



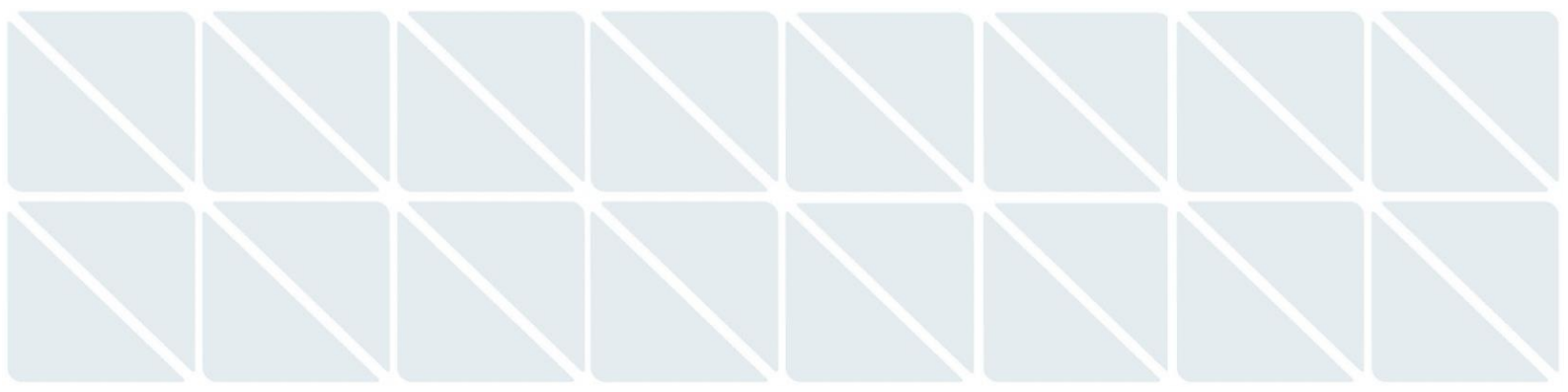
A-squared Studio

The Fitzrovia, 247 Tottenham Court Road, London

Pile Wall Design Calculations, Conforming Scheme

May 2022

2176-A2S-XX-XX-CA-Y-0002-01





Project Name	The Fitzrovia, 247 Tottenham Court Road, London
Project Number	2176
Client	Franki Foundations UK
Document Name	Pile Wall Design Calculations, Conforming Scheme

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Revision	Date	Prepared by	Checked by	Description	Level of Check (1, 2 or 3)
00	06.05.2022	J. R. Martin	T. Suckling	First Issue – s/s	2
01	31.05.2022	J. R. Martin	T. Suckling	Second Issue (secant spacing changed)	2

Check Level 1 is a general check by another person of principles and application

Check level 2 is an arithmetic check by another person

Check level 3 is a fully independent design for comparison



Executive Summary

A-squared Studio Engineers Ltd (A-Squared) has been commissioned by Franki Foundations UK to undertake the detailed design of secant and contiguous wall piles for the proposed construction at The Fitzrovia, 247 Tottenham Court Road, London. The site is located at the southern end of Tottenham Court Road in central London. It is bounded by Bayley Street to the north, Morwell Street to the east, Tottenham Court Road to the west and No 248 Tottenham Court Road to the south. It may be located by National Grid Reference 529750, 181554.

This document sets out the design of the embedded secant and contiguous pile wall only.

1. The secant pile wall is approximately 180 linear meters long and will comprise 140 No. x 900mm diameter hard and firm piles with a maximum center to center pile spacings of 1400mm
2. The contiguous pile wall is approximately 67 linear meters long and will comprise 72 No. x 750mm diameter hard piles with a maximum center to center pile spacings of 950mm

Piles are to be installed using the Continuous Flight Auger (CFA) Piling techniques.

Piling Platform Level (PPL) of +26.375mOD has been used for all wall sections.

Characteristic wall loads have been provided by the Engineer, AKT II on Piling Layout drawing, 4190 AKT ZZ B2 DR S 20950, T6.

This is a contractor designed element of the works in accordance ICE Specification for Piling and Embedded Retaining Walls.

The design of piles is in accordance with BS EN 1997-1 and the associated UK National Annex and CIRIA C760. Consideration is also given to LDSA Practice Note No. 1 (2017).

The design has been classified as being Geotechnical Category 2 in accordance with BS EN 1997-1.

A detailed CDM risk assessment for the proposed piling works is provided in Appendix A. The Client & Designer for this project are subject to certain duties under the CDM Regulations.

A secant wall pile schedule is provided in Appendix G.

Piling contractor is to review the methodology of installing inclinometers in CFA piles.



Contents

1.	Scope	1
2.	Relevant Documentation.....	2
3.	Pile Design Key Requirements.....	3
4.	Site Investigation	4
5.	Adopted Ground Model	6
6.	Pile Wall Geometry and Design Philosophy	7
7.	WALLAP Analysis	12
8.	Axial Pile Design	14
9.	Structural Calculations.....	16
10.	Design Summary	18

Appendices

Appendix A: CDM Risk Assessment
Appendix B: Ground Investigation Data
Appendix C: Design Plan
Appendix D: WALLAP (Input/Output)
Appendix E: Axial Design Calculations
Appendix F: Structural Calculations
Appendix G: Pile Wall Schedule
Appendix H: References

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	1
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

1. Scope

A-squared Studio Engineers Ltd (A-Squared) has been commissioned by Franki Foundations UK to undertake the detailed design of secant and contiguous wall piles for the proposed construction at The Fitzrovia, 247 Tottenham Court Road, London. The site is located at the southern end of Tottenham Court Road in central London. It is bounded by Bayley Street to the north, Morwell Street to the east, Tottenham Court Road to the west and No 248 Tottenham Court Road to the south. It may be located by National Grid Reference 529750, 181554.

This document sets out the design of the embedded secant and contiguous pile wall only.

1. The secant pile wall is approximately 180 linear meters long and will comprise 140 No. x 900mm diameter hard and firm piles with a maximum center to center pile spacings of 1400mm
2. The contiguous pile wall is approximately 67 linear meters long and will comprise 72 No. x 750mm diameter hard piles with a maximum center to center pile spacings of 950mm

All calculations for the secant and contiguous piles follow herein.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	2
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

2. Relevant Documentation

2.1. Specifications

- STRUCTURAL SPECIFICATIONS, 4190-D40 Embedded Retaining Walls, The Fitzrovia

2.2. Documents

- GEA Ground Investigation Report, J20209A, May 2021

2.3. Drawings

The relevant drawings from AKT II are as follows:

- General Notes Sheet 6, 4190 AKT XX XX DR S 00006, T2
- General Notes Sheet 7, 4190 AKT XX XX DR S 00007, T2
- TOLERANCES, MOVEMENTS, ALLOWABLE FIXING ZONES SHEET 3, 4190 AKT XX XX DR S 00012, T2
- SITE INVESTIGATION BOREHOLES AND TRIAL PIT LOCATIONS, 4190 AKT XX XX DR S 00100, T2
- SITE CONSTRAINTS SECTIONS – SHEET 2 TUNNELS, 4190 AKT XX ZZ DR S 00103, T2
- GROUND FLOOR GA PLAN, 4190 AKT ZZ 00 DR S 21000, T3
- CAPPING BEAM LAYOUT, 4190 AKT ZZ 00 DR S 21001, T3
- BASEMENT LEVEL 1 GA PLAN, 4190 AKT ZZ B1 DR S 20990, T4
- BASEMENT LEVEL 2 GA PLAN, 4190 AKT ZZ B2 DR S 20980, T4
- PILING LAYOUT, 4190 AKT ZZ B2 DR S 20950, T6
- OVERALL SECTIONS SHEET 1, 4190 AKT ZZ ZZ DR S 25000, T4
- OVERALL SECTIONS SHEET 2, 4190 AKT ZZ ZZ DR S 25001, T4
- OVERALL SECTIONS SHEET 3, 4190 AKT ZZ ZZ DR S 25002, T4
- OVERALL SECTIONS SHEET 4, 4190 AKT ZZ ZZ DR S 25003, T4
- OVERALL SECTIONS SHEET 5, 4190 AKT ZZ ZZ DR S 25004, T4
- OVERALL SECTIONS SHEET 6, 4190 AKT ZZ ZZ DR S 25005, T4
- OVERALL SECTIONS SHEET 7, 4190 AKT ZZ ZZ DR S 25006, T4
- SUBSTRUCTURE SECTIONS SHEET 1, 4190 AKT ZZ ZZ DR S 25100, T4
- SUBSTRUCTURE SECTIONS SHEET 2, 4190 AKT ZZ ZZ DR S 25101, T4
- LINER WALL / CAPPING BEAM ELEVATIONS SHEET 1, 4190 AKT ZZ ZZ DR S 26500, T2
- LINER WALL / CAPPING BEAM ELEVATIONS SHEET 2, 4190 AKT ZZ ZZ DR S 26510, T2
- EXISTING BUILDING - SURCHARGE LOADS, 4190-S-HSK-078, P2
- 247 Tottenham Court Road - B2 Propping Concept Sketch TOgden 20220121

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	3
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

3. Pile Design Key Requirements

Pile design in accordance with ICE SPERW 3rd Edition, 2017; BS EN 1992-1-1 and BS EN 1997-1.

Piling Platform Level (PPL) of +26.375mOD has been used for all wall sections.

Characteristic wall loads have been provided by the Engineer, AKT II on Piling Layout drawing, 4190 AKT ZZ B2 DR S 20950, T6. This design has assumed an increased pile center to center spacing for the secant wall piles, therefore AKT II to confirm if the interpretation of the axial loads provided is acceptable.

All secant and contiguous wall sections will be temporarily propped by one or two levels of temporary propping.

The secant walls will be propped in the permanent condition by the proposed floor slabs.

Piles are to be installed using the Continuous Flight Auger (CFA) Piling technique.

The secant pile wall is approximately 180 linear meters long and will comprise 140 No. x 900mm diameter hard and firm piles with a maximum center to center pile spacings of 1400mm .

The contiguous pile wall is approximately 67 linear meters long and will comprise 72 No. x 750mm diameter hard piles with a maximum center to center pile spacings of 950mm.

In order to install the contiguous wall between basement levels B1 and B2, the whole site (box) will need to be dewatered.

For wall sections with type B surcharge it has been assumed that this surcharge is applied at a level of +22.25mOD (the top of the Lynch Hill Gravels). This needs to be confirmed by AKT II.

The contiguous wall surcharge of 20kPa has been applied 2.0m from the rear of the wall, therefore there should be a 2.0m exclusion zone on site from the rear of the wall.

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	4
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

4. Site Investigation

A site-specific ground investigation report has been undertaken by GEA (May 2021). The investigation comprised the following:

- 1 No. Cable percussive borehole logs (BH2) to a maximum depth of 21.0mbgl
- 2 No. Cable percussive borehole logs (BH1 & BH3) to a maximum depth of 4.0mbgl

The site investigation data and strength graphs are presented in Appendix B. The boreholes were undertaken from within the footprint of the proposed development and extends beyond the likely toe of the piles. The relevant boreholes are summarised as follows:

Table 4-1 Boreholes Summary

Borehole	Borehole Level (mOD)	Thickness, m (Level at Base of Strata, mOD)			
		Made Ground	Clay	Lynch Hill Gravel	London Clay
BH1	+24.14	0.6 (+23.54)	1.2 (+22.34)	2.2 (NP)	-
BH2	+24.16	0.5 (+23.66)	1.1 (+22.56)	3.5 (+19.06)	15.9 (NP)
BH3	+24.12	0.37 (+23.75)	1.43 (+22.32)	1.5 (NP)	-

NP – Base of the layer not proven

Made Ground

Made Ground was encountered during the investigation works. A reinforced concrete slab was discovered in all three boreholes which extended to a depth of up to 0.6m.

No SPT N values within the layer range were provided.

Clay

The concrete slab was underlain by soft becoming firm orange-brown silty sandy clay with rootlets which extended to a depth of 1.80 m (22.34 m OD) in each case; identified as possible made ground or a layer of “Brickearth”.

1 No. SPT N values were undertaken within the Brickearth with a result of 27.

Lynch Hill Gravel

The Lynch Hill Gravel layer was encountered in all boreholes and is described as comprising orange-brown, very gravelly sand.

4 No. SPT N values were undertaken within the Lynch Hill Gravel with results ranging from 15 to 49 with an average of 36.

