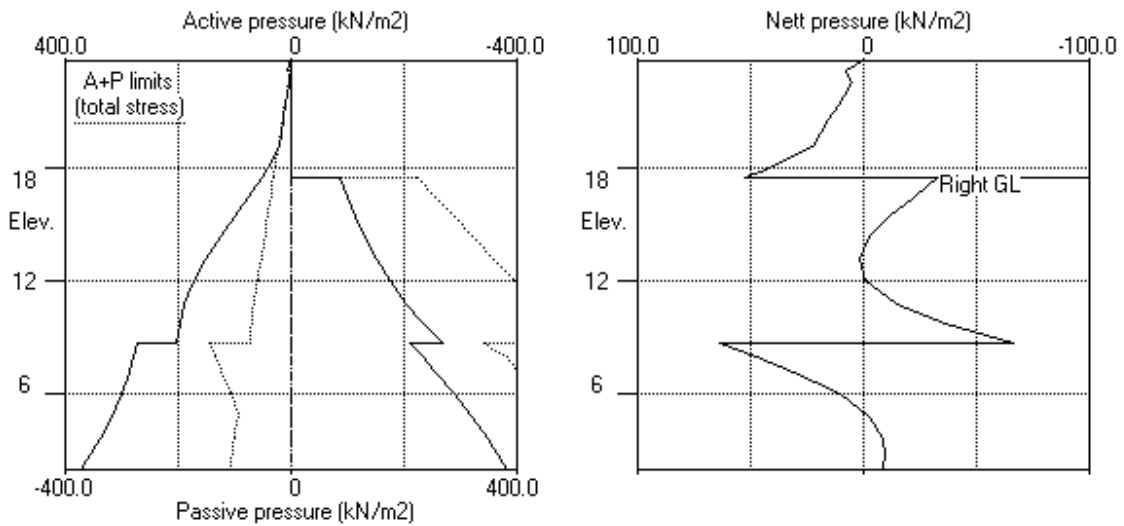
Note: 22.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Excav. to elev. 17.50 on RIGHT side



Stage No.5 Excav. to elev. 17.50 on RIGHT side



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 New contig wall

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 Checked :

Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib.	Toe elev.	Wall Penetr -ation	
9	23.70	17.50		More than one prop. No FoS calc.				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.012	-5.20E-04	0.0	0.0	
2	23.50	3.70	0.012	-5.20E-04	0.4	0.0	-40.6
3	23.25	3.70	0.012	-5.20E-04	-40.2	0.0	
		8.33	0.012	-5.13E-04	-38.7	-9.9	
4	22.58	2.18	0.012	-5.13E-04	-38.7	-9.9	
		5.36	0.013	-4.19E-04	-36.1	-35.0	
5	21.90	8.54	0.013	-2.26E-04	-31.5	-57.7	
6	21.50	10.44	0.013	-6.93E-05	-27.7	-69.5	
7	20.59	22.04	0.013	3.60E-04	-12.9	-83.4	
8	19.90	34.48	0.012	7.24E-04	6.8	-86.3	
9	19.20	44.94	0.012	1.06E-03	34.4	-72.6	
10	18.00	60.99	0.010	1.26E-03	97.9	17.8	-130.7
		60.99	0.010	1.26E-03	-32.8	17.8	
11	17.50	67.45	0.010	1.22E-03	-0.7	9.1	
		43.38	0.010	1.22E-03	-0.7	9.1	
12	16.50	-4.61	0.008	1.13E-03	18.7	19.8	
13	15.45	-9.47	0.007	9.63E-04	11.3	34.0	
14	14.40	-2.03	0.006	7.22E-04	5.3	40.3	
15	13.20	1.84	0.006	4.06E-04	5.2	44.7	
16	12.00	-1.40	0.005	4.94E-05	5.4	51.7	
17	10.80	-14.92	0.006	-3.52E-04	-4.4	56.8	
18	9.78	-36.68	0.006	-6.72E-04	-30.8	44.2	
19	8.75	-66.35	0.007	-7.90E-04	-83.6	-7.0	
		63.99	0.007	-7.90E-04	-83.6	-7.0	
20	7.98	47.44	0.008	-6.47E-04	-40.4	-52.7	
21	7.20	31.37	0.008	-3.54E-04	-9.9	-69.9	
22	6.00	10.88	0.008	1.26E-04	15.5	-59.7	
23	4.80	-2.21	0.008	4.73E-04	20.7	-33.9	
24	3.60	-8.30	0.007	6.41E-04	14.4	-11.3	
25	2.80	-9.40	0.006	6.75E-04	7.3	-2.6	

Run ID. Design\_Case\_03\_with\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
26	2.00	-8.80	0.006	6.82E-04	0.0	0.0	
					Prop force =		40.6 kN/m run
					Prop force =		130.7 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	57199
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	2704
3	23.25	Total>	8.33	8.33	8.33	8.33	8.33	2704
			0.00	8.33	0.00	49.41	2.18	2538
4	22.58	0.00	21.82	1.11	90.49	5.36	5.36	2758
5	21.90	0.00	35.33	6.29	131.58	8.54	8.54	2978
6	21.50	0.00	44.46	9.79	159.40	10.44	10.44	3108
7	20.59	0.00	76.40	22.04	256.58	22.04	22.04a	3405
8	19.90	6.95	90.73	27.53	300.19	27.53	34.48a	3631
9	19.20	13.90	99.86	31.04	327.99	31.04	44.94a	3858
10	18.00	25.90	110.43	35.09	360.16	35.09	60.99a	4249
11	17.50	30.90	114.24	36.55	371.77	36.55	67.45a	4412
12	16.50	40.90	121.80	39.45	394.78	39.45	80.35a	4738
13	15.45	51.40	130.00	42.59	419.71	51.71	103.11	5080
14	14.40	61.90	134.12	44.17	432.25	64.91	126.81	5423
15	13.20	73.90	148.68	49.76	476.57	77.91	151.81	5814
16	12.00	85.90	159.14	53.77	508.42	87.52	173.42	6205
17	10.80	97.90	169.86	57.88	541.04	91.94	189.84	6596
18	9.78	108.15	179.17	61.45	569.39	90.38	198.53	6930
19	8.75	118.40	188.61	65.07	598.09	84.65	203.05	11223
		Total>	307.01	144.81	469.25	273.62	273.62	7038
20	7.98	Total>	321.95	134.67	509.29	280.35	280.35	8126
21	7.20	Total>	336.95	124.58	549.37	287.42	287.42	9214
22	6.00	Total>	360.25	109.05	611.53	300.91	300.91	10898
23	4.80	Total>	383.64	94.50m	673.76	318.59	318.59	12583
24	3.60	Total>	407.10	100.50m	736.08	340.19	340.19	14267
25	2.80	Total>	422.78	104.50m	777.65	356.27	356.27	15390
26	2.00	Total>	438.48	108.50m	819.25	373.31	373.31	115139

RIGHT side

Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses			Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.07	24.07	24.07p	6323

Run ID. Design\_Case\_03\_with\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
12	16.50	0.00	20.01	0.41	84.96	84.96	84.96p	6790
13	15.45	10.50	30.56	4.46	117.07	102.08	112.58	7280
14	14.40	21.00	41.19	8.54	149.43	107.84	128.84	7771
15	13.20	33.00	53.49	13.25	186.87	116.97	149.97	8331
16	12.00	45.00	66.00	18.05	224.93	129.83	174.83	8892
17	10.80	57.00	78.73	22.93	263.69	147.76	204.76	9452
18	9.78	67.25	89.80	27.18	297.38	167.96	235.21	9931
19	8.75	77.50	101.05	31.49	331.61	191.90	269.40	11223
		Total>	178.55	43.75m	340.79	209.63	209.63	7038
20	7.98	Total>	194.92	47.62m	382.25	232.90	232.90	8126
21	7.20	Total>	211.38	51.50m	423.81	256.04	256.04	9214
22	6.00	Total>	237.04	57.50m	488.32	290.02	290.02	10898
23	4.80	Total>	262.89	63.50m	553.02	320.79	320.79	12583
24	3.60	Total>	288.89	69.50m	617.87	348.50	348.50	14267
25	2.80	Total>	306.30	73.50m	661.17	365.67	365.67	15390
26	2.00	Total>	323.75	77.50m	704.52	382.10	382.10	115139

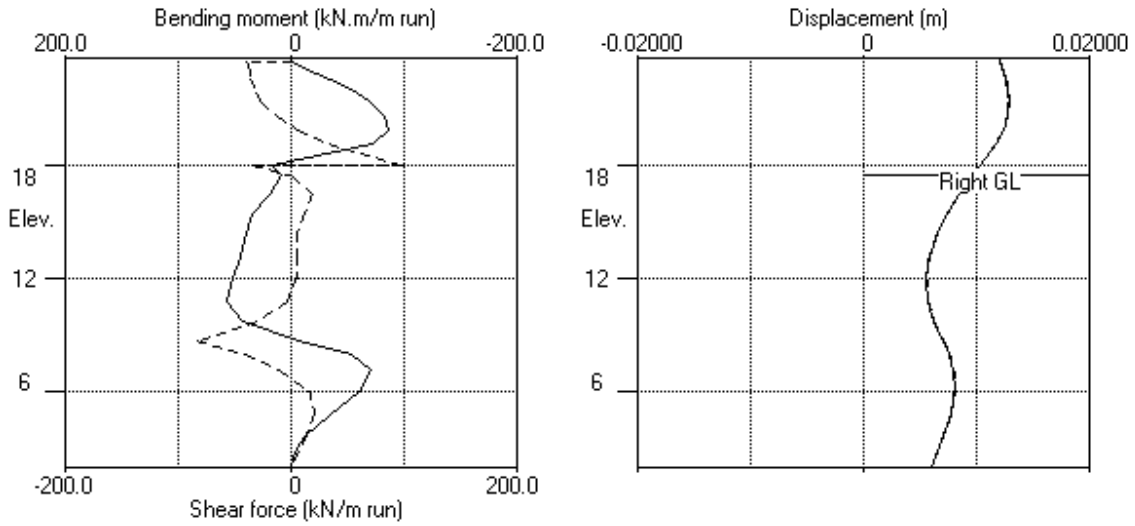
Note: 80.35a Soil pressure at active limit  
 84.96p Soil pressure at passive limit

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 Design Case 3  
 New contig wall

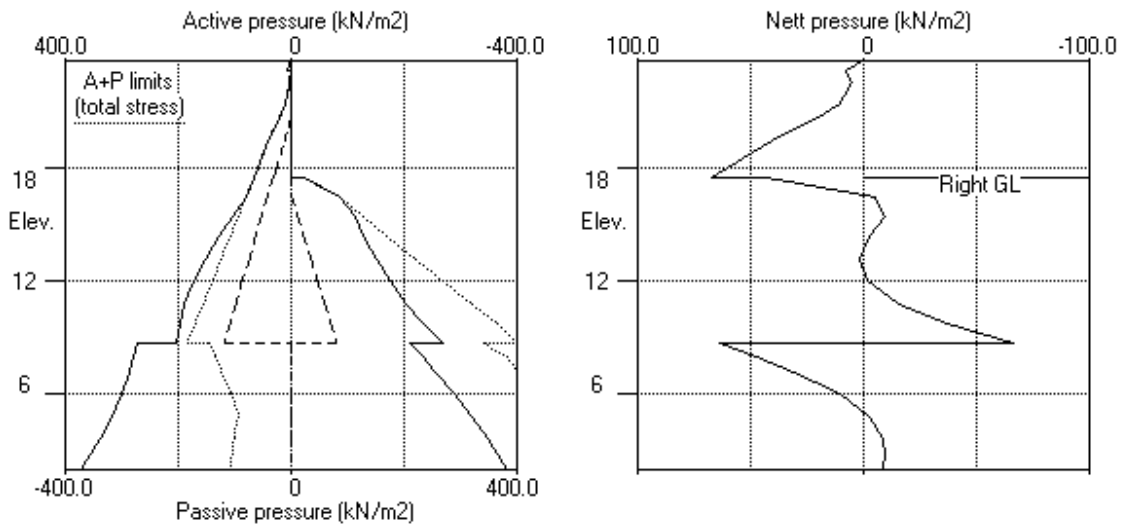
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.9 Change soil type 2 to soil type 4



Stage No.9 Change soil type 2 to soil type 4



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 New contig wall

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 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 2.00</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	23.70	23.70	Cant.	Conditions not suitable for FoS calc.				
2	23.70	23.70	Cant.	Conditions not suitable for FoS calc.				
3	23.70	21.50	Cant.	7.915	3.18	21.26	0.24	L to R
4	23.70	21.50		No analysis at this stage				
5	23.70	17.50	21.90	4.294	n/a	17.28	0.22	L to R
6	23.70	17.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.012	-0.000	0	0	0	0	0	0	0	0
2	23.50	0.012	-0.000	0	0	0	0	0	-61	0	-83
3	23.25	0.012	0.000	0	-15	0	-20	2	-60	3	-81
4	22.58	0.013	0.000	3	-53	3	-72	5	-53	6	-72
5	21.90	0.013	0.000	7	-85	10	-115	9	-48	13	-65
6	21.50	0.013	0.000	12	-100	16	-136	13	-44	18	-60
7	20.59	0.013	0.000	23	-112	31	-151	0	-32	0	-43
8	19.90	0.013	0.000	19	-101	26	-137	34	-20	46	-27
9	19.20	0.012	0.000	14	-73	19	-98	77	-8	104	-10
10	18.00	0.010	0.000	95	-42	128	-56	168	-98	227	-132
11	17.50	0.010	0.000	57	-20	77	-27	56	-54	76	-73
12	16.50	0.009	0.000	30	-7	40	-9	29	-13	39	-17
13	15.45	0.008	0.000	41	-2	55	-2	12	-3	16	-4
14	14.40	0.008	0.000	44	0	59	0	5	0	7	0
15	13.20	0.007	0.000	46	0	63	0	7	0	9	0
16	12.00	0.007	0.000	52	0	70	0	9	0	12	0
17	10.80	0.007	0.000	57	0	77	0	1	-5	1	-6
18	9.78	0.007	0.000	44	0	60	0	0	-31	0	-42
19	8.75	0.008	0.000	0	-8	0	-10	0	-84	0	-113
20	7.98	0.008	0.000	0	-53	0	-72	0	-40	0	-55
21	7.20	0.008	0.000	0	-70	0	-95	0	-10	0	-13
22	6.00	0.008	0.000	0	-60	0	-81	16	0	21	0
23	4.80	0.008	0.000	0	-34	0	-46	21	0	28	0
24	3.60	0.007	0.000	0	-11	0	-15	14	0	19	0
25	2.80	0.006	0.000	0	-3	0	-4	7	0	10	0
26	2.00	0.006	0.000	0	-0	0	-0	0	-0	0	-0



Run ID. Design\_Case\_03\_with\_prop\_SLS  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. elev.	min. elev.	max. elev.	min. elev.	max. min.	max. min.	
1	5	12.00	-17	19.20	7	-23	5	16.50	-8	20.59	7	-11
2	6	10.80	-17	19.20	8	-23	5	16.50	-8	20.59	7	-11
3	23	20.59	-24	7.20	31	-32	13	21.50	-31	8.75	18	-41
4	No calculation at this stage											
5	56	10.80	-70	7.20	76	-95	56	17.50	-83	8.75	76	-113
6	No calculation at this stage											
7	No calculation at this stage											
8	55	10.80	-74	19.90	75	-99	54	18.00	-83	8.75	73	-112
9	57	10.80	-86	19.90	77	-116	98	18.00	-84	8.75	132	-113
10	95	18.00	-112	20.59	128	-151	168	18.00	-98	18.00	227	-132

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum elev.	minimum elev.	maximum elev.	minimum elev.	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.1
3	0.005	23.70	0.000	23.70	Excav. to elev. 21.50 on RIGHT side
4	No calculation at this stage				Install prop no.3 at elev. 21.90
5	0.012	23.70	0.000	23.70	Excav. to elev. 17.50 on RIGHT side
6	No calculation at this stage				Install prop no.2 at elev. 18.00
7	No calculation at this stage				Install prop no.1 at elev. 23.50
8	0.013	21.50	0.000	23.70	Remove prop no.3 at elev. 21.90
9	0.013	21.50	0.000	23.70	Change soil type 2 to soil type 4
10	0.013	21.50	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

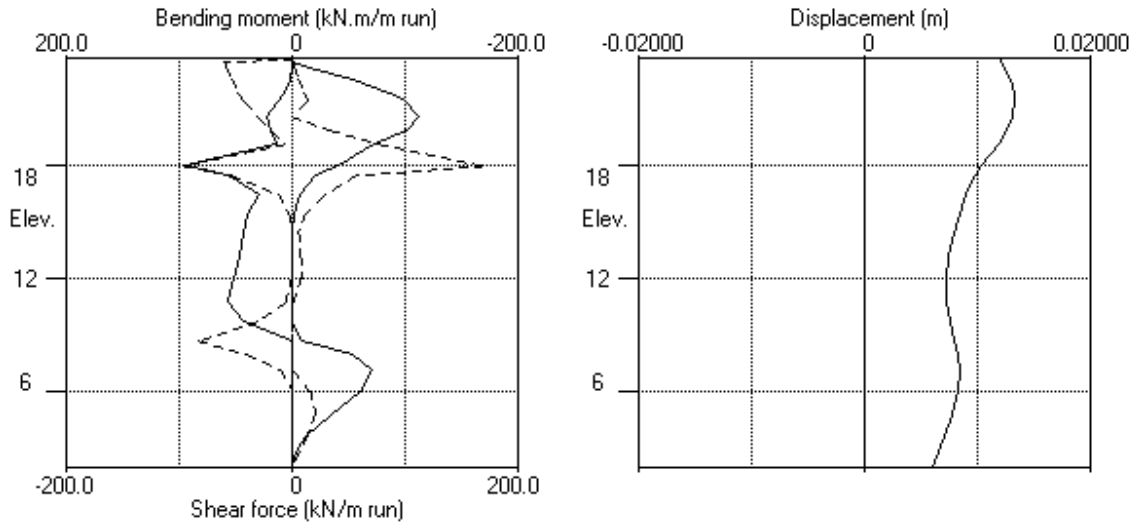
Stage no.	Prop no. 1			Prop no. 2			Prop no. 3		
	at elev. 23.50			at elev. 18.00			at elev. 21.90		
	Calculated	Factored	Factored	Calculated	Factored	Factored	Calculated	Factored	Factored
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
5	---	---	---	---	---	---	58	346	467
8	36	36	49	34	34	46	---	---	---
9	41	41	55	131	131	176	---	---	---
10	62	62	83	266	266	359	---	---	---

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Design Case 3  
New contig wall

Sheet No.  
Job No. 371654  
Made by : MM  
Date:13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



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 Data filename/Run ID: Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	23.70	1 Made Ground	1 Made Ground
2	23.25	2 London Clay	2 London Clay
3	8.75	3 Lambeth Group	3 Lambeth Group

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh, kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. ( Nu ) NC/OC	Active limit Ka ( Kac )	Passive limit Kp ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground	18.50	15000	1.000	NC (0.490)	1.000 (2.474)	1.000 ( 2.475)	0.0u
2	London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	80.00u ( 4.390)
3	Lambeth G.. ( 0.00 )	20.00	72000 ( 5231)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	180.0u ( 13.08)
4	London Cl.. ( 20.00 )	20.00	28800 ( 2610)	1.000	OC (0.200)	0.384 (1.452)	3.043 ( 4.814)	5.000d
5	Lambeth G.. ( 8.75 )	20.00	57600 ( 4185)	1.000 ( 1.000)	OC (0.200)	0.384 (1.452)	3.043 ( 4.814)	0.0d

**Additional soil parameters associated with Ka and Kp**

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	0.666	0.00	0.00	0.666	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00
3	Lambeth Group	0.00	0.666	0.00	0.00	0.666	0.00
4	London Clay Drained	23.00	0.645	0.00	23.00	0.645	0.00
5	Lambeth Group D	23.00	0.645	0.00	23.00	0.645	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	20.59	20.59

Automatic water pressure balancing at toe of wall : No

Water press.		Left side			Right side			
profile no.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	20.59	20.59	0.0	1	16.50	16.50	0.0
2	1	23.70	23.70	0.0	1	16.50	16.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 2.00  
 Maximum finite element length = 1.20 m  
 Youngs modulus of wall E = 2.8000E+07 kN/m2  
 Moment of inertia of wall I = 5.7800E-03 m4/m run  
 E.I = 161840 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m <sup>2</sup>	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	23.50	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
2	18.00	1.00	0.500000	2.800E+08	22.25	0.00	0	Strut	No	R
3	21.90	6.00	0.017663	2.050E+07	4.00	45.00	0	Strut	No	R

**SURCHARGE LOADS**

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpand. to wall	Surcharge kN/m <sup>2</sup>	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.90	1.20 (L)	32.15	1.00	100.00	=	N/A	1.00 -
2	17.00	-0.00 (R)	23.80	20.00	12.00	=	N/A	1.00 -

Note: L = Left side, R = Right side

Limit State Categories P/U = Permanent Unfavourable  
P/F = Permanent Favourable  
Var = Variable (unfavourable)

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 21.90 No analysis at this stage
2	Apply water pressure profile no.2 ( Worst Cred. )
3	Excavate to elevation 21.50 on RIGHT side
4	Install strut or anchor no.3 at elevation 21.90
5	Excavate to elevation 17.00 on RIGHT side
6	Install strut or anchor no.2 at elevation 18.00
7	Install strut or anchor no.1 at elevation 23.50
8	Remove strut or anchor no.3 at elevation 21.90
9	Change properties of soil type 2 to soil type 4 Ko pressures will not be reset
10	Apply water pressure profile no.2 ( Worst Cred. )

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m<sup>3</sup>

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) = 21.70 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 23.80 m

Width of excavation on Left side of wall = 20.00 m

Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 23.70 m

Distance to rigid boundary on Right side = 23.70 m

## OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 21.90	Yes	Yes	Yes
2	Apply water pressure profile no.2	Yes	Yes	Yes
3	Excav. to elev. 21.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.3 at elev. 21.90	Yes	Yes	Yes
5	Excav. to elev. 17.00 on RIGHT side	Yes	Yes	Yes
6	Install prop no.2 at elev. 18.00	Yes	Yes	Yes
7	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
8	Remove prop no.3 at elev. 21.90	Yes	Yes	Yes
9	Change soil type 2 to soil type 4	Yes	Yes	Yes
10	Apply water pressure profile no.2	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

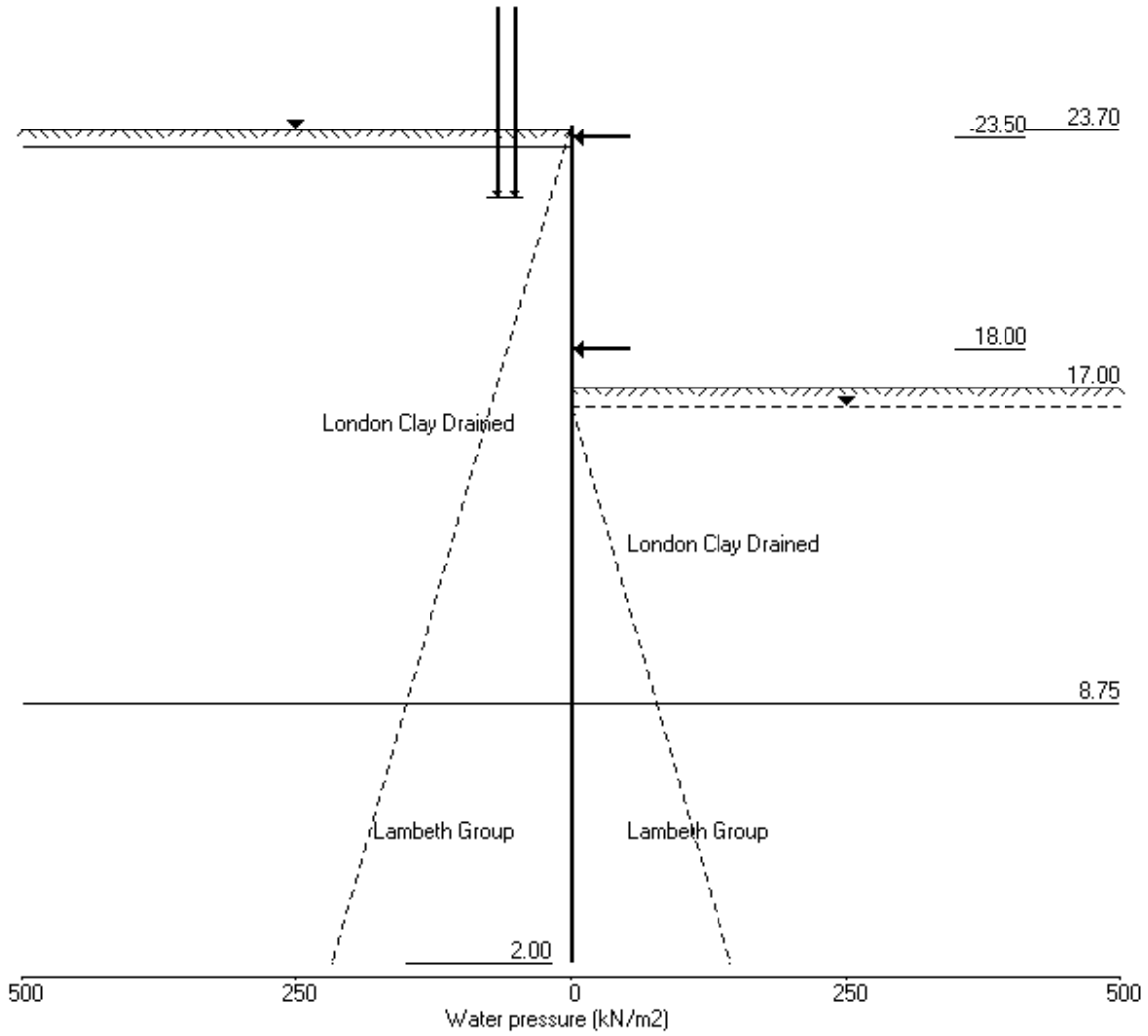
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 Data filename/Run ID: Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.10 Apply water pressure profile no.2 (Worst Cred.)



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 21.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr -ation	
3	23.70	21.50	Cant.	5.658	3.18	21.13	0.37	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.006	6.12E-04	0.0	0.0	
2	23.50	3.70	0.005	6.12E-04	0.4	0.0	
3	23.25	8.32	0.005	6.12E-04	1.9	0.3	
		2.25	0.005	6.12E-04	1.9	0.3	
4	22.58	5.63	0.005	6.06E-04	4.5	2.5	
5	21.90	9.00	0.004	5.85E-04	9.5	7.4	
6	21.50	11.00	0.004	5.61E-04	13.5	12.0	
		-17.97	0.004	5.61E-04	13.5	12.0	
7	20.59	-13.92	0.004	4.64E-04	-1.0	22.8	
8	19.90	-3.33	0.003	3.73E-04	-7.0	19.3	
9	19.20	1.45	0.003	3.02E-04	-7.7	13.8	
10	18.00	3.22	0.003	2.31E-04	-4.9	5.4	
11	17.00	2.78	0.003	2.09E-04	-1.9	1.8	
12	16.50	2.51	0.003	2.05E-04	-0.6	1.1	
13	15.45	1.79	0.002	1.96E-04	1.7	1.5	
14	14.40	1.47	0.002	1.79E-04	3.4	3.8	
15	13.20	1.02	0.002	1.33E-04	4.9	8.5	
16	12.00	-0.88	0.002	4.79E-05	5.0	14.6	
17	10.80	-6.21	0.002	-7.88E-05	0.7	19.6	
18	9.78	-14.88	0.002	-1.94E-04	-10.1	16.8	
19	8.75	-26.99	0.002	-2.42E-04	-31.5	-1.5	
		25.28	0.002	-2.42E-04	-31.5	-1.5	
20	7.98	18.30	0.002	-1.94E-04	-14.6	-18.5	
21	7.20	11.65	0.003	-9.17E-05	-3.0	-24.4	
22	6.00	3.47	0.003	7.31E-05	6.0	-20.0	
23	4.80	-1.37	0.002	1.86E-04	7.3	-10.6	
24	3.60	-3.16	0.002	2.37E-04	4.6	-3.2	
25	2.80	-3.06	0.002	2.47E-04	2.1	-0.6	
26	2.00	-2.17	0.002	2.48E-04	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 21.50 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
1	23.70	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
		Total>	0.00	0.00	0.00	0.00	0.00	4348
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	4348
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	4348
		Total>	8.33	2.25m	124.54	2.25	2.25a	10675
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	11288
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	11900
6	21.50	Total>	44.46	11.00m	174.26	11.00	11.00a	12263
7	20.59	Total>	76.40	15.55m	213.27	32.23	32.23	13088
8	19.90	Total>	97.68	19.02m	239.94	55.87	55.87	13719
9	19.20	Total>	113.76	22.50m	261.42	73.90	73.90	14350
10	18.00	Total>	136.33	28.50m	293.31	98.78	98.78	15438
11	17.00	Total>	153.01	33.50m	317.75	117.58	117.58	16346
12	16.50	Total>	162.70	36.00m	331.33	126.87	126.87	16799
13	15.45	Total>	181.40	41.25m	358.17	146.54	146.54	17752
14	14.40	Total>	200.44	46.50m	385.37	166.54	166.54	18705
15	13.20	Total>	222.58	52.50m	416.82	189.52	189.52	19793
16	12.00	Total>	245.04	58.50m	448.60	211.81	211.81	20882
17	10.80	Total>	267.76	64.50m	480.64	232.14	232.14	21971
18	9.78	Total>	287.32	69.63m	508.16	247.05	247.05	22901
19	8.75	Total>	307.01	78.28	535.80	259.89	259.89	23831
		Total>	307.01	191.11	422.93	292.57	292.57	7603
20	7.98	Total>	321.95	188.14	455.80	303.75	303.75	8778
21	7.20	Total>	336.95	185.22	488.72	315.16	315.16	9953
22	6.00	Total>	360.25	180.77	539.78	334.20	334.20	11773
23	4.80	Total>	383.64	176.42	590.92	355.39	355.39	13592
24	3.60	Total>	407.10	172.13	642.13	378.54	378.54	15412
25	2.80	Total>	422.78	169.31	676.31	394.79	394.79	16625
26	2.00	Total>	438.48	166.52	710.51	411.55	411.55	17838

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
1	23.70	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
		Total>	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	Total>	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	Total>	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	Total>	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	Total>	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	Total>	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	129.79	28.97	28.97	6314
7	20.59	Total>	18.20	4.55m	155.06	46.15	46.15	6740
8	19.90	Total>	32.11	8.02m	174.37	59.20	59.20	7064
9	19.20	Total>	46.03	11.50m	193.68	72.45	72.45	7389
10	18.00	Total>	70.10	17.50m	227.07	95.55	95.55	7950
11	17.00	Total>	90.20	22.50m	254.94	114.79	114.79	8417
12	16.50	Total>	100.27	25.00m	268.89	124.36	124.36	8650
13	15.45	Total>	121.46	30.25m	298.24	144.75	144.75	9141
14	14.40	Total>	142.71	35.50m	327.64	165.07	165.07	9631
15	13.20	Total>	167.09	41.50m	361.33	188.50	188.50	10192
16	12.00	Total>	191.54	47.50m	395.10	212.68	212.68	10753
17	10.80	Total>	216.08	53.50m	428.96	238.35	238.35	11313
18	9.78	Total>	237.09	58.62m	457.93	261.93	261.93	11792
19	8.75	Total>	258.15	63.75m	486.95	286.88	286.88	12271
		Total>	258.15	142.25	374.09	267.30	267.30	3915



Run ID. Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
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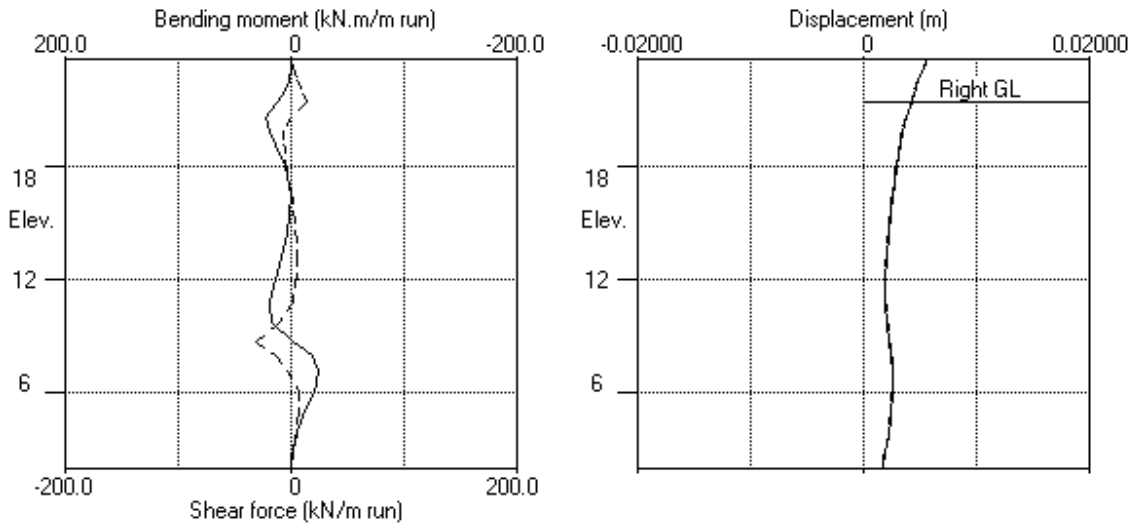
Stage No.3 Excavate to elevation 21.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>RIGHT side</u> <u>Effective stresses</u>					<u>Total</u> <u>earth</u> <u>pressure</u>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u>
		<u>Water</u> <u>press.</u>	<u>Vertic</u> <u>-al</u>	<u>Active</u> <u>limit</u>	<u>Passive</u> <u>limit</u>	<u>Earth</u> <u>pressure</u>		
		kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>3</sup>	
20	7.98	Total>	274.10	140.28	407.96	285.45	285.45	4520
21	7.20	Total>	290.07	138.33	441.85	303.51	303.51	5125
22	6.00	Total>	314.83	135.35	494.36	330.73	330.73	6062
23	4.80	Total>	339.62	132.39	546.91	356.76	356.76	6999
24	3.60	Total>	364.43	129.46	599.47	381.69	381.69	7936
25	2.80	Total>	380.98	127.51	634.52	397.85	397.85	8561
26	2.00	Total>	397.53	125.56	669.57	413.72	413.72	9185

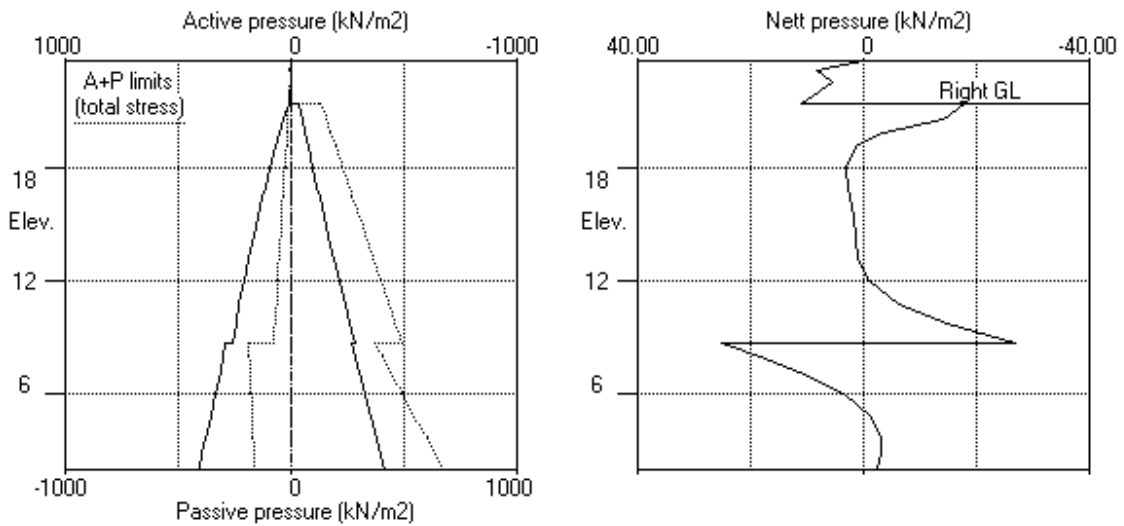
Note: 11.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 21.50 on RIGHT side



Stage No.3 Excav. to elev. 21.50 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 17.00 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	Overall FoS for toe elev. = 2.00		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety at elev.	Moment of equilib. at elev.	Toe elev.	Wall Penetr -ation	
5	23.70	17.00	21.90	2.837	n/a	16.58	0.42	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.012	-1.65E-04	0.0	0.0	
2	23.50	3.70	0.012	-1.65E-04	0.4	0.0	
3	23.25	8.32	0.013	-1.66E-04	1.9	0.3	
		2.25	0.013	-1.66E-04	1.9	0.3	
4	22.58	5.63	0.013	-1.71E-04	4.5	2.5	
5	21.90	9.00	0.013	-1.92E-04	9.5	7.4	-62.8
		9.00	0.013	-1.92E-04	-53.3	7.4	
6	21.50	11.00	0.013	-1.85E-04	-49.3	-13.2	
7	20.59	15.55	0.013	-1.50E-05	-37.3	-47.4	
8	19.90	19.02	0.013	2.36E-04	-25.3	-69.5	
9	19.20	22.50	0.013	5.62E-04	-10.8	-82.4	
10	18.00	32.43	0.012	1.09E-03	22.1	-61.6	
11	17.00	55.62	0.010	1.34E-03	66.2	-20.3	
		-38.53	0.010	1.34E-03	66.2	-20.3	
12	16.50	-32.35	0.010	1.36E-03	48.4	7.9	
13	15.45	-18.74	0.008	1.21E-03	21.6	40.5	
14	14.40	-7.08	0.007	9.09E-04	8.1	52.5	
15	13.20	0.36	0.006	5.04E-04	4.0	56.6	
16	12.00	-1.39	0.006	6.76E-05	3.4	61.3	
17	10.80	-15.48	0.006	-3.96E-04	-6.7	63.9	
18	9.78	-39.15	0.007	-7.52E-04	-34.7	48.6	
19	8.75	-71.61	0.008	-8.81E-04	-91.5	-7.9	
		69.83	0.008	-8.81E-04	-91.5	-7.9	
20	7.98	51.85	0.008	-7.24E-04	-44.3	-57.9	
21	7.20	34.35	0.009	-4.01E-04	-10.9	-76.8	
22	6.00	12.00	0.009	1.27E-04	16.9	-65.8	
23	4.80	-2.33	0.008	5.09E-04	22.7	-37.5	
24	3.60	-9.08	0.008	6.95E-04	15.8	-12.5	
25	2.80	-10.38	0.007	7.33E-04	8.1	-2.9	
26	2.00	-9.77	0.007	7.40E-04	0.0	-0.0	
At elev. 21.90			Prop force =		62.8 kN/m run (horiz.)		
			=		88.8 kN/m run (inclined)		

(continued)

Stage No.5 Excavate to elevation 17.00 on RIGHT side

LEFT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	2149
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	2149
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	2149
		Total>	8.33	2.25m	124.54	2.25	2.25a	5277
4	22.58	Total>	21.82	5.63m	143.28	5.63	5.63a	5580
5	21.90	Total>	35.33	9.00m	162.02	9.00	9.00a	5883
6	21.50	Total>	44.46	11.00m	174.26	11.00	11.00a	6062
7	20.59	Total>	76.40	15.55m	213.27	15.55	15.55a	6470
8	19.90	Total>	97.68	19.02m	239.94	19.02	19.02a	6782
9	19.20	Total>	113.76	22.50m	261.42	22.50	22.50a	7094
10	18.00	Total>	136.33	28.50m	293.31	32.43	32.43	7632
11	17.00	Total>	153.01	33.50m	317.75	55.62	55.62	8080
12	16.50	Total>	162.70	36.00m	331.33	68.01	68.01	8305
13	15.45	Total>	181.40	41.25m	358.17	94.54	94.54	8775
14	14.40	Total>	200.44	46.50m	385.37	120.26	120.26	9246
15	13.20	Total>	222.58	52.50m	416.82	147.00	147.00	9785
16	12.00	Total>	245.04	58.50m	448.60	169.36	169.36	10323
17	10.80	Total>	267.76	64.50m	480.64	185.52	185.52	10861
18	9.78	Total>	287.32	69.63m	508.16	193.30	193.30	11321
19	8.75	Total>	307.01	78.28	535.80	196.49	196.49	11780
		Total>	307.01	191.11	422.93	272.35	272.35	3758
20	7.98	Total>	321.95	188.14	455.80	278.39	278.39	4339
21	7.20	Total>	336.95	185.22	488.72	284.78	284.78	4920
22	6.00	Total>	360.25	180.77	539.78	297.41	297.41	5820
23	4.80	Total>	383.64	176.42	590.92	314.53	314.53	6719
24	3.60	Total>	407.10	172.13	642.13	335.87	335.87	7619
25	2.80	Total>	422.78	169.31	676.31	351.88	351.88	8218
26	2.00	Total>	438.48	166.52	710.51	368.97	368.97	8818

RIGHT side								
Node no.	Y coord	Effective stresses					Total earth pressure	Coeff. of subgrade reaction
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	164.72	94.15	94.15	8610
12	16.50	Total>	10.00	2.50m	178.60	100.36	100.36	8849
13	15.45	Total>	31.03	7.75m	207.78	113.28	113.28	9351
14	14.40	Total>	52.12	13.00m	237.03	127.34	127.34	9853
15	13.20	Total>	76.37	19.00m	270.60	146.65	146.65	10427
16	12.00	Total>	100.82	25.00m	304.36	170.75	170.75	11000
17	10.80	Total>	125.51	31.00m	338.37	201.01	201.01	11574
18	9.78	Total>	146.80	36.12m	367.62	232.46	232.46	12063
19	8.75	Total>	168.29	41.25m	397.06	268.10	268.10	12553
		Total>	168.29	52.41	284.20	202.51	202.51	4005