London Clay

The London Clay in encountered in borehole BH2 only from an elevation of +19.06mOD. The layer is described as comprising high strength becoming very high strength, stiff brown mottled grey, becoming very stiff grey, fissured silty clay.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	5
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

5 No. SPT N values were undertaken within the London Clay with results ranging from 21 to 39 with an average of 30. SPT N values can be approximated to undrained shear strength using the relationship $c_u = f_1 * N$ with f_1 ranging from 4 to 6, thus a value of 5.0 has been applied for this scheme, which shows good correlation with the site specific undrained triaxial tests results.

5 No. samples were subject to undrained triaxial testing with results ranging from 71kPa to 185kPa with an average of 124kPa.

Groundwater

Groundwater was not encountered in any of the boreholes during drilling.

Groundwater monitoring provided groundwater levels of +20.66 mOD, +20.94mOD and +20.96mOD from within the Lynch Hill Gravel.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	6
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

5. Adopted Ground Model

Based on the information provided, technical literature and previous experience, the following ground profiles have been adopted for the purposes of the design. Tables below show the ground model used for wall design.

Table 5-1 Characteristic geotechnical parameters for wall design

Stratum	Top of Strata(mOD)	Bulk Density (kN/m ³)	Φ (degrees)	c _u (kPa)	c' (kPa)	E _u (MPa)	E' (MPa)
Made Ground	+26.70	18	30	-	-	-	10
Clay	+23.50	19	24	50	0	800c _u	0.75E _u
Lynch Hill Gravel	+22.25	19	35	-	-	-	60
London Clay	+19.00	20	25	85+7.813z ^[1]	5	1000c _u	0.8E _u

Note:
[1] z is depth below the top of the strata

A summary of the borehole logs and SPT plot from the site-specific ground investigation are presented in Appendix B.

The short-term groundwater level assumed for the design has been taken at +21.0mOD. This has been raised to +26.2mOD in the long-term.

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	7
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

6. Pile Wall Geometry and Design Philosophy

6.1. Design Sections

8 No. design sections have been identified for the pile wall design. The location of these sections in plan is shown in Appendix C.

The top of the pile wall will typically be +26.70mOD for all secant design sections, and +21.98mOD for the contig wall design section.

Formation level has been taken at:

- +20.93mOD for wall sections SW01-A and SW01-B
- +18.68mOD for wall section SW02-A
- +14.83mOD for wall sections SW03-A and SW04 -A
- +15.93mOD for wall sections SW03-B, SW05-B, and contiguous wall section 3
- +16.43mOD for contiguous wall section 1
- +15.13mOD for contiguous wall section 2 (lift pit)

Back of wall surcharge loadings are as per PILING LAYOUT, 4190 AKT ZZ B2 DR S 20950, T6 and EXISTING BUILDING - SURCHARGE LOADS, 4190-S-HSK-078, P2.

If surcharges are found to be greater than those specified then these calculations must be revised.

For wall sections with type B surcharge it has been assumed that this surcharge is applied at a level of +22.25mOD (the top of the Lynch Hill Gravels). This needs to be confirmed by AKT II.

The secant pile wall will be propped at 1 or 2 levels in the temporary condition, and by the reinforced concrete floor slabs in the permanent condition. It has been assumed that the top temporary prop at capping beam level will be installed at +25.5mOD for all secant wall sections. It has been assumed that secant wall sections SW03-A, SW04-A, SW03-B and SW05-B will have a second level of temporary propping installed at +21.0mOD.

It has been assumed that the contiguous wall will have one level of temporary propping installed at +21.5mOD. All temporary propping to be designed and installed by others.

The secant pile is designed to resist axial loads as well as groundwater pressure and back of wall surcharges. Axial design of the piles is summarised in section 8.

The contiguous wall is not designed to accommodate any axial loads or resist long-term water pressure. It has been assumed that this long-term water pressure will be taken by the 500mm thick reinforced wall to be installed in front of the contiguous wall.

Typical retained heights and back of wall surcharges are shown in Table 6-1.

Table 6-1 Secant wall design sections summary

Design Section	Temporary Formation Level (mOD)	SLS Retained Height (m)	Surcharge Type	Applied Surcharge Uniform [kN/m ²]	Applied Surcharge Line Load [kN/m ²] ^[1]
SW01-A	+20.99	5.7	A	Variable 25	NA



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	8
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

SW02-A	+18.74	7.9	A	Variable 25	NA
SW03-A	+15.99	10.7	A	Variable 25	NA
SW04-A	+15.99	10.7	A	Variable 25	NA
SW01-B	+20.99	5.7	B	Permanent 35 Variable 7.5	Permanent 485 Variable 111
SW03-B	+15.99	10.7	B	Permanent 35 Variable 7.5	Permanent 485 Variable 111
SW05-B	+15.99	10.7	B	Permanent 35 Variable 7.5	Permanent 485 Variable 111
Contiguous (B1-B2)	+15.99	6.1	-	Variable 20 ^[2]	-

Notes:

[1] Line load surcharge represents the footing of the adjacent building, applied at the site boundary with a width of 1.0m

[2] Construction surcharge applied 2.0m behind the rear of the wall

Secant wall primary piles are designed to be installed 1.0m below top of London Clay layer (+18.0mOD). This means wall sections SW03-A, SW04-A, SW03-B and SW05-B will be hanging secant.

6.2. Construction Sequence

The sequences for each wall section are summarised below, these sequences must be followed. If the proposed sequences below are not correct, then the designer must be contacted immediately with the correct construction sequence clearly communicated.

Design Section SW01-A and SW01-B

1. Install secant pile wall to design depth through a reinforced concrete, scalloped guide wall
2. Excavate to +25.0mOD and construct capping beam
3. Install temporary propping at +25.50mOD
4. Excavate to +21.00mOD (plus additional 100mm over-dig in ULS, therefore a controlled excavation must take place)
5. Cast B1 level slab
6. Cast ground floor level slab
7. Remove temporary prop at +25.50mOD
8. Switch to long term drained conditions and accidental ground water level



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	9
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

The above sequence assumes that the level B1 basement floor slabs are constructed within 6 weeks of the excavation to final formation level. If this is not the case, then the geotechnical engineer must be contacted immediately, and the design calculations revised.

Design Section SW02-A

1. Install secant pile wall to design depth through a reinforced concrete, scalloped guide wall
2. Excavate to +25.0mOD and construct capping beam
3. Install temporary propping at +25.50mOD
4. Excavate to +18.74mOD (plus additional 100mm over-dig in ULS, therefore a controlled excavation must take place)
5. Cast B2 level slab
6. Cast B1 level slab
7. Cast ground floor level slab
8. Remove temporary prop at +25.50mOD
9. Switch to long term drained conditions and accidental ground water level

The above sequence assumes that the level B2 basement floor slabs are constructed within 6 weeks of the excavation to final formation level. If this is not the case, then the geotechnical engineer must be contacted immediately, and the design calculations revised.

Design Section SW03-A and SW04-A

1. Install secant pile wall to design depth through a reinforced concrete, scalloped guide wall
2. Excavate to +25.0mOD and construct capping beam (excavate to +24.0mOD for wall section SW04-A)
3. Install temporary propping at +25.50mOD
4. Excavate to +20.50mOD
5. Install temporary propping at +21.00mOD
6. Excavate to form a berm, width at top 900mm, width at bottom 2600mm, top level +16.48mOD, bottom level +14.83mOD (plus additional 100mm over-dig in ULS, therefore a controlled excavation must take place)
7. Cast B2 level slab
8. Cast B1 level slab
9. Remove temporary prop at +21.00mOD
10. Cast ground floor level slab
11. Remove temporary prop at +25.50mOD
12. Switch to long term drained conditions and accidental ground water level

The above sequence assumes that the level B2 basement floor slabs are constructed within 6 weeks of the excavation to final formation level. If this is not the case, then the geotechnical engineer must be contacted immediately, and the design calculations revised.

Design Section SW03-B and SW05-B

1. Install secant pile wall to design depth through a reinforced concrete, scalloped guide wall
2. Excavate to +25.0mOD and construct capping beam (excavate to +24.0mOD for wall section SW05-B)
3. Install temporary propping at +25.50mOD
4. Excavate to +20.50mOD

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	10
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

5. Install temporary propping at +21.00mOD
6. Excavate to +15.93mOD (plus additional 100mm over-dig in ULS, therefore a controlled excavation must take place)
7. Cast B2 level slab
8. Cast B1 level slab
9. Remove temporary prop at +21.00mOD
10. Cast ground floor level slab
11. Remove temporary prop at +25.50mOD
12. Switch to long term drained conditions and accidental ground water level

The above sequence assumes that the level B2 basement floor slabs are constructed within 6 weeks of the excavation to final formation level. If this is not the case, then the geotechnical engineer must be contacted immediately, and the design calculations revised.

Design Section - Contiguous Wall

1. Install contiguous pile wall to design depth
2. Excavate on both sides of the wall to +21.98mOD
3. Excavate to +20.75mOD and construct capping beam
4. Install temporary propping at +21.50mOD
5. Excavate to formation level (varies, see schedule section 6.1) (plus additional 100mm over-dig in ULS, therefore a controlled excavation must take place)
6. Cast B1 level slab
7. Remove temporary propping at +21.50mOD
8. Switch to long term drained conditions

The contiguous wall is not designed to accommodate any axial loads or resist long-term water pressure.

6.3. Temporary Propping Requirements

The following requirements shall be in place for the design calculations and movement predictions contained within this report to be valid:

- Temporary prop stiffness to be a minimum of 30,000kN/m/m for all props, with no requirement for preload (higher prop stiffnesses are acceptable)

6.4. Design philosophy

The design of the embedded retaining wall is in accordance with BS EN 1997-1 and CIRIA C760 as non-contradictory complementary information.

The following summarises the basis of the design:

Design Approach 1 - Combination 2

- Factored soil parameters in accordance with BS EN 1997-1
- Permanent surcharge factored by 1.0



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	11
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

- Variable surcharge factored by 1.3
- Over-excavation of up to 0.1m is considered
- Bending moments and shear forces x 1.0

Design Approach 1 - Combination 1

- Unfactored soil parameters in accordance with BS EN 1997-1
- Permanent surcharge factored by $1.35/1.35 = 1.0$
- Variable surcharge factored by $1.5/1.35 = 1.11$
- Over-excavation of up to 0.1m is considered
- Bending moments and shear forces x 1.35

Serviceability limit state analysis - for estimation of wall deflections

- Unfactored soil parameters in accordance with BS EN 1997-1
- Permanent surcharge factored by = 1.0
- Variable surcharge factored by = 1.0
- No consideration of over-excavation

For design purposes the groundwater table is raised to 0.5mbgl in the long-term condition for all secant design sections.

The contiguous wall is not designed to resist long-term water pressure. It has been assumed that long-term water pressure will be taken by the 500mm thick reinforced wall to be installed in front of the contiguous wall.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	12
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

7. WALLAP Analysis

The wall stability has been carried out using software WALLAP licensed by Geosolve (version 6.07). The forces within the embedded retaining walls and deflections have also been determined with this software.

The full input and output of the WALLAP analysis is presented in Appendix D and summarised below:

Table 7-1 Summary of WALLAP results

Design Section	PPL (mOD)	TOW (mOD)	SLS Retained Height (m)	Required Secondary Pile Length from PPL (m)	Maximum Design Bending Moment per Pile (kNm)	Maximum Design Shear Force per Pile (kN)	Predicted Horizontal SLS Wall Deflections (mm)
SW01-A	+26.375	+26.700	5.8	11.9	350	174	6
SW02-A	+26.375	+26.700	8.0	14.9	419	273	8
SW03-A	+26.375	+26.700	11.9	17.9	570	441	11
SW04-A	+26.375	+26.700	11.9	17.9	570	441	11
SW01-B	+26.375	+26.700	5.8	11.9	554	186	7
SW03-B	+26.375	+26.700	10.8	17.9	1375	652	18
SW05-B	+26.375	+26.700	10.8	17.9	1375	652	18
Contiguous 1 (B1-B2)	+26.375	+21.980	5.6	15.0	246	87	5
Contiguous 2 (B1-B2)	+26.375	+21.980	6.9	17.0	482	126	9
Contiguous 3 (B1-B2)	+26.375	+21.980	6.1	15.0	290	90	5

The pile wall design is only suitable for a temporary propping system which provides the same, or higher stiffnesses than those stated in Section 6.3 – if the propping arrangement changes to provide a lower stiffness than assumed, these design calculations will be invalid and must be revised.

The design bending moments from the above table are used in the ULS structural design of the pile wall (Section 9).

The maximum SLS horizontal prop loads for temporary and permanent for each design section are provided in Table 7-2.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	13
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Table 7-2 horizontal, SLS (unfactored) temporary loads

Design Section	SLS Temporary Prop Forces (kN/m)		SLS permanent Slab Forces (kN/m)		
	Temp Prop 1	Temp Prop 2	B2 Level	B1 Level	GF Level
SW01-A	107	-	-	124	109
SW02-A	130	-	114	187	126
SW03-A	116	150	272	404	98
SW04-A	116	150	272	404	98
SW01-B	115	-	-	137	112
SW03-B	100	200	373	341	118
SW05-B	100	200	373	341	118
Contiguous 1 (B1-B2)	39	-	-	50	-
Contiguous 2 (B1-B2)	49	-	-	73	-
Contiguous 3 (B1-B2)	49	-	-	73	-

ULS combination 1 prop loads can be found on the WALLAP summary in Appendix D.

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	14
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

8. Axial Pile Design

8.1. Preamble

The 900mm diameter secant pile wall is designed to resist axial loading. The 750mm diameter contiguous pile wall is not designed to resist any axial loading.

The design of the piles will be in accordance with BS EN 1997-1 and part of LDSA Practice Note 1.

The pile wall design is based on no pile load tests being carried out and thus the R4 resistance factors as detailed in NA to BS EN 1997-1 are used.

The axial geotechnical design resistance of piles ($R_{c;d}$) is calculated as follows:

$$R_{c;d} = \frac{\left(\frac{R_{s;k}}{\gamma_s} + \frac{R_{b;k}}{\gamma_b} \right)}{\gamma_{Rd}}$$

where:

$$R_{s;k} = \pi \times d \times l \times q_{s;k}$$

$$R_{b;k} = \frac{\pi \times d^2}{4} \times q_{b;k}$$

γ_s and γ_b are partial factors which vary for Combination 1 (R1) and 2 (R4), and γ_{Rd} is the model factor of 1.4. These values are defined in the NA to BS EN 1997-1 (2004): Table A.NA.8 which is reproduced below.

Table A.NA.7 **Partial resistance factors (γ_R) for bored piles for the STR and GEO limit states**

Resistance	Symbol	Set		
		R1	R4 without explicit verification of SLS ^{A)}	R4 with explicit verification of SLS ^{A)}
Base	γ_b	1.0	2.0	1.7
Shaft (compression)	γ_s	1.0	1.6	1.4
Total/combined (compression)	γ_t	1.0	2.0	1.7
Shaft in tension	$\gamma_{s;t}$	1.0	2.0	1.7

^{A)} The lower γ -values in R4 may be adopted (a) if serviceability is verified by load tests (preliminary and/or working) carried out on more than 1% of the constructed piles to loads not less than 1.5 times the representative load for which they are designed, or (b) if settlement is explicitly predicted by a means no less reliable than in (a), or (c) if settlement at the serviceability limit state is of no concern.

Figure 8-1 Excerpt of Table A.NA.8 from the U.K. NA to BS EN 1997-1

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	15
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

8.2. Pile Loading

Characteristic wall loads have been provided by the Engineer, AKT II on Piling Layout drawing, 4190 AKT ZZ B2 DR S 20950, T6. This design has assumed an increased pile center to center spacing for the secant wall piles, therefore AKT II to confirm if the interpretation of the axial loads provided is acceptable.

Table 8-1 Axial Forces

Design Section	Permanent Loading [kN/pile]	Variable Loading [kN/pile]
SW01	425	50
SW02	515	60
SW03	770	90
SW04	770	90
SW05	770	90

The axial pile capacity calculations for the secant pile wall are included in Appendix E.

The 750mm diameter contiguous pile wall is not designed to resist any axial loading.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	16
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

9. Structural Calculations

9.1. Concrete Strength

Once drilled to the required length, the (Hard) secant wall piles will be filled with a minimum C28/35 at 28 days concrete (with a maximum aggregate size of 20mm).

The firm secant wall pile concrete strength is to be specified by Franki Foundations UK.

9.2. Compression Capacity

In accordance with BS EN 1992. The design compression resistance for a 900mm diameter pile is 8282kN which exceeds the maximum combination 1 compression action per pile.

9.3. Aggressivity Assessment

No concrete class has been recommended in the relevant design documents or ground investigation report. No SO4 data has been provided. Therefore, a concrete class of DS-2 is recommended.

9.4. Minimum Reinforcement

All pile reinforcement shall be Grade B500. Ductility class B or C.

In accordance with BS EN 1536 (2010), the minimum area of longitudinal steel reinforcement (A_s) to be installed in a 900mm diameter piles shall be no less than 0.0025m².

9.5. Cover

In accordance with BS EN 1536 (2010) the minimum cover to pile reinforcement (links) shall be 75mm.

9.6. Reinforcement Cage Design

The structural calculations have been undertaken in accordance with BS EN 1992-1-1:2004 and the UK National Annex. The recommendations from BS EN 1536 regarding minimum pile reinforcement and clear bar spacing are also considered.

The main and shear reinforcement of the piles have been determined using the Oasys software AdSec 10.0 and in-house spreadsheets which are presented in Appendix F and summarised in Table 9-1.

Table 9-1 Pile reinforcement summary

Design Section	PPL (mOD)	Pile Diameter (mm)	Combination 1 Action (kN)	Maximum Design Bending Moment Per Pile (kNm)	Maximum Design Shear Force Per Pile (kN)	Main Reinforcement	Shear Reinforcement
SW01-A	+26.375	900	699	350	174	12 x B20	750mm OD, B10 at 250mm c/c
SW02-A	+26.375	900	846	419	273	12 x B20	750mm OD, B10 at 250mm c/c
SW03-A	+26.375	900	1265	570	441	10 x B25	750mm OD, B10 at 150mm c/c



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	17
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

SW04-A	+26.375	900	1265	570	441	10 x B25	750mm OD, B10 at 150mm c/c
SW01-B	+26.375	900	699	554	186	14 x B20	750mm OD, B10 at 250mm c/c
SW03-B	+26.375	900	1265	1375	652	14 x B32	750mm OD, B10 at 100mm c/c
SW05-B	+26.375	900	1265	1375	652	14 x B32	750mm OD, B10 at 100mm c/c
Contiguous 1	+26.375	750	-	246	87	8 x B20	600mm OD, B10 at 250mm c/c
Contiguous 2	+26.375	750	-	482	126	10 x B25	600mm OD, B10 at 250mm c/c
Contiguous 3	+26.375	750	-	290	90	8 x B20	600mm OD, B10 at 250mm c/c

The main reinforcement cage length is governed by lateral stability, see the pile schedule in Appendix G for details.

No allowance has been made for any crack control reinforcement.

9.7. Projection

When trimming the main reinforcement, the pile wall main bars are to be left at ~50mm below the TOW level (top of capping beam) throughout to ensure the maximum possible projection length is achieved.

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	18
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

10. Design Summary

The secant and contiguous wall piles for The Fitzrovia, 247 Tottenham Court Road, London can be summarised as follows:

The secant pile wall is approximately 180 linear meters long and will comprise 140 No. x 900mm diameter hard and firm piles with a maximum center to center pile spacings of 1400mm.

The contiguous pile wall is approximately 67 linear meters long and will comprise 72 No. x 750mm diameter hard piles with a maximum center to center pile spacings of 950mm.

Piles are to be installed using the Continuous Flight Auger (CFA) Piling techniques.

Piling Platform Level (PPL) of +26.375mOD has been used for all wall sections.

Pile lengths from PPL are governed by axial and lateral stability see the pile schedule in Appendix G.

Pile reinforcement is summarised in Table 9-1.

The Hard secant wall and contiguous wall piles are to be constructed using C28/35 concrete at 28 days. Maximum aggregate size = 20mm. Minimum design concrete classification of DS-2. Cover to reinforcement to be 75mm.

Piling contractor is to review the methodology of installing inclinometers in CFA piles.

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix A: CDM Risk Assessment

Project:	The Fitzrovia, 247 Tottenham Court Road		
Project No:	2176		
Revision:	1		
Prepared by:	Jonathan Martin	Date	31/05/2022
Reviewed by:	Tony Suckling	Date	31/05/2022

Severity	Risk Level				
	Likelihood of Exposure to Hazard				
	Almost Certain	Likely	Possible	Unlikely	Improbable
Fatalities	H	H	H	H	M
Major	H	H	H	M	L
Minor	H	M	M	L	L
None anticipated	L	L	L	L	L

Ref No	HAZARD DESCRIPTION	Risk Level Before Design Mitigation (H / M / L)	DESIGN MITIGATION ACTION	Risk Level After Design Mitigation (H / M / L)	SIGNIFICANT RESIDUAL RISKS Comments for, or Actions required by Others?
1.0	Working with large plant	H	Piling Contractor to employ safe specialist procedures	L	Action Piling Contractor/Pile Designer
2.0	Services below ground.	H	No works to be started until a permit to dig has been provided by the Main Contractor.	L	Action Main Contractor
3.0	Access to pile for integrity testing, if required.	M	Testing to be suitably programmed by the Main Contractor prior to placing cap reinforcement - if testing is required.	L	Action Main Contractor
4.0	Rig instability	H	Piles are to be installed from a suitably designed, installed and maintained piling platform level	L	Action Piling Contractor
5.0	Ground conditions being weaker than expected	M	Experienced engineer to confirm pile arisings. Geotechnical engineer to be informed immediately if ground conditions differ from those assumed.	L	Action Piling Contractor
6.0	Trimming reinforcement anchorage	M	Secant pile reinforcement to be left 50mm below the capping beam level	L	Action Main Contractor
7.0	Temporary propping sequence	M	The temporary propping arrangement and sequence, temporary prop stiffness and prop pre load are to be as per the design calculations, if the sequence, propping stiffness or pre load is changed in anyway A-squared must be contacted immediately and these calculations revised (if required)	L	Action Engineer / Main Contractor
8.0	Over-dig during construction of basement	M	Control to be in place when digging down to formation level. 0.1m accidental over-dig is considered in design. Therefore a controlled excavation must take place.	L	Action Main Contractor
9.0	Pile wall deflections	M	The deflections quoted in this design report are best estimate predictions of pile wall deflection and must not be considered a "red trigger level". The pile wall should be monitored for deflection along its length to confirm deflection predictions are not exceeded	L	Action Engineer / Main Contractor
10.0	Obstructions	M	The piling contractor should be aware of obstructions within the backfill material, such as cobbles of concrete etc.	L	Action Piling Contractor
11.0	Axial Pile Loads	M	The axial loading used when determining the pile lengths is an interpretation of the loads provided by AKT II. These loads need to be confirmed.	L	Action Engineer
12.0	Installing Inclinometers	M	Piling contractor is to review the methodology of installing inclinometers in CFA piles.	L	Action Engineer
13.0	Pile Layout Drawing	M	Pile Layout Drawing has not been provided for 900mm diameter retaining wall scheme with a spacing of 1400mm c/c. A2 to provide revised layout drawing.	L	Action Engineer
14.0	Surcharge type B	M	For wall sections with type B surcharge it has been assumed that this surcharge is applied at a level of +22.25mOD (the top of the Lynch Hill Gravels). This needs to be confirmed by AKT II .	L	Action Engineer
15.0	Concrete class	M	No concrete class has been recommended in the relevant design documents or ground investigation report. No SO4 data has been provided. Therefore, a concrete class of DS-2 is recommended.	L	Action Engineer
16.0	Contiguous Wall Surcharge	M	The contiguous wall surcharge of 20kPa has been applied 2.0m from the rear of the wall, therefore there should be a 2.0m exclusion zone on site from the rear of the wall.	L	Action Engineer

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix B: Ground Investigation Data