Run ID. Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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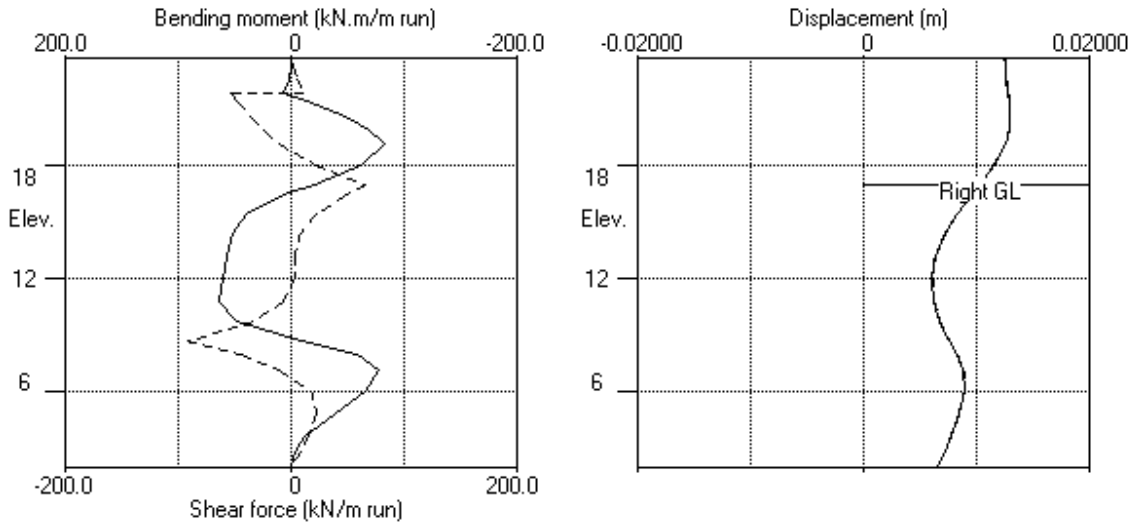
Stage No.5 Excavate to elevation 17.00 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
20	7.98	Total>	184.66	50.86	318.49	226.54	226.54	4624
21	7.20	Total>	201.13	49.42	352.89	250.43	250.43	5243
22	6.00	Total>	226.84	55.00m	406.35	285.40	285.40	6201
23	4.80	Total>	252.76	61.00m	460.02	316.86	316.86	7160
24	3.60	Total>	278.85	67.00m	513.87	344.95	344.95	8118
25	2.80	Total>	296.34	71.00m	549.86	362.26	362.26	8757
26	2.00	Total>	313.88	75.00m	585.90	378.73	378.73	9396

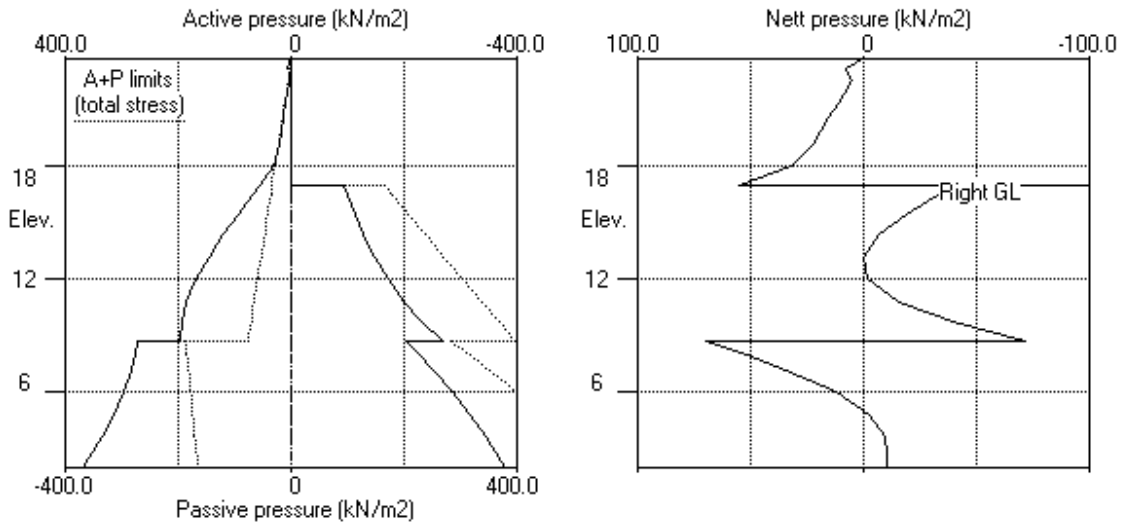
Note: 22.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Excav. to elev. 17.00 on RIGHT side



Stage No.5 Excav. to elev. 17.00 on RIGHT side



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 2.00		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>at elev.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>		
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>		
			<u>More than one prop.</u>	<u>No FoS calc.</u>					
9	23.70	17.00							

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>		
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>		
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m		
1	23.70	0.00	0.012	-7.25E-04	0.0	0.0			
2	23.50	3.70	0.013	-7.25E-04	0.4	0.0	-52.3		
		3.70	0.013	-7.25E-04	-51.9	0.0			
3	23.25	8.32	0.013	-7.15E-04	-50.4	-12.8			
		4.50	0.013	-7.15E-04	-50.4	-12.8			
4	22.58	11.25	0.013	-5.95E-04	-45.1	-45.1			
5	21.90	19.54	0.013	-3.50E-04	-34.7	-72.1			
6	21.50	25.89	0.014	-1.57E-04	-25.6	-84.2			
7	20.59	45.44	0.013	3.27E-04	6.8	-88.6			
8	19.90	58.95	0.013	6.72E-04	43.1	-72.1			
9	19.20	70.08	0.013	8.86E-04	87.9	-27.2			
10	18.00	86.92	0.012	4.37E-04	182.1	148.2	-372.4		
		86.92	0.012	4.37E-04	-190.2	148.2			
11	17.00	100.38	0.012	-2.74E-05	-96.6	2.3			
		83.73	0.012	-2.74E-05	-96.6	2.3			
12	16.50	66.32	0.012	2.54E-05	-59.1	-36.5			
13	15.45	44.66	0.011	3.67E-04	-0.8	-68.8			
14	14.40	22.99	0.011	7.56E-04	34.7	-51.3			
15	13.20	-1.94	0.010	9.50E-04	47.4	-0.9			
16	12.00	-21.45	0.009	7.50E-04	33.3	54.8			
17	10.80	-29.62	0.008	2.54E-04	2.7	79.1			
18	9.78	-42.13	0.008	-2.09E-04	-34.1	67.2			
19	8.75	-59.31	0.008	-4.59E-04	-86.1	11.8			
		61.74	0.008	-4.59E-04	-86.1	11.8			
20	7.98	46.28	0.009	-3.99E-04	-44.2	-36.5			
21	7.20	31.19	0.009	-1.75E-04	-14.2	-57.1			
22	6.00	11.63	0.009	2.29E-04	11.5	-52.2			
23	4.80	-0.90	0.008	5.36E-04	17.9	-30.7			
24	3.60	-7.18	0.008	6.88E-04	13.1	-10.4			
25	2.80	-8.60	0.007	7.20E-04	6.7	-2.5			
26	2.00	-8.26	0.007	7.26E-04	0.0	-0.0			

At elev. 23.50 Prop force = 52.3 kN/m run  
 At elev. 18.00 Prop force = 372.4 kN/m run

(continued)

Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

LEFT side									
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction	
			Vertic -al	Active limit	Passive limit	Earth pressure			
1	23.70	Total>	0.00	0.00	0.00	0.00	0.00	73810	
2	23.50	Total>	3.70	3.70	3.70	3.70	3.70	8766	
3	23.25	Total>	8.33	8.32	8.33	8.32	8.32	8766	
			4.50	3.83	0.00	25.89	0.00	4.50a	8804
4	22.58	11.25	10.57	0.00	42.18	0.00	11.25a	9567	
5	21.90	18.00	17.33	1.54	58.48	1.54	19.54a	10331	
6	21.50	22.00	22.46	3.89	70.89	3.89	25.89a	7781	
7	20.59	31.10	45.30	14.34	126.00	14.34	45.44a	8524	
8	19.90	38.05	59.63	20.90	160.60	20.90	58.95a	9091	
9	19.20	45.00	68.76	25.08	182.65	25.08	70.08a	9658	
10	18.00	57.00	79.33	29.92	208.16	29.92	86.92a	5174	
11	17.00	67.00	86.91	33.38	226.46	33.38	100.38a	5571	
12	16.50	72.00	90.70	35.12	235.62	35.12	107.12a	5769	
13	15.45	82.50	98.90	38.87	255.40	38.87	121.37a	6186	
14	14.40	93.00	107.44	42.78	276.02	42.78	135.78a	6603	
15	13.20	105.00	117.58	47.42	300.50	47.42	152.42a	7079	
16	12.00	117.00	128.04	52.21	325.76	52.21	169.21a	7555	
17	10.80	129.00	138.76	57.11	351.63	57.11	186.11a	8032	
18	9.78	139.25	148.07	61.37	374.11	61.37	200.62a	8438	
19	8.75	149.50	157.51	65.69	396.88	65.69	215.19a	8845	
		Total>	307.01	191.11	422.93	268.30	268.30	5641	
20	7.98	Total>	321.95	188.14	455.80	275.61	275.61	6512	
21	7.20	Total>	336.95	185.22	488.72	283.20	283.20	7384	
22	6.00	Total>	360.25	180.77	539.78	297.22	297.22	8734	
23	4.80	Total>	383.64	176.42	590.92	315.24	315.24	13951	
24	3.60	Total>	407.10	172.13	642.13	336.82	336.82	15819	
25	2.80	Total>	422.78	169.31	676.31	352.77	352.77	17064	
26	2.00	Total>	438.48	166.52	710.51	369.72	369.72	18309	

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.58	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	20.59	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	19.90	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	17.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	16.66	16.66	16.66p	5571
12	16.50	0.00	10.00	0.00	40.80	40.80	40.80p	5769
13	15.45	10.50	20.53	3.00	66.21	66.21	76.71p	6186
14	14.40	21.00	31.12	7.85	91.79	91.79	112.79p	6603
15	13.20	33.00	43.37	13.46	121.36	121.36	154.36p	7079
16	12.00	45.00	55.82	19.16	151.41	145.66	190.66	7555
17	10.80	57.00	68.51	24.96	182.04	158.73	215.73	8032
18	9.78	67.25	79.55	30.02	208.70	175.51	242.76	8438



Run ID. Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

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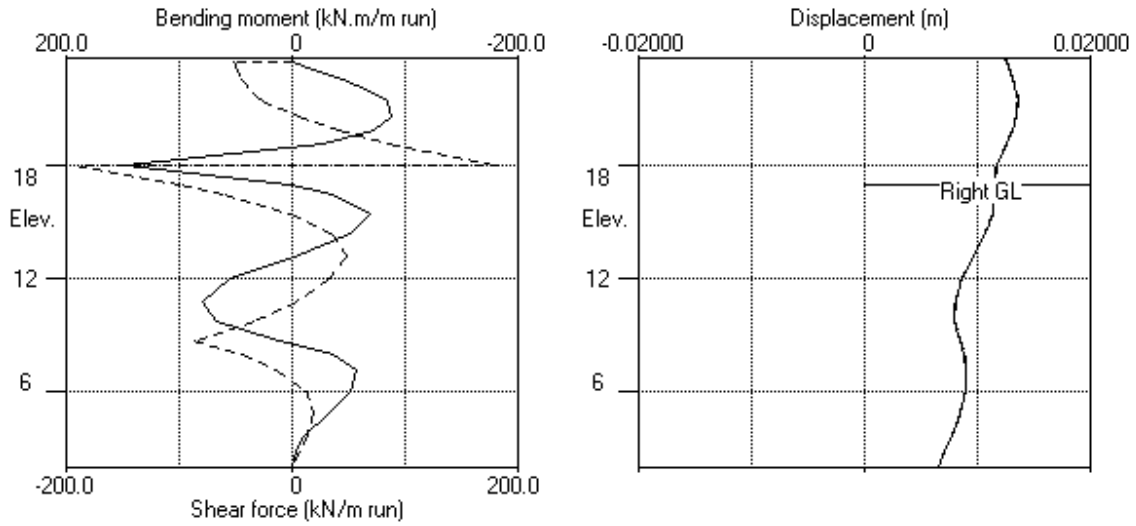
Stage No.9 Change properties of soil type 2 to soil type 4  
 Ko pressures will not be reset

RIGHT side								
Node no.	Y coord	Water press. kN/m2	Vertic -al kN/m2	Effective stresses		Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
				Active limit kN/m2	Passive limit kN/m2			
19	8.75	77.50	90.79	35.16	235.82	197.00	274.50	8845
		Total>	168.29	52.41	284.20	206.56	206.56	5641
20	7.98	Total>	184.66	50.86	318.49	229.32	229.32	6512
21	7.20	Total>	201.13	49.42	352.89	252.01	252.01	7384
22	6.00	Total>	226.84	55.00m	406.35	285.59	285.59	8734
23	4.80	Total>	252.76	61.00m	460.02	316.14	316.14	13951
24	3.60	Total>	278.85	67.00m	513.87	344.00	344.00	15819
25	2.80	Total>	296.34	71.00m	549.86	361.37	361.37	17064
26	2.00	Total>	313.88	75.00m	585.90	377.98	377.98	18309

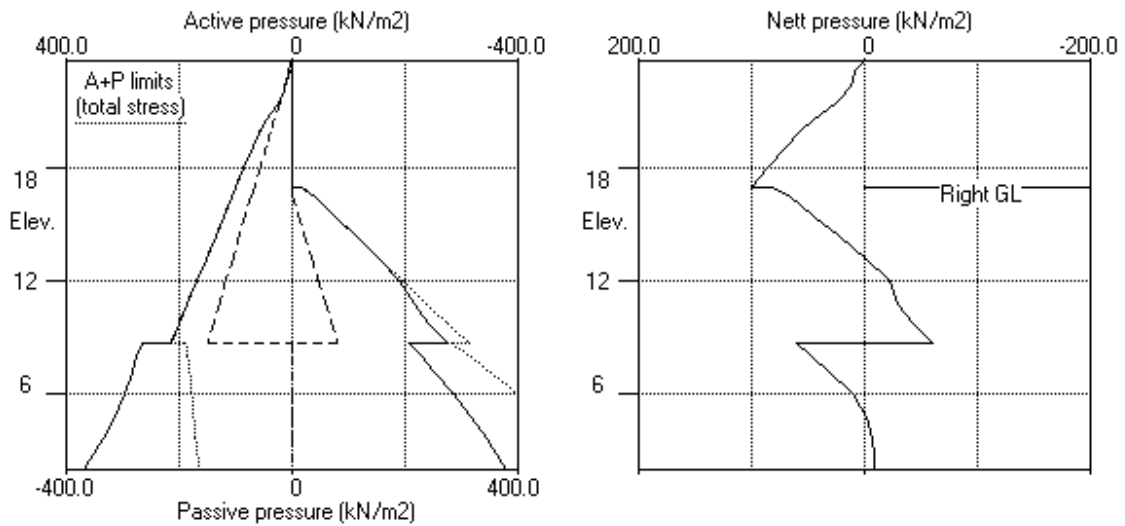
Note: 215.19a Soil pressure at active limit  
 154.36p Soil pressure at passive limit

Units: kN,m

Stage No.9 Change soil type 2 to soil type 4



Stage No.9 Change soil type 2 to soil type 4



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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 2.00</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	23.70	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	23.70	21.50	Cant.	5.658	3.18	21.13	0.37	L to R
4	23.70	21.50		No analysis at this stage				
5	23.70	17.00	21.90	2.837	n/a	16.58	0.42	L to R
6	23.70	17.00		No analysis at this stage				

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

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 Design Case 3  
 New contig wall

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 23.80m  
 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: Left side 23.70 from wall  
 Right side 23.70 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.012	-0.000	0.0	-0.0	0.0	0.0
2	23.50	0.013	-0.000	0.0	-0.0	0.4	-51.9
3	23.25	0.013	0.000	0.3	-12.8	1.9	-50.4
4	22.58	0.013	0.000	2.5	-45.1	4.5	-45.1
5	21.90	0.013	0.000	7.4	-72.1	9.5	-53.3
6	21.50	0.014	0.000	12.0	-84.2	13.5	-49.3
7	20.59	0.014	0.000	22.8	-88.6	6.8	-37.3
8	19.90	0.013	0.000	19.3	-85.0	43.1	-25.3
9	19.20	0.013	0.000	13.8	-82.4	87.9	-10.8
10	18.00	0.012	0.000	148.2	-61.6	182.1	-190.2
11	17.00	0.012	0.000	2.3	-20.3	66.2	-96.6
12	16.50	0.012	0.000	18.5	-36.5	48.4	-59.1
13	15.45	0.011	0.000	43.0	-68.8	21.6	-0.8
14	14.40	0.011	0.000	52.5	-51.3	34.7	0.0
15	13.20	0.010	0.000	56.6	-0.9	47.4	0.0
16	12.00	0.009	0.000	61.3	0.0	33.3	0.0
17	10.80	0.008	0.000	79.1	0.0	2.7	-6.7
18	9.78	0.008	0.000	67.2	0.0	0.0	-34.7
19	8.75	0.008	0.000	11.8	-7.9	0.0	-91.5
20	7.98	0.009	0.000	0.0	-57.9	0.0	-44.3
21	7.20	0.009	0.000	0.0	-76.8	0.0	-14.2
22	6.00	0.009	0.000	0.0	-65.8	16.9	0.0
23	4.80	0.008	0.000	0.0	-37.5	22.7	0.0
24	3.60	0.008	0.000	0.0	-12.5	15.8	0.0
25	2.80	0.007	0.000	0.0	-2.9	8.1	0.0
26	2.00	0.007	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				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	5.1	12.00	-16.9	19.20	5.6	17.00	-8.4	20.59
2	6.4	10.80	-17.6	19.20	5.6	17.00	-8.6	20.59
3	22.8	20.59	-24.4	7.20	13.5	21.50	-31.5	8.75
4	No calculation at this stage							
5	63.9	10.80	-82.4	19.20	66.2	17.00	-91.5	8.75
6	No calculation at this stage							
7	No calculation at this stage							
8	63.2	10.80	-85.0	19.90	54.1	17.00	-91.4	8.75
9	148.2	18.00	-88.6	20.59	182.1	18.00	-190.2	18.00
10	148.2	18.00	-88.6	20.59	182.1	18.00	-190.2	18.00

Run ID. Design\_Case\_03\_with\_prop\_ULS2  
 Design Case 3  
 New contig wall

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				Stage description
no.	maximum m	elev.	minimum m	elev.	
1	0.001	18.00	-0.000	23.70	Apply surcharge no.1 at elev. 21.90
2	0.001	18.00	-0.000	23.70	Apply water pressure profile no.2
3	0.006	23.70	0.000	23.70	Excav. to elev. 21.50 on RIGHT side
4	No calculation at this stage				Install prop no.3 at elev. 21.90
5	0.013	20.59	0.000	23.70	Excav. to elev. 17.00 on RIGHT side
6	No calculation at this stage				Install prop no.2 at elev. 18.00
7	No calculation at this stage				Install prop no.1 at elev. 23.50
8	0.014	20.59	0.000	23.70	Remove prop no.3 at elev. 21.90
9	0.014	21.50	0.000	23.70	Change soil type 2 to soil type 4
10	0.014	21.50	0.000	23.70	Apply water pressure profile no.2

**Prop forces at each stage (horizontal components)**

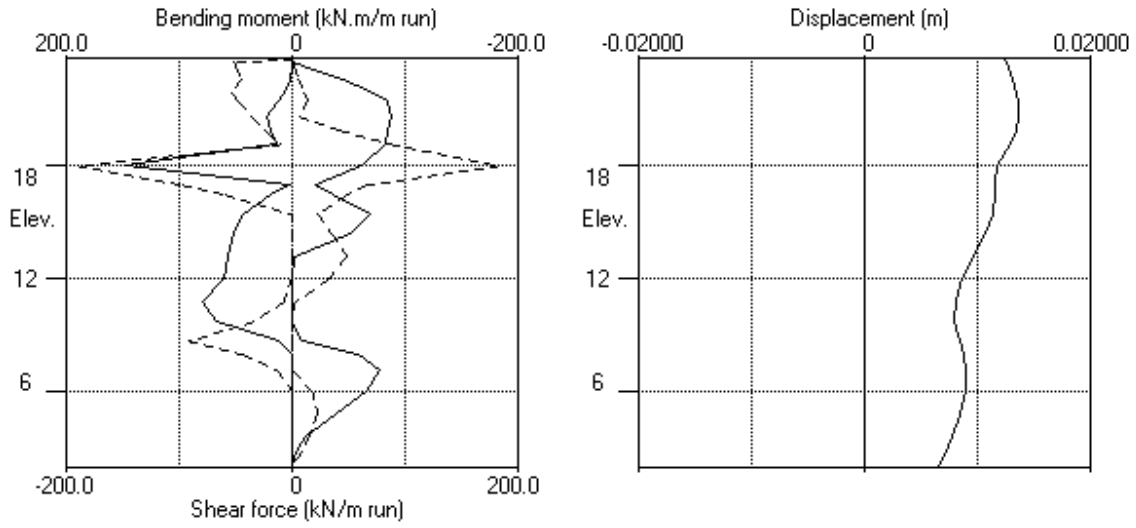
Stage	Strut no. 1		Strut no. 2		Strut no. 3	
no.	at elev. 23.50		at elev. 18.00		at elev. 21.90	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
5	---	---	---	---	62.81	376.87
8	39.23	39.23	36.52	36.52	---	---
9	52.28	52.28	372.37	372.37	---	---
10	52.28	52.28	372.37	372.37	---	---

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Data filename/Run ID: Design\_Case\_03\_with\_prop\_ULS2  
Design Case 3  
New contig wall

Sheet No.  
Job No. 371654  
Made by : MM  
Date:13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes





# **APPENDIX C**

## **WALLAP OUTPUTS: SHEET PILED WALL**

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DESIGN CASE 04



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 Data filename/Run ID: Design\_Case 04 Sheet Pile\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	23.70	1 Made Ground	1 Made Ground
2	21.50	2 London Clay	2 London Clay

**SOIL PROPERTIES**

Soil type	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy )	Ko (dKo/dy)	NC/OC ( Nu )	Ka ( Kac )	Kp ( Kpc )	kN/m2 ( dc/dy )
1 Made Ground ( 23.70 )	18.50	15000 ( 1500)	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000)	
2 London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	80.00u ( 4.390)

**Additional soil parameters associated with Ka and Kp**

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall adhesion coeff.	Back-fill	Soil friction angle	Wall adhesion coeff.	Back-fill
1 Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2 London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation: Left side 23.70, Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Left side				Right side			
	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	20.00	20.00	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 20.20 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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) = 7.500 m

Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

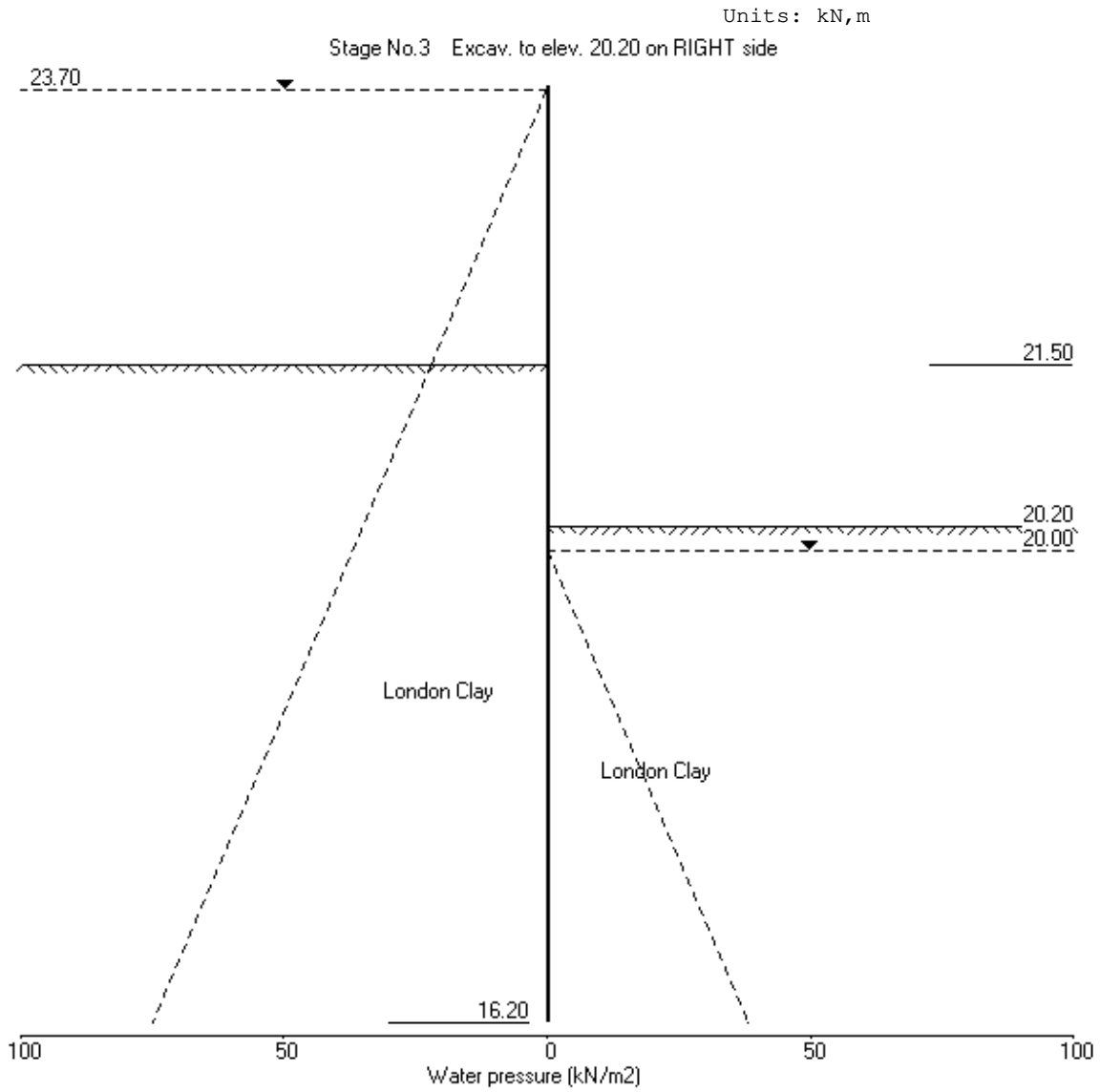
Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 20.20 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
Checked :



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

				<b>FoS for toe</b>	<b>Toe elev. for</b>		
				<b>elev. = 16.20</b>	<b>FoS = 1.000</b>		
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>			

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.18E-04	0.0	-0.0	
2	23.45	0.87	-0.001	-2.18E-04	0.1	0.0	
3	23.20	1.74	-0.001	-2.18E-04	0.4	0.1	
4	22.80	0.07	-0.001	-2.19E-04	0.8	0.1	
5	22.40	-3.75	-0.001	-2.20E-04	0.1	0.4	
6	22.00	-7.62	-0.001	-2.21E-04	-2.2	0.0	
7	21.75	-10.06	-0.001	-2.20E-04	-4.4	-0.8	
8	21.50	-12.52	-0.001	-2.14E-04	-7.2	-2.3	
		9.97	-0.001	-2.14E-04	-7.2	-2.3	
9	21.30	8.72	-0.001	-2.06E-04	-5.4	-3.5	
10	21.05	7.21	-0.001	-1.92E-04	-3.4	-4.6	
11	20.80	5.79	-0.001	-1.74E-04	-1.8	-5.2	
12	20.50	4.25	-0.001	-1.52E-04	-0.3	-5.5	
13	20.20	2.93	-0.000	-1.28E-04	0.8	-5.3	
14	20.00	2.16	-0.000	-1.14E-04	1.3	-5.1	
15	19.60	0.94	-0.000	-8.68E-05	2.0	-4.4	
16	19.20	0.07	-0.000	-6.40E-05	2.2	-3.6	
17	18.80	-0.48	-0.000	-4.62E-05	2.1	-2.7	
18	18.40	-0.79	-0.000	-3.31E-05	1.8	-1.9	
19	18.00	-0.92	-0.000	-2.42E-05	1.5	-1.2	
20	17.60	-0.93	-0.000	-1.86E-05	1.1	-0.7	
21	17.20	-0.87	-0.000	-1.55E-05	0.7	-0.3	
22	16.80	-0.77	-0.000	-1.42E-05	0.4	-0.1	
23	16.50	-0.70	-0.000	-1.39E-05	0.2	-0.0	
24	16.20	-0.62	-0.000	-1.38E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	203.71	36.37	36.37	18903
9	21.30	Total>	26.00	12.00m	209.89	39.76	39.76	19183
10	21.05	Total>	31.00	13.25m	217.60	44.03	44.03	19533
11	20.80	Total>	36.00	14.50m	225.32	48.33	48.33	19882
12	20.50	Total>	42.00	16.00m	234.58	53.58	53.58	20302
13	20.20	Total>	48.00	17.50m	243.84	58.93	58.93	20722
14	20.00	Total>	52.00	18.50m	250.01	62.56	62.56	21001
15	19.60	Total>	60.01	20.50m	262.36	69.96	69.96	21561
16	19.20	Total>	68.01	22.50m	274.72	77.55	77.55	22120
17	18.80	Total>	76.02	24.50m	287.07	85.28	85.28	22680
18	18.40	Total>	84.03	26.50m	299.42	93.13	93.13	23239
19	18.00	Total>	92.04	28.50m	311.78	101.08	101.08	23799
20	17.60	Total>	100.06	30.50m	324.15	109.08	109.08	24358
21	17.20	Total>	108.07	32.50m	336.51	117.12	117.12	24917
22	16.80	Total>	116.10	34.50m	348.88	125.18	125.18	25477
23	16.50	Total>	122.12	36.00m	358.16	131.22	131.22	25896
24	16.20	Total>	128.14	37.50m	367.44	137.27	137.27	26316

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7026
2	23.45	0.00	4.63	1.63	15.78	1.63	1.63a	7202
3	23.20	0.00	9.25	3.26	31.56	3.26	3.26a	7377
4	22.80	0.00	16.65	5.87	56.81	8.93	8.93	7658
5	22.40	0.00	24.05	8.48	82.06	16.75	16.75	7939
6	22.00	0.00	31.45	11.09	107.31	24.62	24.62	8221
7	21.75	0.00	36.08	12.73	123.09	29.56	29.56	8396
8	21.50	0.00	40.70	14.36	138.88	34.52	34.52	8572
		Total>	40.70	11.00m	222.41	26.40	26.40	19816
9	21.30	Total>	44.70	12.00m	228.59	31.04	31.04	20109
10	21.05	Total>	49.70	13.25m	236.30	36.81	36.81	20476
11	20.80	Total>	54.70	14.50m	244.02	42.54	42.54	20842
12	20.50	Total>	60.70	16.00m	253.28	49.33	49.33	21282
13	20.20	Total>	66.70	17.50m	262.54	56.01	56.01	21722
14	20.00	Total>	70.70	18.50m	268.71	60.40	60.40	22015
15	19.60	Total>	78.70	20.50m	281.06	69.03	69.03	22602
16	19.20	Total>	86.70	22.50m	293.40	77.47	77.47	23188
17	18.80	Total>	94.70	24.50m	305.75	85.76	85.76	23774
18	18.40	Total>	102.70	26.50m	318.10	93.92	93.92	24361
19	18.00	Total>	110.70	28.50m	330.44	102.00	102.00	24947
20	17.60	Total>	118.70	30.50m	342.79	110.01	110.01	25534
21	17.20	Total>	126.70	32.50m	355.14	117.99	117.99	26120
22	16.80	Total>	134.70	34.50m	367.48	125.95	125.95	26707

Run ID. Design\_Case 04 Sheet Pile\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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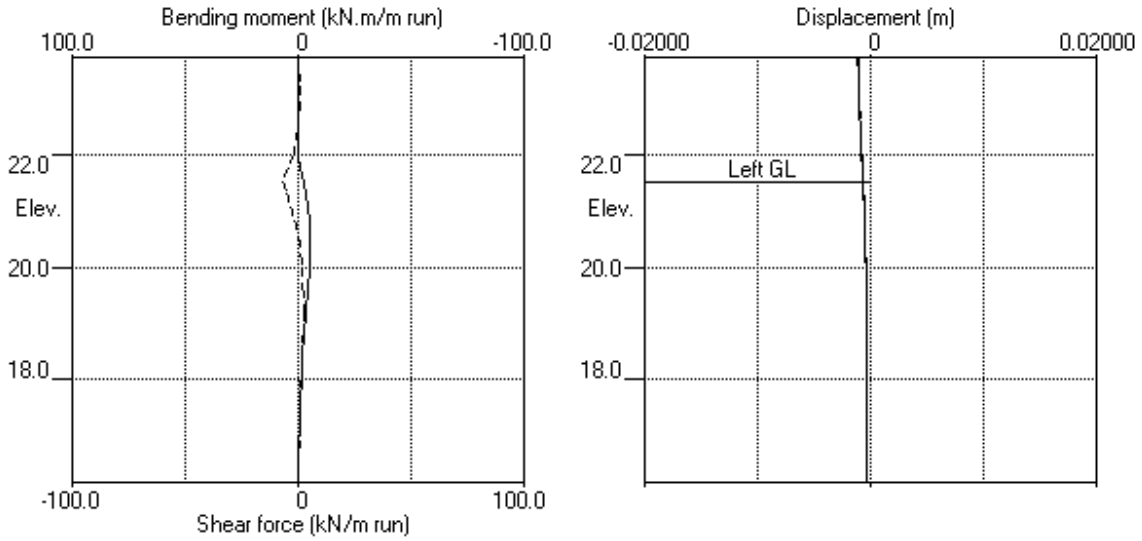
Stage No.1 Excavate to elevation 21.50 on LEFT side

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
23	16.50	Total>	140.70	36.00m	376.74	131.92	131.92	27147
24	16.20	Total>	146.70	37.50m	386.00	137.89	137.89	27586

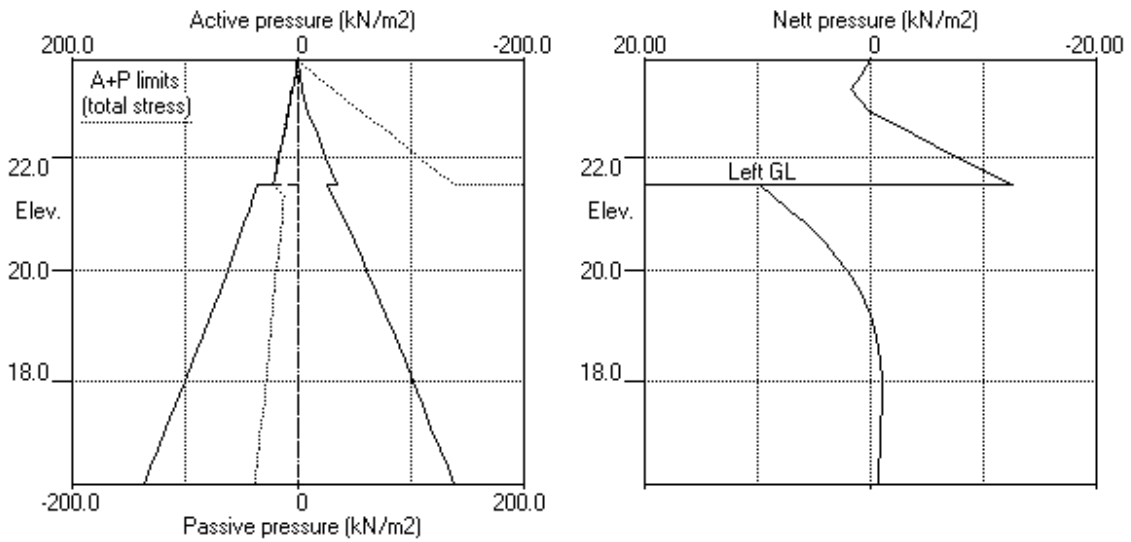
Note: 3.26a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 20.20 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
3	21.50	20.20	Cant.	4.758	16.84	18.56	1.64	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.012	2.80E-03	0.0	-0.0	
2	23.45	2.50	0.011	2.80E-03	0.3	0.0	
3	23.20	5.00	0.010	2.80E-03	1.3	0.2	
4	22.80	9.00	0.009	2.79E-03	4.0	1.0	
5	22.40	13.00	0.008	2.78E-03	8.5	3.5	
6	22.00	17.00	0.007	2.75E-03	14.5	8.0	
7	21.75	19.50	0.006	2.71E-03	19.0	12.2	
8	21.50	22.00	0.005	2.66E-03	24.2	17.6	
9	21.30	12.00	0.005	2.60E-03	27.6	22.8	
10	21.05	13.25	0.004	2.51E-03	30.8	30.1	
11	20.80	14.50	0.004	2.39E-03	34.2	38.2	
12	20.50	16.00	0.003	2.20E-03	38.8	49.2	
13	20.20	17.50	0.002	1.96E-03	43.8	61.6	
		-101.18	0.002	1.96E-03	43.8	61.6	
14	20.00	-84.69	0.002	1.78E-03	25.2	68.4	
15	19.60	-60.49	0.001	1.38E-03	-3.8	71.6	
16	19.20	-37.22	0.001	9.88E-04	-23.3	66.6	
17	18.80	-11.25	0.001	6.43E-04	-33.0	54.3	
18	18.40	5.24	0.000	3.73E-04	-34.2	40.2	
19	18.00	14.29	0.000	1.82E-04	-30.3	26.9	
20	17.60	18.07	0.000	6.06E-05	-23.9	15.9	
21	17.20	18.53	0.000	-7.01E-06	-16.5	7.8	
22	16.80	17.20	0.000	-3.69E-05	-9.4	2.7	
23	16.50	15.69	0.000	-4.39E-05	-4.5	0.6	
24	16.20	14.03	0.000	-4.53E-05	0.0	0.0	



(continued)

Stage No.3 Excavate to elevation 20.20 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	203.71	22.00	22.00a	31627
9	21.30	Total>	26.00	12.00m	209.89	12.00	12.00a	32095
10	21.05	Total>	31.00	13.25m	217.60	13.25	13.25a	32679
11	20.80	Total>	36.00	14.50m	225.32	14.50	14.50a	33264
12	20.50	Total>	42.00	16.00m	234.58	16.00	16.00a	33966
13	20.20	Total>	48.00	17.50m	243.84	17.50	17.50a	34668
14	20.00	Total>	52.00	18.50m	250.01	18.50	18.50a	35136
15	19.60	Total>	60.01	20.50m	262.36	20.50	20.50a	36072
16	19.20	Total>	68.01	22.50m	274.72	31.54	31.54	37008
17	18.80	Total>	76.02	24.50m	287.07	51.25	51.25	37944
18	18.40	Total>	84.03	26.50m	299.42	66.69	66.69	38880
19	18.00	Total>	92.04	28.50m	311.78	78.78	78.78	39816
20	17.60	Total>	100.06	30.50m	324.15	88.50	88.50	40752
21	17.20	Total>	108.07	32.50m	336.51	96.73	96.73	41688
22	16.80	Total>	116.10	34.50m	348.88	104.17	104.17	42624
23	16.50	Total>	122.12	36.00m	358.16	109.51	109.51	43326
24	16.20	Total>	128.14	37.50m	367.44	114.79	114.79	44028

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	20.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	195.84	118.68	118.68	42148
14	20.00	Total>	4.00	1.00m	202.01	103.19	103.19	42717
15	19.60	Total>	12.00	3.00m	214.36	80.99	80.99	43855
16	19.20	Total>	20.00	5.00m	226.71	68.76	68.76	44992
17	18.80	Total>	28.01	7.00m	239.06	62.50	62.50	46130
18	18.40	Total>	36.02	9.00m	251.42	61.45	61.45	47268
19	18.00	Total>	44.04	11.00m	263.78	64.49	64.49	48406
20	17.60	Total>	52.06	13.00m	276.15	70.43	70.43	49544
21	17.20	Total>	60.09	15.00m	288.53	78.21	78.21	50682
22	16.80	Total>	68.13	17.00m	300.92	86.97	86.97	51820

Run ID. Design\_Case 04 Sheet Pile\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

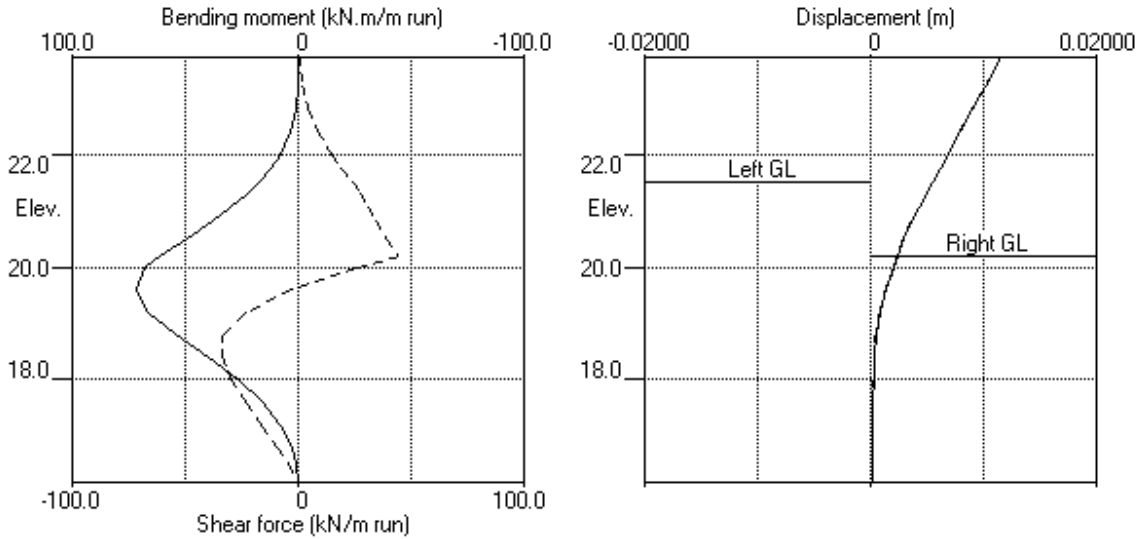
Stage No.3 Excavate to elevation 20.20 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Effective stresses				Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
			Vertic -al kN/m <sup>2</sup>	Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>	Earth pressure kN/m <sup>2</sup>		
23	16.50	Total>	74.17	18.50m	310.21	93.82	93.82	52673
24	16.20	Total>	80.22	20.00m	319.52	100.77	100.77	53527