CALCULATION SHEET



A-squared Studio

One Westminster
Bridge Road
London
SE1 7XW

Tel: +44 (0)20 7620 2868
e-mail: contact@a2-studio.com
<http://a2-studio.com/>

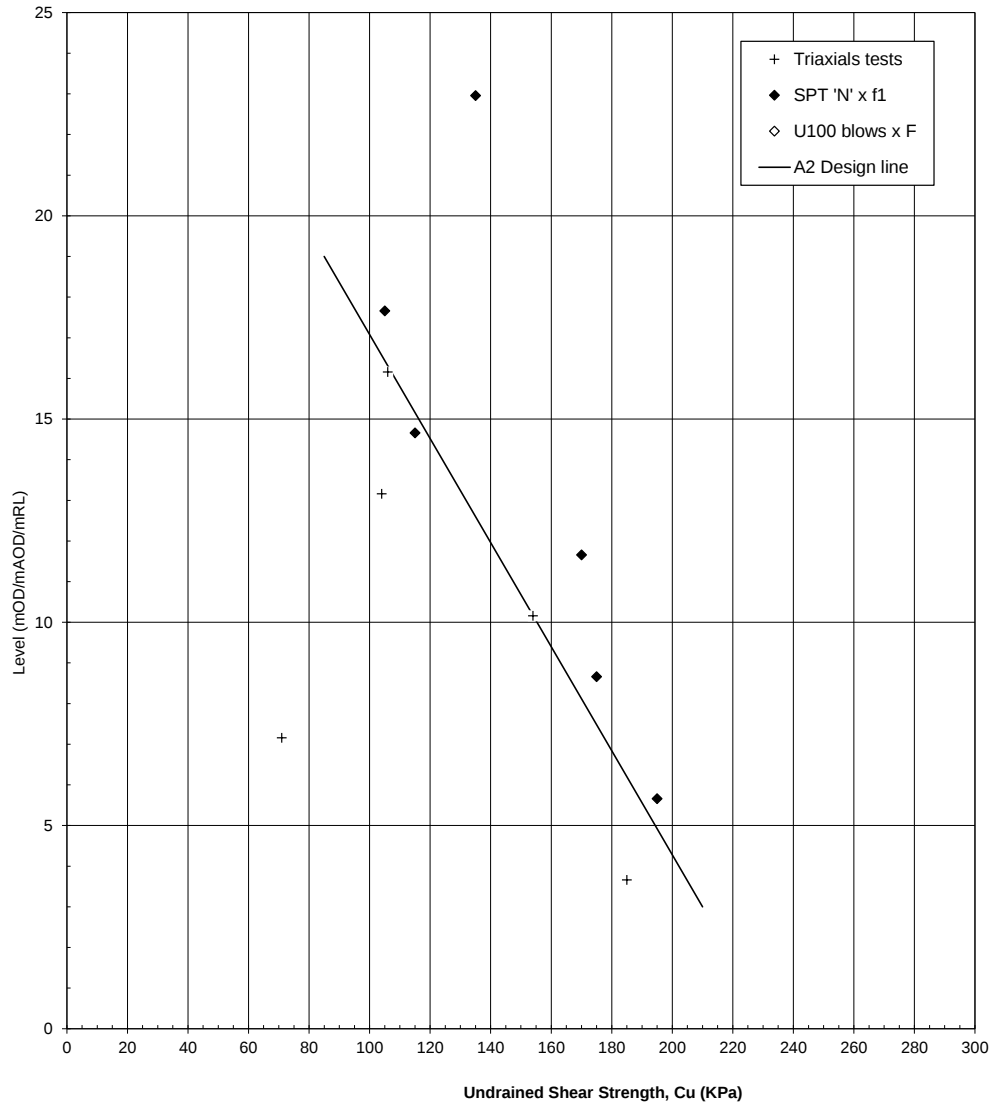
Sheet No. _____ of _____
Enq. _____ Con. No. **2176**
Calculated by : ASK Date : **02/02/2022**
Checked by : JRM Date : **02-Feb-22**

247 Tottenham Court Road,

Geological Section

Cu .vs. SPT N relationship : $f_1 = 5.00$
Cu .vs. U100 blows relationship : $F = 2.25$

Graph of Level .vs. All Shear Strength Data in Clay Soils



CALCULATION SHEET



A-squared Studio

One Westminster
Bridge Road
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SE1 7XW

Tel: +44 (0)20 7620 2868

e-mail: contact@a2-studio.com
<http://a2-studio.com/>

Sheet No.

of

Enq.

Con. No.

2176

Calculated by: ASK

Date :

02/02/2022

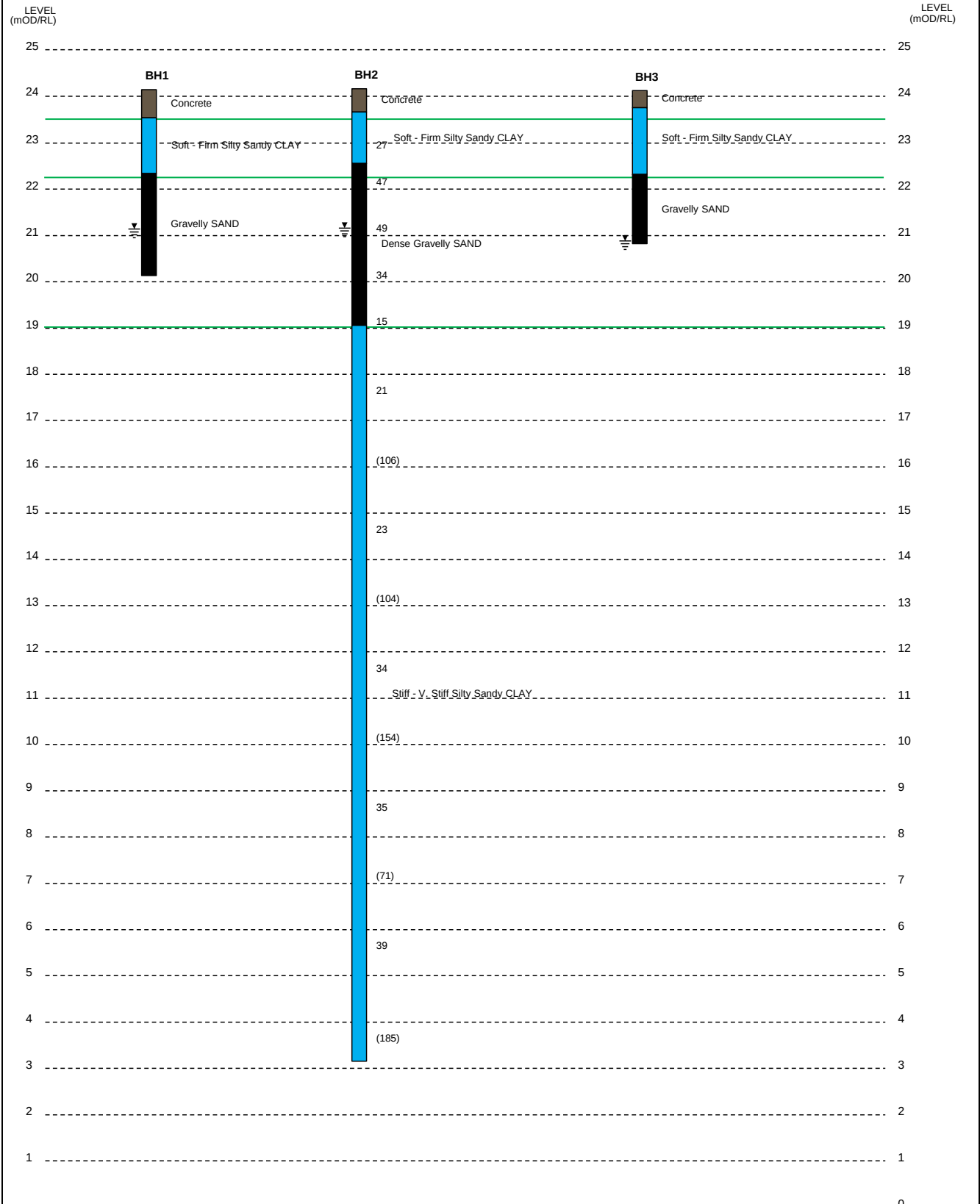
Checked by: JRM

Date :

02/02/2022

247 Tottenham Court Road,

Geological Section



CALCULATION SHEET



A-squared Studio

One Westminster
Bridge Road
London
SE1 7XW

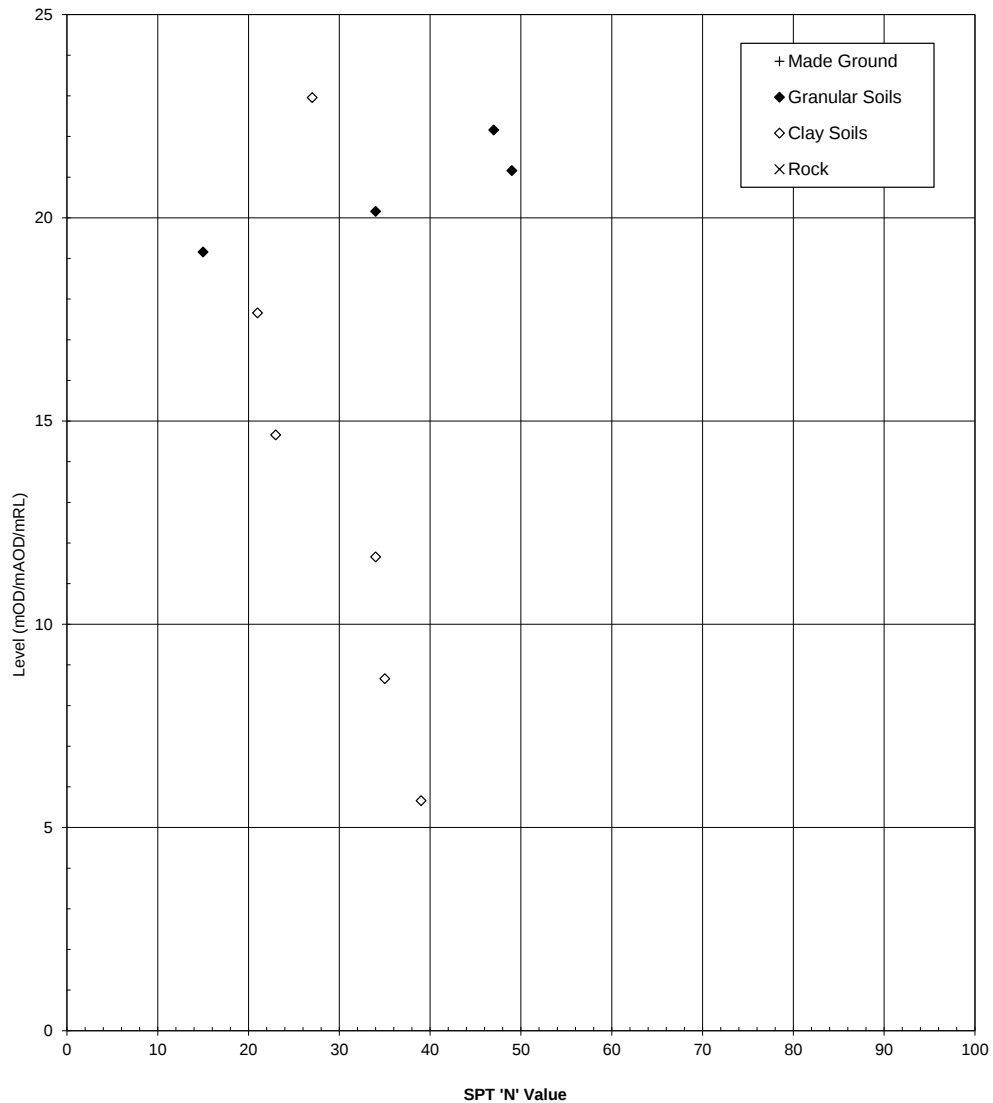
Tel: +44 (0)20 7620 2868
e-mail: contact@a2-studio.com
<http://a2-studio.com/>

Sheet No. _____ of _____
Enq. _____ Con. No. **2176**
Calculated by : ASK Date : **02/02/2022**
Checked by : JRM Date : **02-Feb-22**

247 Tottenham Court Road,

Geological Section

Graph of Level .vs. SPT 'N' in All Soils



	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix C: Design Plan and Sections

- NOTES
- DO NOT SCALE FROM THIS DRAWING.
 - ALL DIMENSIONS IN mm UNO.
 - FOR GENERAL NOTES, SEE DRAWINGS 4190-AKT-XX-DR-S-0001 TO 00008. FOR MOVEMENTS AND TOLERANCES, SEE DRAWINGS 4190-AKT-XX-XX-DR-S-00010 TO 00014. FOR BEAM AND COLUMN SCHEDULES SEE DRAWING 4190-AKT-ZZ-XX-DR-S-00300
 - ALL DIMENSIONS RELATING TO EXISTING & ADJACENT STRUCTURES, PARTY WALLS ARE BASED ON ARCHIVE INFORMATION OR LIMITED SURVEY INFORMATION AND ARE THEREFORE SUBJECT TO CONFIRMATION ON SITE.
 - CONCRETE GRADE – C35/45 UNO.
 - ALL STEELWORK GRADE S355 UNO.
 - FOR GENERAL NOTES ON SITE WIDE HEALTH AND SAFETY INFORMATION REFER TO DRAWING 4190-AKT-XX-XX-DR-S-00005 SECTION 18.
 - REFER TO LIFT TRADE CONTRACTOR DRAWINGS FOR ALL LIFT BUILDERS WORKS, INCLUDING HOLES FOR MONITOR BUTTONS, CAST-IN FIXINGS, LIFTING EYES ETC.
 - ALL PRECAST ELEMENTS TO BE DESIGNED BY OTHERS. REFERENCES SHOULD BE MADE TO THE ARCHITECT'S INFORMATION REGARDING PRECAST STAIRS.
 - FIRE RATING FOR STRUCTURAL ELEMENTS 60 MINUTES AND 120 MINUTES FOR FIREFIGHTING STAIR AND LIFT ENCLOSURE U.N.O. REFERENCE SHOULD BE MADE TO JGA'S FIRE ENGINEERING REPORT: BL5251/nh/11plp 03/11/17
 - WATERPROOFING TO ARCHITECT'S DETAILS.

PILE DESIGN TO BE COMPLETED BY CONTRACTOR TO MINIMISE EMBEDMENT DEPTH. PILE DESIGN TO BE SUBMITTED TO ENGINEER FOR REVIEW OF COMPLIANCE WITH OVERALL SUBSTRUCTURE DESIGN PHILOSOPHY AND GROUND MOVEMENT ANALYSES

ALL SURCHARGES TO BE VERIFIED BY CONTRACTOR AS NECESSARY

FOR RETAINING WALL PILE PERFORMANCE CRITERIA REFER TO DRAWING No. 4190-AKT-XX-XX-DR-S-00012

CONTRACTOR TO PROVIDE AS BUILT SURVEY OF SECANT PILED WALL, LINER WALL, SHEET PILED AND RETAINING WALLS UPON COMPLETION. ALL OUT OF TOLERANCE PILES TO BE REPORTED TO THE CA.

ALL CONCRETE ELEMENTS IN CONTACT WITH WATER / GROUND, TYPICALLY RAFT SLABS, PITS, RETAINING WALLS, AND CAPPING BEAMS, ARE TO BE FORMED IN WATERTIGHT CONSTRUCTION. THE CONTRACTOR IS TO SPECIFY, DETAIL AND COORDINATE THE USE OF CONCRETE ADDITIVES, WATER BARS ETC. TO ACHIEVE THIS.

PRESENCE / EXTENT OF ANY EXISTING BASEMENTS TO ADJACENT PROPERTIES TBC VIA SITE SURVEY

SECANT PILED WALL DESIGN REQUIREMENTS:

- THE PILE DESIGNER IS RESPONSIBLE FOR DETERMINING THE RETAINED LOADS AS PART OF THE RETAINING WALL DESIGN. A MINIMUM VARIABLE SURCHARGE LOADING OF 25kN/m² SHOULD BE TAKEN.
- INTERNAL FORCES AT THE PILE HEAD DUE TO RETAINED LOADS ARE NOT SHOWN AS THESE SHOULD BE DETERMINED AS PART OF THE SECANT PILED WALL DESIGN REFLECTING THE LEVELS OF TEMPORARY AND PERMANENT PROPPING.
- THE SECANT PILED WALL IS TO BE DESIGNED FOR BOTH TEMPORARY AND PERMANENT CONDITIONS WITH A DESIGN LIFE OF 120 YEARS AS REQUIRED FOR STRUCTURES SUPPORTING HIGHWAYS

T 6	14.03.22	PILE DIAMETER, SETTING OUT, LOADING AND NOTES REVISED	DT	SP
T 5	14.01.22	REVISED AS CLOUDED	DT	SP
T 4	22.09.21	PILE CENTRELINE SETTING OUT ADDED	DT	SP
T 3	30.07.21	ISSUED FOR STAGE 4A	DT	SP
T 2	07.06.21	ISSUED FOR STAGE 3	DT	SP
T 1	30.06.21	ISSUED FOR STAGE 3 + SUBMISSION	YG	SP

REV	DATE	DESCRIPTION	BY	CHECKED

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CLIENT

THE FITZROVIA

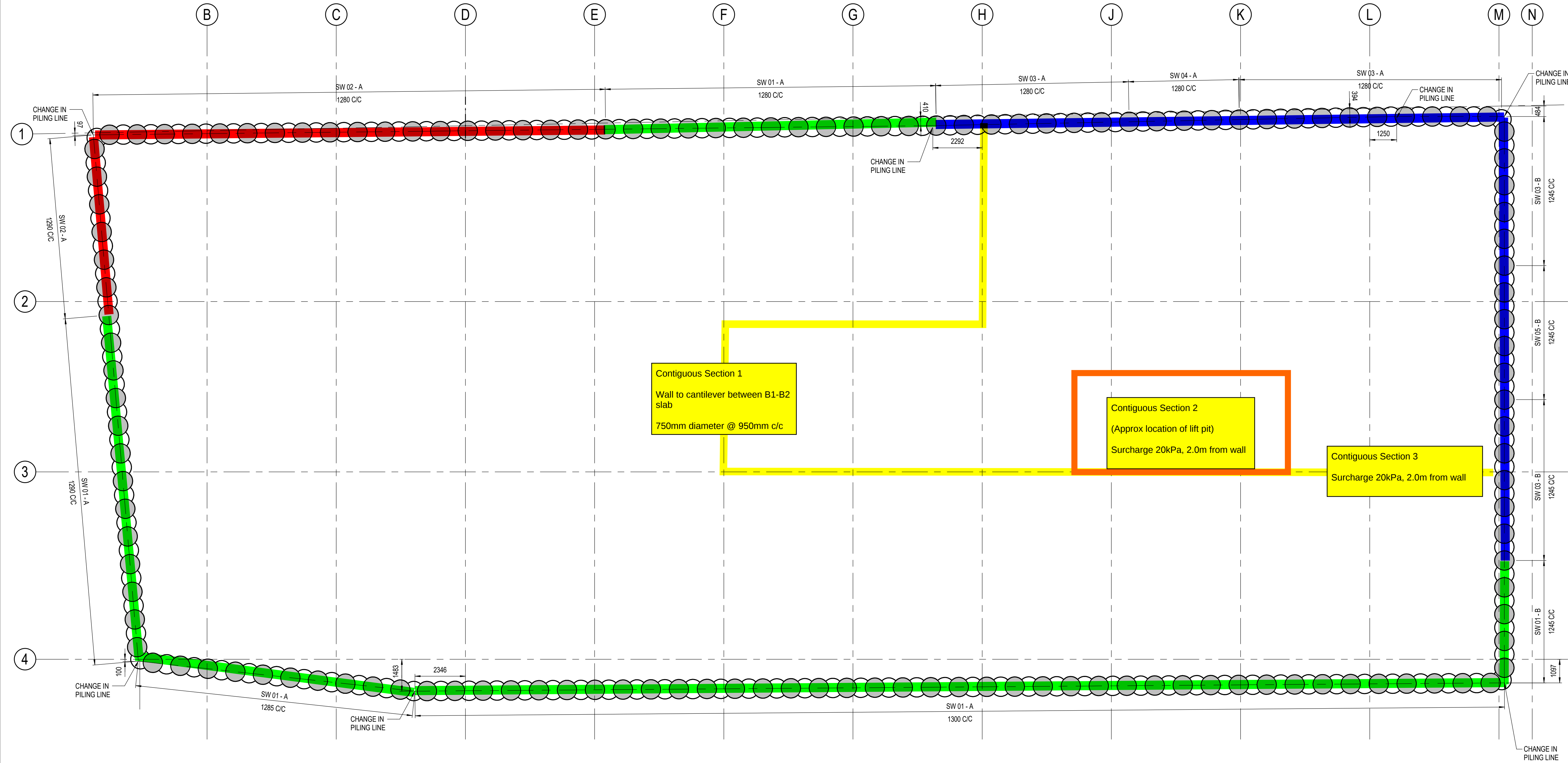
PROJECT

PIILING LAYOUT

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PROJECT No.	PROJECT STAGE	SATISFACTORY CODE	SCALE

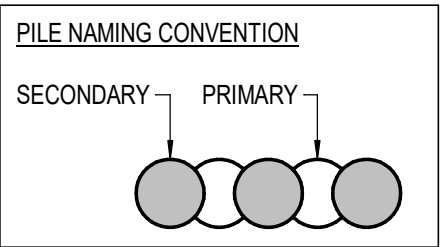
4190 AKT ZZ B2 DR S 20950 T6	PROJECT ID	ORIGINATOR	ZONE	LEVEL	TYPE	ROLE	DRAWING No.	REVISION
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STAGE 4



SURCHARGE LOADS				
TYPE	UNIFORM		LINE	
	G (kN/m2)	Q (kN/m2)	G (kN/m)	Q (kN/m)
A	-	25	-	-
B	35	7.5	485	111

REFER TO SKETCH 4190-S-HSK-078 FOR ADDITIONAL INFORMATION RELATING TO LOADING FROM NEIGHBOURING STRUCTURES (TYPE B). HEIGHT OF APPLIED LOAD TO MATCH NEIGHBOURING BASEMENT FFL



PILE REF	PILE CUT OFF LEVEL	SECONDARY PILE LENGTH - CUT OFF LEVEL TO TOE LEVEL	SECONDARY PILE TOE LEVEL	PRIMARY PILE LENGTH - CUT OFF LEVEL TO TOE LEVEL	PRIMARY PILE TOE LEVEL	DIAMETER	UNFACTORED LOADS AT PILE HEAD - PERMANENT WORKS ONLY		
							VERTICAL (AXIAL) +VE COMPRESSION & -VE TENSION		
							PERMANENT LOAD	IMPOSED LOAD	TOTAL LOAD
	[mOD]	[m]	[mOD]	[m]	[mOD]	[mm]	[kN/pile]	[kN/pile]	[kN/pile]
SW 01	25.375	12.375	13.000	9.375	16.000	900	+425	+50	+475
SW 02	25.375	13.375	12.000	9.375	16.000	900	+515	+60	+575
SW 03	25.375	16.375	9.000	10.375	15.000	900	+770	+90	+860
SW 04	24.375	15.375	9.000	9.375	15.000	900	+770	+90	+860
SW 05	24.375	15.275	9.000	9.275	15.000	900	+770	+90	+860

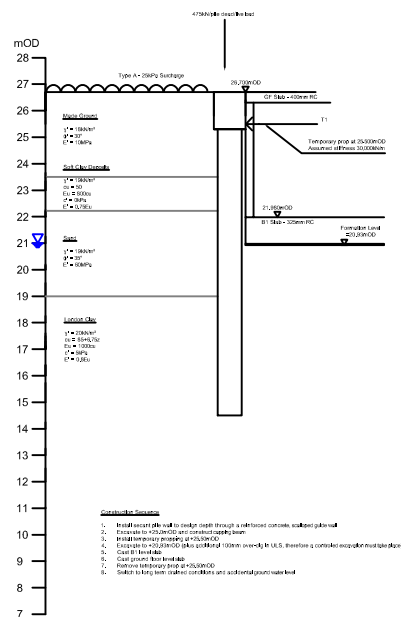
CUT OFF LEVELS FOR SW 04 AND SW 05 TBC FOLLOWING FINAL SETTING OUT BY UKPN AND LIFT MANUFACTURER

PILE SPACING, TOE DEPTHS AND PILING LEVEL TBC THROUGH DETAILED DESIGN AND COORDINATION WITH PILING CONTRACTOR. MINIMUM TOE DEPTH TO BE THE LOWER OF: 1m BELOW FORMATION LEVEL OR INTERLOCK INTO CLAY OF 2m. ALLOW FOR 5% ADDITIONAL NUMBER OF PILES