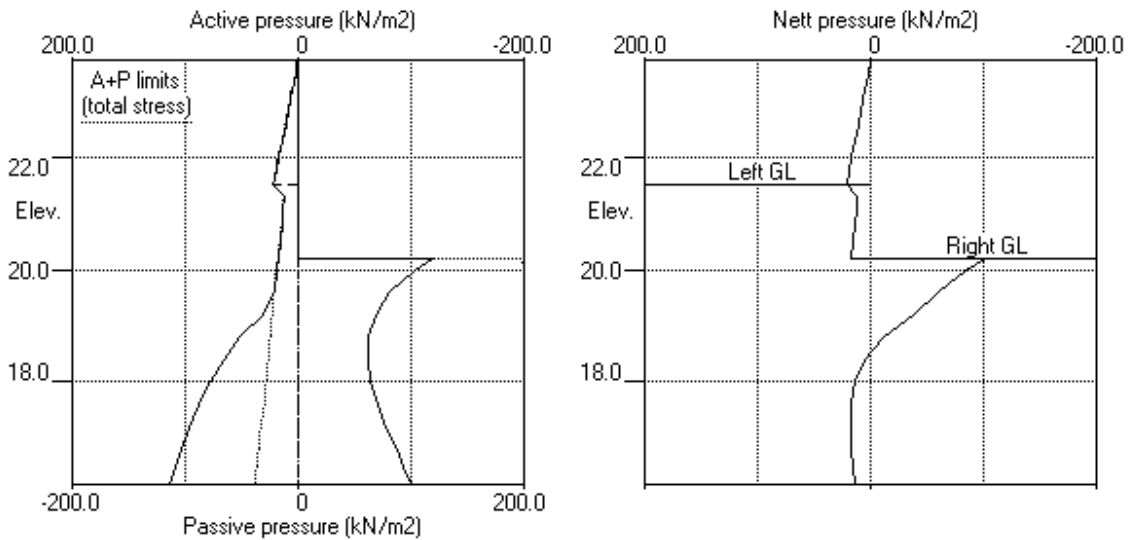
Note: 20.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 20.20 on RIGHT side



Stage No.3 Excav. to elev. 20.20 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>FoS for toe</u> <u>elev. = 16.20</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety</u>	<u>Moment</u> <u>at</u> <u>equilib.</u> <u>at elev.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	20.20	Cant.	4.758	16.84	18.56	1.64	L to R

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.012	-0.001	0	-0	0	-0	0	0	0	0
2	23.45	0.011	-0.001	0	0	0	0	0	0	0	0
3	23.20	0.010	-0.001	0	0	0	0	1	0	2	0
4	22.80	0.009	-0.001	1	0	1	0	4	0	5	0
5	22.40	0.008	-0.001	3	0	5	0	8	0	11	0
6	22.00	0.007	-0.001	8	0	11	0	14	-2	20	-3
7	21.75	0.006	-0.001	12	-1	16	-1	19	-4	26	-6
8	21.50	0.005	-0.001	18	-2	24	-3	24	-7	33	-10
9	21.30	0.005	-0.001	23	-4	31	-5	28	-5	37	-7
10	21.05	0.004	-0.001	30	-5	41	-6	31	-3	42	-5
11	20.80	0.004	-0.001	38	-5	52	-7	34	-2	46	-3
12	20.50	0.003	-0.001	49	-6	66	-7	39	-0	52	-0
13	20.20	0.002	-0.000	62	-5	83	-7	44	0	59	0
14	20.00	0.002	-0.000	68	-5	92	-7	25	0	34	0
15	19.60	0.001	-0.000	72	-5	97	-6	2	-4	3	-5
16	19.20	0.001	-0.000	67	-4	90	-5	2	-23	3	-32
17	18.80	0.001	-0.000	54	-3	73	-4	2	-33	3	-45
18	18.40	0.000	-0.000	40	-2	54	-3	2	-34	3	-46
19	18.00	0.000	-0.000	27	-1	36	-2	2	-30	2	-41
20	17.60	0.000	-0.000	16	-1	21	-1	1	-24	2	-32
21	17.20	0.000	-0.000	8	-0	11	-0	1	-17	1	-22
22	16.80	0.000	-0.000	3	-0	4	-0	0	-9	1	-13
23	16.50	0.000	-0.000	1	-0	1	-0	0	-4	0	-6
24	16.20	0.000	-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						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	min.	max.	elev.	min.	elev.	max.	min.	
	kN.m/m		kN.m/m	kN.m/m		kN/m		kN/m		kN/m		
1	0	22.40	-5	20.50	0	-7	2	19.20	-7	21.50	3	-10
2	0	22.40	-6	20.50	0	-7	2	19.20	-7	21.50	3	-10
3	72	19.60	-0	23.70	97	-0	44	20.20	-34	18.40	59	-46

Run ID. Design\_Case 04 Sheet Pile\_SLS  
Ugly Brown Building  
River wall assessment

Sheet No.  
Date:13-05-2020  
Checked :

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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

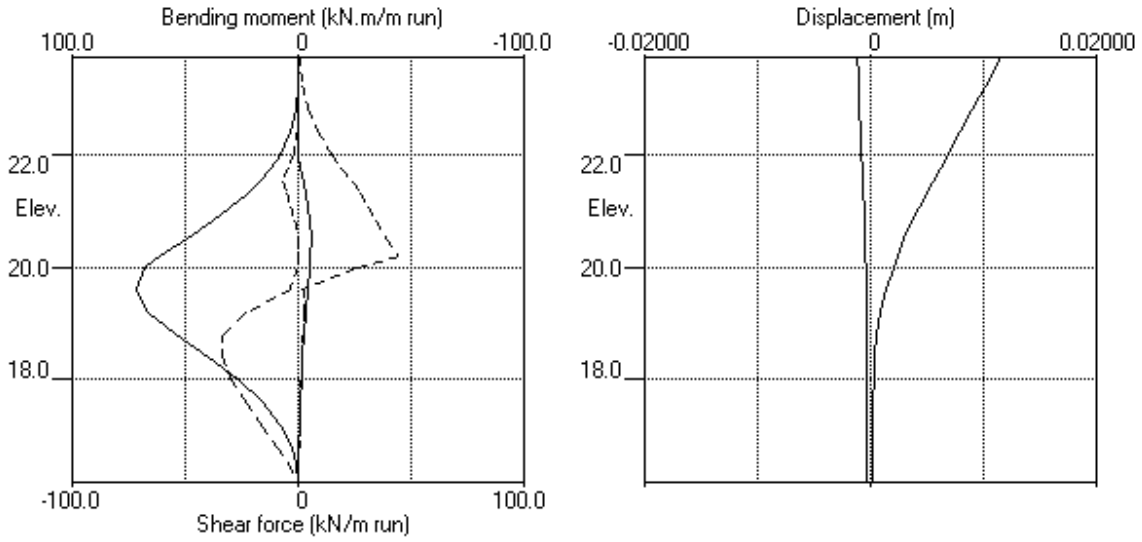
Stage	Displacement				
no.	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>Stage description</u>
	m		m		
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.012	23.70	0.000	23.70	Excav. to elev. 20.20 on RIGHT side

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Made by : MM  
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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol. state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy )	Ko (dKo/dy)	NC/OC ( Nu )	Ka ( Kac )	Kp ( Kpc )	kN/m2 ( dc/dy )
1 Made Ground ( 23.70 )	18.50	15000 ( 1500)	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000)	
2 London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	80.00u ( 4.390)

**Additional soil parameters associated with Ka and Kp**

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall adhesion coeff.	Back-fill	Soil friction angle	Wall adhesion coeff.	Back-fill
1 Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2 London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile	Point no.	Left side Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	19.50	19.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Worst Cred. )
3	Excavate to elevation 19.70 on RIGHT side



**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2  
Water pressures : Worst Credible  
Partial factor on C' = 1.250  
Partial factor on Phi' = 1.250  
Partial factor on Cu = 1.400  
Partial factor on Soil Modulus = 1.000  
Partial factor on Permanent Unfavourable loads = 1.000  
Partial factor on Permanent Favourable loads = 1.000  
Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:  
Method of analysis - Strength Factor method  
Overall 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) = 7.500 m

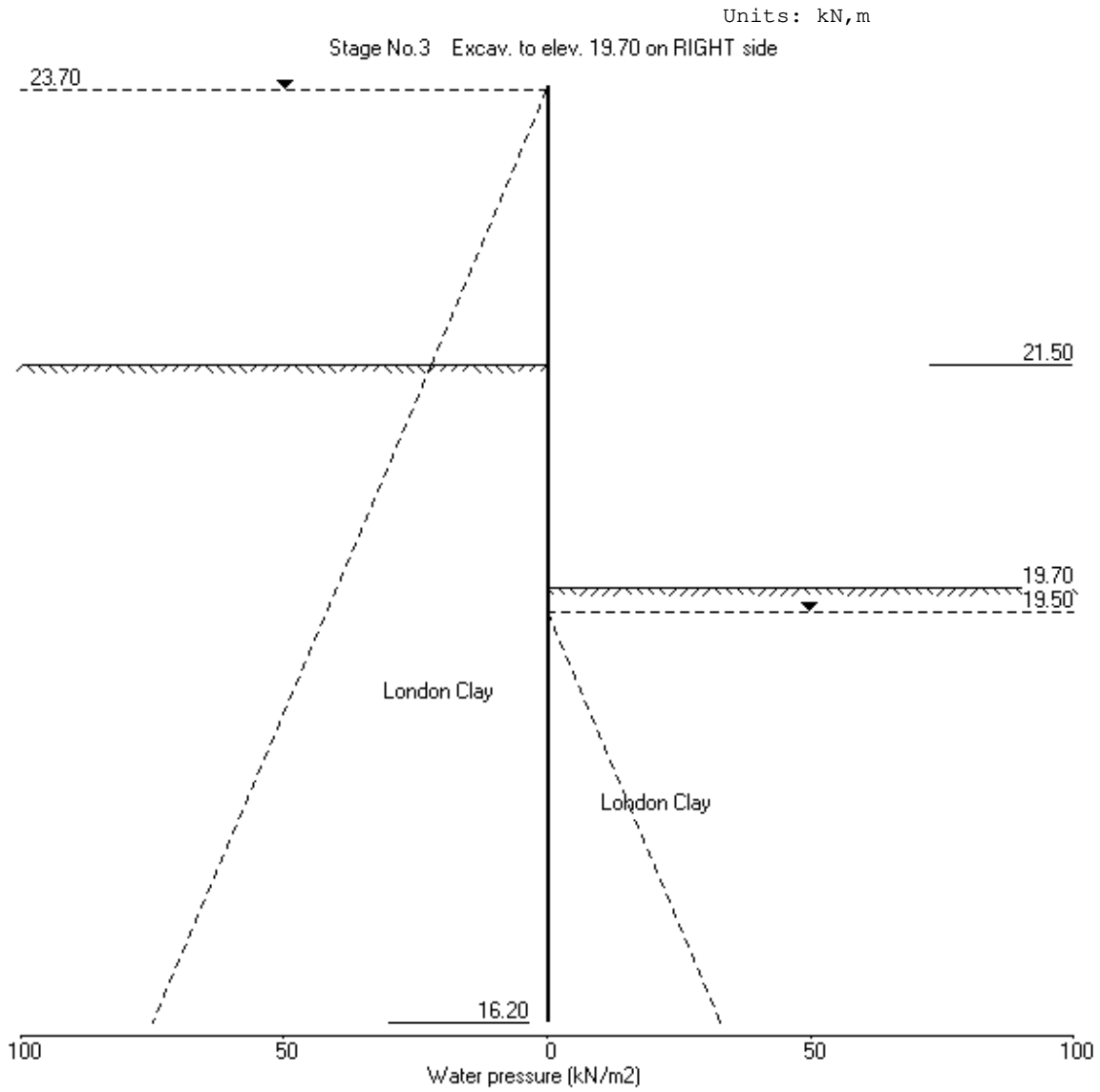
Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m  
  
Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m  
  
Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Graph.	Passive output pressures
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 19.70 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
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Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

		Overall					
		FoS for toe		Toe elev. for			
		elev. = 16.20		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>
<u>No.</u>	<u>Act.</u> <u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>
1	21.50 23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.31E-04	0.0	-0.0	
2	23.45	0.53	-0.001	-2.31E-04	0.1	0.0	
3	23.20	1.05	-0.001	-2.31E-04	0.3	0.0	
4	22.80	0.26	-0.001	-2.31E-04	0.5	0.0	
5	22.40	-3.60	-0.001	-2.31E-04	-0.1	0.1	
6	22.00	-7.51	-0.001	-2.31E-04	-2.4	-0.3	
7	21.75	-9.98	-0.001	-2.28E-04	-4.5	-1.1	
8	21.50	-12.46	-0.001	-2.22E-04	-7.4	-2.6	
		10.40	-0.001	-2.22E-04	-7.4	-2.6	
9	21.30	9.07	-0.001	-2.12E-04	-5.4	-3.9	
10	21.05	7.46	-0.001	-1.97E-04	-3.3	-4.9	
11	20.80	5.96	-0.001	-1.78E-04	-1.7	-5.5	
12	20.40	3.85	-0.001	-1.46E-04	0.3	-5.7	
13	20.05	2.35	-0.000	-1.18E-04	1.4	-5.4	
14	19.70	1.17	-0.000	-9.33E-05	2.0	-4.8	
15	19.50	0.63	-0.000	-8.03E-05	2.2	-4.3	
16	19.15	-0.09	-0.000	-6.07E-05	2.3	-3.5	
17	18.80	-0.56	-0.000	-4.51E-05	2.2	-2.7	
18	18.40	-0.87	-0.000	-3.18E-05	1.9	-1.9	
19	18.00	-0.98	-0.000	-2.28E-05	1.5	-1.2	
20	17.60	-0.97	-0.000	-1.72E-05	1.1	-0.7	
21	17.20	-0.89	-0.000	-1.42E-05	0.7	-0.3	
22	16.80	-0.78	-0.000	-1.29E-05	0.4	-0.1	
23	16.50	-0.68	-0.000	-1.26E-05	0.2	-0.0	
24	16.20	-0.59	-0.000	-1.25E-05	-0.0	0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	36.66	36.66	19432
9	21.30	Total>	26.00	12.00m	157.35	40.01	40.01	19720
10	21.05	Total>	31.00	13.25m	164.29	44.22	44.22	20079
11	20.80	Total>	36.00	14.50m	171.23	48.48	48.48	20438
12	20.40	Total>	44.00	16.50m	182.34	55.45	55.45	21014
13	20.05	Total>	51.00	18.25m	192.05	61.71	61.71	21517
14	19.70	Total>	58.01	20.00m	201.77	68.13	68.13	22020
15	19.50	Total>	62.01	21.00m	207.33	71.87	71.87	22307
16	19.15	Total>	69.01	22.75m	217.05	78.52	78.52	22811
17	18.80	Total>	76.02	24.50m	226.78	85.29	85.29	23314
18	18.40	Total>	84.03	26.50m	237.89	93.15	93.15	23889
19	18.00	Total>	92.04	28.50m	249.01	101.09	101.09	24464
20	17.60	Total>	100.06	30.50m	260.13	109.11	109.11	25039
21	17.20	Total>	108.07	32.50m	271.25	117.16	117.16	25614
22	16.80	Total>	116.10	34.50m	282.38	125.22	125.22	26189
23	16.50	Total>	122.12	36.00m	290.73	131.28	131.28	26621
24	16.20	Total>	128.14	37.50m	299.08	137.33	137.33	27052

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7140
2	23.45	0.00	4.63	1.97	12.22	1.97	1.97a	7319
3	23.20	0.00	9.25	3.95	24.43	3.95	3.95a	7497
4	22.80	0.00	16.65	7.10	43.98	8.74	8.74	7783
5	22.40	0.00	24.05	10.26	63.53	16.60	16.60	8069
6	22.00	0.00	31.45	13.42	83.07	24.51	24.51	8354
7	21.75	0.00	36.08	15.39	95.29	29.48	29.48	8533
8	21.50	0.00	40.70	17.36	107.50	34.46	34.46	8711
		Total>	40.70	11.00m	170.50	26.26	26.26	20138
9	21.30	Total>	44.70	12.00m	176.06	30.94	30.94	20436
10	21.05	Total>	49.70	13.25m	183.00	36.76	36.76	20809
11	20.80	Total>	54.70	14.50m	189.94	42.52	42.52	21181
12	20.40	Total>	62.70	16.50m	201.05	51.60	51.60	21777
13	20.05	Total>	69.70	18.25m	210.76	59.36	59.36	22299
14	19.70	Total>	76.70	20.00m	220.48	66.97	66.97	22820
15	19.50	Total>	80.70	21.00m	226.03	71.24	71.24	23118
16	19.15	Total>	87.70	22.75m	235.75	78.61	78.61	23640
17	18.80	Total>	94.70	24.50m	245.47	85.85	85.85	24161
18	18.40	Total>	102.70	26.50m	256.57	94.01	94.01	24757
19	18.00	Total>	110.70	28.50m	267.68	102.08	102.08	25353
20	17.60	Total>	118.70	30.50m	278.78	110.08	110.08	25949
21	17.20	Total>	126.70	32.50m	289.89	118.05	118.05	26545
22	16.80	Total>	134.70	34.50m	300.99	126.00	126.00	27141

Run ID. Design\_Case 04 Sheet Pile\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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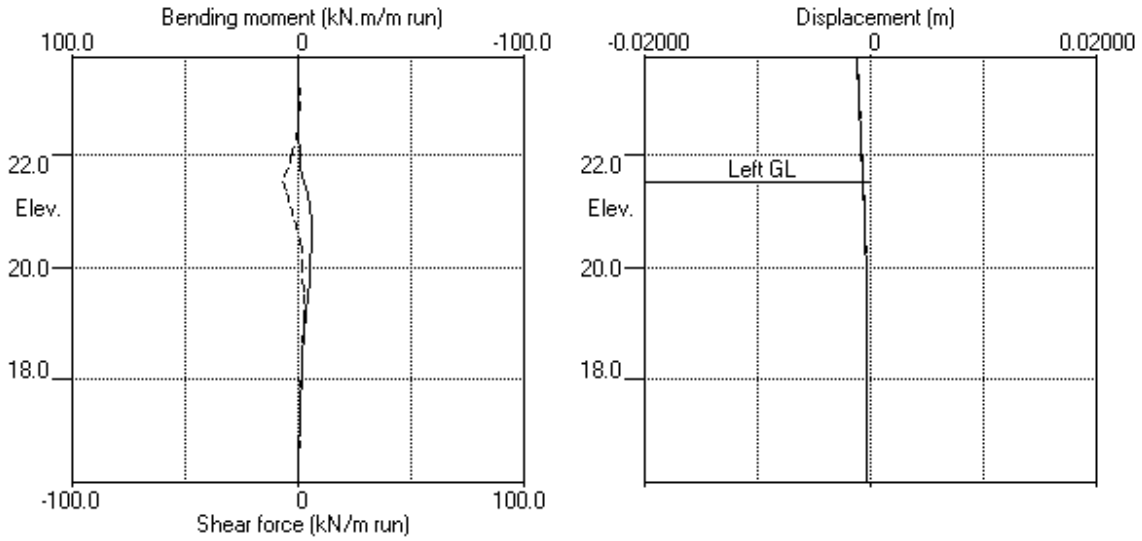
Stage No.1 Excavate to elevation 21.50 on LEFT side

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
23	16.50	Total>	140.70	36.00m	309.32	131.96	131.96	27588
24	16.20	Total>	146.70	37.50m	317.65	137.93	137.93	28035

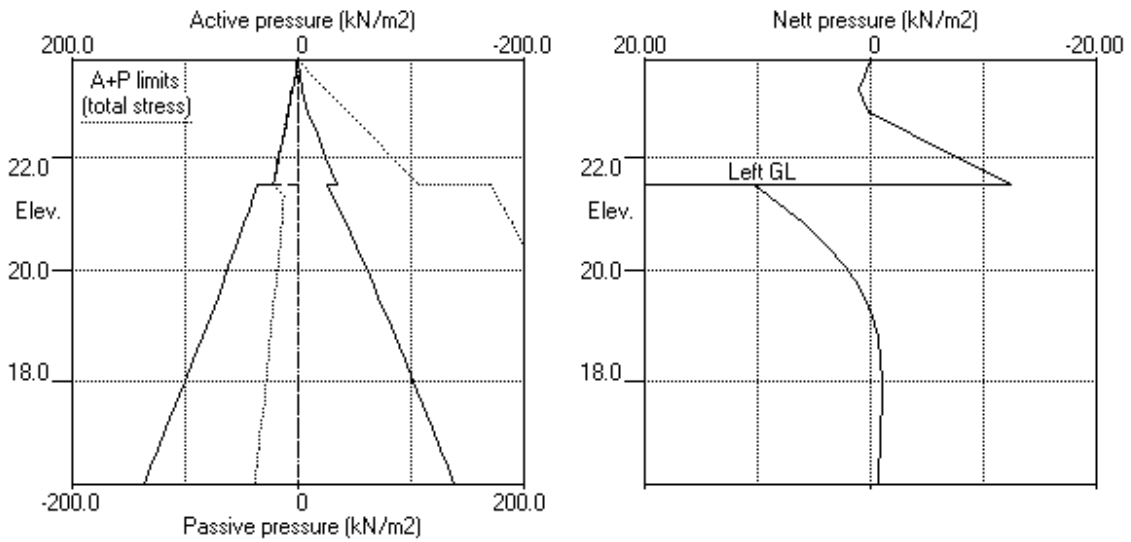
Note: 3.95a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN, m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 19.70 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 16.20						
Stage	Ground level	Prop	Factor	Moment	Toe	Wall	Direction	
No.	Act.	Pass.	of	of equilib.	elev.	Penetr	of	
		Elev.	Safety	at elev.		-ation	failure	
3	21.50	19.70	Cant.	2.230	16.96	17.45	2.25	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure	Wall disp.	Wall rotation	Shear force	Bending moment	Prop forces
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.018	4.00E-03	0.0	-0.0	
2	23.45	2.50	0.017	4.00E-03	0.3	0.0	
3	23.20	5.00	0.016	4.00E-03	1.3	0.2	
4	22.80	9.00	0.014	4.00E-03	4.0	1.0	
5	22.40	13.00	0.013	3.99E-03	8.5	3.5	
6	22.00	17.00	0.011	3.95E-03	14.5	8.0	
7	21.75	19.50	0.010	3.92E-03	19.0	12.2	
8	21.50	22.00	0.009	3.86E-03	24.2	17.6	
9	21.30	12.00	0.008	3.81E-03	27.6	22.8	
10	21.05	13.25	0.007	3.71E-03	30.8	30.1	
11	20.80	14.50	0.007	3.59E-03	34.2	38.2	
12	20.40	16.50	0.005	3.33E-03	40.4	53.2	
13	20.05	18.25	0.004	3.03E-03	46.5	68.4	
14	19.70	20.00	0.003	2.64E-03	53.2	85.9	
		-123.76	0.003	2.64E-03	53.2	85.9	
15	19.50	-116.03	0.003	2.38E-03	29.2	95.0	
16	19.15	-84.93	0.002	1.90E-03	-5.9	98.1	
17	18.80	-59.02	0.001	1.43E-03	-31.1	91.9	
18	18.40	-20.32	0.001	9.56E-04	-47.0	74.8	
19	18.00	5.22	0.000	5.87E-04	-50.0	54.3	
20	17.60	20.67	0.000	3.33E-04	-44.9	34.7	
21	17.20	29.36	0.000	1.82E-04	-34.8	18.5	
22	16.80	34.28	0.000	1.09E-04	-22.1	6.9	
23	16.50	36.91	0.000	9.13E-05	-11.4	1.8	
24	16.20	39.34	0.000	8.75E-05	0.0	0.0	

(continued)

Stage No.3 Excavate to elevation 19.70 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	22.00	22.00a	29744
9	21.30	Total>	26.00	12.00m	157.35	12.00	12.00a	30184
10	21.05	Total>	31.00	13.25m	164.29	13.25	13.25a	30734
11	20.80	Total>	36.00	14.50m	171.23	14.50	14.50a	31284
12	20.40	Total>	44.00	16.50m	182.34	16.50	16.50a	32165
13	20.05	Total>	51.00	18.25m	192.05	18.25	18.25a	32935
14	19.70	Total>	58.01	20.00m	201.77	20.00	20.00a	33705
15	19.50	Total>	62.01	21.00m	207.33	21.00	21.00a	34145
16	19.15	Total>	69.01	22.75m	217.05	22.75	22.75a	34916
17	18.80	Total>	76.02	24.50m	226.78	28.96	28.96	35686
18	18.40	Total>	84.03	26.50m	237.89	53.34	53.34	36566
19	18.00	Total>	92.04	28.50m	249.01	72.16	72.16	37446
20	17.60	Total>	100.06	30.50m	260.13	86.72	86.72	38327
21	17.20	Total>	108.07	32.50m	271.25	98.42	98.42	39207
22	16.80	Total>	116.10	34.50m	282.38	108.54	108.54	40087
23	16.50	Total>	122.12	36.00m	290.73	115.68	115.68	40747
24	16.20	Total>	128.14	37.50m	299.08	122.74	122.74	41407

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	20.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	19.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	143.76	143.76	143.76p	45855
15	19.50	Total>	4.00	1.00m	149.32	137.03	137.03	46453
16	19.15	Total>	11.00	2.75m	159.04	107.68	107.68	47501
17	18.80	Total>	18.00	4.50m	168.76	87.98	87.98	48549
18	18.40	Total>	26.01	6.50m	179.87	73.66	73.66	49747
19	18.00	Total>	34.02	8.50m	190.98	66.94	66.94	50944
20	17.60	Total>	42.04	10.50m	202.11	66.04	66.04	52142
21	17.20	Total>	50.06	12.50m	213.24	69.06	69.06	53339
22	16.80	Total>	58.10	14.50m	224.38	74.26	74.26	54537



Run ID. Design\_Case 04 Sheet Pile\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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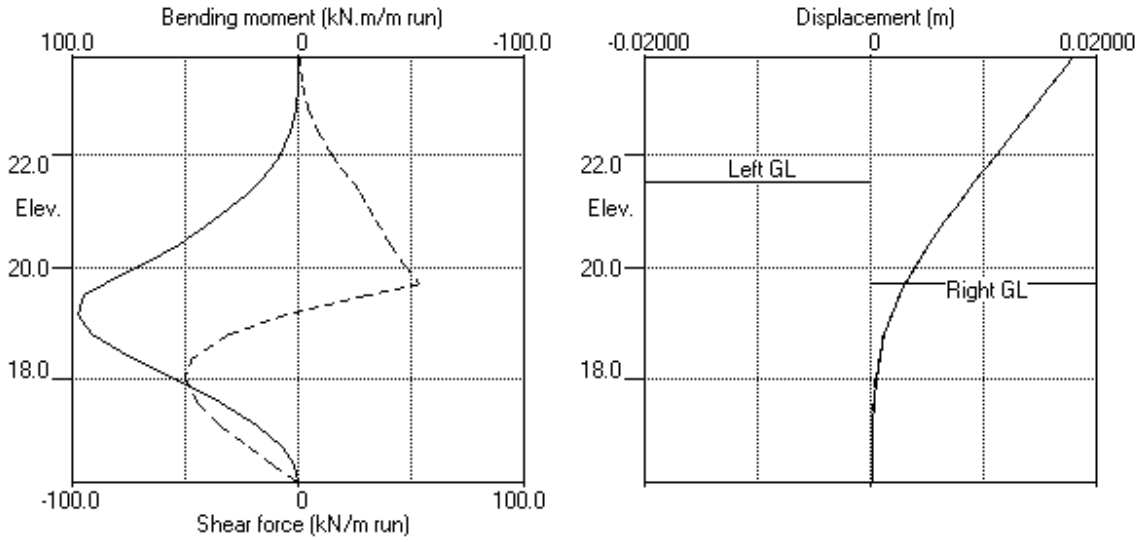
Stage No.3 Excavate to elevation 19.70 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Effective stresses				Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
			Vertic -al kN/m <sup>2</sup>	Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>	Earth pressure kN/m <sup>2</sup>		
23	16.50	Total>	64.13	16.00m	232.74	78.77	78.77	55435
24	16.20	Total>	70.17	17.50m	241.11	83.40	83.40	56333

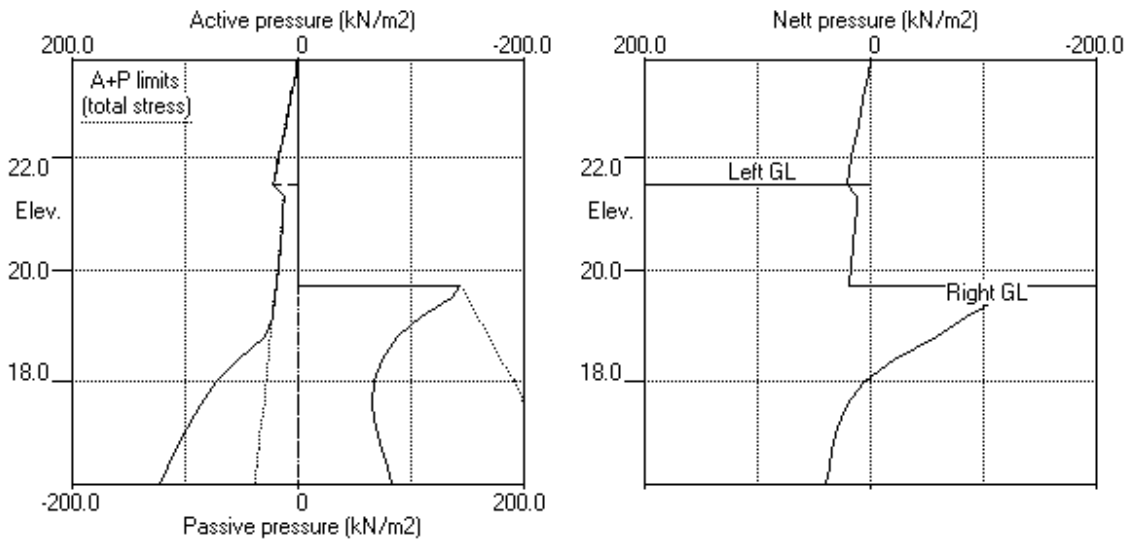
Note: 22.75a Soil pressure at active limit  
 143.76p Soil pressure at passive limit

Units: kN, m

Stage No.3 Excav. to elev. 19.70 on RIGHT side



Stage No.3 Excav. to elev. 19.70 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 16.20</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	19.70	Cant.	2.230	16.96	17.45	2.25	L to R

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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.018	-0.001	0.0	-0.0	0.0	0.0
2	23.45	0.017	-0.001	0.0	0.0	0.3	0.0
3	23.20	0.016	-0.001	0.2	0.0	1.3	0.0
4	22.80	0.014	-0.001	1.0	0.0	4.0	0.0
5	22.40	0.013	-0.001	3.5	0.0	8.5	-0.1
6	22.00	0.011	-0.001	8.0	-0.3	14.5	-2.4
7	21.75	0.010	-0.001	12.2	-1.1	19.0	-4.5
8	21.50	0.009	-0.001	17.6	-2.6	24.2	-7.4
9	21.30	0.008	-0.001	22.8	-3.9	27.6	-5.4
10	21.05	0.007	-0.001	30.1	-4.9	30.8	-3.4
11	20.80	0.007	-0.001	38.2	-5.6	34.2	-1.8
12	20.40	0.005	-0.001	53.2	-5.8	40.4	0.0
13	20.05	0.004	-0.000	68.4	-5.5	46.5	0.0
14	19.70	0.003	-0.000	85.9	-4.9	53.2	0.0
15	19.50	0.003	-0.000	95.0	-4.5	29.2	0.0
16	19.15	0.002	-0.000	98.1	-3.7	2.3	-5.9
17	18.80	0.001	-0.000	91.9	-2.9	2.2	-31.1
18	18.40	0.001	-0.000	74.8	-2.0	1.9	-47.0
19	18.00	0.000	-0.000	54.3	-1.3	1.6	-50.0
20	17.60	0.000	-0.000	34.7	-0.8	1.2	-44.9
21	17.20	0.000	-0.000	18.5	-0.4	0.8	-34.8
22	16.80	0.000	-0.000	6.9	-0.1	0.5	-22.1
23	16.50	0.000	-0.000	1.8	-0.0	0.2	-11.4
24	16.20	0.000	-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				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	0.1	22.40	-5.7	20.40	2.3	19.15	-7.4	21.50
2	0.1	22.40	-5.8	20.40	2.3	19.15	-7.4	21.50
3	98.1	19.15	-0.0	23.70	53.2	19.70	-50.0	18.00

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
		m		m	
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.018	23.70	0.000	23.70	Excav. to elev. 19.70 on RIGHT side

Run ID. Design\_Case 04 Sheet Pile\_ULS2  
Ugly Brown Building  
River wall assessment

Sheet No.  
Date:13-05-2020  
Checked :

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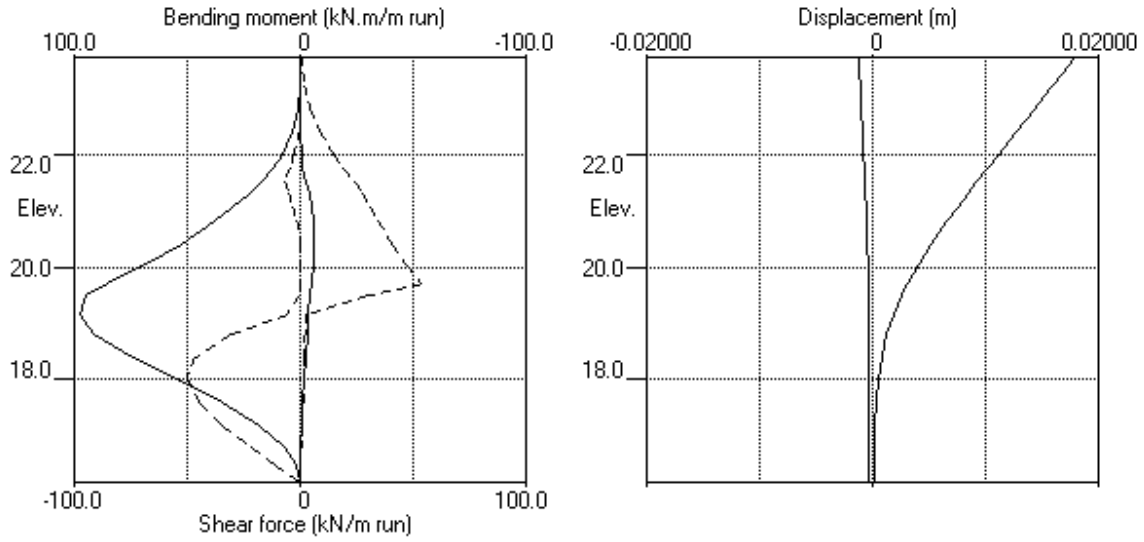
**Summary of results (continued)**

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**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. ( Nu )	Active limit ( Kac )	Passive limit ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground ( 23.70 )	18.50	15000 ( 1500 )	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000 )	
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475 )	80.00u ( 4.390 )

**Additional soil parameters associated with Ka and Kp**

Soil type No.	Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	20.00	20.00	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow ? tension	L/R
1	23.50	5.00	0.017663	2.050E+08	20.00	0.00	0	Strut	No	R

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 22.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 23.50
5	Excavate to elevation 20.20 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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

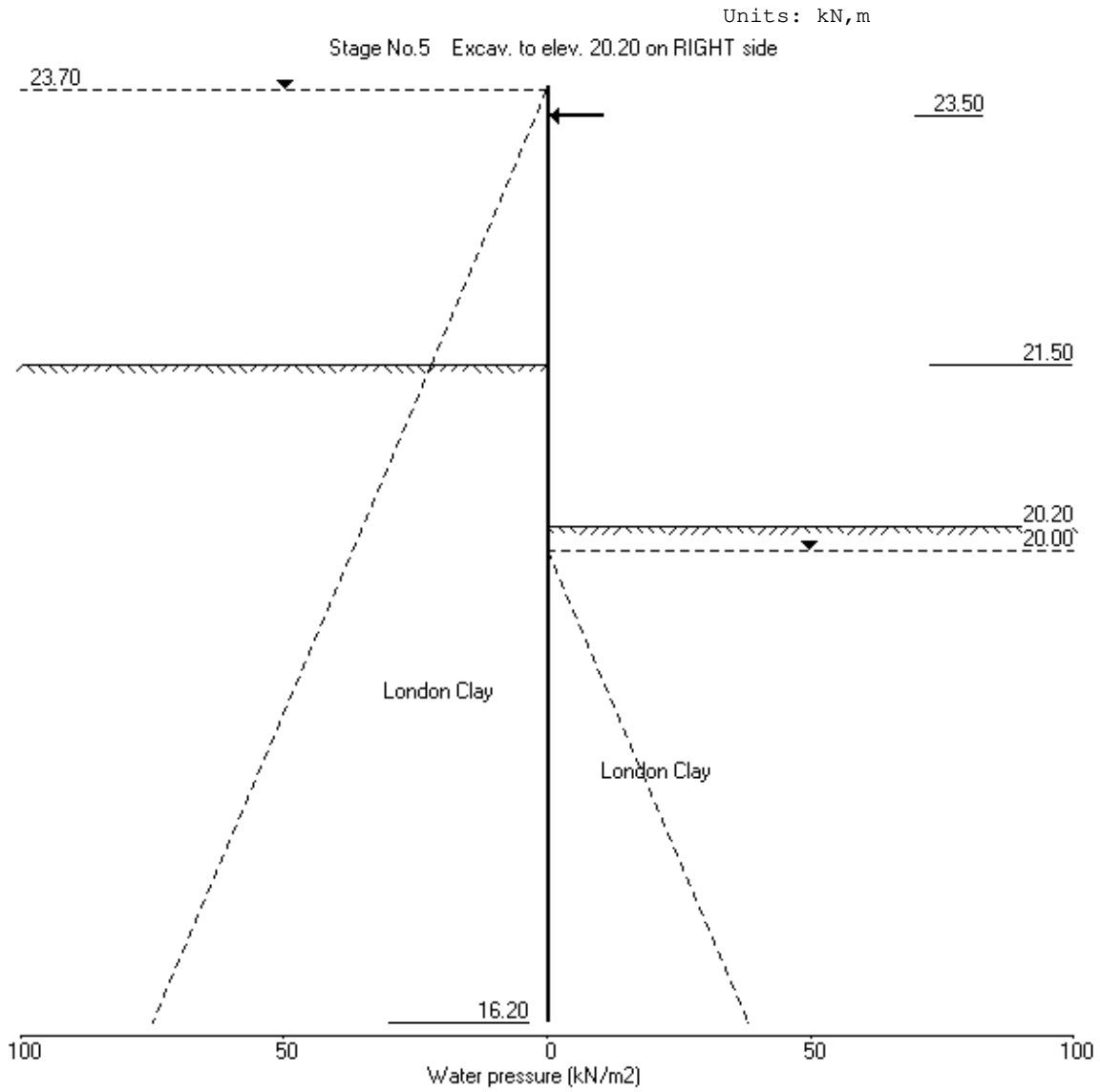
Bending moment and displacement calculation:  
Method - Subgrade reaction model using Influence Coefficients  
Open Tension Crack analysis? - No  
Non-linear Modulus Parameter (L) = 7.500 m

Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m  
  
Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m  
  
Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Graph.	Passive output pressures
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 22.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
5	Excav. to elev. 20.20 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes





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 Data filename/Run ID: Design\_Case\_04 Sheet Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

				FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.08E-04	0.0	-0.0	
2	23.50	0.69	-0.001	-2.08E-04	0.1	0.0	
3	23.25	1.56	-0.001	-2.08E-04	0.4	0.1	
4	23.00	1.81	-0.001	-2.09E-04	0.8	0.1	
5	22.75	-0.53	-0.001	-2.09E-04	0.9	0.3	
6	22.50	-2.89	-0.001	-2.11E-04	0.5	0.5	
7	22.25	-5.28	-0.001	-2.13E-04	-0.5	0.5	
8	22.00	-7.68	-0.001	-2.14E-04	-2.1	0.2	
9	21.75	-10.11	-0.001	-2.14E-04	-4.4	-0.6	
10	21.50	-12.55	-0.001	-2.09E-04	-7.2	-2.0	
		9.67	-0.001	-2.09E-04	-7.2	-2.0	
11	21.30	8.49	-0.001	-2.02E-04	-5.4	-3.2	
12	21.05	7.04	-0.001	-1.88E-04	-3.4	-4.3	
13	20.80	5.68	-0.001	-1.72E-04	-1.8	-5.0	
14	20.50	4.20	-0.001	-1.50E-04	-0.4	-5.3	
15	20.20	2.92	-0.001	-1.28E-04	0.7	-5.2	
16	20.00	2.18	-0.000	-1.13E-04	1.2	-5.0	
17	19.60	0.98	-0.000	-8.70E-05	1.8	-4.3	
18	19.20	0.13	-0.000	-6.47E-05	2.1	-3.5	
19	18.80	-0.42	-0.000	-4.72E-05	2.0	-2.7	
20	18.40	-0.74	-0.000	-3.42E-05	1.8	-1.9	
21	18.00	-0.88	-0.000	-2.53E-05	1.5	-1.2	
22	17.60	-0.90	-0.000	-1.97E-05	1.1	-0.7	
23	17.20	-0.85	-0.000	-1.66E-05	0.8	-0.4	
24	16.80	-0.77	-0.000	-1.52E-05	0.4	-0.1	
25	16.50	-0.71	-0.000	-1.49E-05	0.2	-0.0	
26	16.20	-0.65	-0.000	-1.48E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