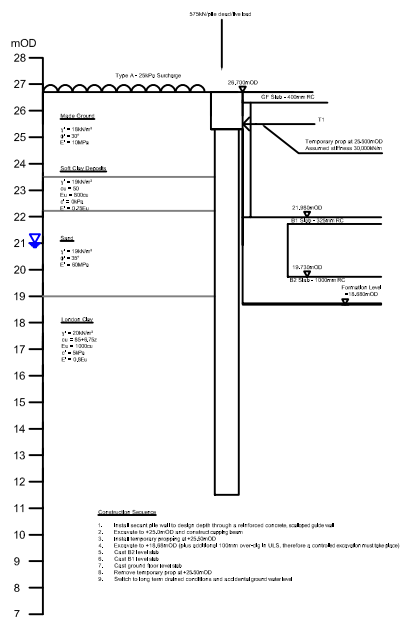
PILES TO BE DESIGNED TO FORM PART OF AN ASSISTED RAFT SCHEME, AS SUCH THE LOADS ON THE PILES WILL VARY DEPENDING ON THE ANTICIPATED STIFFNESS OF THE PILES AND SOME ITERATION IS LIKELY TO BE REQUIRED TO REACH THE FINAL LOAD VALUES

PILE TOE DEPTHS SHOWN ARE INDICATIVE FOR PRICING ONLY AND REFLECT THE MINIMUM REQUIREMENT FOR STABILITY. OVERALL PILE LENGTHS MAY NEED TO BE INCREASED TO GIVE THE REQUIRED LOAD CAPACITY

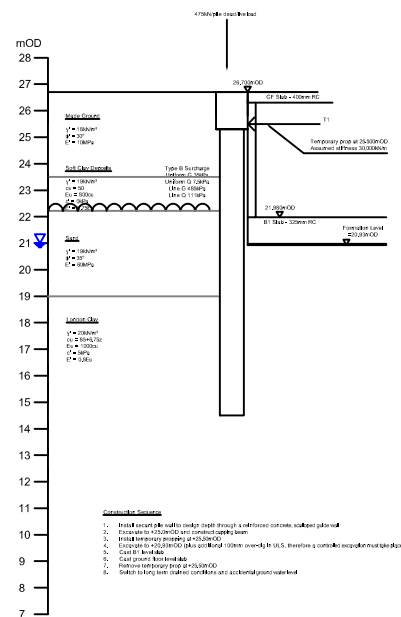
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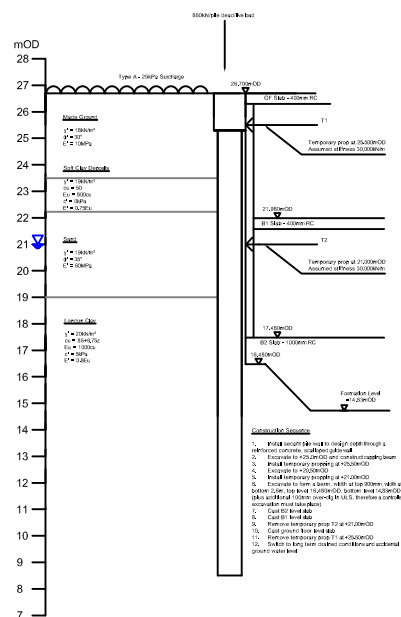
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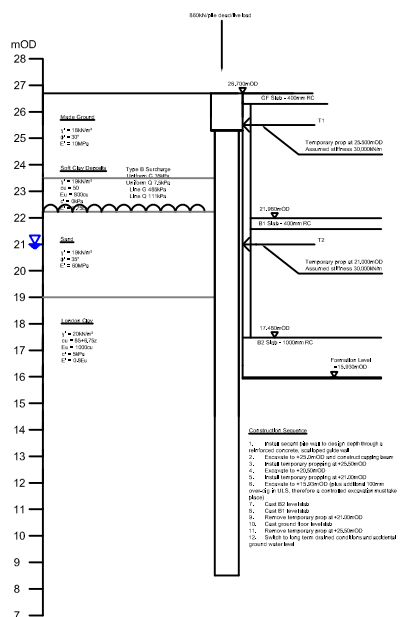
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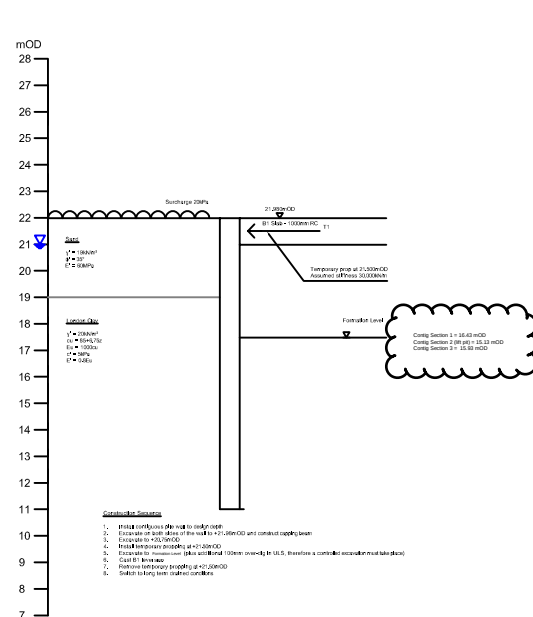
Design Section SW03 A and SW04 A



Design Section SW03 B and SW05 B



Design Section Contiguous Wall



	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix D: WALLAP (Input/Output)

2176 - TCR

Embedded Pile Retaining Wall
Summary of WALLAP Analyses

Design Section	Propped or Cantilever	Load Case	Pile dia (mm)	Spacing (mm)	PPL (mOD)	TOW (mOD)	Overdig (m)	Formation level (mOD)	Retained height (m)	Surcharge type	q (kPa)	Pile Toe level (mOD)	Reqd length of pile from PPL (m)	Emb	Ratio Emb / H	FOS	Mmax (kNm/m)	Vmax (kN/m)	dmax (mm)	Mk (kNm)	Vk (kN)	yL	Mdes per pile (kNm)	Vdes per pile (kN)	M/h3 (N/mm ³)	T1 (Capping Beam) (kN/m)	T2 (kN/m)	B2 (kN/m)	B1 (kN/m)	GF (kN/m)
SW01-A	Temp Propped at 1 No. levels with 30,000kN/m stiffness	DA1-C1	900	1300	26.375	26.700	0.10	20.83	5.87	A	25	18.375	8.00	2.46	0.42	-	250	124	-	325	161	1.35	439	218	0.60	113	-	-	127	113
		DA1-C2	900	1300	26.375	26.700	0.10	20.83	5.87	A	25	18.375	8.00	2.46	0.42	1.076	215	101	-	280	131	1.00	280	131	0.38	109	-	-	111	99
		SLS	900	1300	26.375	26.700	0.00	20.93	5.77	A	25	18.375	8.00	2.56	0.44	1.492	239	128	6	311	166	1.35	419	225	0.58	107	-	-	124	109
SW02-A	Temp Propped at 1 No. levels with 30,000kN/m stiffness	DA1-C1	900	1300	26.375	26.700	0.10	18.58	8.12	A	25	14.375	12.00	4.21	0.52	-	299	195	-	389	254	1.35	525	342	0.72	132	-	116	188	127
		DA1-C2	900	1300	26.375	26.700	0.10	18.58	8.12	A	25	14.375	12.00	4.21	0.52	1.625	262	180	-	341	234	1.00	341	234	0.47	125	-	170	133	112
		SLS	900	1300	26.375	26.700	0.00	18.68	8.02	A	25	14.375	12.00	4.31	0.54	2.335	297	193	8	386	251	1.35	521	339	0.72	130	-	114	187	126
SW03-A, SW04-A	Temp Propped at 2 No. levels with 30,000kN/m stiffness	DA1-C1	900	1300	26.375	26.700	0.10	14.73	11.97	A	25	12.375	14.00	2.36	0.20	-	407	314	-	529	408	1.35	714	551	0.98	118	157	279	409	99
		DA1-C2	900	1300	26.375	26.700	0.10	14.73	11.97	A	25	12.375	14.00	2.36	0.20	2.345	331	266	-	430	346	1.00	430	346	0.59	107	151	296	327	88
		SLS	900	1300	26.375	26.700	0.00	14.83	11.87	A	25	12.375	14.00	2.46	0.21	3.406	398	315	11	517	410	1.35	698	553	0.96	116	150	272	404	98
SW01-B	Temp Propped at 1 No. levels with 30,000kN/m stiffness	DA1-C1	900	1300	26.375	26.700	0.10	20.83	5.87	B	485+111 35+7.5	15.875	10.50	4.96	0.84	-	286	115	-	372	150	1.35	502	202	0.69	120	-	-	145	114
		DA1-C2	900	1300	26.375	26.700	0.10	20.83	5.87	B	485+111 35+7.5	15.875	10.50	4.96	0.84	1.023	397	133	-	516	173	1.00	516	173	0.71	138	-	-	139	114
		SLS	900	1300	26.375	26.700	0.00	20.93	5.77	B	485+111 35+7.5	15.875	10.50	5.06	0.88	1.458	276	111	7	359	144	1.35	484	195	0.66	117	-	-	137	112
SW03-B, SW05-B	Temp Propped at 2 No. levels with 30,000kN/m stiffness	DA1-C1	900	1300	26.375	26.700	0.10	15.83	10.87	B	485+111 35+7.5	10.375	16.00	5.46	0.50	-	407	314	-	529	408	1.35	714	551	0.98	118	157	279	409	99
		DA1-C2	900	1300	26.375	26.700	0.10	15.83	10.87	B	485+111 35+7.5	10.375	16.00	5.46	0.50	1.580	981	443	-	1275	576	1.00	1275	576	1.75	124	485	517	470	124
		SLS	900	1300	26.375	26.700	0.00	15.93	10.77	B	485+111 35+7.5	10.375	16.00	5.56	0.52	2.251	690	468	18	897	608	1.35	1211	821	1.66	136	269	504	460	118
CONTIGUOUS 1 (B1 - B2) Propped	Temp Propped at 1 No. levels with 30,000kN/m stiffness	DA1-C1	750	950	26.375	21.980	0.10	16.33	5.65	20kPa, 0.5m from wall	20	11.375	15.00	4.96	0.88	-	186	88	-	177	84	1.35	239	113	0.57	59	-	-	74	-
		DA1-C2	750	950	26.375	21.980	0.10	16.33	5.65	20kPa, 0.5m from wall	20	11.375	15.00	4.96	0.88	1.096	259	92	-	246	87	1.00	246	87	0.58	49	-	-	92	-
		SLS	750	950	26.375	21.980	0.00	16.43	5.55	20kPa, 0.5m from wall	20	11.375	15.00	5.06	0.91	1.398	166	82	5	158	78	1.35	213	105	0.50	52	-	-	67	-
CONTIGUOUS 2 (B1 - B2) Propped	Temp Propped at 1 No. levels with 30,000kN/m stiffness	DA1-C1	750	950	26.375	21.980	0.10	15.03	6.95	20kPa, 2.0m from wall	20	9.375	17.00	5.66	0.81	-	337	123	-	320	117	1.35	432	158	1.02	67	-	-	101	-
		DA1-C2	750	950	26.375	21.980	0.10	15.03	6.95	20kPa, 2.0m from wall	20	9.375	17.00	5.66	0.81	1.014	507	133	-	482	126	1.00	482	126	1.14	55	-	-	133	-
		SLS	750	950	26.375	21.980	0.00	15.13	6.85	20kPa, 2.0m from wall	20	9.375	17.00	5.76	0.84	1.289	328	120	9	312	114	1.35	421	154	1.00	66	-	-	98	-

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types
		Left side Right side
1	26.70	1 MG 1 MG
2	23.50	5 Alluvium Dr 5 Alluvium Dr
3	22.25	3 SAND 3 SAND
4	19.00	4 LC UnDr 4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil		Wall	Back-	Soil		Wall	Back-
friction angle		adhesion coeff.	fill angle	friction angle		adhesion coeff.	fill angle
No. Description							
1 MG		30.00	0.500	0.00	30.00		0.500
2 Alluvium UnDr		0.00	0.500	0.00	0.00		0.500
3 SAND		35.00	0.500	0.00	35.00		0.500
4 LC UnDr		0.00	0.500	0.00	0.00		0.500
5 Alluvium Dr		24.00	0.500	0.00	24.00		0.500
6 LC Dr		25.00	0.500	0.00	25.00		0.500
7 CONCRETE		40.00	0.000	0.00	40.00		0.000
8 LC UnDr		0.00	0.500	0.00	0.00		0.500

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	15.83	15.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	15.93	15.93	0.0 MC+WC
					2	15.93	26.20	100.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 10.37
Maximum finite element length = 1.00 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.75	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	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/m2		Equiv. soil type	Partial factor/ Category
1	26.66	0.50(L)	50.00	25.00	Near edge	25.00 =	N/A	1.30 Var
2	15.93	-0.00(R)	50.00	25.00	Far edge	100.00 =	N/A	1.00 P/U
3	22.25	1.00(L)	40.00	1.00	Near edge	485.00 =	N/A	1.00 P/U
4	22.25	1.00(L)	40.00	1.00	Far edge	111.00 =	N/A	1.30 Var
5	22.25	0.50(L)	40.00	20.00	Near edge	35.00 =	N/A	1.00 P/U
6	22.25	0.50(L)	40.00	20.00	Far edge	7.50 =	N/A	1.30 Var

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	Change EI of wall to 450887 kN.m ² /m run Reset wall displacements to zero at this stage
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Worst Cred.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.50 on RIGHT side
10	Install strut or anchor no.5 at elevation 21.00
11	Excavate to elevation 15.93 on RIGHT side
12	Excavate to elevation 15.83 on RIGHT side
13	Fill to elevation 15.93 on RIGHT side with soil type 1
14	Fill to elevation 17.48 on RIGHT side with soil type 7
15	Install strut or anchor no.4 at elevation 17.00
16	Install strut or anchor no.3 at elevation 21.75
17	Remove strut or anchor no.5 at elevation 21.00
18	Install strut or anchor no.2 at elevation 26.50
19	Remove strut or anchor no.1 at elevation 25.50
20	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
21	Apply surcharge no.2 at elevation 15.93
22	Apply water pressure profile no.2 (Worst Cred.)
23	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 16.33 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 200.00 m

Width of excavation on Left side of wall = 24.00 m

Width of excavation on Right side of wall = 24.00 m

Distance to rigid boundary on Left side = 24.00 m

Distance to rigid boundary on Right side = 24.00 m

OUTPUT OPTIONS

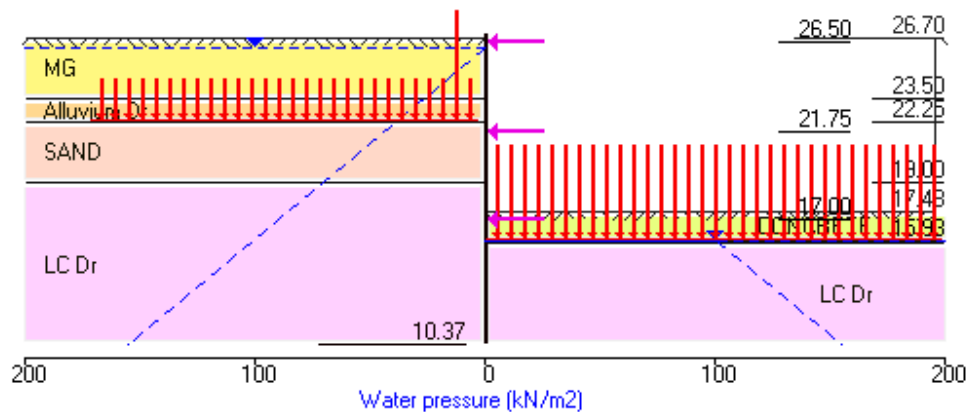
Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
10	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
11	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
12	Excav. to elev. 15.83 on RIGHT side	Yes	Yes	Yes
13	Fill to elev. 15.93 on RIGHT side	Yes	Yes	Yes
14	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
15	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
16	Install prop no.3 at elev. 21.75	Yes	Yes	Yes
17	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
18	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
19	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
20	Change soil type 4 to soil type 6	Yes	Yes	Yes
21	Apply surcharge no.2 at elev. 15.93	Yes	Yes	Yes
22	Apply water pressure profile no.2	Yes	Yes	Yes
23	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
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Stage No.23 Change EI of wall to 322062kN.m2/m run



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Sheet No.
 Job No. 2176
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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

Overall								
				FoS for toe		Toe elev. for		
Stage	Ground	level	Prop	elev. =	10.37	FoS =	1.000	
<u>No.</u>	<u>Act.</u>	<u>Pass.</u>	<u>Elev.</u>	<u>Factor</u>	<u>Moment</u>	<u>Toe</u>	<u>Wall</u>	<u>Direction</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	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
5	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
6	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
7	26.70	25.00	Cant.	2.087	10.92	23.18	1.82	L to R
8	26.70	25.00		No analysis at this stage				
9	26.70	20.50	25.50	1.580	n/a	16.06	4.44	L to R
10	26.70	20.50		No analysis at this stage				

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

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 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 200.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 24.00 from wall
 Right side 24.00 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	26.70	0.005	-0.001	0.0	-0.0	0.0	0.0
2	26.50	0.005	-0.000	0.1	-0.0	1.2	-96.0
3	26.20	0.006	-0.000	0.8	-28.4	6.5	-90.8
4	25.50	0.007	0.000	12.0	-85.1	19.6	-118.7
5	25.00	0.010	0.000	5.7	-121.0	9.5	-114.0
6	24.25	0.014	0.000	15.4	-164.4	12.3	-103.8
7	23.50	0.018	0.000	23.6	-210.0	9.6	-89.9
8	22.88	0.021	0.000	25.4	-260.0	30.0	-72.0
9	22.25	0.025	0.000	16.2	-298.5	67.5	-50.8
10	21.75	0.027	0.000	0.2	-320.3	97.9	-394.0
11	21.00	0.030	0.000	0.0	-432.2	44.0	-442.2
12	20.50	0.032	0.000	0.0	-591.6	48.8	-399.6
13	19.75	0.035	0.000	0.0	-785.9	103.5	-322.4
14	19.00	0.036	0.000	0.0	-918.9	122.3	-236.1
15	18.24	0.037	0.000	0.0	-973.8	159.5	-85.1
16	17.48	0.036	0.000	20.7	-980.8	331.6	0.0
17	17.00	0.035	0.000	72.8	-925.8	400.4	-120.7
18	16.46	0.034	0.000	111.8	-817.8	254.5	-40.0
19	15.93	0.033	0.000	136.7	-660.6	349.9	0.0
20	15.83	0.033	0.000	138.9	-626.4	366.7	0.0
21	14.92	0.031	0.000	132.6	-352.9	322.5	-17.6
22	14.00	0.028	0.000	103.8	-274.9	242.7	-33.9
23	13.00	0.024	0.000	142.1	-176.5	124.8	-36.2
24	12.00	0.019	0.000	184.3	-90.1	73.7	-29.7
25	11.18	0.016	0.000	134.9	-20.4	33.2	-142.8
26	10.37	0.012	0.000	0.0	-0.0	0.0	0.0

Run ID. 2176_TCR_SW03-B_900_ULS2
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
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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>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	17.48	-0.0	14.00	0.0	26.70	0.0	26.70
2	11.6	13.00	-75.0	19.00	26.9	17.00	-28.3	21.00
3	16.1	13.00	-99.2	19.00	35.6	17.00	-36.9	21.00
4	16.3	13.00	-114.1	19.00	39.2	17.00	-42.1	21.00
5	16.4	13.00	-118.3	19.00	40.3	17.00	-43.6	21.00
6	17.5	13.00	-124.3	19.00	41.8	17.00	-47.2	21.00
7	25.4	22.88	-106.1	19.00	37.4	17.00	-51.7	21.00
8	No calculation at this stage							
9	138.9	15.83	-333.0	21.00	130.9	18.24	-118.7	25.50
10	No calculation at this stage							
11	184.3	12.00	-943.7	18.24	346.9	15.93	-427.4	21.00
12	169.5	12.00	-973.1	17.48	350.8	15.83	-440.6	21.00
13	169.7	12.00	-973.4	17.48	351.6	15.83	-440.7	21.00
14	174.6	12.00	-980.8	17.48	366.7	15.83	-442.2	21.00
15	No calculation at this stage							
16	No calculation at this stage							
17	170.7	12.00	-962.5	18.24	324.6	15.83	-381.0	21.75
18	No calculation at this stage							
19	170.7	12.00	-958.3	18.24	325.2	15.83	-387.1	21.75
20	0.1	26.50	-712.3	19.00	352.4	17.00	-304.4	21.75
21	0.1	26.50	-726.4	19.00	343.3	17.00	-310.2	21.75
22	0.1	26.50	-796.8	19.00	400.4	17.00	-394.0	21.75
23	0.1	26.50	-673.5	19.00	395.7	17.00	-370.4	21.75

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	14.00	0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.002	18.24	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.003	18.24	-0.000	26.70	Apply surcharge no.4 at elev. 22.25
4	0.004	18.24	-0.000	26.70	Apply surcharge no.5 at elev. 22.25
5	0.004	18.24	-0.000	26.70	Apply surcharge no.6 at elev. 22.25
6	0.004	18.24	-0.000	26.70	Apply water pressure profile no.1
7	0.005	19.00	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.012	21.00	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
10	No calculation at this stage				Install prop no.5 at elev. 21.00
11	0.035	18.24	-0.000	26.70	Excav. to elev. 15.93 on RIGHT side
12	0.036	18.24	-0.000	26.70	Excav. to elev. 15.83 on RIGHT side
13	0.036	18.24	-0.000	26.70	Fill to elev. 15.93 on RIGHT side
14	0.036	18.24	-0.000	26.70	Fill to elev. 17.48 on RIGHT side
15	No calculation at this stage				Install prop no.4 at elev. 17.00
16	No calculation at this stage				Install prop no.3 at elev. 21.75
17	0.037	18.24	-0.001	26.70	Remove prop no.5 at elev. 21.00
18	No calculation at this stage				Install prop no.2 at elev. 26.50
19	0.037	18.24	-0.001	26.70	Remove prop no.1 at elev. 25.50
20	0.036	18.24	-0.001	26.70	Change soil type 4 to soil type 6
21	0.036	18.24	-0.001	26.70	Apply surcharge no.2 at elev. 15.93
22	0.036	18.24	-0.001	26.70	Apply water pressure profile no.2
23	0.037	18.24	-0.001	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW03-B_900_ULS2
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

| Sheet No.
 | Date:27-05-2022
Checked :

Summary of results (continued)

Prop forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 25.50		--- Strut no. 2 --- at elev. 26.50		--- Strut no. 3 --- at elev. 21.75	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
9	123.46	123.46	---	---	---	---
11	103.37	103.37	---	---	---	---
12	100.65	100.65	---	---	---	---
13	100.71	100.71	---	---	---	---
14	102.08	102.08	---	---	---	---
17	99.53	99.53	---	---	385.49	385.49
19	---	---	72.52	72.52	417.73	417.73
20	---	---	84.79	84.79	325.00	325.00
21	---	---	83.97	83.97	331.50	331.50
22	---	---	97.07	97.07	469.50	469.50
23	---	---	75.97	75.97	468.29	468.29

Run ID. 2176_TCR_SW03-B_900_ULS2
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

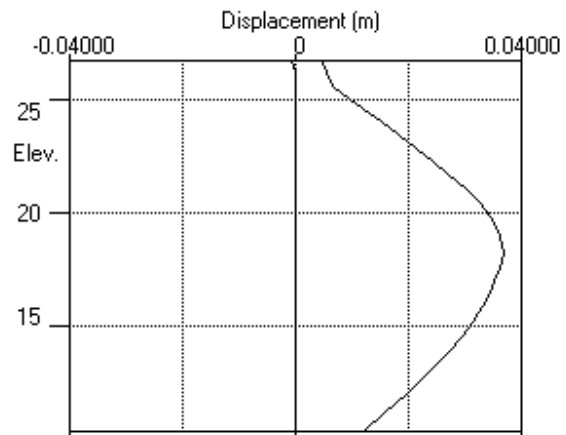
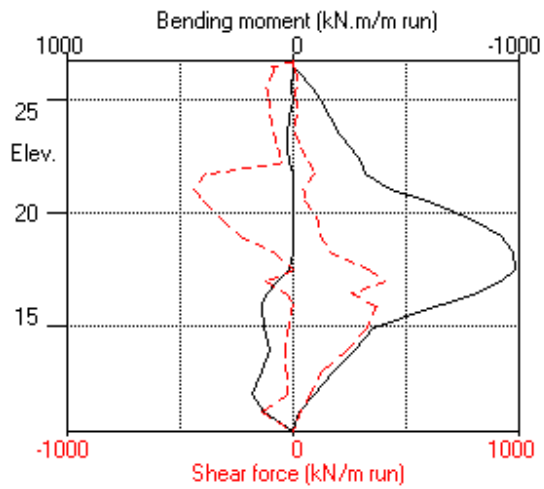
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Stage no.	--- Strut no. 4 --- at elev. 17.00		--- Strut no. 5 --- at elev. 21.00	
	kN/m run	kN/prop	kN/m run	kN/prop
11	---	---	467.97	467.97
12	---	---	484.60	484.60
13	---	---	484.60	484.60
14	---	---	484.58	484.58
17	105.39	105.39	---	---
19	100.79	100.79	---	---
20	451.92	451.92	---	---
21	421.42	421.42	---	---
22	484.32	484.32	---	---
23	516.38	516.38	---	---