		LEFT side							
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction	
				Active limit	Passive limit				
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0	
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	0.0	
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	0.0	
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	0.0	
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	0.0	
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	0.0	
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0	
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0	
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0	
		Total>	22.00	22.00w	203.71	36.16	36.16	18505	
11	21.30	Total>	26.00	12.00m	209.89	39.58	39.58	18778	
12	21.05	Total>	31.00	13.25m	217.60	43.88	43.88	19121	
13	20.80	Total>	36.00	14.50m	225.32	48.22	48.22	19463	
14	20.50	Total>	42.00	16.00m	234.58	53.50	53.50	19874	
15	20.20	Total>	48.00	17.50m	243.84	58.88	58.88	20284	
16	20.00	Total>	52.00	18.50m	250.01	62.52	62.52	20558	
17	19.60	Total>	60.01	20.50m	262.36	69.94	69.94	21106	
18	19.20	Total>	68.01	22.50m	274.72	77.53	77.53	21653	
19	18.80	Total>	76.02	24.50m	287.07	85.26	85.26	22201	
20	18.40	Total>	84.03	26.50m	299.42	93.12	93.12	22749	
21	18.00	Total>	92.04	28.50m	311.78	101.05	101.05	23296	
22	17.60	Total>	100.06	30.50m	324.15	109.05	109.05	23844	
23	17.20	Total>	108.07	32.50m	336.51	117.08	117.08	24392	
24	16.80	Total>	116.10	34.50m	348.88	125.13	125.13	24939	
25	16.50	Total>	122.12	36.00m	358.16	131.17	131.17	25350	
26	16.20	Total>	128.14	37.50m	367.44	137.21	137.21	25761	

		RIGHT side							
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction	
				Active limit	Passive limit				
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	6947	
2	23.50	0.00	3.70	1.31	12.63	1.31	1.31a	7086	
3	23.25	0.00	8.33	2.94	28.41	2.94	2.94a	7260	
4	23.00	0.00	12.95	4.57	44.19	5.19	5.19	7434	
5	22.75	0.00	17.58	6.20	59.97	10.03	10.03	7607	
6	22.50	0.00	22.20	7.83	75.75	14.89	14.89	7781	
7	22.25	0.00	26.83	9.46	91.53	19.78	19.78	7955	
8	22.00	0.00	31.45	11.09	107.31	24.68	24.68	8128	
9	21.75	0.00	36.08	12.73	123.09	29.61	29.61	8302	
10	21.50	0.00	40.70	14.36	138.88	34.55	34.55	8476	
		Total>	40.70	11.00m	222.41	26.48	26.48	19594	
11	21.30	Total>	44.70	12.00m	228.59	31.09	31.09	19884	
12	21.05	Total>	49.70	13.25m	236.30	36.84	36.84	20246	
13	20.80	Total>	54.70	14.50m	244.02	42.54	42.54	20609	
14	20.50	Total>	60.70	16.00m	253.28	49.30	49.30	21043	
15	20.20	Total>	66.70	17.50m	262.54	55.96	55.96	21478	
16	20.00	Total>	70.70	18.50m	268.71	60.34	60.34	21768	
17	19.60	Total>	78.70	20.50m	281.06	68.96	68.96	22348	
18	19.20	Total>	86.70	22.50m	293.40	77.40	77.40	22928	
19	18.80	Total>	94.70	24.50m	305.75	85.69	85.69	23508	
20	18.40	Total>	102.70	26.50m	318.10	93.85	93.85	24088	

Run ID. Design\_Case\_04 Sheet Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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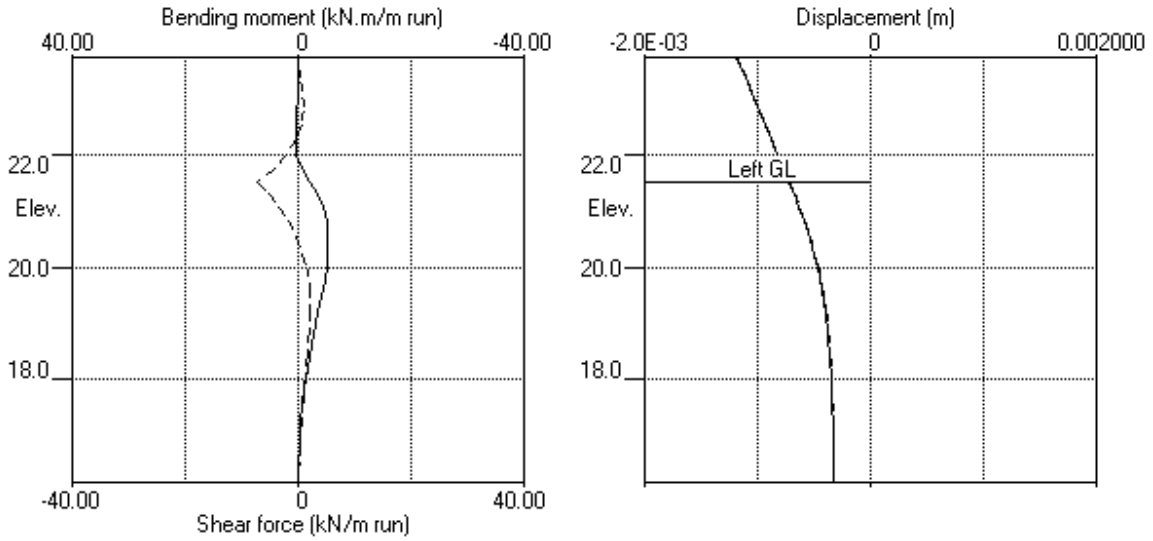
Stage No.1 Excavate to elevation 21.50 on LEFT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	18.00	Total>	110.70	28.50m	330.44	101.93	101.93	24668
22	17.60	Total>	118.70	30.50m	342.79	109.95	109.95	25248
23	17.20	Total>	126.70	32.50m	355.14	117.93	117.93	25827
24	16.80	Total>	134.70	34.50m	367.48	125.90	125.90	26407
25	16.50	Total>	140.70	36.00m	376.74	131.88	131.88	26842
26	16.20	Total>	146.70	37.50m	386.00	137.86	137.86	27277

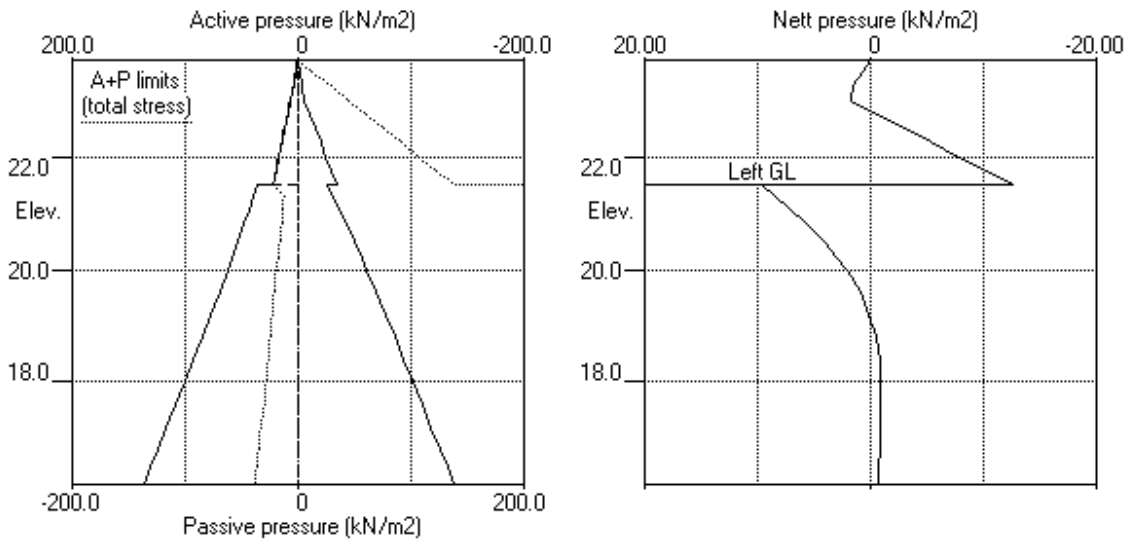
Note: 2.94a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 22.50 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
3	21.50	22.50	Cant.	30.469	17.51	21.03	1.47	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.001	4.21E-04	0.0	-0.0	
2	23.50	2.00	0.001	4.21E-04	0.2	0.0	
3	23.25	4.50	0.001	4.21E-04	1.0	0.2	
4	23.00	7.00	0.001	4.20E-04	2.5	0.5	
5	22.75	9.50	0.001	4.17E-04	4.5	1.4	
6	22.50	12.00	0.001	4.09E-04	7.2	2.8	
7	22.25	-1.28	0.000	3.96E-04	8.5	4.8	
8	22.00	-0.70	0.000	3.74E-04	8.3	7.1	
9	21.75	-1.59	0.000	3.46E-04	8.0	9.1	
10	21.50	-2.53	0.000	3.10E-04	7.5	11.1	
		-9.30	0.000	3.10E-04	7.5	11.1	
11	21.30	-19.52	0.000	2.76E-04	4.6	12.5	
12	21.05	-14.37	0.000	2.31E-04	0.4	13.0	
13	20.80	-9.89	-0.000	1.85E-04	-2.7	12.6	
14	20.50	-5.45	-0.000	1.33E-04	-5.0	11.4	
15	20.20	-2.02	-0.000	8.87E-05	-6.1	9.7	
16	20.00	-0.26	-0.000	6.29E-05	-6.3	8.4	
17	19.60	2.02	-0.000	2.22E-05	-6.0	5.9	
18	19.20	3.11	-0.000	-4.92E-06	-4.9	3.6	
19	18.80	3.37	-0.000	-2.08E-05	-3.6	1.9	
20	18.40	3.07	-0.000	-2.84E-05	-2.3	0.7	
21	18.00	2.47	-0.000	-3.06E-05	-1.2	0.0	
22	17.60	1.72	-0.000	-3.00E-05	-0.4	-0.3	
23	17.20	0.91	-0.000	-2.85E-05	0.1	-0.3	
24	16.80	0.09	-0.000	-2.73E-05	0.3	-0.2	
25	16.50	-0.54	-0.000	-2.69E-05	0.3	-0.1	
26	16.20	-1.18	-0.000	-2.68E-05	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 22.50 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	0.0
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	0.0
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	0.0
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	0.0
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	0.0
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	203.71	22.00	22.00a	33268
11	21.30	Total>	26.00	12.00m	209.89	13.70	13.70	33761
12	21.05	Total>	31.00	13.25m	217.60	21.41	21.41	34376
13	20.80	Total>	36.00	14.50m	225.32	28.77	28.77	34991
14	20.50	Total>	42.00	16.00m	234.58	37.10	37.10	35730
15	20.20	Total>	48.00	17.50m	243.84	44.89	44.89	36468
16	20.00	Total>	52.00	18.50m	250.01	49.80	49.80	36960
17	19.60	Total>	60.01	20.50m	262.36	59.05	59.05	37945
18	19.20	Total>	68.01	22.50m	274.72	67.67	67.67	38930
19	18.80	Total>	76.02	24.50m	287.07	75.83	75.83	39914
20	18.40	Total>	84.03	26.50m	299.42	83.71	83.71	40899
21	18.00	Total>	92.04	28.50m	311.78	91.42	91.42	41883
22	17.60	Total>	100.06	30.50m	324.15	99.05	99.05	42868
23	17.20	Total>	108.07	32.50m	336.51	106.65	106.65	43852
24	16.80	Total>	116.10	34.50m	348.88	114.24	114.24	44837
25	16.50	Total>	122.12	36.00m	358.16	119.93	119.93	45575
26	16.20	Total>	128.14	37.50m	367.44	125.62	125.62	46314

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	0.00	0.00	0.00	11972
7	22.25	0.00	4.63	1.63	15.78	15.78	15.78p	12239
8	22.00	0.00	9.25	3.26	31.56	17.70	17.70	12506
9	21.75	0.00	13.88	4.89	47.35	21.09	21.09	12773
10	21.50	0.00	18.50	6.53	63.13	24.53	24.53	13041
		Total>	18.50	5.00m	200.21	31.30	31.30	30147
11	21.30	Total>	22.50	6.00m	206.39	33.23	33.23	30593
12	21.05	Total>	27.50	7.25m	214.11	35.78	35.78	31150
13	20.80	Total>	32.51	8.50m	221.82	38.66	38.66	31708
14	20.50	Total>	38.51	10.00m	231.09	42.55	42.55	32377
15	20.20	Total>	44.51	11.50m	240.35	46.91	46.91	33046
16	20.00	Total>	48.52	12.50m	246.53	50.06	50.06	33492
17	19.60	Total>	56.53	14.50m	258.89	57.03	57.03	34385
18	19.20	Total>	64.54	16.50m	271.24	64.55	64.55	35277
19	18.80	Total>	72.56	18.50m	283.61	72.47	72.47	36169

Run ID. Design\_Case\_04 Sheet Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 22.50 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses			Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>	Earth pressure kN/m <sup>2</sup>		
20	18.40	Total>	80.58	20.50m	295.97	80.64	80.64	37061
21	18.00	Total>	88.60	22.50m	308.34	88.95	88.95	37953
22	17.60	Total>	96.63	24.50m	320.72	97.33	97.33	38846
23	17.20	Total>	104.66	26.50m	333.10	105.73	105.73	39738
24	16.80	Total>	112.70	28.50m	345.48	114.15	114.15	40630
25	16.50	Total>	118.73	30.00m	354.77	120.47	120.47	41299
26	16.20	Total>	124.76	31.50m	364.06	126.80	126.80	41968

Note: 22.00a Soil pressure at active limit  
 15.78p Soil pressure at passive limit

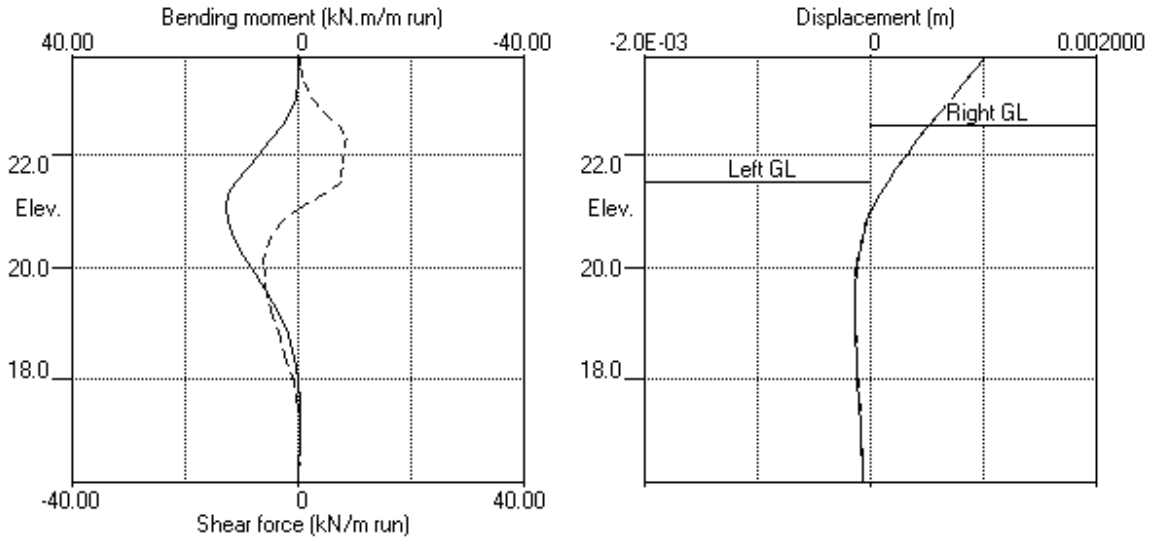


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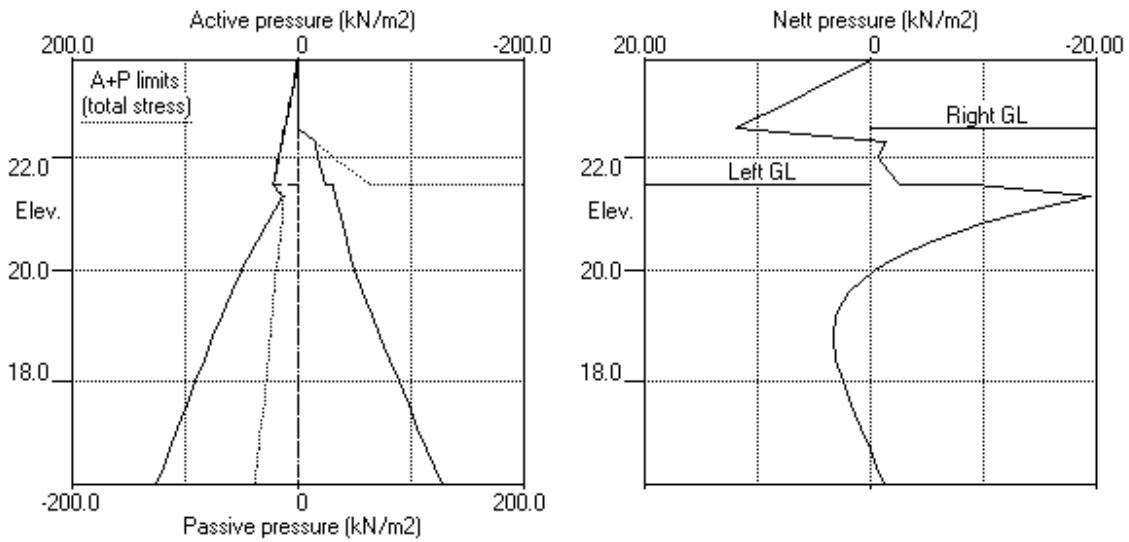
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 22.50 on RIGHT side



Stage No.3 Excav. to elev. 22.50 on RIGHT side



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 Ugly Brown Building  
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Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 20.20 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
5	21.50	20.20	23.50	8.441	n/a	20.07	0.13	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.001	-3.80E-04	0.0	-0.0	
2	23.50	2.00	0.001	-3.80E-04	0.2	0.0	-20.4
		2.00	0.001	-3.80E-04	-20.2	0.0	
3	23.25	4.50	0.002	-3.71E-04	-19.4	-5.0	
4	23.00	7.00	0.002	-3.45E-04	-18.0	-9.7	
5	22.75	9.50	0.002	-3.03E-04	-15.9	-14.0	
6	22.50	12.00	0.002	-2.47E-04	-13.2	-17.6	
7	22.25	14.50	0.002	-1.79E-04	-9.9	-20.5	
8	22.00	17.00	0.002	-1.02E-04	-6.0	-22.4	
9	21.75	19.50	0.002	-2.14E-05	-1.4	-23.3	
10	21.50	22.00	0.002	6.11E-05	3.8	-23.0	
11	21.30	12.00	0.002	1.24E-04	7.2	-21.7	
12	21.05	13.25	0.002	1.98E-04	10.3	-19.6	
13	20.80	14.50	0.002	2.63E-04	13.8	-16.6	
14	20.50	16.00	0.002	3.24E-04	18.4	-11.9	
15	20.20	17.50	0.002	3.61E-04	23.4	-5.7	
		-22.40	0.002	3.61E-04	23.4	-5.7	
16	20.00	-23.68	0.002	3.71E-04	18.8	-1.3	
17	19.60	-17.82	0.001	3.62E-04	10.5	4.4	
18	19.20	-12.68	0.001	3.30E-04	4.4	7.1	
19	18.80	-8.39	0.001	2.87E-04	0.2	7.9	
20	18.40	-4.94	0.001	2.43E-04	-2.5	7.3	
21	18.00	-2.20	0.001	2.06E-04	-3.9	5.9	
22	17.60	-0.01	0.001	1.77E-04	-4.3	4.2	
23	17.20	1.85	0.001	1.58E-04	-4.0	2.4	
24	16.80	3.55	0.001	1.48E-04	-2.9	1.0	
25	16.50	4.82	0.001	1.46E-04	-1.6	0.3	
26	16.20	6.13	0.001	1.45E-04	0.0	-0.0	
At elev. 23.50			Prop force =		20.4 kN/m run		

(continued)

Stage No.5 Excavate to elevation 20.20 on RIGHT side

LEFT side

Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	
		Total>	22.00	22.00w	203.71	22.00	22.00a	16757
11	21.30	Total>	26.00	12.00m	209.89	12.00	12.00a	17005
12	21.05	Total>	31.00	13.25m	217.60	13.25	13.25a	17315
13	20.80	Total>	36.00	14.50m	225.32	14.50	14.50a	17625
14	20.50	Total>	42.00	16.00m	234.58	16.00	16.00a	17997
15	20.20	Total>	48.00	17.50m	243.84	17.50	17.50a	18369
16	20.00	Total>	52.00	18.50m	250.01	18.63	18.63	18616
17	19.60	Total>	60.01	20.50m	262.36	29.56	29.56	19112
18	19.20	Total>	68.01	22.50m	274.72	40.08	40.08	19608
19	18.80	Total>	76.02	24.50m	287.07	50.14	50.14	20104
20	18.40	Total>	84.03	26.50m	299.42	59.77	59.77	20600
21	18.00	Total>	92.04	28.50m	311.78	69.05	69.05	21096
22	17.60	Total>	100.06	30.50m	324.15	78.06	78.06	21592
23	17.20	Total>	108.07	32.50m	336.51	86.92	86.92	22088
24	16.80	Total>	116.10	34.50m	348.88	95.71	95.71	22584
25	16.50	Total>	122.12	36.00m	358.16	102.29	102.29	22956
26	16.20	Total>	128.14	37.50m	367.44	108.91	108.91	23328

RIGHT side

Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	
4	23.00	0.00	0.00	0.00	0.00	0.00	0.00	
5	22.75	0.00	0.00	0.00	0.00	0.00	0.00	
6	22.50	0.00	0.00	0.00	0.00	0.00	0.00	
7	22.25	0.00	0.00	0.00	0.00	0.00	0.00	
8	22.00	0.00	0.00	0.00	0.00	0.00	0.00	
9	21.75	0.00	0.00	0.00	0.00	0.00	0.00	
10	21.50	0.00	0.00	0.00	0.00	0.00	0.00	
11	21.30	0.00	0.00	0.00	0.00	0.00	0.00	
12	21.05	0.00	0.00	0.00	0.00	0.00	0.00	
13	20.80	0.00	0.00	0.00	0.00	0.00	0.00	
14	20.50	0.00	0.00	0.00	0.00	0.00	0.00	
15	20.20	0.00	0.00	0.00	0.00	0.00	0.00	
		Total>	0.00	0.00	195.84	39.90	39.90	20631
16	20.00	Total>	4.00	1.00m	202.01	42.30	42.30	20909
17	19.60	Total>	12.00	3.00m	214.36	47.38	47.38	21466
18	19.20	Total>	20.00	5.00m	226.71	52.75	52.75	22023
19	18.80	Total>	28.01	7.00m	239.06	58.53	58.53	22580
20	18.40	Total>	36.02	9.00m	251.42	64.71	64.71	23137

Run ID. Design\_Case\_04 Sheet Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
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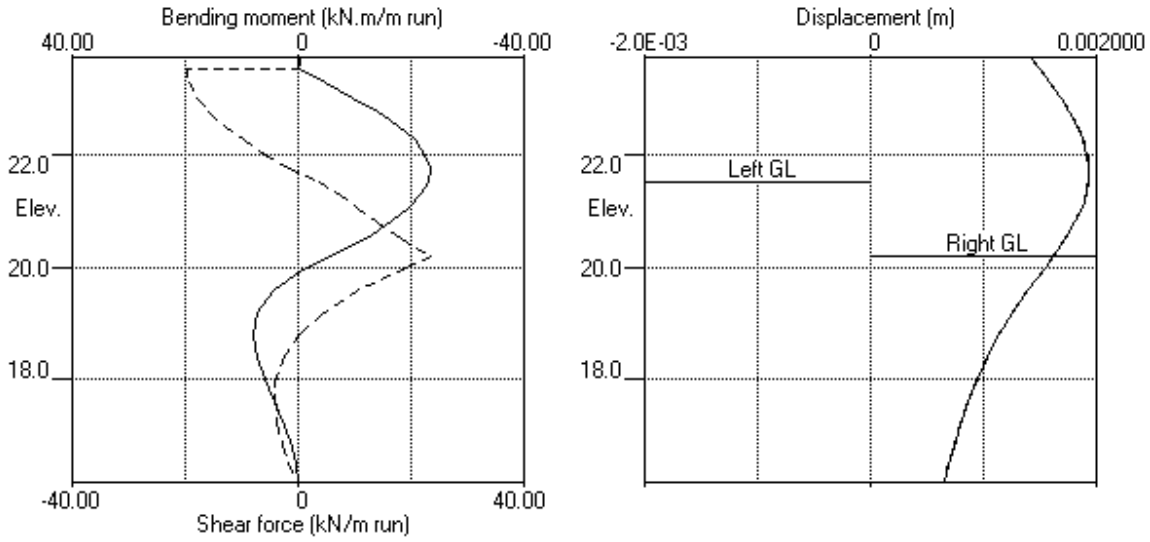
Stage No.5 Excavate to elevation 20.20 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	18.00	Total>	44.04	11.00m	263.78	71.25	71.25	23694
22	17.60	Total>	52.06	13.00m	276.15	78.07	78.07	24251
23	17.20	Total>	60.09	15.00m	288.53	85.07	85.07	24808
24	16.80	Total>	68.13	17.00m	300.92	92.15	92.15	25365
25	16.50	Total>	74.17	18.50m	310.21	97.47	97.47	25783
26	16.20	Total>	80.22	20.00m	319.52	102.78	102.78	26201

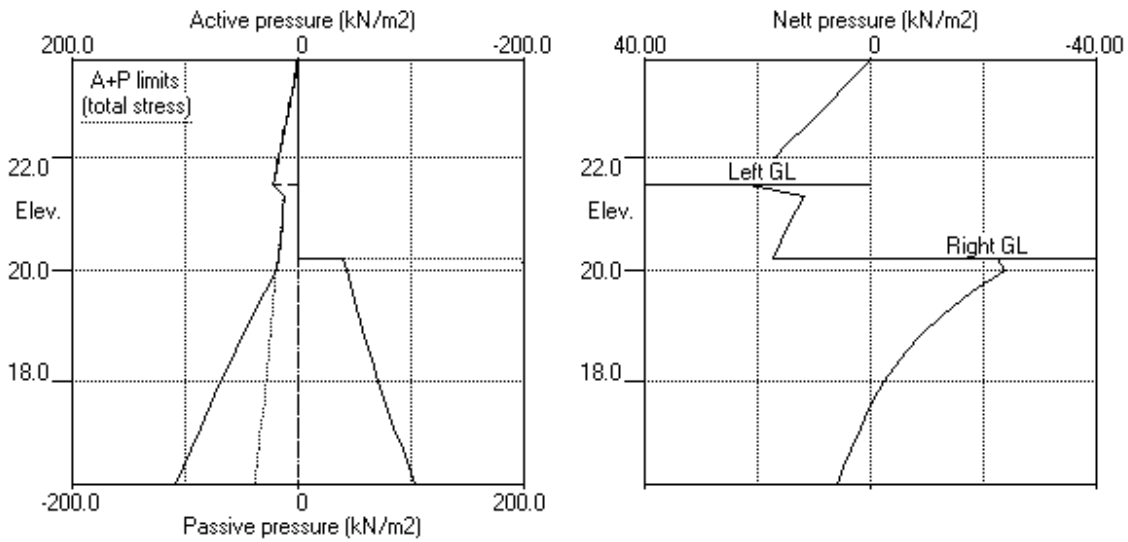
Note: 17.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Excav. to elev. 20.20 on RIGHT side



Stage No.5 Excav. to elev. 20.20 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 16.20</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	22.50	Cant.	30.469	17.51	21.03	1.47	L to R
4	21.50	22.50		No analysis at this stage				
5	21.50	20.20	23.50	8.441	n/a	20.07	0.13	L to R

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	23.70	0.001	-0.001	0	-0	0	-0	0	0	0	0
2	23.50	0.001	-0.001	0	0	0	0	0	-20	0	-27
3	23.25	0.002	-0.001	0	-5	0	-7	1	-19	1	-26
4	23.00	0.002	-0.001	0	-10	1	-13	2	-18	3	-24
5	22.75	0.002	-0.001	1	-14	2	-19	5	-16	6	-21
6	22.50	0.002	-0.001	3	-18	4	-24	7	-13	10	-18
7	22.25	0.002	-0.001	5	-21	7	-28	9	-10	12	-13
8	22.00	0.002	-0.001	7	-22	10	-30	8	-6	11	-8
9	21.75	0.002	-0.001	9	-23	12	-31	8	-4	11	-6
10	21.50	0.002	-0.001	11	-23	15	-31	7	-7	10	-10
11	21.30	0.002	-0.001	12	-22	17	-29	7	-5	10	-7
12	21.05	0.002	-0.001	13	-20	18	-26	10	-4	14	-5
13	20.80	0.002	-0.001	13	-17	17	-22	14	-3	19	-4
14	20.50	0.002	-0.001	11	-12	15	-16	18	-5	25	-7
15	20.20	0.002	-0.001	10	-6	13	-8	23	-6	32	-8
16	20.00	0.002	-0.000	8	-5	11	-7	19	-6	25	-9
17	19.60	0.001	-0.000	6	-4	8	-6	11	-6	14	-8
18	19.20	0.001	-0.000	7	-4	10	-5	4	-5	6	-7
19	18.80	0.001	-0.000	8	-3	11	-4	2	-4	3	-5
20	18.40	0.001	-0.000	7	-2	10	-3	2	-2	2	-3
21	18.00	0.001	-0.000	6	-1	8	-2	2	-4	2	-5
22	17.60	0.001	-0.000	4	-1	6	-1	1	-4	2	-6
23	17.20	0.001	-0.000	2	0	3	-1	1	-4	1	-5
24	16.80	0.001	-0.000	1	0	1	0	0	-3	1	-4
25	16.50	0.001	-0.000	0	0	0	0	0	-2	0	-2
26	16.20	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						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	min.	max.	elev.	min.	elev.	max.	min.	
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	
1	1	22.25	-5	20.50	1	-7	2	19.20	-7	21.50	3	-10
2	1	22.25	-5	20.50	1	-7	2	19.20	-7	21.50	3	-10
3	13	21.05	0	17.20	18	0	9	22.25	-6	20.00	12	-9
4	No calculation at this stage											
5	8	18.80	-23	21.75	11	-31	23	20.20	-20	23.50	32	-27

Run ID. Design\_Case\_04 Sheet Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage no.	maximum m	elev.	minimum m	elev.	Stage description
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.001	23.70	-0.000	19.20	Excav. to elev. 22.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 23.50
5	0.002	21.75	0.000	23.70	Excav. to elev. 20.20 on RIGHT side

**Prop forces at each stage (horizontal components)**

Stage no.	Prop no. 1 at elev. 23.50		
	--Calculated--	Factored	
	kN per m run	kN per prop	kN per prop
5	20	102	138

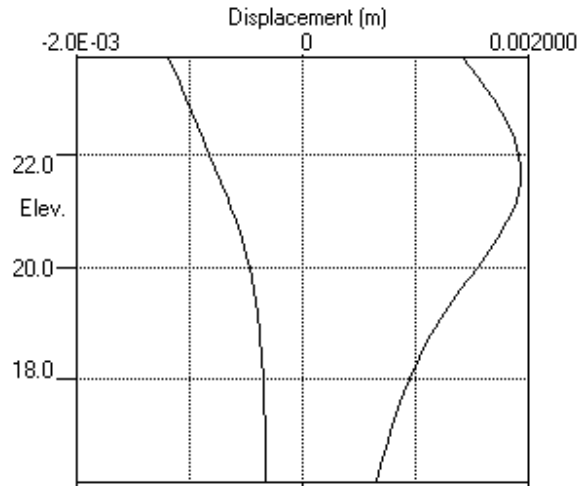
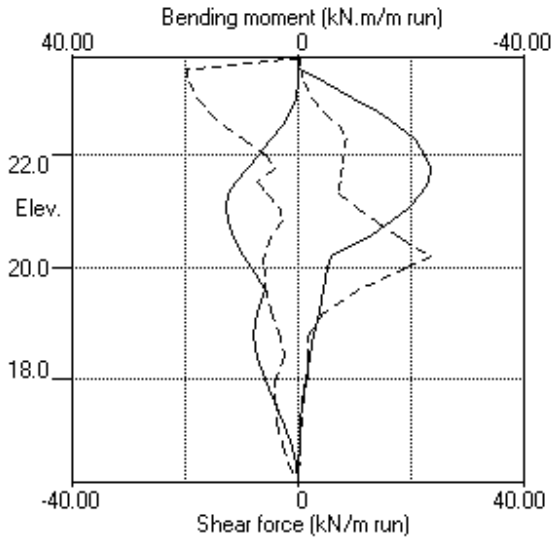


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Ugly Brown Building  
River wall assessment

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Job No. 371654  
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Date:13-05-2020  
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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

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. ( Nu )	Active limit ( Kac )	Passive limit ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground ( 23.70 )	18.50	15000 ( 1500 )	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000 )	
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475 )	80.00u ( 4.390 )

**Additional soil parameters associated with Ka and Kp**

No.	Soil type Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	19.50	19.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow ? tension	L/R
1	23.50	5.00	0.017663	2.050E+08	5.00	0.00	0	Strut	No	R

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Worst Cred. )
3	Excavate to elevation 22.50 on RIGHT side
4	Install strut or anchor no.1 at elevation 23.50
5	Excavate to elevation 19.70 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:  
 Method of analysis - Strength Factor method  
 Overall 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) = 7.500 m

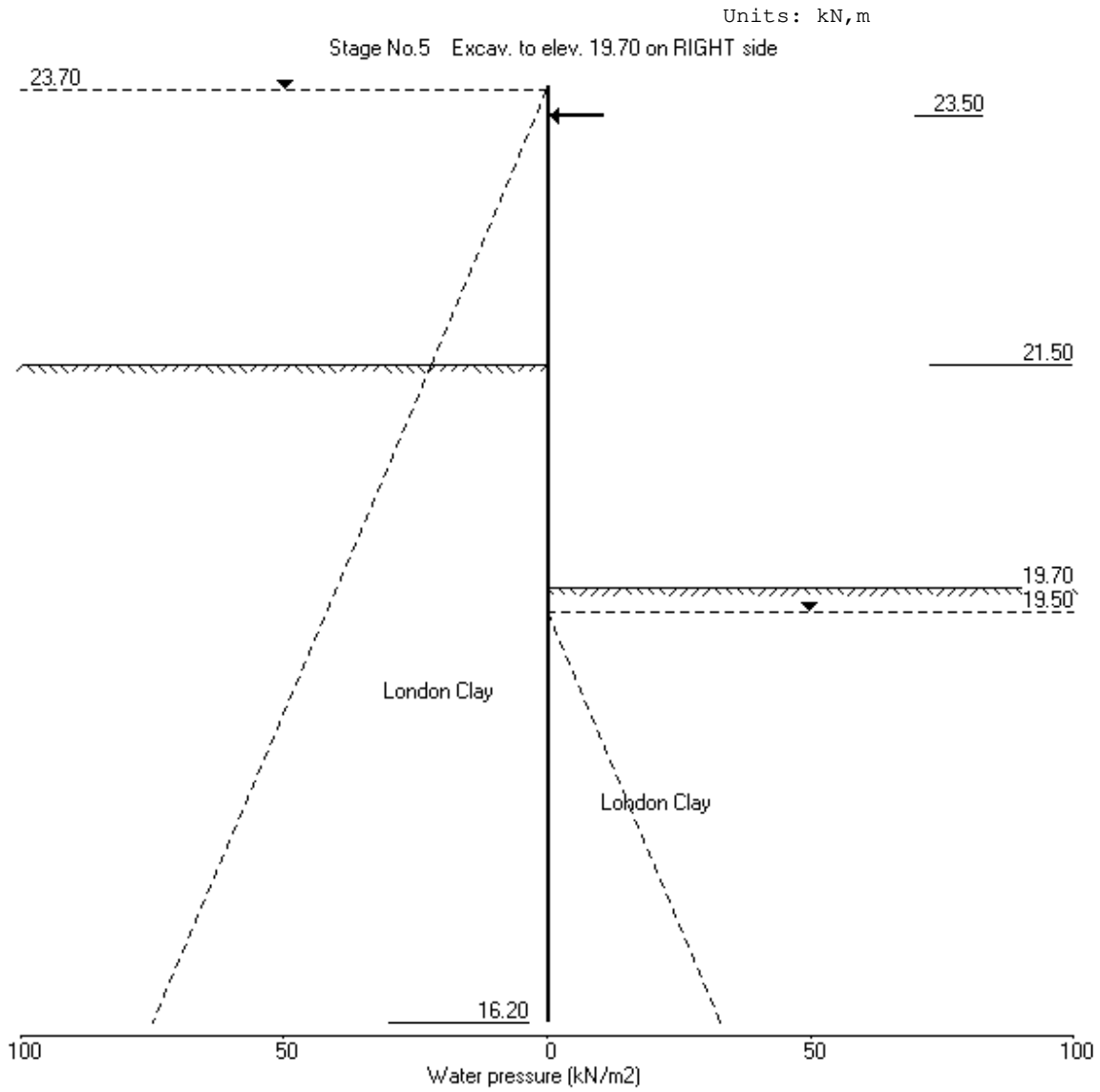
Boundary conditions:  
 Length of wall (normal to plane of analysis) = 46.58 m  
  
 Width of excavation on Left side of wall = 20.00 m  
 Width of excavation on Right side of wall = 20.00 m  
  
 Distance to rigid boundary on Left side = 20.00 m  
 Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Passive	Graph. output
		Bending mom.	pressures	
		Shear force		
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 22.50 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
5	Excav. to elev. 19.70 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
Checked :



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 Ugly Brown Building  
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Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

Overall								
FoS for toe				Toe elev. for				
elev. = 16.20				FoS = 1.000				
Stage	Ground level		Prop	Factor	Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of	equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
				Conditions not suitable for FoS calc.				
1	21.50	23.70	Cant.					

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure	Wall disp.	Wall rotation	Shear force	Bending moment	Prop forces
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.21E-04	0.0	-0.0	
2	23.50	0.42	-0.001	-2.21E-04	0.0	0.0	
3	23.25	0.95	-0.001	-2.21E-04	0.2	0.0	
4	23.00	1.47	-0.001	-2.22E-04	0.5	0.1	
5	22.75	-0.34	-0.001	-2.22E-04	0.7	0.2	
6	22.50	-2.73	-0.001	-2.23E-04	0.3	0.3	
7	22.25	-5.15	-0.001	-2.24E-04	-0.7	0.3	
8	22.00	-7.58	-0.001	-2.25E-04	-2.3	-0.1	
9	21.75	-10.03	-0.001	-2.23E-04	-4.5	-0.9	
10	21.50	-12.49	-0.001	-2.17E-04	-7.3	-2.4	
		10.14	-0.001	-2.17E-04	-7.3	-2.4	
11	21.30	8.87	-0.001	-2.09E-04	-5.4	-3.6	
12	21.05	7.32	-0.001	-1.94E-04	-3.4	-4.7	
13	20.80	5.87	-0.001	-1.76E-04	-1.7	-5.3	
14	20.40	3.83	-0.001	-1.45E-04	0.2	-5.6	
15	20.05	2.36	-0.000	-1.18E-04	1.3	-5.3	
16	19.70	1.20	-0.000	-9.35E-05	1.9	-4.7	
17	19.50	0.68	-0.000	-8.08E-05	2.1	-4.3	
18	19.15	-0.03	-0.000	-6.14E-05	2.2	-3.5	
19	18.80	-0.51	-0.000	-4.60E-05	2.1	-2.7	
20	18.40	-0.82	-0.000	-3.28E-05	1.8	-1.9	
21	18.00	-0.94	-0.000	-2.38E-05	1.5	-1.2	
22	17.60	-0.95	-0.000	-1.82E-05	1.1	-0.7	
23	17.20	-0.88	-0.000	-1.51E-05	0.7	-0.3	
24	16.80	-0.78	-0.000	-1.38E-05	0.4	-0.1	
25	16.50	-0.70	-0.000	-1.35E-05	0.2	-0.0	
26	16.20	-0.62	-0.000	-1.34E-05	0.0	0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	0.0
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	0.0
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	0.0
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	0.0
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	0.0
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00m	151.79	36.50	36.50	19101
11	21.30	Total>	26.00	12.00m	157.35	39.87	39.87	19384
12	21.05	Total>	31.00	13.25m	164.29	44.11	44.11	19737
13	20.80	Total>	36.00	14.50m	171.23	48.41	48.41	20090
14	20.40	Total>	44.00	16.50m	182.34	55.41	55.41	20656
15	20.05	Total>	51.00	18.25m	192.05	61.69	61.69	21150
16	19.70	Total>	58.01	20.00m	201.77	68.12	68.12	21645
17	19.50	Total>	62.01	21.00m	207.33	71.87	71.87	21928
18	19.15	Total>	69.01	22.75m	217.05	78.52	78.52	22422
19	18.80	Total>	76.02	24.50m	226.78	85.29	85.29	22917
20	18.40	Total>	84.03	26.50m	237.89	93.14	93.14	23482
21	18.00	Total>	92.04	28.50m	249.01	101.09	101.09	24048
22	17.60	Total>	100.06	30.50m	260.13	109.09	109.09	24613
23	17.20	Total>	108.07	32.50m	271.25	117.14	117.14	25178
24	16.80	Total>	116.10	34.50m	282.38	125.20	125.20	25743
25	16.50	Total>	122.12	36.00m	290.73	131.25	131.25	26167
26	16.20	Total>	128.14	37.50m	299.08	137.29	137.29	26591

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7060
2	23.50	0.00	3.70	1.58	9.77	1.58	1.58a	7201
3	23.25	0.00	8.33	3.55	21.99	3.55	3.55a	7378
4	23.00	0.00	12.95	5.53	34.21	5.53	5.53a	7554
5	22.75	0.00	17.58	7.50	46.42	9.84	9.84	7731
6	22.50	0.00	22.20	9.47	58.64	14.73	14.73	7907
7	22.25	0.00	26.83	11.44	70.86	19.65	19.65	8084
8	22.00	0.00	31.45	13.42	83.07	24.58	24.58	8260
9	21.75	0.00	36.08	15.39	95.29	29.53	29.53	8437
10	21.50	0.00	40.70	17.36	107.50	34.49	34.49	8613
		Total>	40.70	11.00m	170.50	26.35	26.35	19911
11	21.30	Total>	44.70	12.00m	176.06	31.00	31.00	20206
12	21.05	Total>	49.70	13.25m	183.00	36.79	36.79	20574
13	20.80	Total>	54.70	14.50m	189.94	42.53	42.53	20943
14	20.40	Total>	62.70	16.50m	201.05	51.58	51.58	21532
15	20.05	Total>	69.70	18.25m	210.76	59.33	59.33	22047
16	19.70	Total>	76.70	20.00m	220.48	66.92	66.92	22563
17	19.50	Total>	80.70	21.00m	226.03	71.19	71.19	22858
18	19.15	Total>	87.70	22.75m	235.75	78.55	78.55	23373
19	18.80	Total>	94.70	24.50m	245.47	85.80	85.80	23889
20	18.40	Total>	102.70	26.50m	256.57	93.96	93.96	24478

Run ID. Design\_Case\_04\_Sheet Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
21	18.00	Total>	110.70	28.50m	267.68	102.03	102.03	25067
22	17.60	Total>	118.70	30.50m	278.78	110.04	110.04	25657
23	17.20	Total>	126.70	32.50m	289.89	118.01	118.01	26246
24	16.80	Total>	134.70	34.50m	300.99	125.97	125.97	26835
25	16.50	Total>	140.70	36.00m	309.32	131.94	131.94	27277
26	16.20	Total>	146.70	37.50m	317.65	137.91	137.91	27719

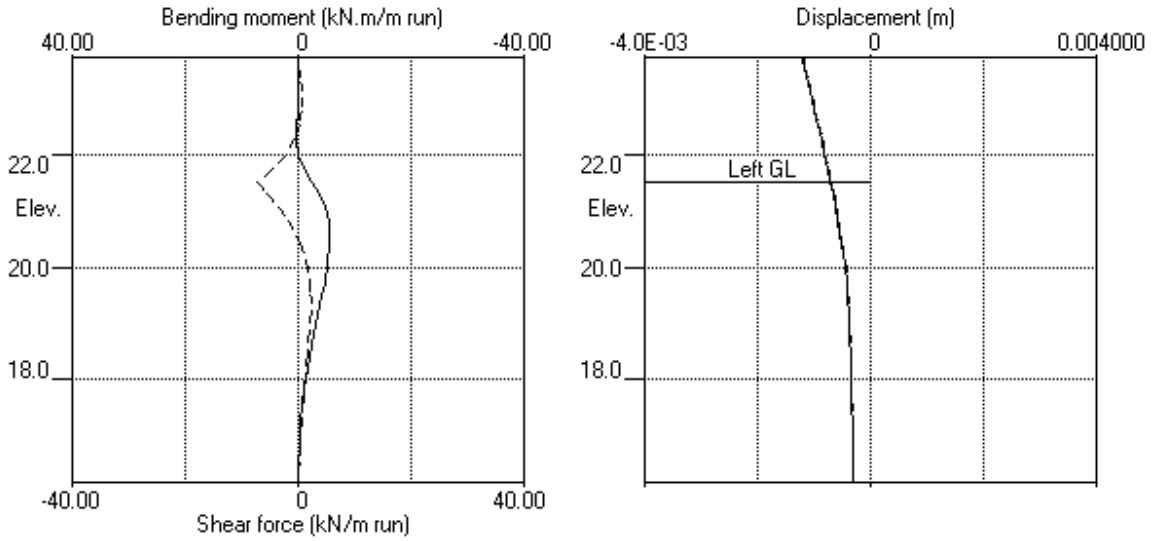
Note: 5.53a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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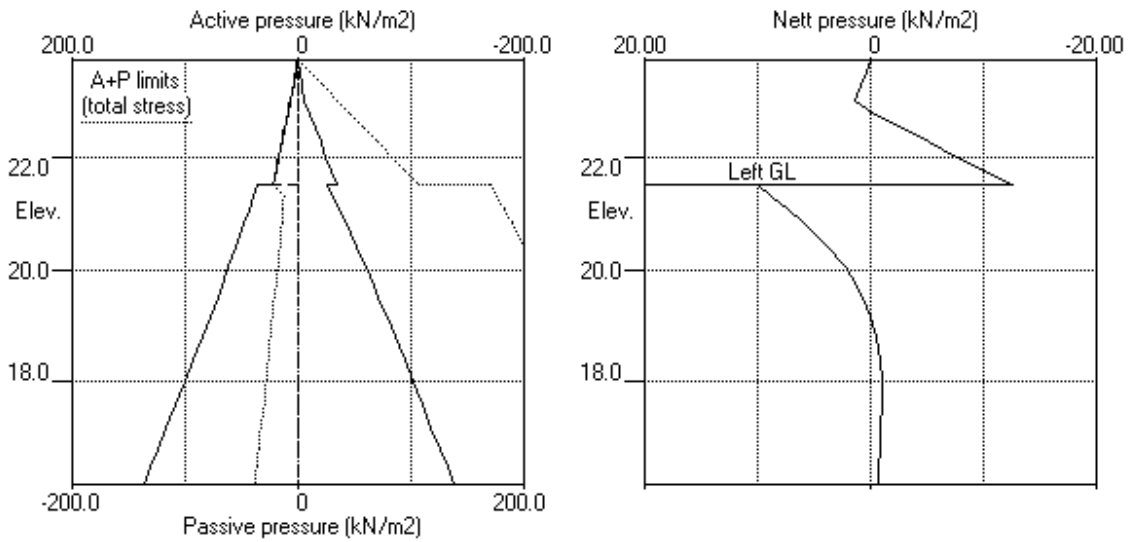
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side





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 Ugly Brown Building  
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Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 22.50 on RIGHT side

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 16.20		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>		
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>		
3	21.50	22.50	Cant.	21.813	17.50	20.84	1.66	L to R	

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.001	4.42E-04	0.0	-0.0	
2	23.50	2.00	0.001	4.42E-04	0.2	0.0	
3	23.25	4.50	0.001	4.41E-04	1.0	0.2	
4	23.00	7.00	0.001	4.40E-04	2.5	0.6	
5	22.75	9.50	0.001	4.37E-04	4.5	1.3	
6	22.50	12.00	0.001	4.29E-04	7.2	2.8	
7	22.25	2.28	0.000	4.16E-04	9.0	4.9	
8	22.00	-1.19	0.000	3.94E-04	9.1	7.3	
9	21.75	-1.99	0.000	3.64E-04	8.7	9.5	
10	21.50	-2.85	0.000	3.26E-04	8.1	11.6	
		-10.04	0.000	3.26E-04	8.1	11.6	
11	21.30	-20.86	0.000	2.91E-04	5.0	13.2	
12	21.05	-15.35	0.000	2.43E-04	0.5	13.8	
13	20.80	-10.58	-0.000	1.94E-04	-2.7	13.4	
14	20.40	-4.53	-0.000	1.23E-04	-5.8	11.5	
15	20.05	-0.79	-0.000	7.21E-05	-6.7	9.2	
16	19.70	1.68	-0.000	3.22E-05	-6.5	6.8	
17	19.50	2.61	-0.000	1.47E-05	-6.1	5.5	
18	19.15	3.43	-0.000	-7.86E-06	-5.1	3.5	
19	18.80	3.60	-0.000	-2.16E-05	-3.8	2.0	
20	18.40	3.26	-0.000	-2.93E-05	-2.5	0.7	
21	18.00	2.61	-0.000	-3.15E-05	-1.3	0.0	
22	17.60	1.80	-0.000	-3.07E-05	-0.4	-0.3	
23	17.20	0.95	-0.000	-2.90E-05	0.2	-0.3	
24	16.80	0.07	-0.000	-2.77E-05	0.4	-0.2	
25	16.50	-0.59	-0.000	-2.72E-05	0.3	-0.1	
26	16.20	-1.27	-0.000	-2.71E-05	0.0	0.0	

(continued)

Stage No.3 Excavate to elevation 22.50 on RIGHT side

		LEFT side							
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction	
				Active limit	Passive limit				
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0	
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	0.0	
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	0.0	
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	0.0	
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	0.0	
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	0.0	
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0	
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0	
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0	
		Total>	22.00	22.00w	151.79	22.00	22.00a	34096	
11	21.30	Total>	26.00	12.00m	157.35	12.97	12.97	34601	
12	21.05	Total>	31.00	13.25m	164.29	20.88	20.88	35231	
13	20.80	Total>	36.00	14.50m	171.23	28.40	28.40	35862	
14	20.40	Total>	44.00	16.50m	182.34	39.59	39.59	36871	
15	20.05	Total>	51.00	18.25m	192.05	48.55	48.55	37754	
16	19.70	Total>	58.01	20.00m	201.77	56.83	56.83	38637	
17	19.50	Total>	62.01	21.00m	207.33	61.30	61.30	39141	
18	19.15	Total>	69.01	22.75m	217.05	68.77	68.77	40024	
19	18.80	Total>	76.02	24.50m	226.78	75.89	75.89	40907	
20	18.40	Total>	84.03	26.50m	237.89	83.74	83.74	41916	
21	18.00	Total>	92.04	28.50m	249.01	91.42	91.42	42925	
22	17.60	Total>	100.06	30.50m	260.13	99.02	99.02	43934	
23	17.20	Total>	108.07	32.50m	271.25	106.59	106.59	44943	
24	16.80	Total>	116.10	34.50m	282.38	114.15	114.15	45953	
25	16.50	Total>	122.12	36.00m	290.73	119.83	119.83	46709	
26	16.20	Total>	128.14	37.50m	299.08	125.49	125.49	47466	

		RIGHT side							
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction	
				Active limit	Passive limit				
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3	
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
4	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
5	22.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
6	22.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
		Total>	0.00	0.00	0.00	0.00	0.00	12153	
7	22.25	0.00	4.63	1.97	12.22	12.22	12.22p	12424	
8	22.00	0.00	9.25	3.95	24.43	18.19	18.19	12695	
9	21.75	0.00	13.88	5.92	36.65	21.49	21.49	12966	
10	21.50	0.00	18.50	7.89	48.87	24.85	24.85	13238	
		Total>	18.50	5.00m	148.30	32.04	32.04	30602	
11	21.30	Total>	22.50	6.00m	153.85	33.83	33.83	31055	
12	21.05	Total>	27.50	7.25m	160.80	36.23	36.23	31621	
13	20.80	Total>	32.51	8.50m	167.74	38.98	38.98	32187	
14	20.40	Total>	40.51	10.50m	178.85	44.12	44.12	33093	
15	20.05	Total>	47.52	12.25m	188.58	49.34	49.34	33885	
16	19.70	Total>	54.53	14.00m	198.30	55.15	55.15	34678	
17	19.50	Total>	58.53	15.00m	203.86	58.69	58.69	35131	
18	19.15	Total>	65.54	16.75m	213.59	65.34	65.34	35923	
19	18.80	Total>	72.56	18.50m	223.32	72.29	72.29	36715	

Run ID. Design\_Case\_04\_Sheet Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 22.50 on RIGHT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>Water</u> <u>press.</u> kN/m <sup>2</sup>	<u>RIGHT side</u> <u>Effective stresses</u>				<u>Total</u> <u>earth</u> <u>pressure</u> kN/m <sup>2</sup>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u> kN/m <sup>3</sup>
			<u>Vertic</u> <u>-al</u> kN/m <sup>2</sup>	<u>Active</u> <u>limit</u> kN/m <sup>2</sup>	<u>Passive</u> <u>limit</u> kN/m <sup>2</sup>	<u>Earth</u> <u>pressure</u> kN/m <sup>2</sup>		
20	18.40	Total>	80.58	20.50m	234.45	80.48	80.48	37621
21	18.00	Total>	88.60	22.50m	245.58	88.81	88.81	38527
22	17.60	Total>	96.63	24.50m	256.71	97.21	97.21	39432
23	17.20	Total>	104.66	26.50m	267.85	105.64	105.64	40338
24	16.80	Total>	112.70	28.50m	278.99	114.08	114.08	41244
25	16.50	Total>	118.73	30.00m	287.35	120.42	120.42	41923
26	16.20	Total>	124.76	31.50m	295.71	126.76	126.76	42602

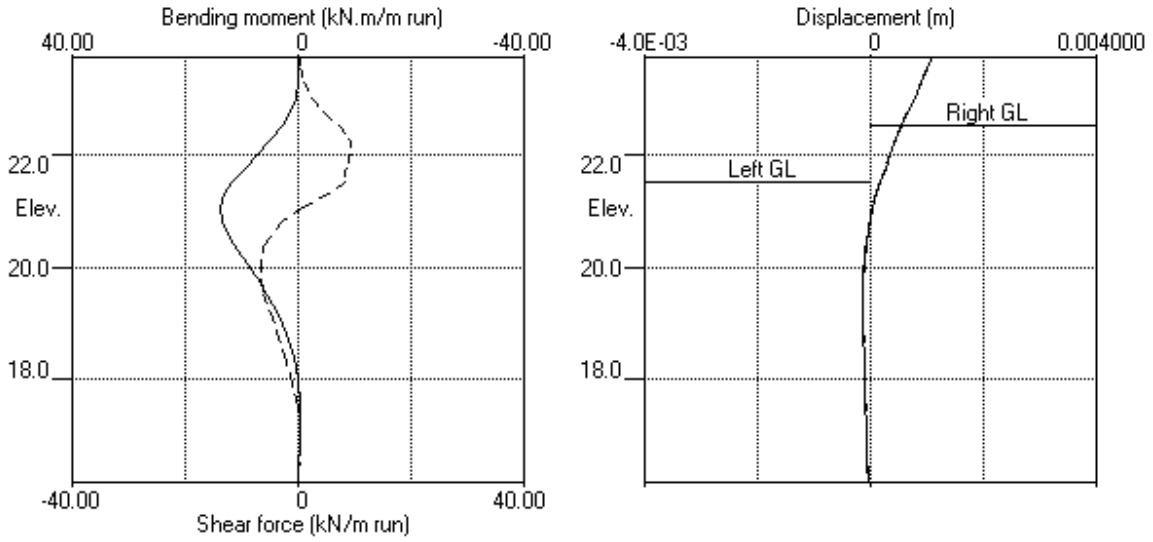
Note: 22.00a Soil pressure at active limit  
 12.22p Soil pressure at passive limit

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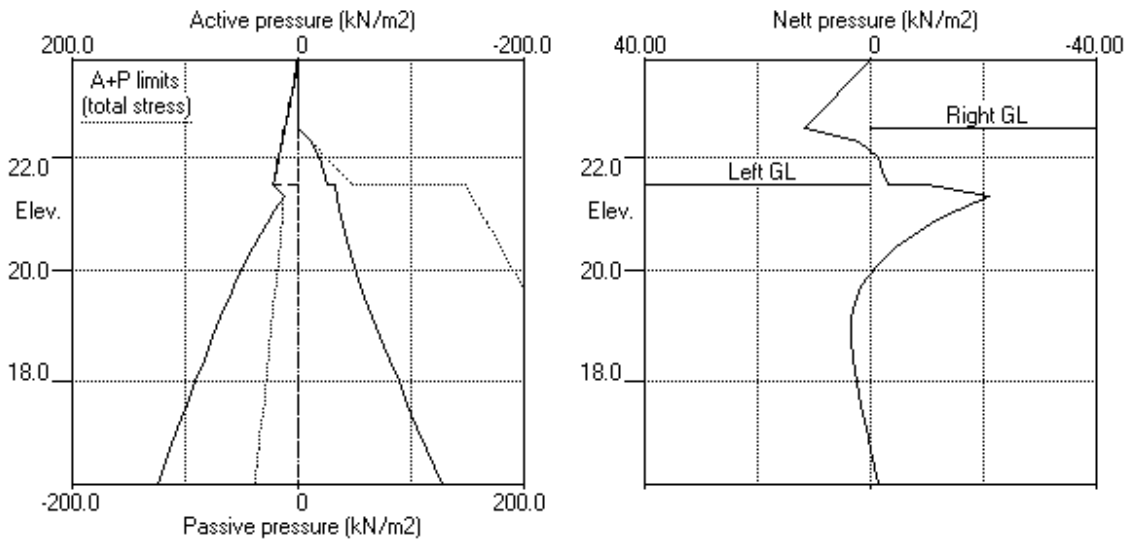
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 22.50 on RIGHT side



Stage No.3 Excav. to elev. 22.50 on RIGHT side



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 Ugly Brown Building  
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Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 19.70 on RIGHT side

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

		Overall		FoS for toe		Toe elev. for			
				elev. = 16.20		FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>		
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>equiv.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
				<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
5	21.50	19.70	23.50	4.920	n/a	19.47	0.23	L to R	

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.001	-7.38E-04	0.0	-0.0	
2	23.50	2.00	0.001	-7.38E-04	0.2	0.0	-24.6
		2.00	0.001	-7.38E-04	-24.4	0.0	
3	23.25	4.50	0.001	-7.28E-04	-23.6	-6.0	
4	23.00	7.00	0.002	-6.96E-04	-22.2	-11.8	
5	22.75	9.50	0.002	-6.44E-04	-20.1	-17.1	
6	22.50	12.00	0.002	-5.75E-04	-17.4	-21.8	
7	22.25	14.50	0.002	-4.90E-04	-14.1	-25.8	
8	22.00	17.00	0.002	-3.93E-04	-10.2	-28.7	
9	21.75	19.50	0.002	-2.87E-04	-5.6	-30.7	
10	21.50	22.00	0.002	-1.76E-04	-0.4	-31.5	
11	21.30	12.00	0.002	-8.74E-05	3.0	-31.0	
12	21.05	13.25	0.002	2.12E-05	6.1	-30.0	
13	20.80	14.50	0.002	1.24E-04	9.6	-28.1	
14	20.40	16.50	0.002	2.70E-04	15.8	-23.2	
15	20.05	18.25	0.002	3.70E-04	21.9	-16.7	
16	19.70	20.00	0.002	4.31E-04	28.6	-7.9	
		-29.80	0.002	4.31E-04	28.6	-7.9	
17	19.50	-28.60	0.002	4.46E-04	22.7	-2.5	
18	19.15	-22.88	0.002	4.43E-04	13.7	3.6	
19	18.80	-17.48	0.002	4.17E-04	6.6	7.0	
20	18.40	-11.92	0.001	3.73E-04	0.8	8.3	
21	18.00	-7.08	0.001	3.27E-04	-3.0	7.7	
22	17.60	-2.86	0.001	2.89E-04	-5.0	5.9	
23	17.20	0.92	0.001	2.62E-04	-5.4	3.6	
24	16.80	4.51	0.001	2.47E-04	-4.3	1.5	
25	16.50	7.19	0.001	2.43E-04	-2.6	0.4	
26	16.20	9.96	0.001	2.42E-04	0.0	0.0	

At elev. 23.50 Prop force = 24.6 kN/m run

(continued)

Stage No.5 Excavate to elevation 19.70 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.25	4.50	0.00	0.00	0.00	0.00	4.50	0.0
4	23.00	7.00	0.00	0.00	0.00	0.00	7.00	0.0
5	22.75	9.50	0.00	0.00	0.00	0.00	9.50	0.0
6	22.50	12.00	0.00	0.00	0.00	0.00	12.00	0.0
7	22.25	14.50	0.00	0.00	0.00	0.00	14.50	0.0
8	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
9	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
10	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	22.00	22.00a	16792
11	21.30	Total>	26.00	12.00m	157.35	12.00	12.00a	17041
12	21.05	Total>	31.00	13.25m	164.29	13.25	13.25a	17351
13	20.80	Total>	36.00	14.50m	171.23	14.50	14.50a	17662
14	20.40	Total>	44.00	16.50m	182.34	16.50	16.50a	18159
15	20.05	Total>	51.00	18.25m	192.05	18.25	18.25a	18594
16	19.70	Total>	58.01	20.00m	201.77	20.00	20.00a	19029
17	19.50	Total>	62.01	21.00m	207.33	23.41	23.41	19277
18	19.15	Total>	69.01	22.75m	217.05	33.10	33.10	19712
19	18.80	Total>	76.02	24.50m	226.78	42.58	42.58	20147
20	18.40	Total>	84.03	26.50m	237.89	53.10	53.10	20644
21	18.00	Total>	92.04	28.50m	249.01	63.26	63.26	21141
22	17.60	Total>	100.06	30.50m	260.13	73.13	73.13	21638
23	17.20	Total>	108.07	32.50m	271.25	82.80	82.80	22135
24	16.80	Total>	116.10	34.50m	282.38	92.39	92.39	22632
25	16.50	Total>	122.12	36.00m	290.73	99.58	99.58	23004
26	16.20	Total>	128.14	37.50m	299.08	106.81	106.81	23377

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	23.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	22.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	20.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	20.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	19.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	143.76	49.80	49.80	22960
17	19.50	Total>	4.00	1.00m	149.32	52.01	52.01	23260
18	19.15	Total>	11.00	2.75m	159.04	55.98	55.98	23784
19	18.80	Total>	18.00	4.50m	168.76	60.06	60.06	24309
20	18.40	Total>	26.01	6.50m	179.87	65.02	65.02	24909

Run ID. Design\_Case\_04\_Sheet Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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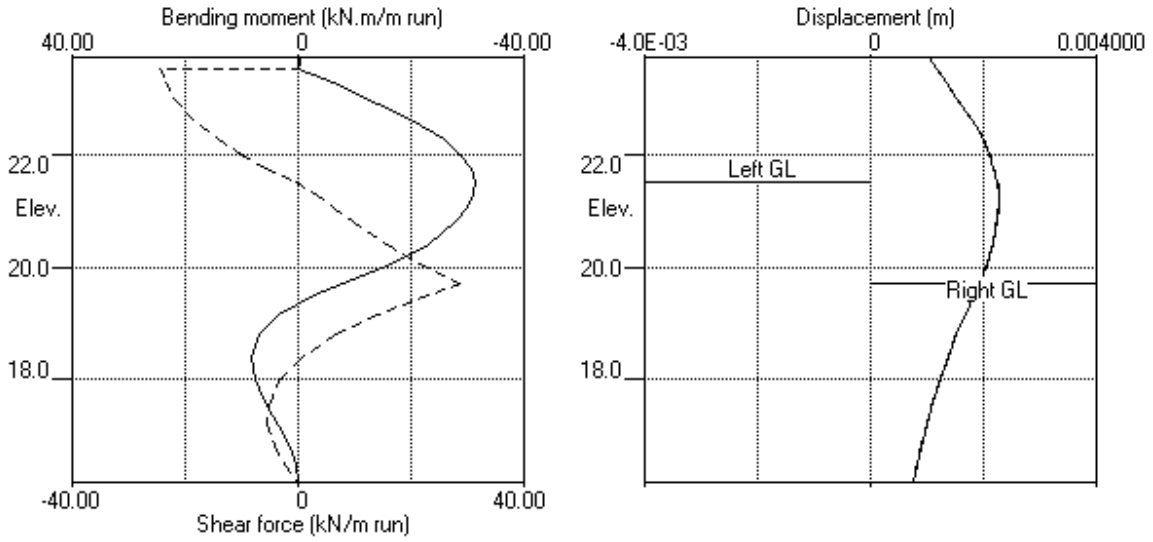
Stage No.5 Excavate to elevation 19.70 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	18.00	Total>	34.02	8.50m	190.98	70.34	70.34	25508
22	17.60	Total>	42.04	10.50m	202.11	75.99	75.99	26108
23	17.20	Total>	50.06	12.50m	213.24	81.88	81.88	26708
24	16.80	Total>	58.10	14.50m	224.38	87.88	87.88	27307
25	16.50	Total>	64.13	16.00m	232.74	92.39	92.39	27757
26	16.20	Total>	70.17	17.50m	241.11	96.85	96.85	28207

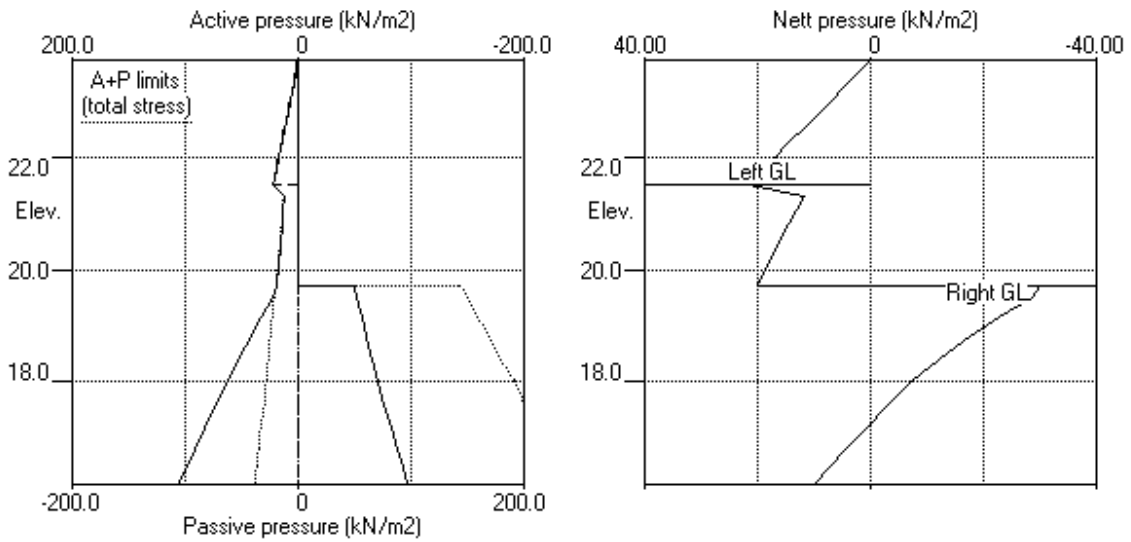
Note: 20.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Excav. to elev. 19.70 on RIGHT side



Stage No.5 Excav. to elev. 19.70 on RIGHT side





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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Factor</u> <u>Moment</u> <u>of</u> <u>equilib.</u>		<u>Toe</u> <u>Wall</u> <u>elev.</u> <u>Penetr</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Safety</u>	<u>at elev.</u>	<u>elev.</u>	<u>-ation</u>	
	Overall			<b>FoS for toe</b>		<b>Toe elev. for</b>		
				<b>elev. = 16.20</b>		<b>FoS = 1.000</b>		
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	22.50	Cant.	21.813	17.50	20.84	1.66	L to R
4	21.50	22.50		No analysis at this stage				
5	21.50	19.70	23.50	4.920	n/a	19.47	0.23	L to R

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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m		kN.m/m		kN/m	
1	23.70	0.001	-0.001	0.0	-0.0	0.0	0.0
2	23.50	0.001	-0.001	0.0	0.0	0.2	-24.4
3	23.25	0.001	-0.001	0.2	-6.0	1.0	-23.6
4	23.00	0.002	-0.001	0.6	-11.8	2.5	-22.2
5	22.75	0.002	-0.001	1.3	-17.1	4.5	-20.1
6	22.50	0.002	-0.001	2.8	-21.8	7.2	-17.4
7	22.25	0.002	-0.001	4.9	-25.8	9.0	-14.1
8	22.00	0.002	-0.001	7.3	-28.7	9.1	-10.2
9	21.75	0.002	-0.001	9.5	-30.7	8.7	-5.6
10	21.50	0.002	-0.001	11.6	-31.5	8.1	-7.3
11	21.30	0.002	-0.001	13.2	-31.0	5.0	-5.5
12	21.05	0.002	-0.001	13.8	-30.0	6.1	-3.5
13	20.80	0.002	-0.001	13.4	-28.1	9.6	-2.7
14	20.40	0.002	-0.001	11.5	-23.2	15.8	-5.8
15	20.05	0.002	-0.000	9.2	-16.7	21.9	-6.7
16	19.70	0.002	-0.000	6.8	-7.9	28.6	-6.5
17	19.50	0.002	-0.000	5.5	-4.4	22.7	-6.1
18	19.15	0.002	-0.000	3.6	-3.6	13.7	-5.1
19	18.80	0.002	-0.000	7.0	-2.9	6.6	-3.8
20	18.40	0.001	-0.000	8.3	-2.0	1.9	-2.5
21	18.00	0.001	-0.000	7.7	-1.3	1.6	-3.0
22	17.60	0.001	-0.000	5.9	-0.8	1.2	-5.0
23	17.20	0.001	-0.000	3.6	-0.4	0.8	-5.4
24	16.80	0.001	-0.000	1.5	-0.2	0.5	-4.3
25	16.50	0.001	-0.000	0.4	-0.1	0.3	-2.6
26	16.20	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				Shear force				
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.	
		kN.m/m		kN.m/m		kN/m		kN/m	
1	0.3	22.50	-5.6	20.40	2.2	19.15	-7.3	21.50	
2	0.3	22.50	-5.6	20.40	2.2	19.15	-7.3	21.50	
3	13.8	21.05	-0.3	17.20	9.1	22.00	-6.7	20.05	
4	No calculation at this stage								
5	8.3	18.40	-31.5	21.50	28.6	19.70	-24.4	23.50	

Run ID. Design\_Case\_04\_Sheet Pile\_prop\_ULS2  
Ugly Brown Building  
River wall assessment

Sheet No.  
Date:13-05-2020  
Checked :

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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				
no.	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>Stage description</u>
	m		m		
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.001	23.70	-0.000	19.15	Excav. to elev. 22.50 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 23.50
5	0.002	21.05	0.000	23.70	Excav. to elev. 19.70 on RIGHT side

**Prop forces at each stage (horizontal components)**

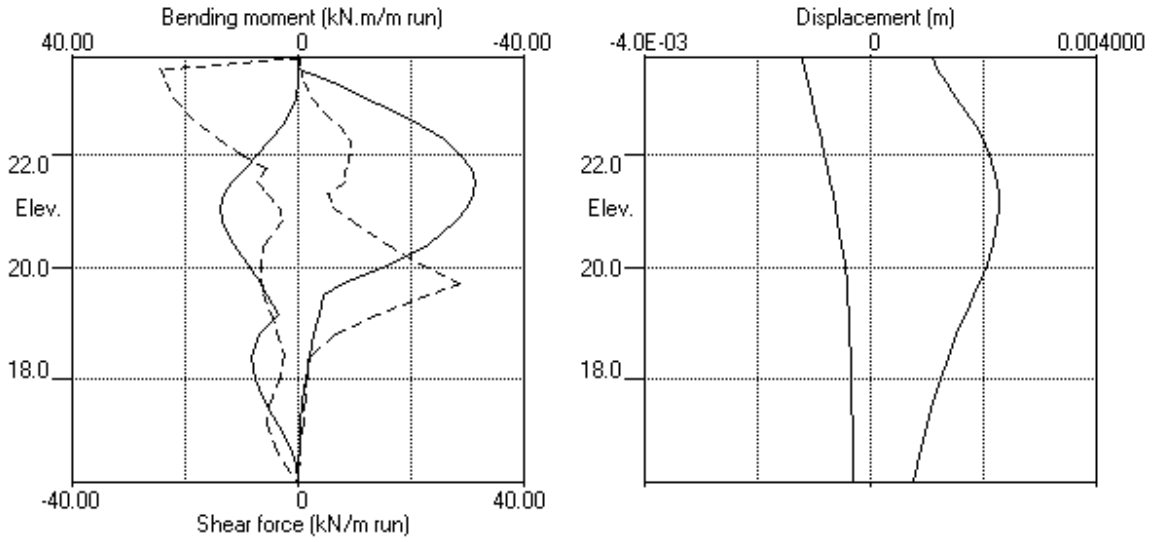
Stage	--- Strut no. 1 ---	
no.	at elev. 23.50	
	kN/m run	kN/prop
5	24.64	123.22

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Ugly Brown Building  
River wall assessment

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Job No. 371654  
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Date:13-05-2020  
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Units: kN,m

Bending moment, shear force, displacement envelopes



DESIGN CASE 05

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 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**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. ( Nu )	Active limit ( Kac )	Passive limit ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground ( 23.70 )	18.50	15000 ( 1500 )	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000 )	
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475 )	80.00u ( 4.390 )

**Additional soil parameters associated with Ka and Kp**

Soil type No.	Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	18.50	18.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow ? tension	L/R
1	23.50	5.00	0.017663	2.050E+08	20.00	0.00	0	Strut	No	R

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 22.70 on RIGHT side
4	Install strut or anchor no.1 at elevation 23.50
5	Excavate to elevation 18.70 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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) = 7.500 m

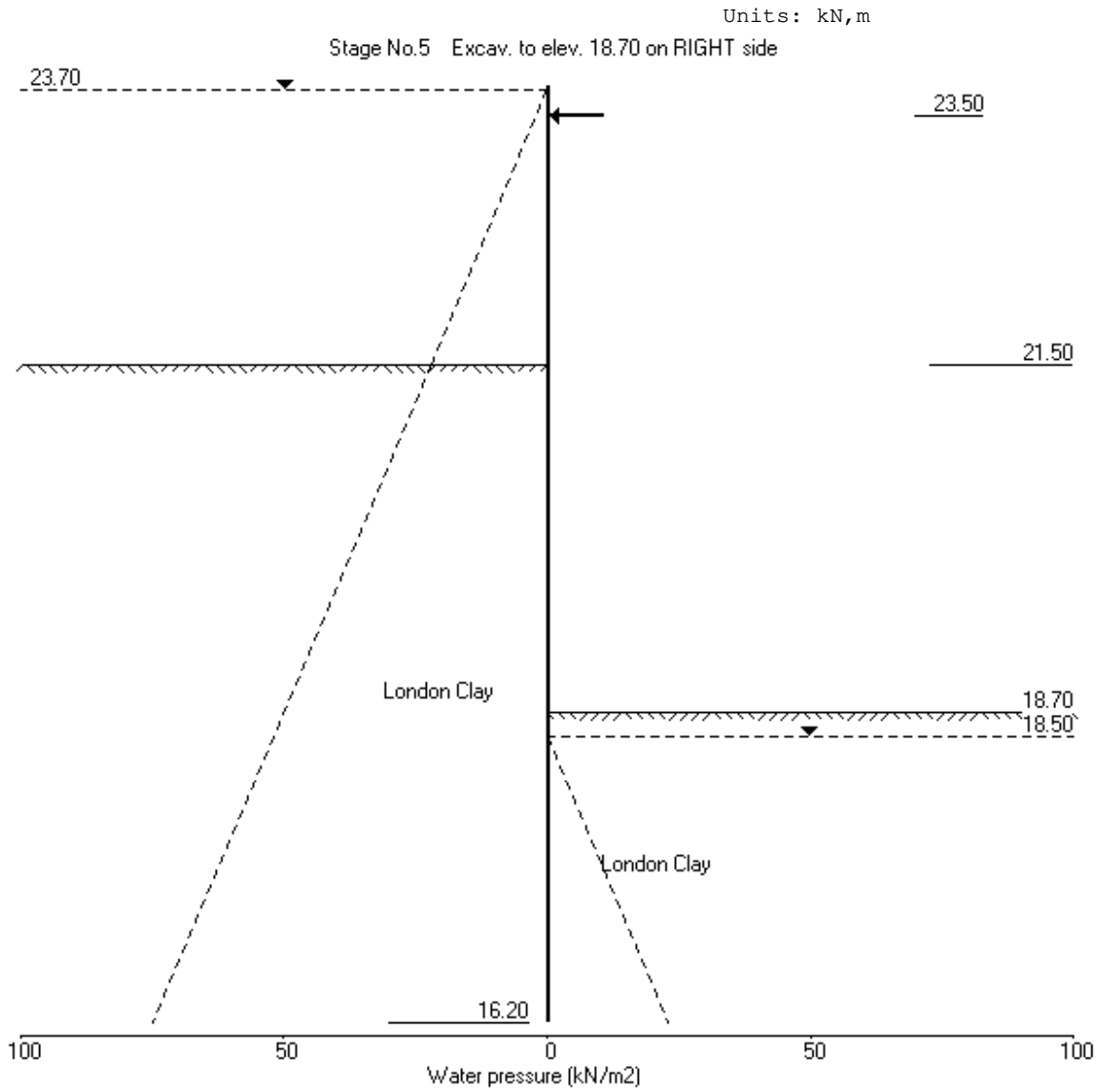
Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m  
  
Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m  
  
Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Graph.	Passive output pressures
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 22.70 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
5	Excav. to elev. 18.70 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
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 Ugly Brown Building  
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Sheet No.  
 Job No. 371654  
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 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

				FoS for toe elev. = 16.20	Toe elev. for FoS = 1.000		
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>			

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.13E-04	0.0	0.0	
2	23.50	0.69	-0.001	-2.13E-04	0.1	0.0	
3	23.10	2.08	-0.001	-2.13E-04	0.6	0.1	
4	22.70	-0.95	-0.001	-2.14E-04	0.9	0.3	
5	22.35	-4.28	-0.001	-2.16E-04	-0.1	0.4	
6	22.00	-7.66	-0.001	-2.17E-04	-2.2	0.1	
7	21.75	-10.09	-0.001	-2.16E-04	-4.4	-0.7	
8	21.50	-12.54	-0.001	-2.11E-04	-7.2	-2.1	
		9.77	-0.001	-2.11E-04	-7.2	-2.1	
9	21.30	8.56	-0.001	-2.03E-04	-5.4	-3.4	
10	21.05	7.09	-0.001	-1.89E-04	-3.4	-4.5	
11	20.80	5.71	-0.001	-1.72E-04	-1.8	-5.1	
12	20.40	3.76	-0.001	-1.43E-04	0.1	-5.4	
13	20.00	2.17	-0.000	-1.13E-04	1.3	-5.0	
14	19.60	0.96	-0.000	-8.67E-05	1.9	-4.3	
15	19.20	0.11	-0.000	-6.44E-05	2.1	-3.5	
16	18.95	-0.27	-0.000	-5.28E-05	2.1	-3.0	
17	18.70	-0.54	-0.000	-4.31E-05	2.0	-2.5	
18	18.50	-0.69	-0.000	-3.66E-05	1.9	-2.1	
19	18.25	-0.82	-0.000	-3.00E-05	1.7	-1.6	
20	18.00	-0.89	-0.000	-2.49E-05	1.5	-1.2	
21	17.60	-0.91	-0.000	-1.93E-05	1.1	-0.7	
22	17.20	-0.86	-0.000	-1.63E-05	0.7	-0.4	
23	16.80	-0.77	-0.000	-1.49E-05	0.4	-0.1	
24	16.50	-0.71	-0.000	-1.46E-05	0.2	-0.0	
25	16.20	-0.64	-0.000	-1.45E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00m	203.71	36.22	36.22	18635
9	21.30	Total>	26.00	12.00m	209.89	39.63	39.63	18911
10	21.05	Total>	31.00	13.25m	217.60	43.92	43.92	19255
11	20.80	Total>	36.00	14.50m	225.32	48.25	48.25	19600
12	20.40	Total>	44.00	16.50m	237.67	55.30	55.30	20151
13	20.00	Total>	52.00	18.50m	250.01	62.53	62.53	20703
14	19.60	Total>	60.01	20.50m	262.36	69.94	69.94	21254
15	19.20	Total>	68.01	22.50m	274.72	77.53	77.53	21806
16	18.95	Total>	73.02	23.75m	282.44	82.35	82.35	22151
17	18.70	Total>	78.02	25.00m	290.16	87.22	87.22	22495
18	18.50	Total>	82.03	26.00m	296.34	91.15	91.15	22771
19	18.25	Total>	87.03	27.25m	304.06	96.09	96.09	23116
20	18.00	Total>	92.04	28.50m	311.78	101.06	101.06	23460
21	17.60	Total>	100.06	30.50m	324.15	109.06	109.06	24012
22	17.20	Total>	108.07	32.50m	336.51	117.09	117.09	24563
23	16.80	Total>	116.10	34.50m	348.88	125.14	125.14	25115
24	16.50	Total>	122.12	36.00m	358.16	131.18	131.18	25529
25	16.20	Total>	128.14	37.50m	367.44	137.23	137.23	25942

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	6980
2	23.50	0.00	3.70	1.31	12.63	1.31	1.31a	7120
3	23.10	0.00	11.10	3.92	37.88	3.92	3.92a	7399
4	22.70	0.00	18.50	6.53	63.13	10.95	10.95	7678
5	22.35	0.00	24.98	8.81	85.22	17.78	17.78	7923
6	22.00	0.00	31.45	11.09	107.31	24.66	24.66	8167
7	21.75	0.00	36.08	12.73	123.09	29.59	29.59	8341
8	21.50	0.00	40.70	14.36	138.88	34.54	34.54	8516
		Total>	40.70	11.00m	222.41	26.45	26.45	19687
9	21.30	Total>	44.70	12.00m	228.59	31.07	31.07	19978
10	21.05	Total>	49.70	13.25m	236.30	36.83	36.83	20342
11	20.80	Total>	54.70	14.50m	244.02	42.54	42.54	20706
12	20.40	Total>	62.70	16.50m	256.36	51.54	51.54	21289
13	20.00	Total>	70.70	18.50m	268.71	60.36	60.36	21872
14	19.60	Total>	78.70	20.50m	281.06	68.98	68.98	22454
15	19.20	Total>	86.70	22.50m	293.40	77.42	77.42	23037
16	18.95	Total>	91.70	23.75m	301.12	82.61	82.61	23401
17	18.70	Total>	96.70	25.00m	308.84	87.76	87.76	23765
18	18.50	Total>	100.70	26.00m	315.01	91.84	91.84	24056
19	18.25	Total>	105.70	27.25m	322.73	96.91	96.91	24421
20	18.00	Total>	110.70	28.50m	330.44	101.95	101.95	24785
21	17.60	Total>	118.70	30.50m	342.79	109.96	109.96	25367

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
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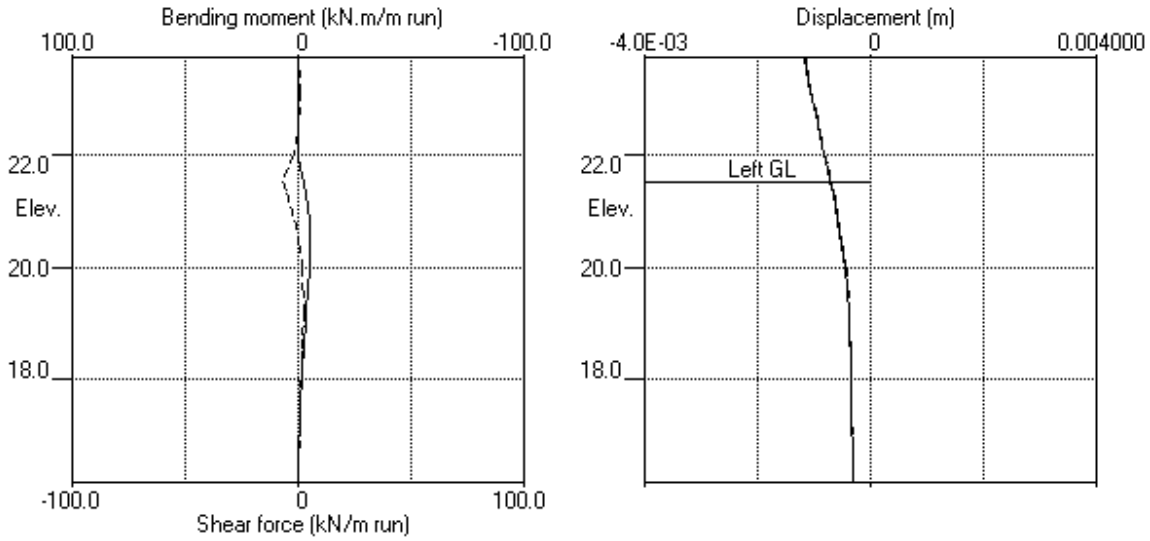
Stage No.1 Excavate to elevation 21.50 on LEFT side

<u>Node no.</u>	<u>Y coord</u>	<u>RIGHT side</u>					<u>Total earth pressure</u>	<u>Coeff. of subgrade reaction</u>
		<u>Water press.</u>	<u>Vertic -al</u>	<u>Effective stresses</u>		<u>Earth pressure</u>		
		<u>kN/m2</u>	<u>kN/m2</u>	<u>Active limit</u>	<u>Passive limit</u>	<u>kN/m2</u>	<u>kN/m3</u>	
22	17.20	Total>	126.70	32.50m	355.14	117.95	25950	
23	16.80	Total>	134.70	34.50m	367.48	125.91	26533	
24	16.50	Total>	140.70	36.00m	376.74	131.89	26969	
25	16.20	Total>	146.70	37.50m	386.00	137.87	27406	

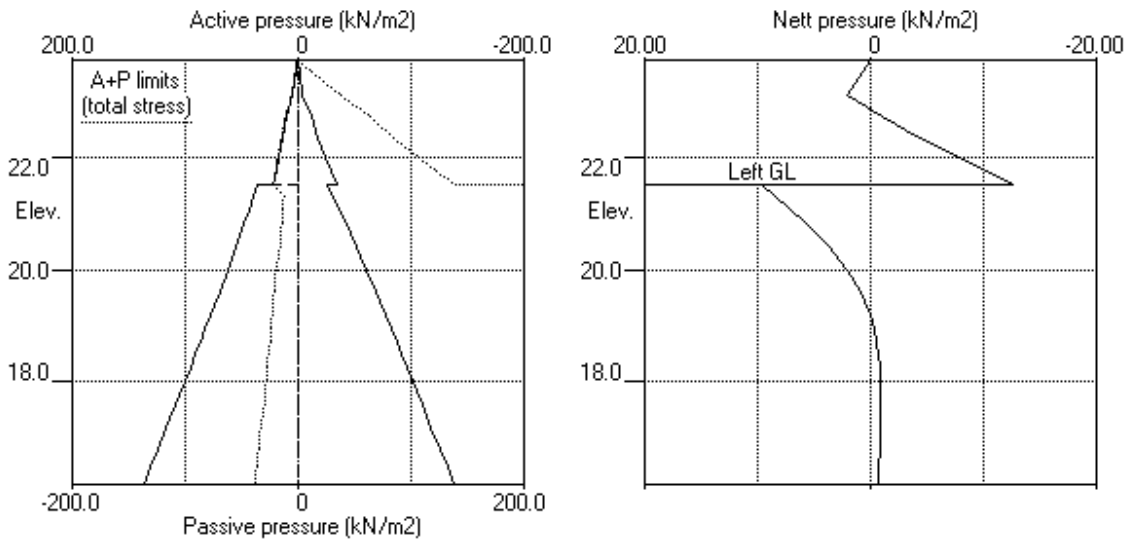
Note: 3.92a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 22.70 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment at elev.	Toe elev.	Wall Penetration	
3	21.50	22.70	Cant.	45.563	18.16	21.40	1.30	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.001	3.22E-04	0.0	0.0	
2	23.50	2.00	0.001	3.22E-04	0.2	0.0	
3	23.10	6.00	0.000	3.21E-04	1.8	0.4	
4	22.70	10.00	0.000	3.16E-04	5.0	1.5	
5	22.35	-0.00	0.000	3.03E-04	6.7	3.9	
6	22.00	-1.61	0.000	2.77E-04	6.5	6.2	
7	21.75	-2.78	0.000	2.53E-04	5.9	7.8	
8	21.50	-4.00	0.000	2.22E-04	5.1	9.1	
		-8.04	0.000	2.22E-04	5.1	9.1	
9	21.30	-14.64	-0.000	1.95E-04	2.8	10.1	
10	21.05	-10.63	-0.000	1.59E-04	-0.4	10.3	
11	20.80	-7.18	-0.000	1.23E-04	-2.6	9.9	
12	20.40	-2.85	-0.000	7.13E-05	-4.6	8.3	
13	20.00	0.08	-0.000	2.99E-05	-5.1	6.2	
14	19.60	1.82	-0.000	1.87E-07	-4.8	4.2	
15	19.20	2.65	-0.000	-1.86E-05	-3.9	2.4	
16	18.95	2.82	-0.000	-2.57E-05	-3.2	1.5	
17	18.70	2.81	-0.000	-3.00E-05	-2.5	0.8	
18	18.50	2.70	-0.000	-3.17E-05	-1.9	0.4	
19	18.25	2.38	-0.000	-3.24E-05	-1.3	-0.0	
20	18.00	1.99	-0.000	-3.19E-05	-0.8	-0.3	
21	17.60	1.31	-0.000	-3.01E-05	-0.1	-0.4	
22	17.20	0.61	-0.000	-2.80E-05	0.3	-0.3	
23	16.80	-0.11	-0.000	-2.66E-05	0.4	-0.2	
24	16.50	-0.65	-0.000	-2.61E-05	0.3	-0.1	
25	16.20	-1.20	-0.000	-2.60E-05	-0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 22.70 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00m	203.71	22.00	22.00a	33407
9	21.30	Total>	26.00	12.00m	209.89	17.83	17.83	33902
10	21.05	Total>	31.00	13.25m	217.60	24.98	24.98	34520
11	20.80	Total>	36.00	14.50m	225.32	31.83	31.83	35138
12	20.40	Total>	44.00	16.50m	237.67	42.15	42.15	36126
13	20.00	Total>	52.00	18.50m	250.01	51.71	51.71	37115
14	19.60	Total>	60.01	20.50m	262.36	60.62	60.62	38104
15	19.20	Total>	68.01	22.50m	274.72	69.02	69.02	39092
16	18.95	Total>	73.02	23.75m	282.44	74.09	74.09	39710
17	18.70	Total>	78.02	25.00m	290.16	79.05	79.05	40328
18	18.50	Total>	82.03	26.00m	296.34	82.97	82.97	40823
19	18.25	Total>	87.03	27.25m	304.06	87.82	87.82	41440
20	18.00	Total>	92.04	28.50m	311.78	92.63	92.63	42058
21	17.60	Total>	100.06	30.50m	324.15	100.29	100.29	43047
22	17.20	Total>	108.07	32.50m	336.51	107.94	107.94	44036
23	16.80	Total>	116.10	34.50m	348.88	115.58	115.58	45024
24	16.50	Total>	122.12	36.00m	358.16	121.32	121.32	45766
25	16.20	Total>	128.14	37.50m	367.44	127.05	127.05	46507

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	11451
5	22.35	0.00	6.48	2.28	22.09	13.50	13.50	11815
6	22.00	0.00	12.95	4.57	44.19	18.61	18.61	12179
7	21.75	0.00	17.58	6.20	59.97	22.28	22.28	12439
8	21.50	0.00	22.20	7.83	75.76	26.00	26.00	12700
		Total>	22.20	6.00m	203.91	30.04	30.04	29358
9	21.30	Total>	26.20	7.00m	210.09	32.47	32.47	29793
10	21.05	Total>	31.20	8.25m	217.81	35.61	35.61	30336
11	20.80	Total>	36.21	9.50m	225.52	39.01	39.01	30879
12	20.40	Total>	44.21	11.50m	237.88	45.00	45.00	31748
13	20.00	Total>	52.22	13.50m	250.23	51.63	51.63	32617
14	19.60	Total>	60.23	15.50m	262.59	58.80	58.80	33485
15	19.20	Total>	68.24	17.50m	274.94	66.38	66.38	34354
16	18.95	Total>	73.25	18.75m	282.67	71.27	71.27	34897
17	18.70	Total>	78.26	20.00m	290.40	76.25	76.25	35440
18	18.50	Total>	82.27	21.00m	296.58	80.27	80.27	35875
19	18.25	Total>	87.28	22.25m	304.31	85.44	85.44	36418
20	18.00	Total>	92.30	23.50m	312.04	90.64	90.64	36961

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 22.70 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>3</sup>
21	17.60	Total>	100.32	25.50m	324.41	98.98	98.98	37830
22	17.20	Total>	108.35	27.50m	336.78	107.33	107.33	38699
23	16.80	Total>	116.38	29.50m	349.16	115.69	115.69	39567
24	16.50	Total>	122.41	31.00m	358.45	121.96	121.96	40219
25	16.20	Total>	128.44	32.50m	367.74	128.25	128.25	40871

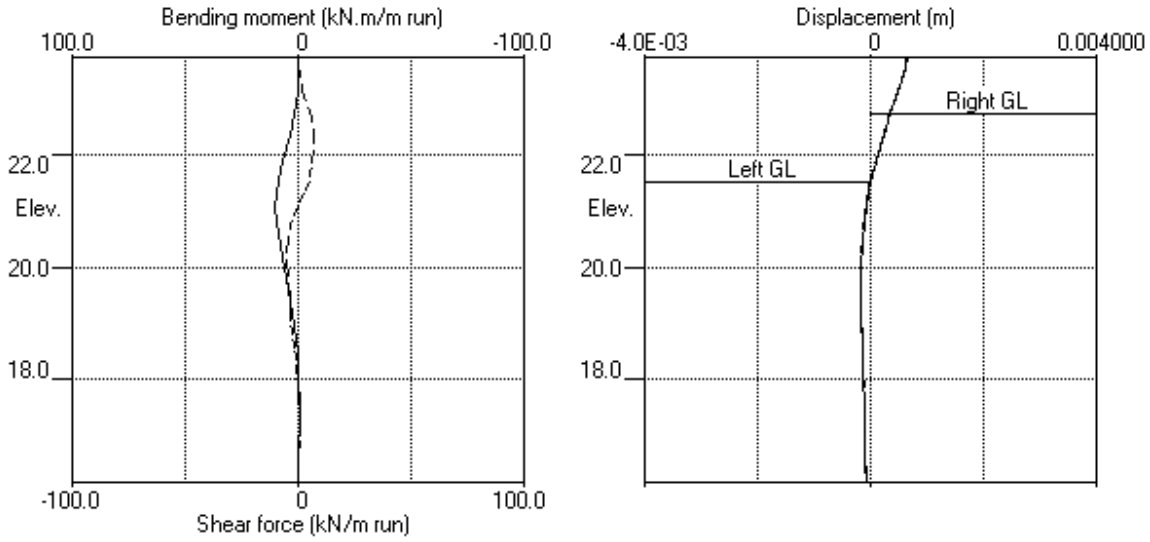
Note: 22.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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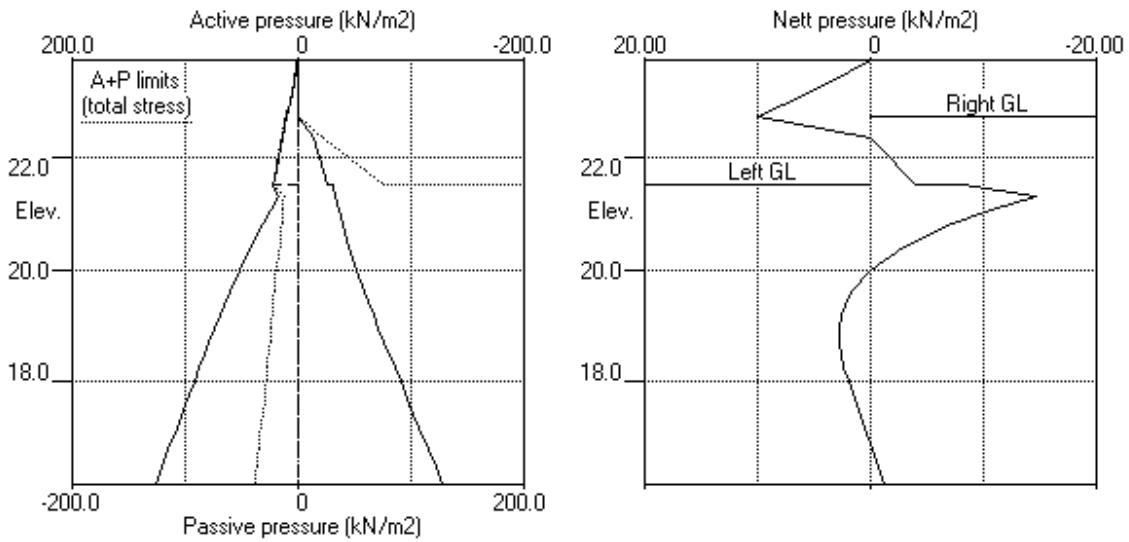
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 22.70 on RIGHT side



Stage No.3 Excav. to elev. 22.70 on RIGHT side





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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 18.70 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
5	21.50	18.70	23.50	4.859	n/a	18.47	0.23	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.001	-1.28E-03	0.0	0.0	
2	23.50	2.00	0.001	-1.28E-03	0.2	0.0	-31.9
		2.00	0.001	-1.28E-03	-31.7	0.0	
3	23.10	6.00	0.002	-1.25E-03	-30.1	-12.4	
4	22.70	10.00	0.002	-1.15E-03	-26.9	-24.1	
5	22.35	13.50	0.003	-1.00E-03	-22.8	-32.5	
6	22.00	17.00	0.003	-8.29E-04	-17.4	-39.6	
7	21.75	19.50	0.003	-6.80E-04	-12.9	-43.4	
8	21.50	22.00	0.004	-5.21E-04	-7.7	-46.0	
9	21.30	12.00	0.004	-3.88E-04	-4.3	-47.0	
10	21.05	13.25	0.004	-2.19E-04	-1.1	-47.8	
11	20.80	14.50	0.004	-4.95E-05	2.3	-47.7	
12	20.40	16.50	0.004	2.16E-04	8.5	-45.6	
13	20.00	18.50	0.004	4.63E-04	15.5	-40.9	
14	19.60	20.50	0.003	6.75E-04	23.3	-33.2	
15	19.20	22.50	0.003	8.33E-04	31.9	-22.2	
16	18.95	23.75	0.003	8.97E-04	37.7	-13.5	
17	18.70	25.00	0.003	9.27E-04	43.8	-3.3	
		-64.12	0.003	9.27E-04	43.8	-3.3	
18	18.50	-59.42	0.002	9.25E-04	31.4	4.5	
19	18.25	-48.82	0.002	8.98E-04	17.9	10.5	
20	18.00	-38.40	0.002	8.55E-04	7.0	13.5	
21	17.60	-22.40	0.002	7.79E-04	-5.1	13.2	
22	17.20	-7.28	0.001	7.15E-04	-11.1	9.3	
23	16.80	7.37	0.001	6.76E-04	-11.1	4.3	
24	16.50	18.38	0.001	6.64E-04	-7.2	1.3	
25	16.20	29.65	0.001	6.61E-04	-0.0	-0.0	

At elev. 23.50 Prop force = 31.9 kN/m run

(continued)

Stage No.5 Excavate to elevation 18.70 on RIGHT side

		LEFT side					Total	Coeff. of
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	earth pressure	subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	203.71	22.00	22.00a	17547
9	21.30	Total>	26.00	12.00m	209.89	12.00	12.00a	17806
10	21.05	Total>	31.00	13.25m	217.60	13.25	13.25a	18131
11	20.80	Total>	36.00	14.50m	225.32	14.50	14.50a	18455
12	20.40	Total>	44.00	16.50m	237.67	16.50	16.50a	18975
13	20.00	Total>	52.00	18.50m	250.01	18.50	18.50a	19494
14	19.60	Total>	60.01	20.50m	262.36	20.50	20.50a	20013
15	19.20	Total>	68.01	22.50m	274.72	22.50	22.50a	20533
16	18.95	Total>	73.02	23.75m	282.44	23.75	23.75a	20857
17	18.70	Total>	78.02	25.00m	290.16	25.00	25.00a	21182
18	18.50	Total>	82.03	26.00m	296.34	28.53	28.53	21441
19	18.25	Total>	87.03	27.25m	304.06	37.70	37.70	21766
20	18.00	Total>	92.04	28.50m	311.78	46.80	46.80	22090
21	17.60	Total>	100.06	30.50m	324.15	61.06	61.06	22610
22	17.20	Total>	108.07	32.50m	336.51	74.98	74.98	23129
23	16.80	Total>	116.10	34.50m	348.88	88.70	88.70	23648
24	16.50	Total>	122.12	36.00m	358.16	99.01	99.01	24038
25	16.20	Total>	128.14	37.50m	367.44	109.43	109.43	24427

		RIGHT side					Total	Coeff. of
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	earth pressure	subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.35	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	20.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	18.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	18.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	212.14	89.12	89.12	32250
18	18.50	Total>	4.00	1.00m	218.31	87.95	87.95	32645
19	18.25	Total>	9.00	2.25m	226.03	86.53	86.53	33139
20	18.00	Total>	14.00	3.50m	233.74	85.19	85.19	33633
21	17.60	Total>	22.01	5.50m	246.10	83.46	83.46	34424

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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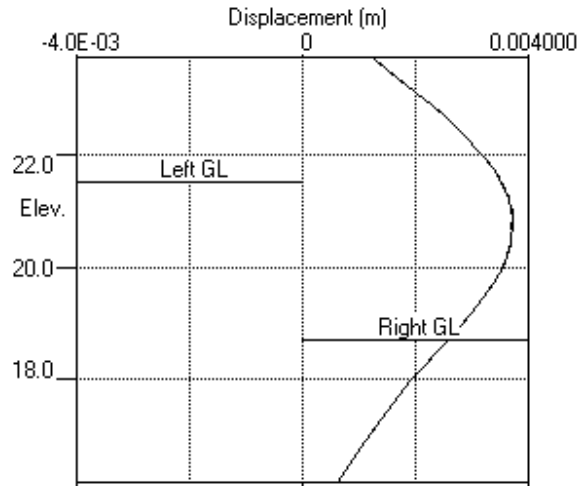
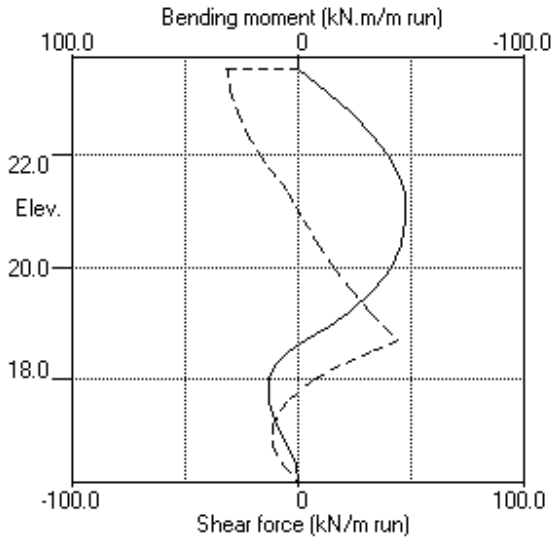
Stage No.5 Excavate to elevation 18.70 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Effective stresses				Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
			Vertic -al kN/m <sup>2</sup>	Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>	Earth pressure kN/m <sup>2</sup>		
22	17.20	Total>	30.02	7.50m	258.45	82.25	82.25	35215
23	16.80	Total>	38.03	9.50m	270.82	81.34	81.34	36005
24	16.50	Total>	44.05	11.00m	280.10	80.64	80.64	36598
25	16.20	Total>	50.08	12.50m	289.38	79.78	79.78	37191

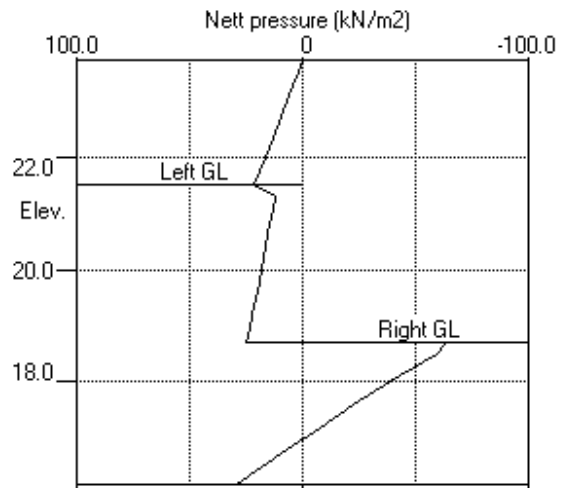
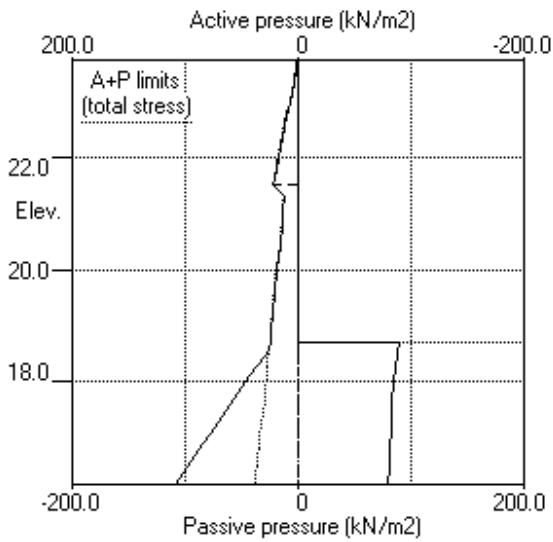
Note: 25.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Excav. to elev. 18.70 on RIGHT side



Stage No.5 Excav. to elev. 18.70 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage No.</u>	<u>Ground level</u>		<u>Prop Elev.</u>	<u>FoS for toe elev. = 16.20</u>		<u>Toe elev. for FoS = 1.000</u>		<u>Direction of failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetration</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	22.70	Cant.	45.563	18.16	21.40	1.30	L to R
4	21.50	22.70		No analysis at this stage				
5	21.50	18.70	23.50	4.859	n/a	18.47	0.23	L to R

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m				kN/m			
1	23.70	0.001	-0.001	0	0	0	0	0	0	0	0
2	23.50	0.001	-0.001	0	0	0	0	0	-32	0	-43
3	23.10	0.002	-0.001	0	-12	0	-17	2	-30	2	-41
4	22.70	0.002	-0.001	1	-24	2	-32	5	-27	7	-36
5	22.35	0.003	-0.001	4	-33	5	-44	7	-23	9	-31
6	22.00	0.003	-0.001	6	-40	8	-53	6	-17	9	-24
7	21.75	0.003	-0.001	8	-43	10	-59	6	-13	8	-17
8	21.50	0.004	-0.001	9	-46	12	-62	5	-8	7	-10
9	21.30	0.004	-0.001	10	-47	14	-64	3	-5	4	-7
10	21.05	0.004	-0.001	10	-48	14	-64	0	-3	0	-5
11	20.80	0.004	-0.001	10	-48	13	-64	2	-3	3	-3
12	20.40	0.004	-0.001	8	-46	11	-62	9	-5	12	-6
13	20.00	0.004	-0.000	6	-41	8	-55	16	-5	21	-7
14	19.60	0.003	-0.000	4	-33	6	-45	23	-5	31	-6
15	19.20	0.003	-0.000	2	-22	3	-30	32	-4	43	-5
16	18.95	0.003	-0.000	2	-14	2	-18	38	-3	51	-4
17	18.70	0.003	-0.000	1	-3	1	-5	44	-2	59	-3
18	18.50	0.002	-0.000	4	-2	6	-3	31	-2	42	-3
19	18.25	0.002	-0.000	11	-2	14	-2	18	-1	24	-2
20	18.00	0.002	-0.000	13	-1	18	-2	7	-1	9	-1
21	17.60	0.002	-0.000	13	-1	18	-1	1	-5	2	-7
22	17.20	0.001	-0.000	9	-0	13	-1	1	-11	1	-15
23	16.80	0.001	-0.000	4	-0	6	-0	0	-11	1	-15
24	16.50	0.001	-0.000	1	-0	2	-0	0	-7	0	-10
25	16.20	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						Shear force					
	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	
1	0	22.35	-5	20.40	1	-7	2	19.20	-7	21.50	3	-10
2	0	22.35	-5	20.40	1	-7	2	18.95	-7	21.50	3	-10
3	10	21.05	-0	17.60	14	-1	7	22.35	-5	20.00	9	-7
4	No calculation at this stage											
5	13	18.00	-48	21.05	18	-64	44	18.70	-32	23.50	59	-43

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				Stage description
no.	maximum m	elev.	minimum m	elev.	
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.001	23.70	-0.000	19.60	Excav. to elev. 22.70 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 23.50
5	0.004	20.80	0.000	23.70	Excav. to elev. 18.70 on RIGHT side

**Prop forces at each stage (horizontal components)**

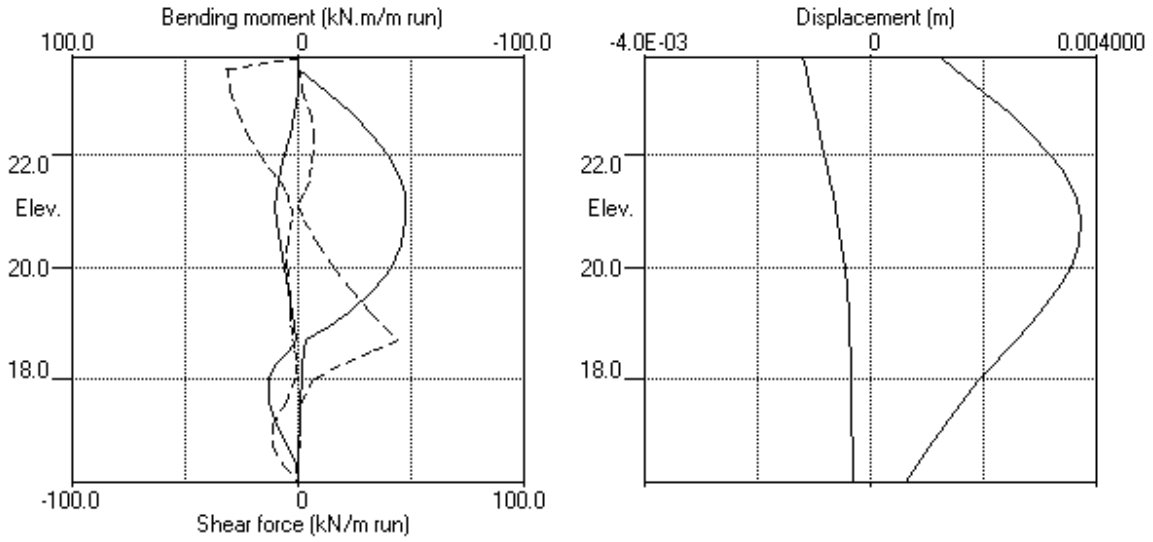
Stage	Prop no. 1		
no.	at elev. 23.50		
	--Calculated--	Factored	
	kN per	kN per	kN per
	m run	prop	prop
5	32	159	215

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date:13-05-2020  
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Units: kN,m

Bending moment, shear force, displacement envelopes





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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol. state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy )	Ko (dKo/dy)	NC/OC ( Nu )	Ka ( Kac )	Kp ( Kpc )	kN/m2 ( dc/dy )
1 Made Ground ( 23.70 )	18.50	15000 ( 1500)	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000)	
2 London Clay ( 20.00 )	20.00	47000 ( 3130)	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475)	80.00u ( 4.390)

**Additional soil parameters associated with Ka and Kp**

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1 Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2 London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile	Point no.	Left side Elev. m	Piezo elev. m	Water press. kN/m2	Right side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	18.00	18.00	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**STRUTS and ANCHORS**

Prop no.	Prop Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	23.50	5.00	0.017663	2.050E+08	20.00	0.00	0	Strut	No	R

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Worst Cred. )
3	Excavate to elevation 22.70 on RIGHT side
4	Install strut or anchor no.1 at elevation 23.50
5	Excavate to elevation 18.20 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:  
 Method of analysis - Strength Factor method  
 Overall 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) = 7.500 m

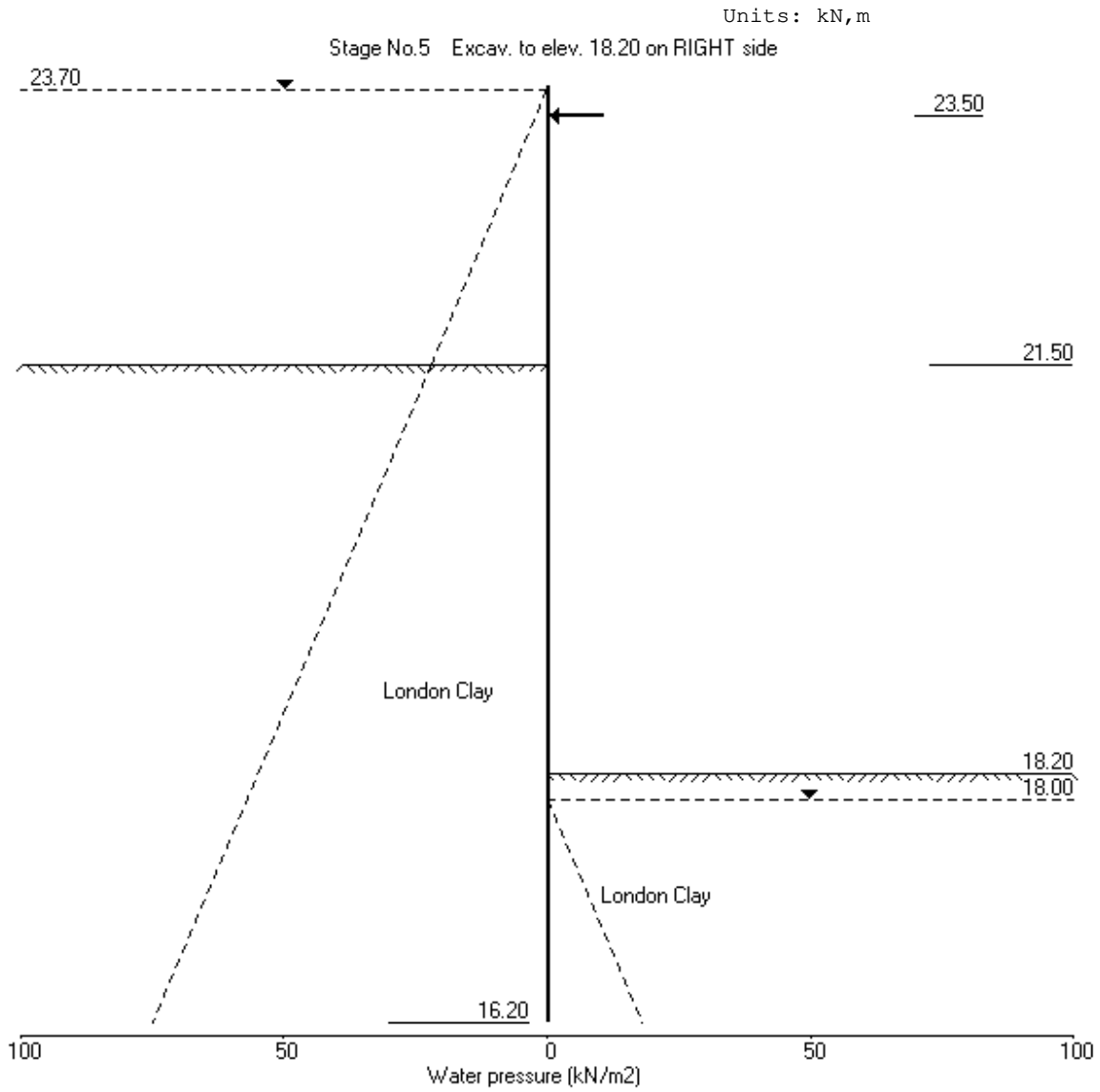
Boundary conditions:  
 Length of wall (normal to plane of analysis) = 46.58 m  
  
 Width of excavation on Left side of wall = 20.00 m  
 Width of excavation on Right side of wall = 20.00 m  
  
 Distance to rigid boundary on Left side = 20.00 m  
 Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Passive	Graph. output
		Bending mom.	pressures	
		Shear force		
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 22.70 on RIGHT side	Yes	Yes	Yes
4	Install prop no.1 at elev. 23.50	Yes	Yes	Yes
5	Excav. to elev. 18.20 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date: 13-05-2020  
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Sheet No.  
 Job No. 371654  
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 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

Overall								
FoS for toe				Toe elev. for				
elev. = 16.20				FoS = 1.000				
Stage	Ground level		Prop	Factor	Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of	at equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
				Conditions not suitable for FoS calc.				
1	21.50	23.70	Cant.					

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure	Wall disp.	Wall rotation	Shear force	Bending moment	Prop forces
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.30E-04	0.0	-0.0	
2	23.50	0.42	-0.001	-2.30E-04	0.0	0.0	
3	23.10	1.26	-0.001	-2.31E-04	0.4	0.1	
4	22.70	-0.70	-0.001	-2.31E-04	0.5	0.1	
5	22.35	-4.08	-0.001	-2.32E-04	-0.3	0.1	
6	22.00	-7.51	-0.001	-2.31E-04	-2.4	-0.3	
7	21.75	-9.98	-0.001	-2.29E-04	-4.6	-1.1	
8	21.50	-12.46	-0.001	-2.22E-04	-7.4	-2.6	
		10.41	-0.001	-2.22E-04	-7.4	-2.6	
9	21.30	9.07	-0.001	-2.13E-04	-5.4	-3.9	
10	21.05	7.46	-0.001	-1.97E-04	-3.3	-5.0	
11	20.80	5.96	-0.001	-1.78E-04	-1.7	-5.6	
12	20.40	3.85	-0.001	-1.46E-04	0.3	-5.7	
13	20.00	2.16	-0.000	-1.14E-04	1.5	-5.3	
14	19.60	0.88	-0.000	-8.66E-05	2.1	-4.6	
15	19.20	-0.00	-0.000	-6.32E-05	2.3	-3.6	
16	18.80	-0.56	-0.000	-4.50E-05	2.2	-2.7	
17	18.50	-0.81	-0.000	-3.46E-05	2.0	-2.1	
18	18.20	-0.94	-0.000	-2.68E-05	1.7	-1.6	
19	18.00	-0.98	-0.000	-2.28E-05	1.5	-1.2	
20	17.60	-0.97	-0.000	-1.72E-05	1.1	-0.7	
21	17.20	-0.89	-0.000	-1.42E-05	0.7	-0.3	
22	16.80	-0.78	-0.000	-1.29E-05	0.4	-0.1	
23	16.50	-0.68	-0.000	-1.26E-05	0.2	-0.0	
24	16.20	-0.59	-0.000	-1.26E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00m	151.79	36.67	36.67	19450
9	21.30	Total>	26.00	12.00m	157.35	40.02	40.02	19738
10	21.05	Total>	31.00	13.25m	164.29	44.23	44.23	20098
11	20.80	Total>	36.00	14.50m	171.23	48.49	48.49	20458
12	20.40	Total>	44.00	16.50m	182.34	55.45	55.45	21033
13	20.00	Total>	52.00	18.50m	193.44	62.62	62.62	21609
14	19.60	Total>	60.01	20.50m	204.55	70.00	70.00	22185
15	19.20	Total>	68.01	22.50m	215.66	77.57	77.57	22760
16	18.80	Total>	76.02	24.50m	226.78	85.29	85.29	23336
17	18.50	Total>	82.03	26.00m	235.11	91.18	91.18	23768
18	18.20	Total>	88.03	27.50m	243.45	97.12	97.12	24199
19	18.00	Total>	92.04	28.50m	249.01	101.10	101.10	24487
20	17.60	Total>	100.06	30.50m	260.13	109.11	109.11	25063
21	17.20	Total>	108.07	32.50m	271.25	117.16	117.16	25638
22	16.80	Total>	116.10	34.50m	282.38	125.23	125.23	26214
23	16.50	Total>	122.12	36.00m	290.73	131.28	131.28	26646
24	16.20	Total>	128.14	37.50m	299.08	137.34	137.34	27077

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7139
2	23.50	0.00	3.70	1.58	9.77	1.58	1.58a	7282
3	23.10	0.00	11.10	4.74	29.32	4.74	4.74a	7568
4	22.70	0.00	18.50	7.89	48.87	10.70	10.70	7853
5	22.35	0.00	24.98	10.66	65.97	17.58	17.58	8103
6	22.00	0.00	31.45	13.42	83.07	24.51	24.51	8353
7	21.75	0.00	36.08	15.39	95.29	29.48	29.48	8532
8	21.50	0.00	40.70	17.36	107.50	34.46	34.46	8710
		Total>	40.70	11.00m	170.50	26.27	26.27	20136
9	21.30	Total>	44.70	12.00m	176.06	30.95	30.95	20434
10	21.05	Total>	49.70	13.25m	183.00	36.76	36.76	20806
11	20.80	Total>	54.70	14.50m	189.94	42.53	42.53	21178
12	20.40	Total>	62.70	16.50m	201.05	51.60	51.60	21774
13	20.00	Total>	70.70	18.50m	212.15	60.47	60.47	22370
14	19.60	Total>	78.70	20.50m	223.26	69.11	69.11	22966
15	19.20	Total>	86.70	22.50m	234.36	77.57	77.57	23562
16	18.80	Total>	94.70	24.50m	245.47	85.86	85.86	24158
17	18.50	Total>	100.70	26.00m	253.80	91.98	91.98	24605
18	18.20	Total>	106.70	27.50m	262.13	98.06	98.06	25052
19	18.00	Total>	110.70	28.50m	267.68	102.08	102.08	25350
20	17.60	Total>	118.70	30.50m	278.78	110.08	110.08	25946
21	17.20	Total>	126.70	32.50m	289.89	118.05	118.05	26542
22	16.80	Total>	134.70	34.50m	300.99	126.00	126.00	27138

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
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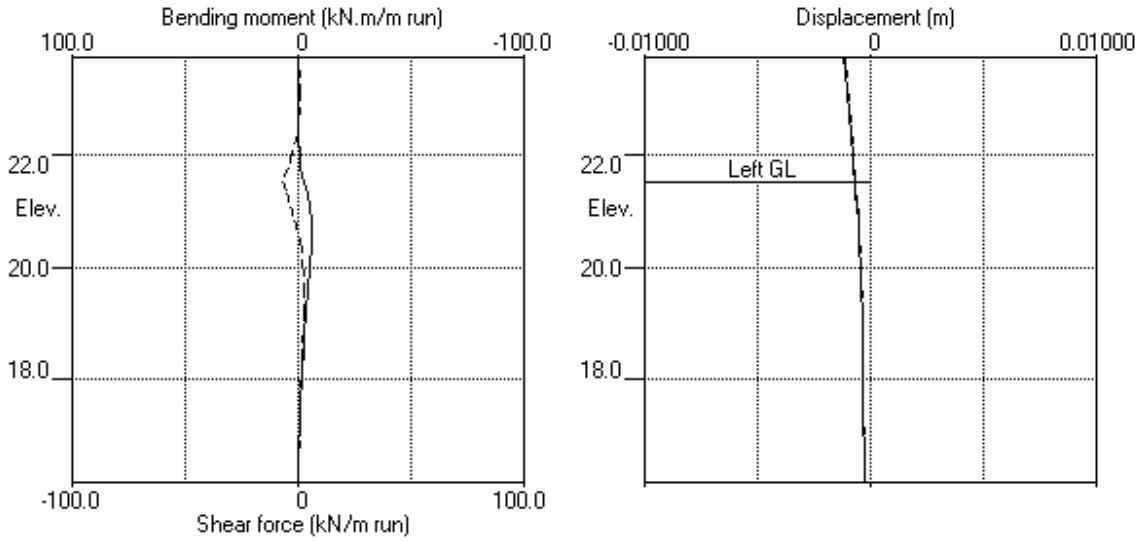
Stage No.1 Excavate to elevation 21.50 on LEFT side

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
23	16.50	Total>	140.70	36.00m	309.32	131.97	131.97	27584
24	16.20	Total>	146.70	37.50m	317.65	137.93	137.93	28031

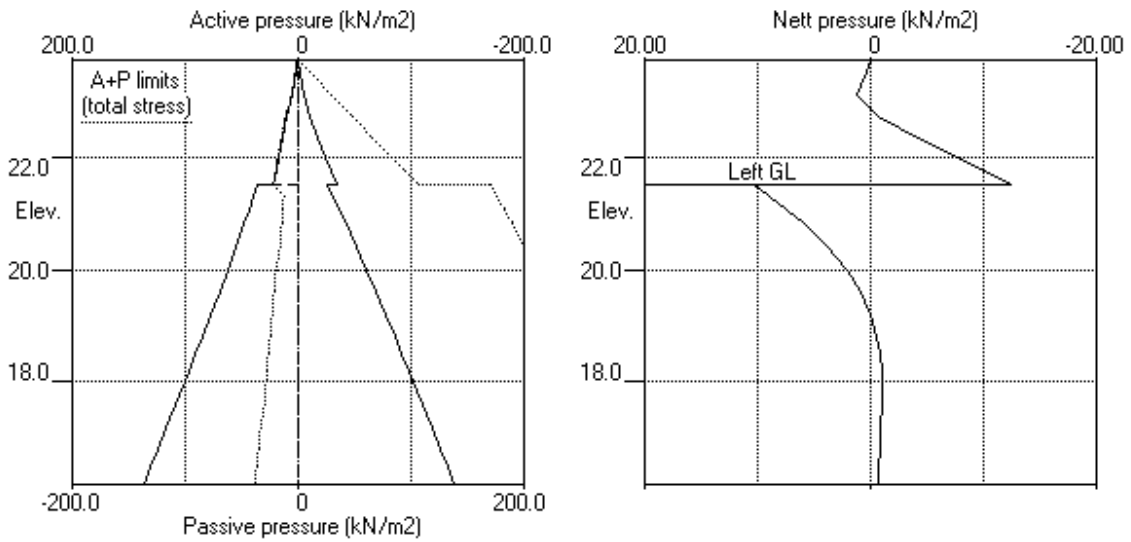
Note: 4.74a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 22.70 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 16.20						
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
3	21.50	22.70	Cant.	32.625	18.16	21.14	1.56	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.001	3.19E-04	0.0	0.0	
2	23.50	2.00	0.001	3.19E-04	0.2	0.0	
3	23.10	6.00	0.000	3.18E-04	1.8	0.4	
4	22.70	10.00	0.000	3.13E-04	5.0	1.5	
5	22.35	-0.22	0.000	3.00E-04	6.7	3.9	
6	22.00	-1.62	0.000	2.74E-04	6.4	6.2	
7	21.75	-2.79	0.000	2.50E-04	5.8	7.7	
8	21.50	-4.01	0.000	2.20E-04	5.0	9.1	
		-8.06	0.000	2.20E-04	5.0	9.1	
9	21.30	-14.50	-0.000	1.93E-04	2.7	10.0	
10	21.05	-10.50	-0.000	1.57E-04	-0.4	10.2	
11	20.80	-7.06	-0.000	1.21E-04	-2.6	9.8	
12	20.40	-2.77	-0.000	7.01E-05	-4.6	8.2	
13	20.00	0.12	-0.000	2.92E-05	-5.1	6.2	
14	19.60	1.82	-0.000	-1.17E-07	-4.7	4.1	
15	19.20	2.61	-0.000	-1.87E-05	-3.8	2.4	
16	18.80	2.76	-0.000	-2.86E-05	-2.7	1.1	
17	18.50	2.60	-0.000	-3.18E-05	-1.9	0.4	
18	18.20	2.30	-0.000	-3.24E-05	-1.2	-0.1	
19	18.00	2.05	-0.000	-3.19E-05	-0.8	-0.3	
20	17.60	1.34	-0.000	-3.00E-05	-0.1	-0.4	
21	17.20	0.62	-0.000	-2.78E-05	0.3	-0.3	
22	16.80	-0.11	-0.000	-2.64E-05	0.4	-0.2	
23	16.50	-0.67	-0.000	-2.59E-05	0.3	-0.1	
24	16.20	-1.23	-0.000	-2.58E-05	-0.0	-0.0	



(continued)

Stage No.3 Excavate to elevation 22.70 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	22.00	22.00a	33651
9	21.30	Total>	26.00	12.00m	157.35	18.00	18.00	34149
10	21.05	Total>	31.00	13.25m	164.29	25.15	25.15	34771
11	20.80	Total>	36.00	14.50m	171.23	31.99	31.99	35394
12	20.40	Total>	44.00	16.50m	182.34	42.29	42.29	36390
13	20.00	Total>	52.00	18.50m	193.44	51.82	51.82	37386
14	19.60	Total>	60.01	20.50m	204.55	60.71	60.71	38381
15	19.20	Total>	68.01	22.50m	215.66	69.10	69.10	39377
16	18.80	Total>	76.02	24.50m	226.78	77.13	77.13	40373
17	18.50	Total>	82.03	26.00m	235.11	83.01	83.01	41120
18	18.20	Total>	88.03	27.50m	243.45	88.80	88.80	41867
19	18.00	Total>	92.04	28.50m	249.01	92.64	92.64	42365
20	17.60	Total>	100.06	30.50m	260.13	100.29	100.29	43361
21	17.20	Total>	108.07	32.50m	271.25	107.92	107.92	44357
22	16.80	Total>	116.10	34.50m	282.38	115.56	115.56	45353
23	16.50	Total>	122.12	36.00m	290.73	121.29	121.29	46100
24	16.20	Total>	128.14	37.50m	299.08	127.01	127.01	46847

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses			Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	11514
5	22.35	0.00	6.48	2.76	17.10	13.72	13.72	11881
6	22.00	0.00	12.95	5.53	34.21	18.62	18.62	12247
7	21.75	0.00	17.58	7.50	46.42	22.29	22.29	12509
8	21.50	0.00	22.20	9.47	58.64	26.01	26.01	12770
		Total>	22.20	6.00m	152.00	30.06	30.06	29522
9	21.30	Total>	26.20	7.00m	157.56	32.50	32.50	29959
10	21.05	Total>	31.20	8.25m	164.50	35.65	35.65	30505
11	20.80	Total>	36.21	9.50m	171.44	39.06	39.06	31051
12	20.40	Total>	44.21	11.50m	182.55	45.06	45.06	31925
13	20.00	Total>	52.22	13.50m	193.67	51.71	51.71	32798
14	19.60	Total>	60.23	15.50m	204.78	58.89	58.89	33672
15	19.20	Total>	68.24	17.50m	215.90	66.49	66.49	34546
16	18.80	Total>	76.26	19.50m	227.02	74.37	74.37	35419
17	18.50	Total>	82.27	21.00m	235.37	80.41	80.41	36075
18	18.20	Total>	88.28	22.50m	243.71	86.51	86.51	36730
19	18.00	Total>	92.30	23.50m	249.28	90.59	90.59	37167
20	17.60	Total>	100.32	25.50m	260.41	98.94	98.94	38040
21	17.20	Total>	108.35	27.50m	271.54	107.31	107.31	38914

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 22.70 on RIGHT side

		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
22	16.80	Total>	116.38	29.50m	282.68	115.67	115.67	39788
23	16.50	Total>	122.41	31.00m	291.04	121.95	121.95	40443
24	16.20	Total>	128.44	32.50m	299.40	128.24	128.24	41098

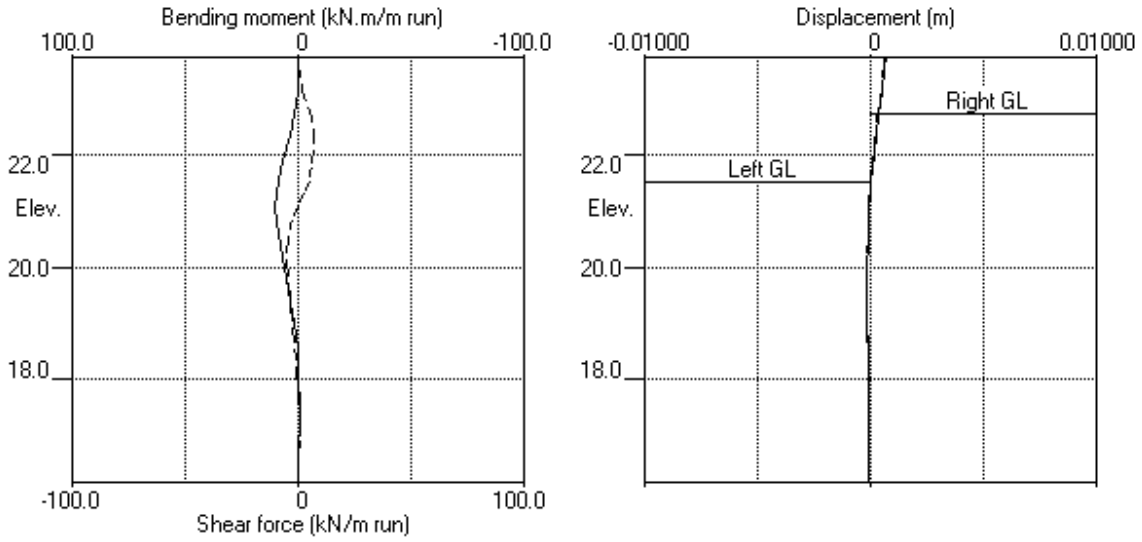
Note: 22.00a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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 Ugly Brown Building  
 River wall assessment

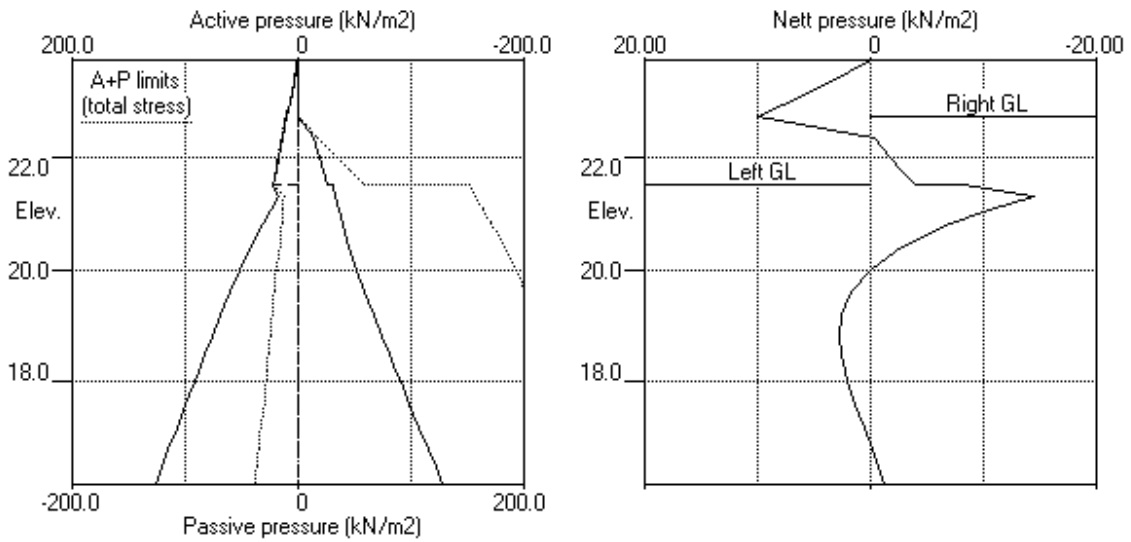
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.3 Excav. to elev. 22.70 on RIGHT side



Stage No.3 Excav. to elev. 22.70 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 5 Excavate to elevation 18.20 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 16.20						
Stage	Ground level	Prop	Factor	Moment	Toe	Wall	Direction	
No.	Act.	Pass.	of	of equilib.	elev.	Penetr	of	
		Elev.	Safety	at elev.		-ation	failure	
5	21.50	18.20	23.50	2.939	n/a	17.82	0.38	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure	Wall disp.	Wall rotation	Shear force	Bending moment	Prop forces
		kN/m2	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	0.001	-1.71E-03	0.0	0.0	
2	23.50	2.00	0.002	-1.71E-03	0.2	0.0	-36.4
		2.00	0.002	-1.71E-03	-36.2	0.0	
3	23.10	6.00	0.002	-1.67E-03	-34.6	-14.2	
4	22.70	10.00	0.003	-1.55E-03	-31.4	-27.7	
5	22.35	13.50	0.003	-1.38E-03	-27.3	-37.7	
6	22.00	17.00	0.004	-1.17E-03	-21.9	-46.3	
7	21.75	19.50	0.004	-1.00E-03	-17.4	-51.3	
8	21.50	22.00	0.004	-8.16E-04	-12.2	-55.0	
9	21.30	12.00	0.005	-6.56E-04	-8.8	-56.9	
10	21.05	13.25	0.005	-4.50E-04	-5.6	-58.8	
11	20.80	14.50	0.005	-2.39E-04	-2.2	-59.8	
12	20.40	16.50	0.005	1.01E-04	4.0	-59.6	
13	20.00	18.50	0.005	4.32E-04	11.0	-56.6	
14	19.60	20.50	0.004	7.39E-04	18.8	-50.7	
15	19.20	22.50	0.004	1.00E-03	27.4	-41.5	
16	18.80	24.50	0.004	1.20E-03	36.8	-28.7	
17	18.50	26.00	0.003	1.29E-03	44.4	-16.5	
18	18.20	27.50	0.003	1.33E-03	52.4	-2.0	
		-94.51	0.003	1.33E-03	52.4	-2.0	
19	18.00	-84.52	0.003	1.33E-03	34.5	7.0	
20	17.60	-55.19	0.002	1.27E-03	6.6	14.1	
21	17.20	-26.25	0.002	1.19E-03	-9.7	12.3	
22	16.80	2.35	0.001	1.14E-03	-14.5	6.3	
23	16.50	24.00	0.001	1.12E-03	-10.5	2.1	
24	16.20	46.17	0.000	1.12E-03	0.0	-0.0	
At elev. 23.50				Prop force =		36.4 kN/m run	

(continued)

Stage No.5 Excavate to elevation 18.20 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	2.00	0.00	0.00	0.00	0.00	2.00	0.0
3	23.10	6.00	0.00	0.00	0.00	0.00	6.00	0.0
4	22.70	10.00	0.00	0.00	0.00	0.00	10.00	0.0
5	22.35	13.50	0.00	0.00	0.00	0.00	13.50	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	22.00	22.00a	17495
9	21.30	Total>	26.00	12.00m	157.35	12.00	12.00a	17754
10	21.05	Total>	31.00	13.25m	164.29	13.25	13.25a	18077
11	20.80	Total>	36.00	14.50m	171.23	14.50	14.50a	18401
12	20.40	Total>	44.00	16.50m	182.34	16.50	16.50a	18919
13	20.00	Total>	52.00	18.50m	193.44	18.50	18.50a	19437
14	19.60	Total>	60.01	20.50m	204.55	20.50	20.50a	19954
15	19.20	Total>	68.01	22.50m	215.66	22.50	22.50a	20472
16	18.80	Total>	76.02	24.50m	226.78	24.50	24.50a	20990
17	18.50	Total>	82.03	26.00m	235.11	26.00	26.00a	21378
18	18.20	Total>	88.03	27.50m	243.45	27.50	27.50a	21766
19	18.00	Total>	92.04	28.50m	249.01	31.98	31.98	22025
20	17.60	Total>	100.06	30.50m	260.13	50.25	50.25	22543
21	17.20	Total>	108.07	32.50m	271.25	68.38	68.38	23061
22	16.80	Total>	116.10	34.50m	282.38	86.38	86.38	23579
23	16.50	Total>	122.12	36.00m	290.73	99.96	99.96	23967
24	16.20	Total>	128.14	37.50m	299.08	113.73	113.73	24355

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.10	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.35	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	20.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	18.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	18.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18	18.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	155.41	122.01	122.01	39735
19	18.00	Total>	4.00	1.00m	160.96	116.50	116.50	40208
20	17.60	Total>	12.00	3.00m	172.07	105.44	105.44	41153
21	17.20	Total>	20.01	5.00m	183.18	94.63	94.63	42098
22	16.80	Total>	28.02	7.00m	194.29	84.03	84.03	43043

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.5 Excavate to elevation 18.20 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>3</sup>
23	16.50	Total>	34.03	8.50m	202.63	75.97	75.97	43752
24	16.20	Total>	40.04	10.00m	210.98	67.56	67.56	44461

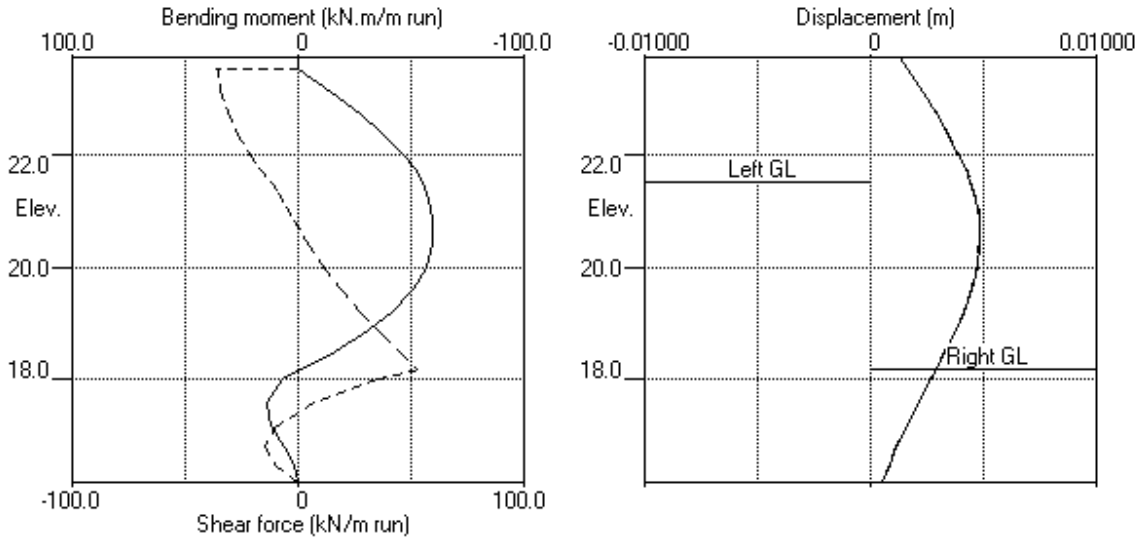
Note: 27.50a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

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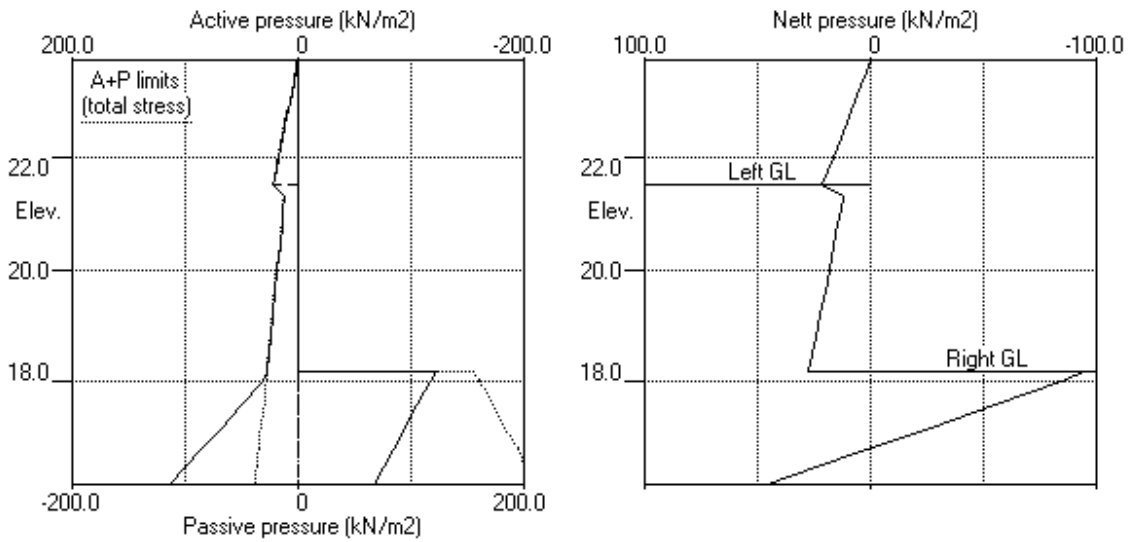
Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date: 13-05-2020  
 Checked :

Units: kN,m

Stage No.5 Excav. to elev. 18.20 on RIGHT side



Stage No.5 Excav. to elev. 18.20 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Factor</u> <u>Moment</u> <u>of</u> <u>equilib.</u>		<u>Toe</u> <u>Wall</u> <u>elev.</u> <u>Penetr</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Safety</u>	<u>at elev.</u>	<u>elev.</u>	<u>-ation</u>	
	Overall			<b>FoS for toe</b>		<b>Toe elev. for</b>		
				<b>elev. = 16.20</b>		<b>FoS = 1.000</b>		
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	22.70	Cant.	32.625	18.16	21.14	1.56	L to R
4	21.50	22.70		No analysis at this stage				
5	21.50	18.20	23.50	2.939	n/a	17.82	0.38	L to R



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.001	-0.001	0.0	-0.0	0.0	0.0
2	23.50	0.002	-0.001	0.0	0.0	0.2	-36.2
3	23.10	0.002	-0.001	0.4	-14.2	1.8	-34.6
4	22.70	0.003	-0.001	1.5	-27.7	5.0	-31.4
5	22.35	0.003	-0.001	3.9	-37.7	6.7	-27.3
6	22.00	0.004	-0.001	6.2	-46.3	6.4	-21.9
7	21.75	0.004	-0.001	7.7	-51.3	5.8	-17.4
8	21.50	0.004	-0.001	9.1	-55.0	5.0	-12.2
9	21.30	0.005	-0.001	10.0	-56.9	2.7	-8.8
10	21.05	0.005	-0.001	10.2	-58.8	0.0	-5.6
11	20.80	0.005	-0.001	9.8	-59.8	0.0	-2.6
12	20.40	0.005	-0.001	8.2	-59.6	4.0	-4.6
13	20.00	0.005	-0.000	6.2	-56.6	11.0	-5.1
14	19.60	0.004	-0.000	4.1	-50.7	18.8	-4.7
15	19.20	0.004	-0.000	2.4	-41.5	27.4	-3.8
16	18.80	0.004	-0.000	1.1	-28.7	36.8	-2.7
17	18.50	0.003	-0.000	0.4	-16.5	44.4	-1.9
18	18.20	0.003	-0.000	0.0	-2.0	52.4	-1.2
19	18.00	0.003	-0.000	7.0	-1.4	34.5	-0.8
20	17.60	0.002	-0.000	14.1	-0.8	6.6	-0.1
21	17.20	0.002	-0.000	12.3	-0.4	0.8	-9.7
22	16.80	0.001	-0.000	6.3	-0.2	0.5	-14.5
23	16.50	0.001	-0.000	2.1	-0.1	0.3	-10.5
24	16.20	0.000	-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				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	0.1	22.35	-5.7	20.40	2.3	19.20	-7.4	21.50
2	0.1	22.35	-5.7	20.40	2.2	19.20	-7.3	21.50
3	10.2	21.05	-0.4	17.60	6.7	22.35	-5.1	20.00
4	No calculation at this stage							
5	14.1	17.60	-59.8	20.80	52.4	18.20	-36.2	23.50

Run ID. Design\_Case\_05\_Sheet\_Pile\_prop\_ULS2  
Ugly Brown Building  
River wall assessment

Sheet No.  
Date:13-05-2020  
Checked :

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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

Stage	Displacement				
no.	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>Stage description</u>
	m		m		
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.001	23.70	-0.000	19.60	Excav. to elev. 22.70 on RIGHT side
4	No calculation at this stage				Install prop no.1 at elev. 23.50
5	0.005	20.40	0.000	23.70	Excav. to elev. 18.20 on RIGHT side

**Prop forces at each stage (horizontal components)**

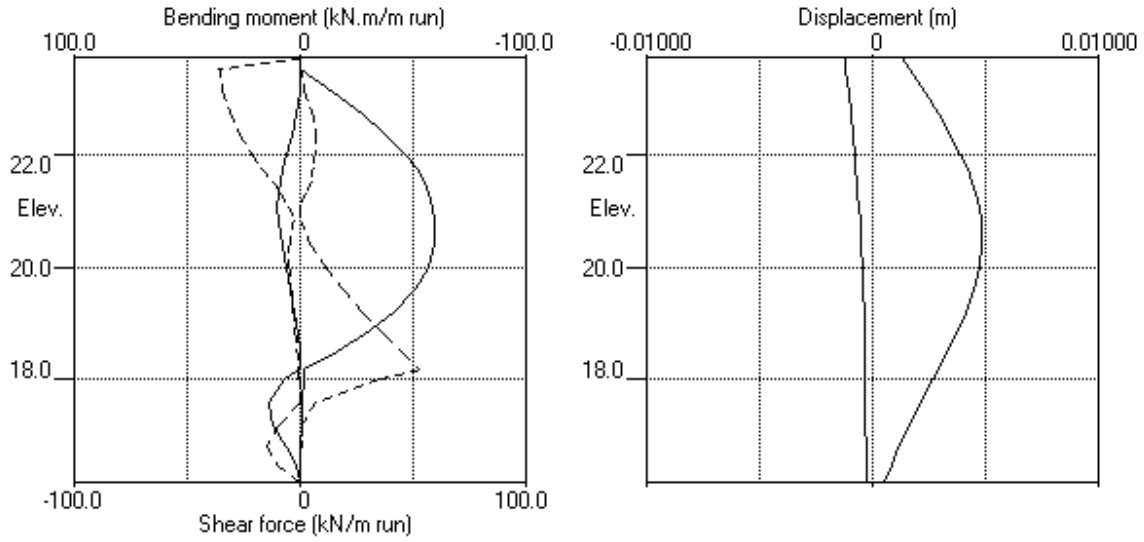
Stage	--- Strut no. 1 ---	
no.	at elev. 23.50	
	kN/m run	kN/prop
5	36.39	181.94

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Ugly Brown Building  
River wall assessment

Sheet No.  
Job No. 371654  
Made by : MM  
Date:13-05-2020  
Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
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Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**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. ( Nu ) ( NC/OC )	Active limit ( Ka ) ( Kac )	Passive limit ( Kpc ) ( Kp )	Cohesion kN/m2 ( dc/dy )
1	Made Ground ( 23.70 )	18.50	15000 ( 1500 )	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000 )	
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475 )	80.00u ( 4.390 )

**Additional soil parameters associated with Ka and Kp**

No.	Soil type Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill	Soil friction angle	Wall adhesion coeff.	Back-fill
1	Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation  
 Left side: 23.70  
 Right side: 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	18.50	18.50	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Mod. Conserv. )
3	Excavate to elevation 18.70 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: Serviceability Limit State  
All loads and soil strengths are unfactored

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) = 7.500 m

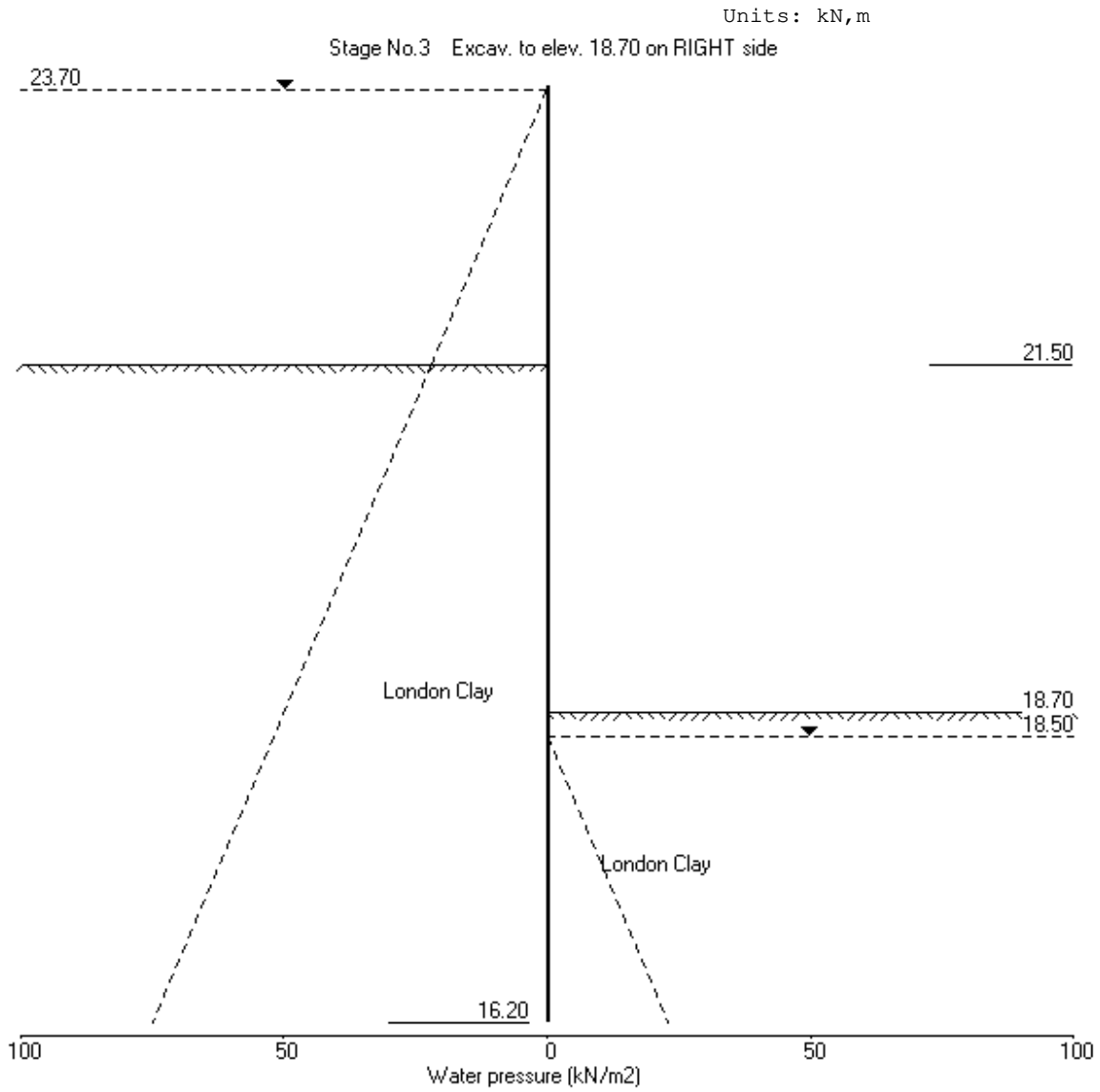
Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m

Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m

Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Passive pressures	Graph. output
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 18.70 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

				FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		
<u>Stage</u>	<u>Ground level</u>	<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>of</u>	<u>of equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>	
			<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.18E-04	0.0	0.0	
2	23.45	0.87	-0.001	-2.18E-04	0.1	0.0	
3	23.20	1.74	-0.001	-2.18E-04	0.4	0.1	
4	22.80	0.06	-0.001	-2.18E-04	0.8	0.1	
5	22.40	-3.75	-0.001	-2.20E-04	0.1	0.4	
6	22.00	-7.62	-0.001	-2.21E-04	-2.2	-0.0	
7	21.75	-10.06	-0.001	-2.19E-04	-4.4	-0.8	
8	21.50	-12.52	-0.001	-2.14E-04	-7.2	-2.3	
		9.94	-0.001	-2.14E-04	-7.2	-2.3	
9	21.30	8.70	-0.001	-2.06E-04	-5.4	-3.5	
10	21.05	7.19	-0.001	-1.91E-04	-3.4	-4.6	
11	20.80	5.78	-0.001	-1.74E-04	-1.8	-5.2	
12	20.40	3.78	-0.001	-1.43E-04	0.1	-5.5	
13	20.00	2.17	-0.000	-1.13E-04	1.3	-5.1	
14	19.60	0.95	-0.000	-8.67E-05	1.9	-4.4	
15	19.20	0.08	-0.000	-6.41E-05	2.2	-3.5	
16	18.95	-0.30	-0.000	-5.24E-05	2.1	-3.0	
17	18.70	-0.57	-0.000	-4.26E-05	2.0	-2.5	
18	18.50	-0.72	-0.000	-3.61E-05	1.9	-2.1	
19	18.25	-0.85	-0.000	-2.95E-05	1.7	-1.6	
20	18.00	-0.91	-0.000	-2.44E-05	1.5	-1.2	
21	17.60	-0.92	-0.000	-1.88E-05	1.1	-0.7	
22	17.20	-0.87	-0.000	-1.57E-05	0.7	-0.4	
23	16.80	-0.77	-0.000	-1.44E-05	0.4	-0.1	
24	16.50	-0.70	-0.000	-1.41E-05	0.2	-0.0	
25	16.20	-0.63	-0.000	-1.40E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

		LEFT side					Total	Coeff. of
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	earth pressure	subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00m	203.71	36.34	36.34	18853
9	21.30	Total>	26.00	12.00m	209.89	39.74	39.74	19132
10	21.05	Total>	31.00	13.25m	217.60	44.00	44.00	19480
11	20.80	Total>	36.00	14.50m	225.32	48.31	48.31	19829
12	20.40	Total>	44.00	16.50m	237.67	55.34	55.34	20387
13	20.00	Total>	52.00	18.50m	250.01	62.55	62.55	20945
14	19.60	Total>	60.01	20.50m	262.36	69.96	69.96	21503
15	19.20	Total>	68.01	22.50m	274.72	77.54	77.54	22061
16	18.95	Total>	73.02	23.75m	282.44	82.36	82.36	22410
17	18.70	Total>	78.02	25.00m	290.16	87.23	87.23	22758
18	18.50	Total>	82.03	26.00m	296.34	91.15	91.15	23037
19	18.25	Total>	87.03	27.25m	304.06	96.10	96.10	23386
20	18.00	Total>	92.04	28.50m	311.78	101.07	101.07	23735
21	17.60	Total>	100.06	30.50m	324.15	109.07	109.07	24293
22	17.20	Total>	108.07	32.50m	336.51	117.11	117.11	24850
23	16.80	Total>	116.10	34.50m	348.88	125.16	125.16	25408
24	16.50	Total>	122.12	36.00m	358.16	131.21	131.21	25827
25	16.20	Total>	128.14	37.50m	367.44	137.25	137.25	26245

		RIGHT side					Total	Coeff. of
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	earth pressure	subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7023
2	23.45	0.00	4.63	1.63	15.78	1.63	1.63a	7199
3	23.20	0.00	9.25	3.26	31.56	3.26	3.26a	7375
4	22.80	0.00	16.65	5.87	56.81	8.94	8.94	7656
5	22.40	0.00	24.05	8.48	82.06	16.75	16.75	7936
6	22.00	0.00	31.45	11.09	107.31	24.62	24.62	8217
7	21.75	0.00	36.08	12.73	123.09	29.56	29.56	8393
8	21.50	0.00	40.70	14.36	138.88	34.52	34.52	8569
		Total>	40.70	11.00m	222.41	26.40	26.40	19808
9	21.30	Total>	44.70	12.00m	228.59	31.04	31.04	20101
10	21.05	Total>	49.70	13.25m	236.30	36.81	36.81	20468
11	20.80	Total>	54.70	14.50m	244.02	42.53	42.53	20834
12	20.40	Total>	62.70	16.50m	256.36	51.56	51.56	21420
13	20.00	Total>	70.70	18.50m	268.71	60.38	60.38	22007
14	19.60	Total>	78.70	20.50m	281.06	69.01	69.01	22593
15	19.20	Total>	86.70	22.50m	293.40	77.46	77.46	23179
16	18.95	Total>	91.70	23.75m	301.12	82.65	82.65	23546
17	18.70	Total>	96.70	25.00m	308.84	87.80	87.80	23912
18	18.50	Total>	100.70	26.00m	315.01	91.88	91.88	24205
19	18.25	Total>	105.70	27.25m	322.73	96.95	96.95	24571
20	18.00	Total>	110.70	28.50m	330.44	101.98	101.98	24938
21	17.60	Total>	118.70	30.50m	342.79	110.00	110.00	25524



Run ID. Design\_Case\_05\_Sheet\_Pile\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
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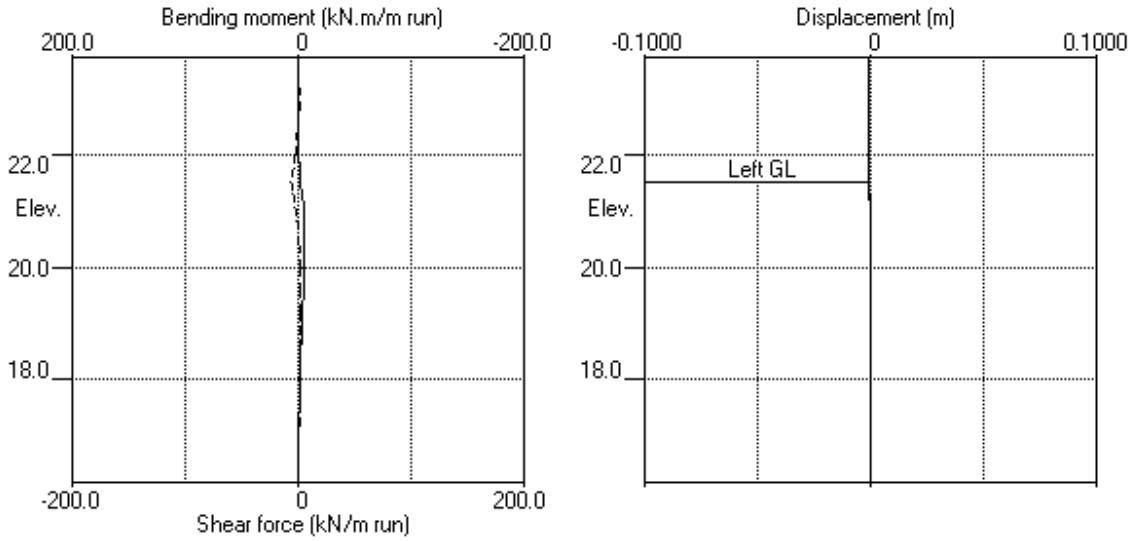
Stage No.1 Excavate to elevation 21.50 on LEFT side

<u>Node</u> <u>no.</u>	<u>Y</u> <u>coord</u>	<u>RIGHT side</u> <u>Effective stresses</u>					<u>Total</u> <u>earth</u> <u>pressure</u>	<u>Coeff. of</u> <u>subgrade</u> <u>reaction</u>
		<u>Water</u> <u>press.</u>	<u>Vertic</u> <u>-al</u>	<u>Active</u> <u>limit</u>	<u>Passive</u> <u>limit</u>	<u>Earth</u> <u>pressure</u>		
		kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>3</sup>
22	17.20	Total>	126.70	32.50m	355.14	117.97	117.97	26110
23	16.80	Total>	134.70	34.50m	367.48	125.94	125.94	26696
24	16.50	Total>	140.70	36.00m	376.74	131.91	131.91	27136
25	16.20	Total>	146.70	37.50m	386.00	137.88	137.88	27576

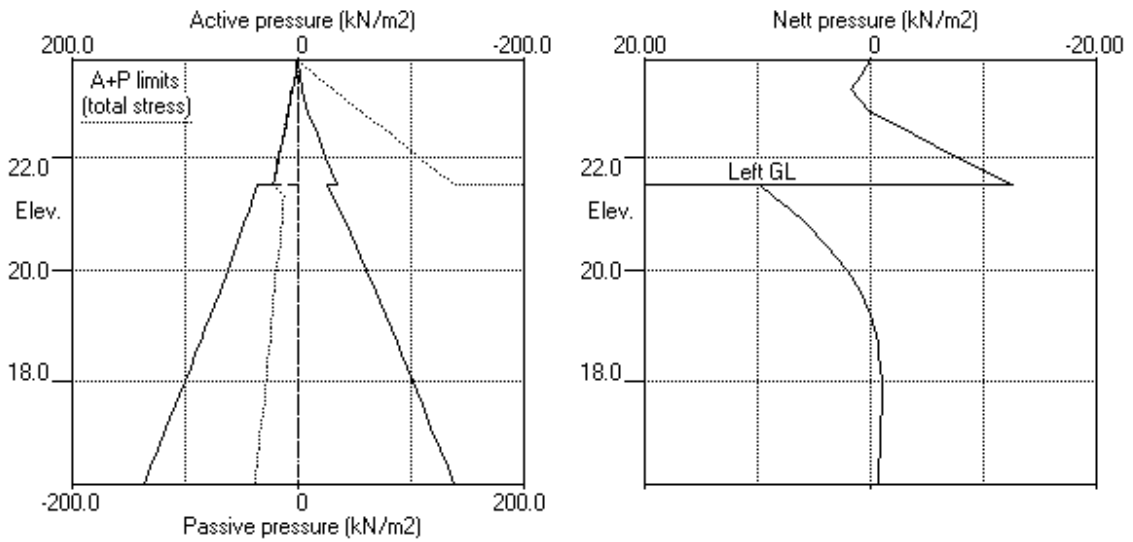
Note: 3.26a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 18.70 on RIGHT side

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

Stage No.	Ground level		Prop Elev.	FoS for toe elev. = 16.20		Toe elev. for FoS = 1.000		Direction of failure
	Act.	Pass.		Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetration	
3	21.50	18.70	Cant.	1.070	16.99	16.29	2.41	L to R

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m <sup>2</sup>	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Prop forces kN/m
1	23.70	0.00	0.043	8.12E-03	0.0	-0.0	
2	23.45	2.50	0.041	8.12E-03	0.3	0.0	
3	23.20	5.00	0.039	8.12E-03	1.3	0.2	
4	22.80	9.00	0.036	8.12E-03	4.0	1.0	
5	22.40	13.00	0.033	8.11E-03	8.5	3.5	
6	22.00	17.00	0.029	8.07E-03	14.5	8.0	
7	21.75	19.50	0.027	8.04E-03	19.0	12.2	
8	21.50	22.00	0.025	7.98E-03	24.2	17.6	
9	21.30	12.00	0.024	7.93E-03	27.6	22.8	
10	21.05	13.25	0.022	7.83E-03	30.8	30.1	
11	20.80	14.50	0.020	7.71E-03	34.2	38.2	
12	20.40	16.50	0.017	7.45E-03	40.4	53.2	
13	20.00	18.50	0.014	7.10E-03	47.4	70.8	
14	19.60	20.50	0.011	6.63E-03	55.2	91.3	
15	19.20	22.50	0.009	6.04E-03	63.8	115.1	
16	18.95	23.75	0.007	5.60E-03	69.6	131.8	
17	18.70	25.00	0.006	5.10E-03	75.7	150.0	
		-187.14	0.006	5.10E-03	75.7	150.0	
18	18.50	-192.31	0.005	4.66E-03	37.8	161.3	
19	18.25	-197.44	0.004	4.07E-03	-11.0	167.0	
20	18.00	-151.79	0.003	3.49E-03	-54.6	158.1	
21	17.60	-75.62	0.002	2.68E-03	-100.1	126.0	
22	17.20	8.41	0.001	2.09E-03	-113.5	79.9	
23	16.80	79.14	-0.000	1.77E-03	-96.0	35.2	
24	16.50	165.02	-0.001	1.67E-03	-59.4	10.3	
25	16.20	231.02	-0.001	1.65E-03	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 18.70 on RIGHT side

LEFT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	203.71	22.00	22.00a	25792
9	21.30	Total>	26.00	12.00m	209.89	12.00	12.00a	26174
10	21.05	Total>	31.00	13.25m	217.60	13.25	13.25a	26651
11	20.80	Total>	36.00	14.50m	225.32	14.50	14.50a	27128
12	20.40	Total>	44.00	16.50m	237.67	16.50	16.50a	27891
13	20.00	Total>	52.00	18.50m	250.01	18.50	18.50a	28655
14	19.60	Total>	60.01	20.50m	262.36	20.50	20.50a	29418
15	19.20	Total>	68.01	22.50m	274.72	22.50	22.50a	30181
16	18.95	Total>	73.02	23.75m	282.44	23.75	23.75a	30658
17	18.70	Total>	78.02	25.00m	290.16	25.00	25.00a	31135
18	18.50	Total>	82.03	26.00m	296.34	26.00	26.00a	31517
19	18.25	Total>	87.03	27.25m	304.06	27.25	27.25a	31994
20	18.00	Total>	92.04	28.50m	311.78	28.50	28.50a	32471
21	17.60	Total>	100.06	30.50m	324.15	46.54	46.54	33234
22	17.20	Total>	108.07	32.50m	336.51	85.63	85.63	33998
23	16.80	Total>	116.10	34.50m	348.88	119.81	119.81	34761
24	16.50	Total>	122.12	36.00m	358.16	176.02	176.02	118960
25	16.20	Total>	128.14	37.50m	367.44	243.52	243.52	120888

RIGHT side								
Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	23.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	22.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	22.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	22.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	21.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	21.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	21.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	21.05	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	20.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	20.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	18.95	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	18.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	212.14	212.14	212.14p	53046
18	18.50	Total>	4.00	1.00m	218.31	218.31	218.31p	53696
19	18.25	Total>	9.00	2.25m	226.03	224.69	224.69	54509
20	18.00	Total>	14.00	3.50m	233.74	180.29	180.29	55321
21	17.60	Total>	22.01	5.50m	246.10	122.16	122.16	56622

Run ID. Design\_Case\_05\_Sheet\_Pile\_SLS  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

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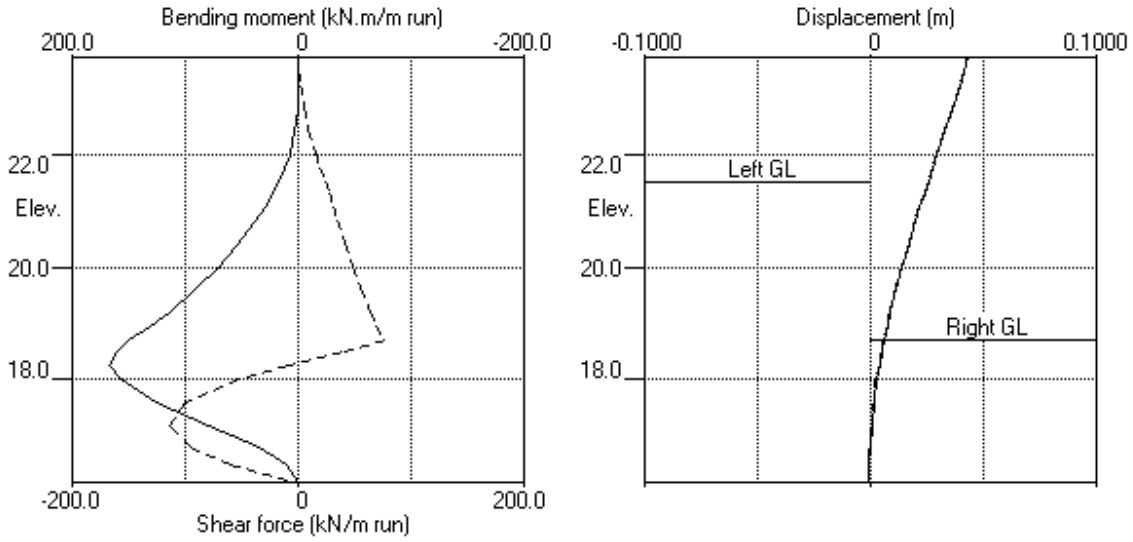
Stage No.3 Excavate to elevation 18.70 on RIGHT side

Node no.	Y coord	Water press.	Effective stresses				Total earth pressure	Coeff. of subgrade reaction
			Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>2</sup>	kN/m <sup>3</sup>	
22	17.20	Total>	30.02	7.50m	258.45	77.22	57922	
23	16.80	Total>	38.03	9.50m	270.82	40.67	59223	
24	16.50	Total>	44.05	11.00m	280.10	11.00	118960	
25	16.20	Total>	50.08	12.50m	289.38	12.50	120888	

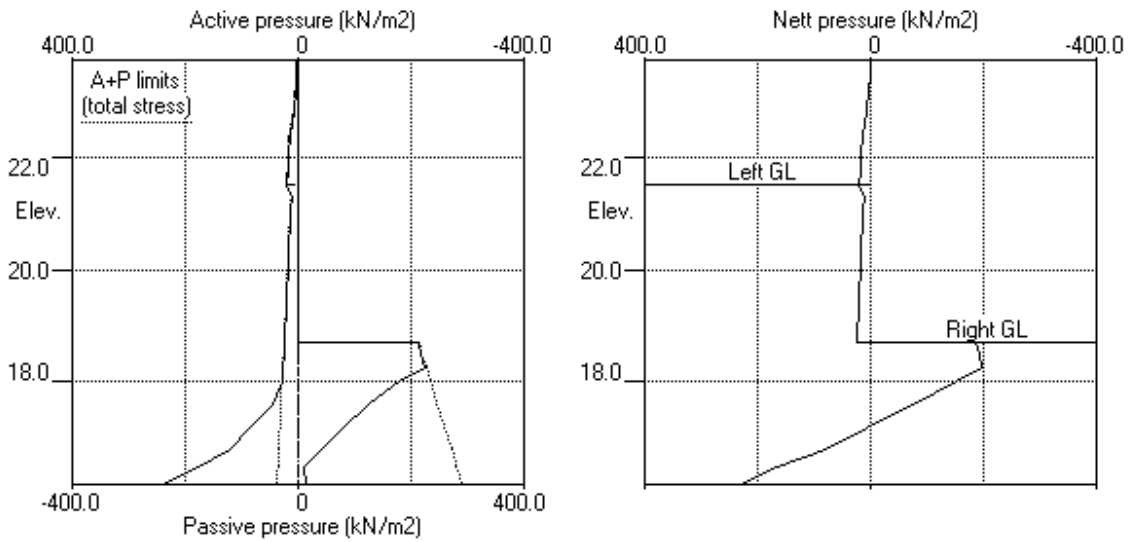
Note: 12.50a Soil pressure at active limit  
 218.31p Soil pressure at passive limit

Units: kN,m

Stage No.3 Excav. to elev. 18.70 on RIGHT side



Stage No.3 Excav. to elev. 18.70 on RIGHT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

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 Units: kN,m

**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: Serviceability Limit State  
 All loads and soil strengths are unfactored

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>FoS for toe</u> <u>elev. = 16.20</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety</u>	<u>Moment</u> <u>at</u> <u>equilib.</u> <u>at elev.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	18.70	Cant.	1.070	16.99	16.29	2.41	L to R

Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: Serviceability Limit State**

Calculated Bending Moments and Prop Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m				kN/m			
1	23.70	0.043	-0.001	0	-0	0	-0	0	0	0	0
2	23.45	0.041	-0.001	0	0	0	0	0	0	0	0
3	23.20	0.039	-0.001	0	0	0	0	1	0	2	0
4	22.80	0.036	-0.001	1	0	1	0	4	0	5	0
5	22.40	0.033	-0.001	3	0	5	0	8	0	11	0
6	22.00	0.029	-0.001	8	-0	11	-0	14	-2	20	-3
7	21.75	0.027	-0.001	12	-1	16	-1	19	-4	26	-6
8	21.50	0.025	-0.001	18	-2	24	-3	24	-7	33	-10
9	21.30	0.024	-0.001	23	-4	31	-5	28	-5	37	-7
10	21.05	0.022	-0.001	30	-5	41	-6	31	-3	42	-5
11	20.80	0.020	-0.001	38	-5	52	-7	34	-2	46	-2
12	20.40	0.017	-0.001	53	-5	72	-7	40	0	55	0
13	20.00	0.014	-0.000	71	-5	96	-7	47	0	64	0
14	19.60	0.011	-0.000	91	-4	123	-6	55	0	75	0
15	19.20	0.009	-0.000	115	-4	155	-5	64	0	86	0
16	18.95	0.007	-0.000	132	-3	178	-4	70	0	94	0
17	18.70	0.006	-0.000	150	-3	202	-4	76	0	102	0
18	18.50	0.005	-0.000	161	-2	218	-3	38	0	51	0
19	18.25	0.004	-0.000	167	-2	225	-2	2	-11	2	-15
20	18.00	0.003	-0.000	158	-1	213	-2	2	-55	2	-74
21	17.60	0.002	-0.000	126	-1	170	-1	1	-100	2	-135
22	17.20	0.001	-0.000	80	-0	108	-1	1	-114	1	-153
23	16.80	0.000	-0.000	35	-0	47	-0	0	-96	1	-130
24	16.50	0.000	-0.001	10	-0	14	-0	0	-59	0	-80
25	16.20	0.000	-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						Shear force					
	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m	kN/m		kN/m		kN/m	kN/m	
1	0	22.40	-5	20.40	0	-7	2	19.20	-7	21.50	3	-10
2	0	22.40	-5	20.40	1	-7	2	19.20	-7	21.50	3	-10
3	167	18.25	-0	23.70	225	-0	76	18.70	-114	17.20	102	-153



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Ugly Brown Building  
River wall assessment

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**Summary of results (continued)**

**Maximum and minimum displacement at each stage**

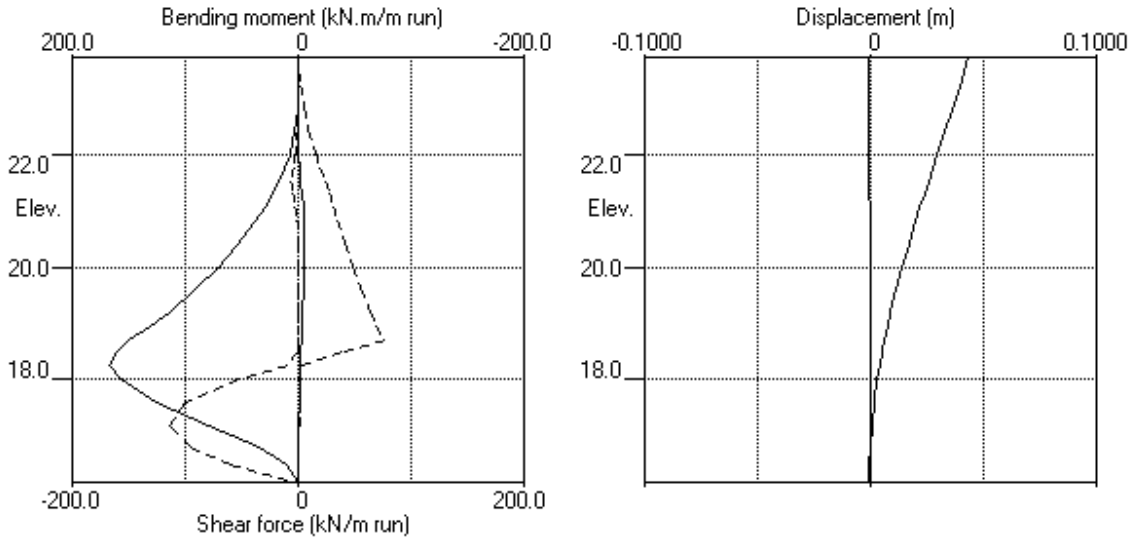
Stage	Displacement				
no.	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>Stage description</u>
	m		m		
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.043	23.70	-0.001	16.20	Excav. to elev. 18.70 on RIGHT side

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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
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 Checked :

Units: kN,m

**INPUT DATA**

**SOIL PROFILE**

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	23.70	1 Made Ground		1 Made Ground
2	21.50	2 London Clay		2 London Clay

**SOIL PROPERTIES (Unfactored SLS soil strengths)**

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. ( Nu )	Active limit ( Kac )	Passive limit ( Kpc )	Cohesion kN/m2 ( dc/dy )
1	Made Ground ( 23.70 )	18.50	15000 ( 1500 )	1.000	OC (0.490)	0.353 (0.000)	3.412 ( 0.000 )	
2	London Clay ( 20.00 )	20.00	47000 ( 3130 )	1.000	OC (0.490)	1.000 (2.474)	1.000 ( 2.475 )	80.00u ( 4.390 )

**Additional soil parameters associated with Ka and Kp**

No.	Soil type Description	parameters for Ka			parameters for Kp		
		Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	25.00	0.641	0.00	25.00	0.641	0.00
2	London Clay	0.00	0.666	0.00	0.00	0.666	0.00

**GROUND WATER CONDITIONS**

Density of water = 10.00 kN/m3  
 Initial water table elevation Left side 23.70 Right side 21.30

Automatic water pressure balancing at toe of wall : No

Water profile no.	Point no.	Left side			Right side			
		Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	23.70	23.70	0.0	1	18.00	18.00	0.0 MC+WC

**WALL PROPERTIES**

Type of structure = Fully Embedded Wall  
 Elevation of toe of wall = 16.20  
 Maximum finite element length = 0.40 m  
 Youngs modulus of wall E = 2.0500E+08 kN/m2  
 Moment of inertia of wall I = 3.4200E-04 m4/m run  
 (Arcelor AZ18) E.I = 70110 kN.m2/m run  
 Yield Moment of wall = Not defined

**CONSTRUCTION STAGES**

Construction stage no.	Stage description
1	Excavate to elevation 21.50 on LEFT side
2	Apply water pressure profile no.1 ( Worst Cred. )
3	Excavate to elevation 18.20 on RIGHT side

**FACTORS OF SAFETY and ANALYSIS OPTIONS**

Limit State options: ULS DA1 Combination 2  
Water pressures : Worst Credible  
Partial factor on C' = 1.250  
Partial factor on Phi' = 1.250  
Partial factor on Cu = 1.400  
Partial factor on Soil Modulus = 1.000  
Partial factor on Permanent Unfavourable loads = 1.000  
Partial factor on Permanent Favourable loads = 1.000  
Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:  
Method of analysis - Strength Factor method  
Overall 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) = 7.500 m

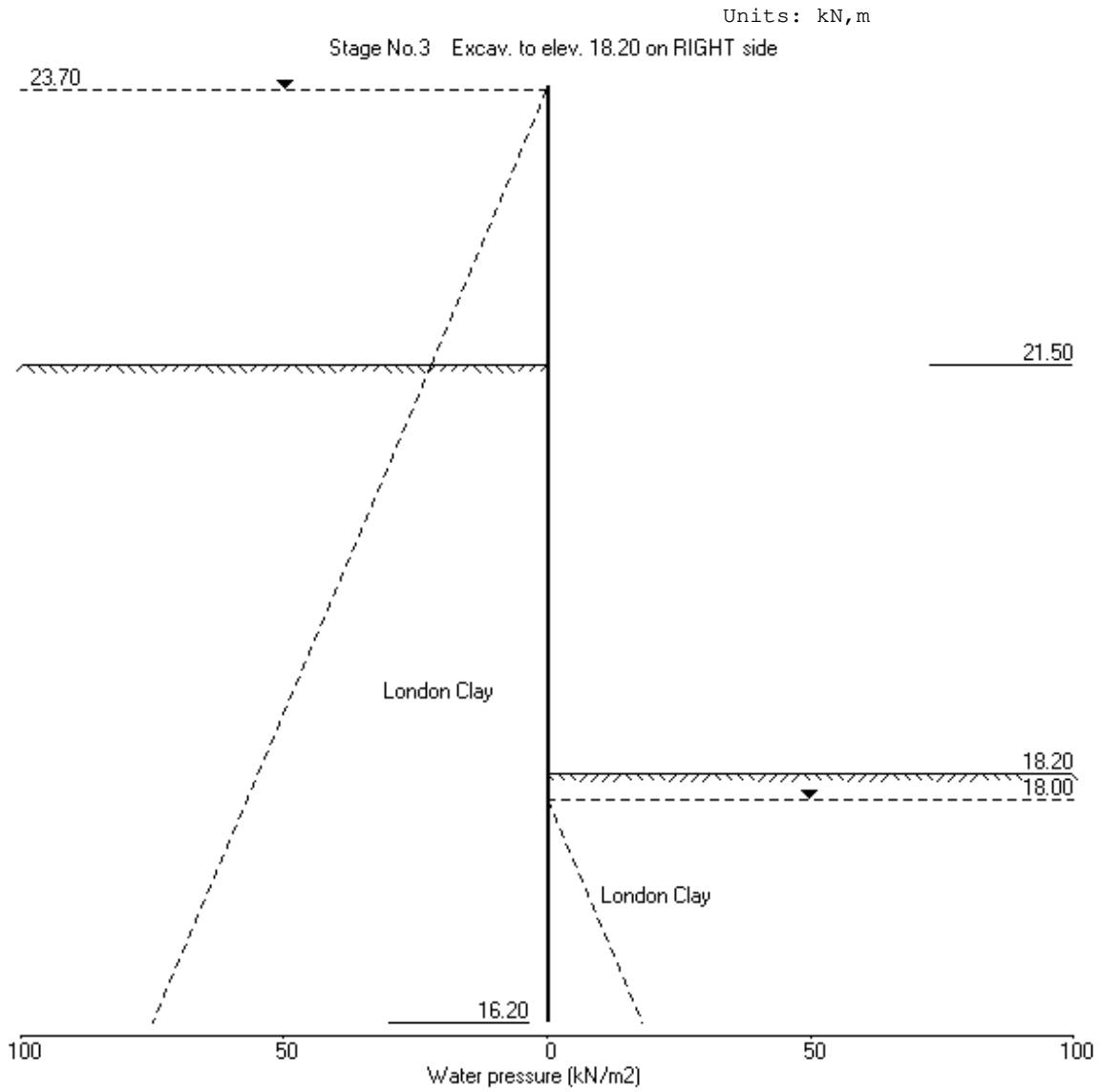
Boundary conditions:  
Length of wall (normal to plane of analysis) = 46.58 m  
  
Width of excavation on Left side of wall = 20.00 m  
Width of excavation on Right side of wall = 20.00 m  
  
Distance to rigid boundary on Left side = 20.00 m  
Distance to rigid boundary on Right side = 20.00 m

**OUTPUT OPTIONS**

Stage no.	Stage description	Displacement	Active, Graph.	Passive output pressures
1	Excav. to elev. 21.50 on LEFT side	Yes	Yes	Yes
2	Apply water pressure profile no.1	Yes	Yes	Yes
3	Excav. to elev. 18.20 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Ugly Brown Building  
River wall assessment

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Units: kN,m

Stage No. 1 Excavate to elevation 21.50 on LEFT side

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

Overall								
				FoS for toe				
				elev. = 16.20	Toe elev. for			
					FoS = 1.000			
<u>Stage</u>	<u>Ground level</u>		<u>Prop</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</u>
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>of</u>	<u>equilib.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>
				<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

Limit State: ULS DA1 Combination 2

<u>Node</u>	<u>Y</u>	<u>Nett</u>	<u>Wall</u>	<u>Wall</u>	<u>Shear</u>	<u>Bending</u>	<u>Prop</u>
<u>no.</u>	<u>coord</u>	<u>pressure</u>	<u>disp.</u>	<u>rotation</u>	<u>force</u>	<u>moment</u>	<u>forces</u>
		kN/m <sup>2</sup>	m	rad.	kN/m	kN.m/m	kN/m
1	23.70	0.00	-0.001	-2.31E-04	0.0	-0.0	
2	23.45	0.53	-0.001	-2.31E-04	0.1	0.0	
3	23.20	1.05	-0.001	-2.31E-04	0.3	0.0	
4	22.80	0.26	-0.001	-2.31E-04	0.5	0.0	
5	22.40	-3.60	-0.001	-2.31E-04	-0.1	0.1	
6	22.00	-7.51	-0.001	-2.31E-04	-2.4	-0.3	
7	21.75	-9.98	-0.001	-2.28E-04	-4.6	-1.1	
8	21.50	-12.46	-0.001	-2.22E-04	-7.4	-2.6	
		10.39	-0.001	-2.22E-04	-7.4	-2.6	
9	21.30	9.06	-0.001	-2.12E-04	-5.4	-3.9	
10	21.05	7.46	-0.001	-1.97E-04	-3.3	-4.9	
11	20.80	5.95	-0.001	-1.78E-04	-1.7	-5.6	
12	20.40	3.85	-0.001	-1.46E-04	0.3	-5.7	
13	20.00	2.15	-0.000	-1.14E-04	1.5	-5.3	
14	19.60	0.88	-0.000	-8.65E-05	2.1	-4.5	
15	19.20	-0.00	-0.000	-6.31E-05	2.3	-3.6	
16	18.80	-0.56	-0.000	-4.50E-05	2.2	-2.7	
17	18.50	-0.81	-0.000	-3.46E-05	2.0	-2.1	
18	18.20	-0.94	-0.000	-2.68E-05	1.7	-1.6	
19	18.00	-0.98	-0.000	-2.28E-05	1.5	-1.2	
20	17.60	-0.97	-0.000	-1.73E-05	1.1	-0.7	
21	17.20	-0.89	-0.000	-1.43E-05	0.7	-0.3	
22	16.80	-0.77	-0.000	-1.30E-05	0.4	-0.1	
23	16.50	-0.68	-0.000	-1.26E-05	0.2	-0.0	
24	16.20	-0.59	-0.000	-1.26E-05	-0.0	-0.0	

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

LEFT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	23.45	2.50	0.00	0.00	0.00	0.00	2.50	0.0
3	23.20	5.00	0.00	0.00	0.00	0.00	5.00	0.0
4	22.80	9.00	0.00	0.00	0.00	0.00	9.00	0.0
5	22.40	13.00	0.00	0.00	0.00	0.00	13.00	0.0
6	22.00	17.00	0.00	0.00	0.00	0.00	17.00	0.0
7	21.75	19.50	0.00	0.00	0.00	0.00	19.50	0.0
8	21.50	22.00	0.00	0.00	0.00	0.00	22.00	0.0
		Total>	22.00	22.00w	151.79	36.66	36.66	19440
9	21.30	Total>	26.00	12.00m	157.35	40.01	40.01	19728
10	21.05	Total>	31.00	13.25m	164.29	44.22	44.22	20087
11	20.80	Total>	36.00	14.50m	171.23	48.48	48.48	20447
12	20.40	Total>	44.00	16.50m	182.34	55.45	55.45	21022
13	20.00	Total>	52.00	18.50m	193.44	62.62	62.62	21597
14	19.60	Total>	60.01	20.50m	204.55	70.00	70.00	22173
15	19.20	Total>	68.01	22.50m	215.66	77.56	77.56	22748
16	18.80	Total>	76.02	24.50m	226.78	85.29	85.29	23323
17	18.50	Total>	82.03	26.00m	235.11	91.17	91.17	23755
18	18.20	Total>	88.03	27.50m	243.45	97.11	97.11	24186
19	18.00	Total>	92.04	28.50m	249.01	101.10	101.10	24474
20	17.60	Total>	100.06	30.50m	260.13	109.11	109.11	25049
21	17.20	Total>	108.07	32.50m	271.25	117.16	117.16	25625
22	16.80	Total>	116.10	34.50m	282.38	125.23	125.23	26200
23	16.50	Total>	122.12	36.00m	290.73	131.28	131.28	26632
24	16.20	Total>	128.14	37.50m	299.08	137.33	137.33	27063

RIGHT side								
Node no.	Y coord	Water press.	Vertic -al	Effective stresses		Earth pressure	Total earth pressure	Coeff. of subgrade reaction
				Active limit	Passive limit			
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	23.70	0.00	0.00	0.00	0.00	0.00	0.00	7140
2	23.45	0.00	4.63	1.97	12.22	1.97	1.97a	7319
3	23.20	0.00	9.25	3.95	24.43	3.95	3.95a	7497
4	22.80	0.00	16.65	7.10	43.98	8.74	8.74	7783
5	22.40	0.00	24.05	10.26	63.53	16.60	16.60	8068
6	22.00	0.00	31.45	13.42	83.07	24.51	24.51	8354
7	21.75	0.00	36.08	15.39	95.29	29.48	29.48	8533
8	21.50	0.00	40.70	17.36	107.50	34.46	34.46	8711
		Total>	40.70	11.00m	170.50	26.27	26.27	20138
9	21.30	Total>	44.70	12.00m	176.06	30.95	30.95	20436
10	21.05	Total>	49.70	13.25m	183.00	36.77	36.77	20808
11	20.80	Total>	54.70	14.50m	189.94	42.53	42.53	21181
12	20.40	Total>	62.70	16.50m	201.05	51.60	51.60	21777
13	20.00	Total>	70.70	18.50m	212.15	60.46	60.46	22373
14	19.60	Total>	78.70	20.50m	223.26	69.11	69.11	22969
15	19.20	Total>	86.70	22.50m	234.36	77.56	77.56	23565
16	18.80	Total>	94.70	24.50m	245.47	85.85	85.85	24161
17	18.50	Total>	100.70	26.00m	253.80	91.98	91.98	24608
18	18.20	Total>	106.70	27.50m	262.13	98.05	98.05	25055
19	18.00	Total>	110.70	28.50m	267.68	102.08	102.08	25353
20	17.60	Total>	118.70	30.50m	278.78	110.08	110.08	25948
21	17.20	Total>	126.70	32.50m	289.89	118.05	118.05	26544
22	16.80	Total>	134.70	34.50m	300.99	126.00	126.00	27140

Run ID. Design\_Case\_05\_Sheet\_Pile\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.1 Excavate to elevation 21.50 on LEFT side

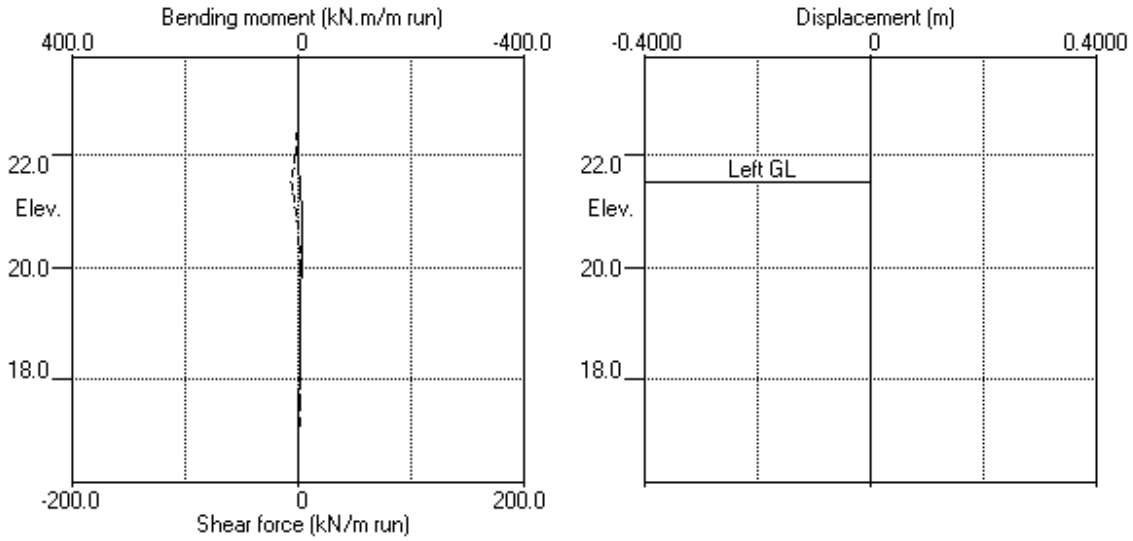
		RIGHT side						
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
23	16.50	Total>	140.70	36.00m	309.32	131.96	131.96	27587
24	16.20	Total>	146.70	37.50m	317.65	137.93	137.93	28034

Note: 3.95a Soil pressure at active limit  
 123.45p Soil pressure at passive limit

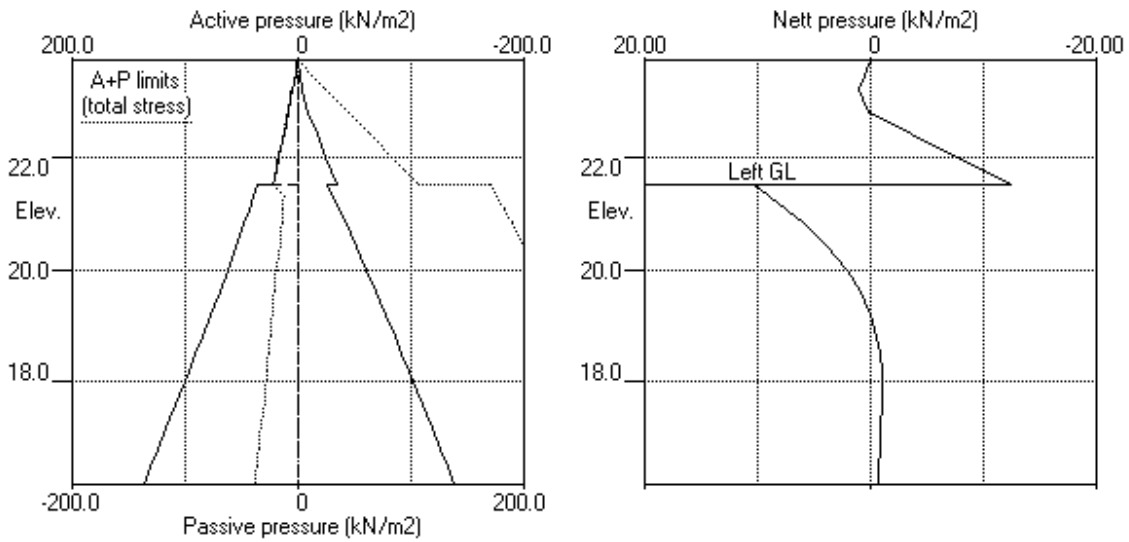


Units: kN,m

Stage No.1 Excav. to elev. 21.50 on LEFT side



Stage No.1 Excav. to elev. 21.50 on LEFT side



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 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Job No. 371654  
 Made by : MM  
 Date:13-05-2020  
 Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 18.20 on RIGHT side

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

		Overall		Toe elev. for				
		FoS for toe		FoS = 1.000				
		elev. = 16.20						
Stage	Ground level	Prop	Factor	Moment	Toe	Wall	Direction	
No.	Act.	Pass.	of	of equilib.	elev.	Penetr	of	
		Elev.	Safety	at elev.		-ation	failure	
3	21.50	18.20	Cant.	0.403	16.94	***	***	L to R

Legend: \*\*\* Result not found

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**  
**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: ULS DA1 Combination 2**

\*\*\*\*\* Passive failure has occurred ! \*\*\*\*\*

		LEFT side						
		Effective stresses				Total	Coeff. of	
Node	Y	Water	Vertic	Active	Passive	Earth	earth	
no.	coord	press.	-al	limit	limit	pressure	subgrade	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	reaction	
1	23.70	0.00	0.00	0.00	0.00		kN/m3	
2	23.45	2.50	0.00	0.00	0.00			
3	23.20	5.00	0.00	0.00	0.00			
4	22.80	9.00	0.00	0.00	0.00			
5	22.40	13.00	0.00	0.00	0.00			
6	22.00	17.00	0.00	0.00	0.00			
7	21.75	19.50	0.00	0.00	0.00			
8	21.50	22.00	0.00	0.00	0.00			
		Total>	22.00	22.00w	151.79			
9	21.30	Total>	26.00	12.00m	157.35			
10	21.05	Total>	31.00	13.25m	164.29			
11	20.80	Total>	36.00	14.50m	171.23			
12	20.40	Total>	44.00	16.50m	182.34			
13	20.00	Total>	52.00	18.50m	193.44			
14	19.60	Total>	60.01	20.50m	204.55			
15	19.20	Total>	68.01	22.50m	215.66			
16	18.80	Total>	76.02	24.50m	226.78			
17	18.50	Total>	82.03	26.00m	235.11			
18	18.20	Total>	88.03	27.50m	243.45			
19	18.00	Total>	92.04	28.50m	249.01			
20	17.60	Total>	100.06	30.50m	260.13			
21	17.20	Total>	108.07	32.50m	271.25			
22	16.80	Total>	116.10	34.50m	282.38			
23	16.50	Total>	122.12	36.00m	290.73			
24	16.20	Total>	128.14	37.50m	299.08			

Run ID. Design\_Case\_05\_Sheet\_Pile\_ULS2  
 Ugly Brown Building  
 River wall assessment

Sheet No.  
 Date:13-05-2020  
 Checked :

(continued)

Stage No.3 Excavate to elevation 18.20 on RIGHT side

RIGHT side								
Node no.	Y coord	Water press. kN/m <sup>2</sup>	Vertic -al kN/m <sup>2</sup>	Effective stresses		Earth pressure kN/m <sup>2</sup>	Total earth pressure kN/m <sup>2</sup>	Coeff. of subgrade reaction kN/m <sup>3</sup>
				Active limit kN/m <sup>2</sup>	Passive limit kN/m <sup>2</sup>			
1	23.70	0.00	0.00	0.00	0.00	0.00		
2	23.45	0.00	0.00	0.00	0.00	0.00		
3	23.20	0.00	0.00	0.00	0.00	0.00		
4	22.80	0.00	0.00	0.00	0.00	0.00		
5	22.40	0.00	0.00	0.00	0.00	0.00		
6	22.00	0.00	0.00	0.00	0.00	0.00		
7	21.75	0.00	0.00	0.00	0.00	0.00		
8	21.50	0.00	0.00	0.00	0.00	0.00		
9	21.30	0.00	0.00	0.00	0.00	0.00		
10	21.05	0.00	0.00	0.00	0.00	0.00		
11	20.80	0.00	0.00	0.00	0.00	0.00		
12	20.40	0.00	0.00	0.00	0.00	0.00		
13	20.00	0.00	0.00	0.00	0.00	0.00		
14	19.60	0.00	0.00	0.00	0.00	0.00		
15	19.20	0.00	0.00	0.00	0.00	0.00		
16	18.80	0.00	0.00	0.00	0.00	0.00		
17	18.50	0.00	0.00	0.00	0.00	0.00		
18	18.20	0.00	0.00	0.00	0.00	0.00		
		Total>	0.00	0.00	155.41			
19	18.00	Total>	4.00	1.00m	160.96			
20	17.60	Total>	12.00	3.00m	172.07			
21	17.20	Total>	20.01	5.00m	183.18			
22	16.80	Total>	28.02	7.00m	194.29			
23	16.50	Total>	34.03	8.50m	202.63			
24	16.20	Total>	40.04	10.00m	210.98			

Note: 10.00a Soil pressure at active limit  
 183.18p Soil pressure at passive limit

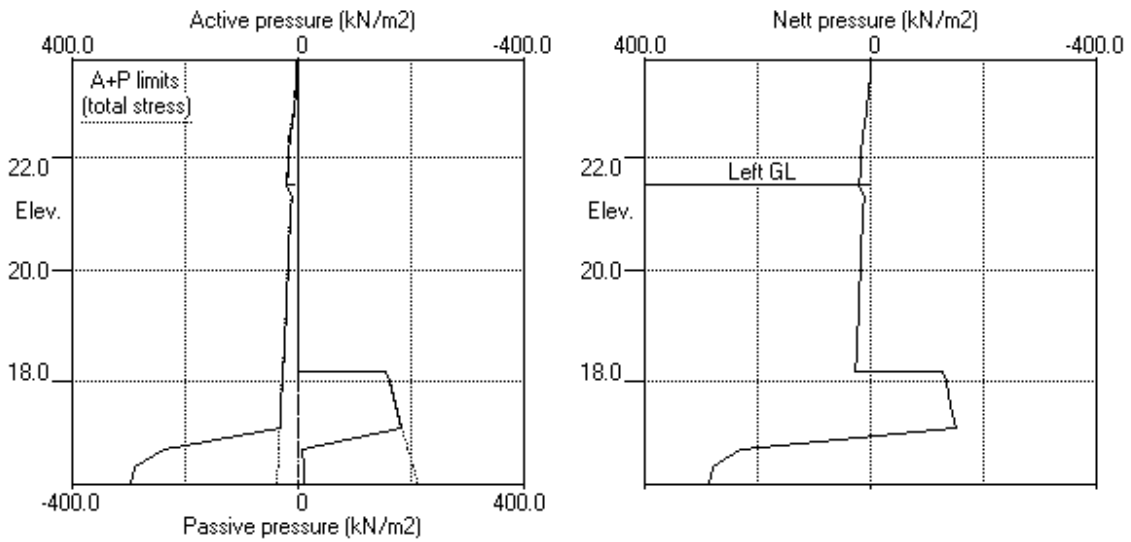
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Ugly Brown Building  
River wall assessment

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Job No. 371654  
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Date: 13-05-2020  
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Units: kN,m

No results for Stage 3  
[ Excavate to elevation 18.20 on RIGHT side ]

Stage No.3 Excav. to elev. 18.20 on RIGHT side



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**Summary of results**

**LIMIT STATE PARAMETERS**

Limit State: ULS DA1 Combination 2  
 Water pressures : Worst Credible  
 Partial factor on C' = 1.250  
 Partial factor on Phi' = 1.250  
 Partial factor on Cu = 1.400  
 Partial factor on Soil Modulus = 1.000  
 Partial factor on Permanent Unfavourable loads = 1.000  
 Partial factor on Permanent Favourable loads = 1.000  
 Partial factor on Variable Unfavourable loads = 1.300

**STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method**

Factor of safety on soil strength

<u>Stage</u> <u>No.</u>	<u>Ground level</u>		<u>Prop</u> <u>Elev.</u>	<u>Overall</u> <u>FoS for toe</u> <u>elev. = 16.20</u>		<u>Toe elev. for</u> <u>FoS = 1.000</u>		<u>Direction</u> <u>of</u> <u>failure</u>
	<u>Act.</u>	<u>Pass.</u>		<u>Factor</u> <u>of</u> <u>Safety at elev.</u>	<u>Moment</u> <u>of</u> <u>equilib.</u>	<u>Toe</u> <u>elev.</u>	<u>Wall</u> <u>Penetr</u> <u>-ation</u>	
1	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.50	23.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.50	18.20	Cant.	0.403	16.94	***	***	L to R

Legend: \*\*\* Result not found

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 River wall assessment

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Units: kN,m

**Summary of results**

**BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall**

**Analysis options**

Length of wall perpendicular to section = 46.58m  
 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: Left side 20.00 from wall  
 Right side 20.00 from wall

**Limit State: ULS DA1 Combination 2**

**Bending moment, shear force and displacement envelopes**

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	23.70	0.213	-0.001	0.0	-0.0	0.0	0.0
2	23.45	0.205	-0.001	0.0	0.0	0.3	0.0
3	23.20	0.197	-0.001	0.2	0.0	1.3	0.0
4	22.80	0.183	-0.001	1.0	0.0	4.0	0.0
5	22.40	0.170	-0.001	3.5	0.0	8.5	-0.1
6	22.00	0.157	-0.001	8.0	-0.3	14.5	-2.4
7	21.75	0.149	-0.001	12.2	-1.1	19.0	-4.6
8	21.50	0.140	-0.001	17.6	-2.6	24.2	-7.4
9	21.30	0.134	-0.001	22.8	-3.9	27.6	-5.4
10	21.05	0.126	-0.001	30.1	-4.9	30.8	-3.4
11	20.80	0.117	-0.001	38.2	-5.6	34.2	-1.7
12	20.40	0.104	-0.001	53.2	-5.7	40.4	0.0
13	20.00	0.091	-0.000	70.8	-5.3	47.4	0.0
14	19.60	0.079	-0.000	91.3	-4.6	55.2	0.0
15	19.20	0.066	-0.000	115.1	-3.7	63.8	0.0
16	18.80	0.054	-0.000	142.5	-2.9	73.2	0.0
17	18.50	0.045	-0.000	165.6	-2.2	80.8	0.0
18	18.20	0.036	-0.000	191.1	-1.7	88.8	0.0
19	18.00	0.030	-0.000	206.2	-1.4	62.8	0.0
20	17.60	0.019	-0.000	220.5	-0.8	8.0	0.0
21	17.20	0.009	-0.000	218.9	-0.4	0.8	-50.5
22	16.80	0.000	-0.001	88.2	-0.1	0.5	-33.9
23	16.50	0.000	-0.009	10.5	-0.0	43.5	0.0
24	16.20	0.000	-0.016	0.0	-0.0	129.2	-0.0

**Maximum and minimum bending moment and shear force at each stage**

Stage no.	Bending moment				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
		kN.m/m		kN.m/m		kN/m		kN/m
1	0.1	22.40	-5.7	20.40	2.3	19.20	-7.4	21.50
2	0.2	22.40	-5.7	20.40	2.2	19.20	-7.3	21.50
3	220.5	17.60	-0.0	16.20	129.2	16.20	-50.5	17.20

**Maximum and minimum displacement at each stage**

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
		m		m	
1	0.000	23.70	-0.001	23.70	Excav. to elev. 21.50 on LEFT side
2	0.000	23.70	-0.001	23.70	Apply water pressure profile no.1
3	0.213	23.70	-0.016	16.20	Excav. to elev. 18.20 on RIGHT side

Run ID. Design\_Case\_05\_Sheet\_Pile\_ULS2  
Ugly Brown Building  
River wall assessment

Sheet No.  
Date:13-05-2020  
Checked :

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**Summary of results (continued)**

\*\*\* Convergence errors have occurred in at least one Construction Stage.  
The errors are cumulative, and the results of all stages must be inspected for significant out of balance moment or shear at the toe of the wall.

Failure of the iterative procedure to converge to an equilibrium solution may be due to a very high ratio of soil stiffness to wall stiffness. The data should be reviewed to see if realistic values have been specified

Out of balance shear forces.

<u>Percentage Error</u>	<u>Interpretation</u>
< 2%	Generally acceptable
2% to 4%	Use with caution
> 4%	Should not be used

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Bending moment, shear force, displacement envelopes