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

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	MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2	Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3	SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5	Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6	LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7	CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

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	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Left side					Right side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	16.33	16.33	0.0	1	16.33	16.33	0.0	

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.016348 m4/m run
 E.I = 457744 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.98	0.50(L)	50.00	50.00	20.00	=	N/A	1.00 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	=	N/A	1.00 P/U

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	Change EI of wall to 320441 kN.m2/m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 16.43 on RIGHT side
7	Install strut or anchor no.2 at elevation 21.78
8	Remove strut or anchor no.1 at elevation 21.50
9	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
10	Change EI of wall to 228886 kN.m2/m run Allow wall to relax with new modulus value

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) = 10.63 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
 Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
 Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

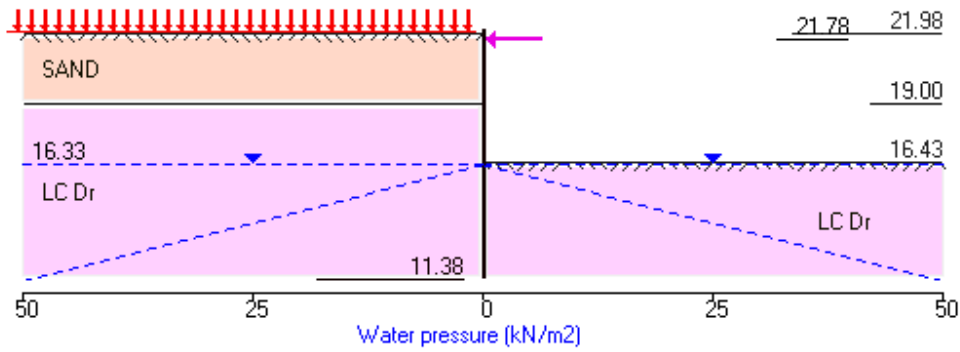
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 320441kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 16.43 on RIGHT side	Yes	Yes	Yes
7	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
8	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
9	Change soil type 4 to soil type 6	Yes	Yes	Yes
10	Change EI of wall to 228886kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Tottenham Court Road
CONTIG 1, 750mm Contig PROPPED

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Stage No.10 Change EI of wall to 228886kN.m²/m run



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 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

Stage No.	Ground Act.	level Pass.	Prop Elev.	FoS for toe elev. = 11.38		Toe elev. for FoS = 1.000		Direction of failure
				Factor of Safety	Moment at elev. of equilib.	Toe elev.	Wall Penetr- -ation	
				Conditions not suitable for FoS calc.				
1	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
2	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
3	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
4	21.98	20.75	Cant.	8.055	12.27	20.06	0.69	L to R
5	21.98	20.75		No analysis at this stage				
6	21.98	16.43	21.50	4.291	n/a	16.22	0.21	L to R
7	21.98	16.43		No analysis at this stage				
8	21.98	16.43	21.78	4.266	n/a	16.21	0.22	L to R
9	21.98	16.43	21.78	1.398	n/a	14.14	2.29	L to R
10	21.98	16.43	21.78	1.398	n/a	14.14	2.29	L to R

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 Tottenham Court Road
 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	0.000	0	-0	0	-0	0	0	0	0
2	21.78	0.002	0.000	0	-0	0	-0	0	-50	0	-67
3	21.50	0.003	0.000	0	-14	0	-19	1	-49	1	-66
4	21.00	0.003	0.000	1	-38	1	-51	3	-47	4	-63
5	20.75	0.003	0.000	2	-49	3	-67	5	-45	6	-61
6	20.28	0.004	0.000	5	-69	7	-94	5	-41	7	-55
7	19.80	0.004	0.000	7	-88	9	-118	2	-35	3	-47
8	19.40	0.005	0.000	7	-100	9	-136	0	-29	0	-40
9	19.00	0.005	0.000	6	-111	9	-150	0	-23	0	-31
10	18.50	0.005	0.000	5	-120	7	-162	0	-12	0	-17
11	18.00	0.005	0.000	3	-123	5	-166	8	-3	11	-4
12	17.40	0.005	0.000	2	-114	3	-154	23	-2	31	-3
13	16.92	0.005	0.000	1	-102	1	-138	39	-2	53	-2
14	16.43	0.005	0.000	0	-82	1	-110	61	-1	82	-1
15	16.33	0.005	0.000	0	-76	0	-103	56	-1	76	-1
16	15.96	0.004	0.000	2	-57	2	-77	56	-1	75	-1
17	15.60	0.004	0.000	14	-37	19	-50	53	-0	72	-1
18	15.00	0.004	0.000	24	-9	33	-13	43	-0	58	-0
19	14.40	0.003	0.000	26	-1	36	-2	30	-2	41	-2
20	13.80	0.003	0.000	31	-1	43	-1	13	-9	17	-12
21	13.20	0.002	0.000	32	-0	43	-0	0	-12	1	-16
22	12.60	0.002	0.000	22	-0	30	-0	0	-20	0	-27
23	12.00	0.001	0.000	9	-0	12	-0	0	-20	0	-27
24	11.69	0.001	-0.000	3	0	5	0	0	-15	0	-20
25	11.38	0.001	-0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_CONTIG 1_SLS
Tottenham Court Road
CONTIG 1, 750mm Contig PROPPED

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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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	18.00	-0	15.60	0	-0	0	21.50
2	0	11.69	-6	18.00	0	-8	2	19.00
3	0	11.69	-6	18.00	0	-8	2	19.00
4	7	19.40	-0	15.00	9	-0	5	18.50
5	No calculation at this stage							
6	24	14.40	-73	18.50	33	-99	60	21.50
7	No calculation at this stage							
8	26	14.40	-75	18.50	36	-101	61	21.78
9	27	13.20	-123	18.00	37	-166	54	21.78
10	32	13.20	-118	18.00	43	-159	56	21.78

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	15.96	-0.000	11.38	Change EI of wall to 320441kN.m2/m run
2	0.000	16.43	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	16.43	0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003	18.50	0.000	21.98	Excav. to elev. 16.43 on RIGHT side
7	No calculation at this stage				Install prop no.2 at elev. 21.78
8	0.003	18.50	0.000	21.98	Remove prop no.1 at elev. 21.50
9	0.005	18.00	0.000	21.98	Change soil type 4 to soil type 6
10	0.005	18.00	0.000	21.98	Change EI of wall to 228886kN.m2/m run

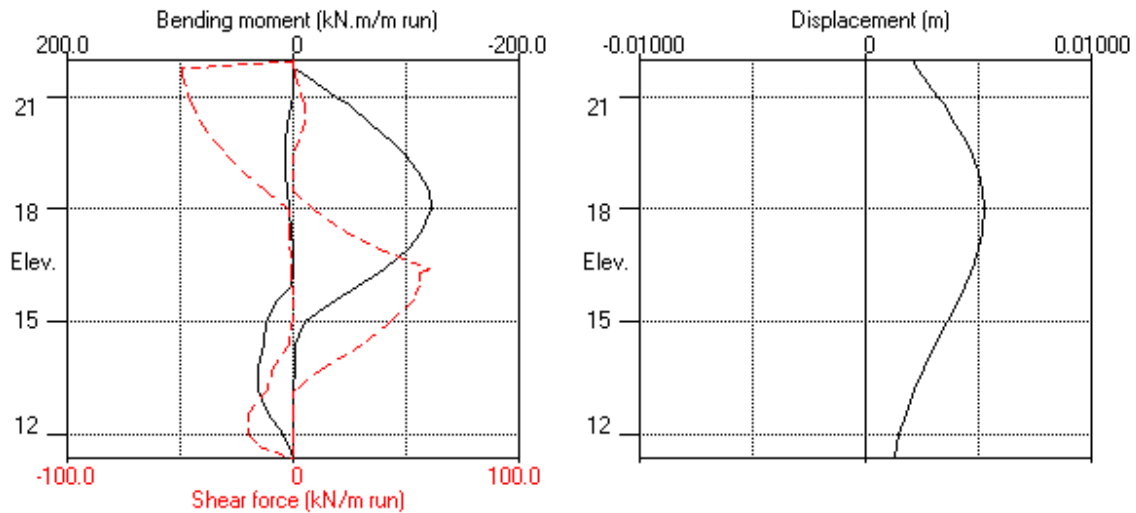
Prop forces at each stage (horizontal components)

Stage no.	Prop no. 1			Prop no. 2		
	at elev. 21.50			at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per	kN per	kN per	kN per	kN per	kN per
	m run	prop	prop	m run	prop	prop
6	39	39	52	---	---	---
8	---	---	---	36	36	48
9	---	---	---	50	50	67
10	---	---	---	48	48	65

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3 SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5 Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6 LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7 CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

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 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Water profile	Left side	Right side						
press. Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	16.33	16.33	0.0	1	16.33	16.33	0.0

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2	Equiv. soil type	Partial factor/ Category
1	21.98	0.50(L)	50.00	20.00	=	N/A 1.10 Var
2	15.90	-0.00(R)	50.00	55.00	=	N/A 1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 16.43 on RIGHT side
7	Excavate to elevation 16.33 on RIGHT side
8	Fill to elevation 16.43 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run
	Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
 Water pressures : Moderately Conservative
 Partial factor on C' = 1.000
 Partial factor on Phi' = 1.000
 Partial factor on Cu = 1.000
 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 = 1.100
 Design factor on calculated Bending Moments = 1.350

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m3
 Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 10.63 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

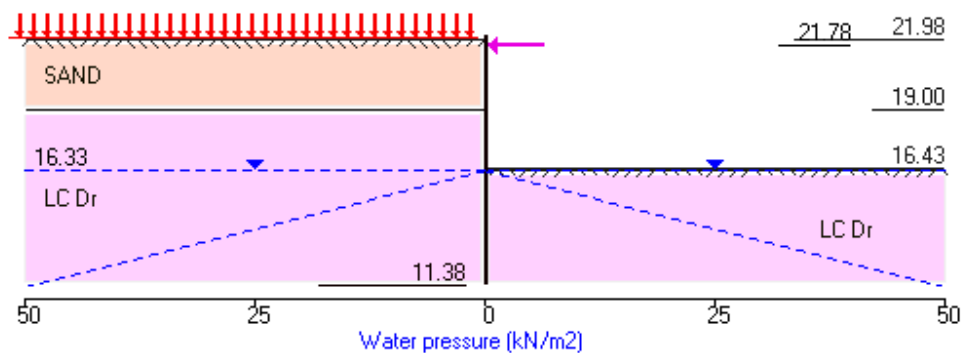
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 16.43 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 16.33 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 16.43 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Stage No.12 Change EI of wall to 346836kN.m2/m run



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 Made by : JRM
 Date: 27-05-2022
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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 = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	0.000	0	-0	0	-0	0	0	0	0
2	21.78	0.003	0.000	0	-0	0	-0	0	-55	0	-74
3	21.50	0.003	0.000	0	-15	0	-21	1	-54	1	-73
4	21.00	0.003	0.000	1	-42	1	-56	3	-52	4	-70
5	20.75	0.003	0.000	2	-54	3	-73	5	-50	7	-67
6	20.28	0.004	0.000	5	-77	7	-104	5	-45	7	-61
7	19.80	0.004	0.000	7	-97	9	-131	2	-39	3	-53
8	19.40	0.004	0.000	7	-112	10	-151	0	-34	0	-46
9	19.00	0.005	0.000	7	-124	9	-167	0	-27	0	-37
10	18.50	0.005	0.000	6	-135	8	-182	0	-16	0	-22
11	18.00	0.005	0.000	4	-138	6	-186	5	-3	7	-5
12	17.40	0.005	0.000	3	-134	4	-181	20	-2	27	-3
13	16.92	0.005	0.000	2	-123	3	-167	39	-2	52	-2
14	16.43	0.004	0.000	1	-104	2	-141	62	-1	84	-2
15	16.33	0.004	0.000	1	-99	1	-134	65	-1	88	-2
16	15.96	0.004	0.000	1	-79	1	-107	57	-1	77	-1
17	15.60	0.004	0.000	3	-59	4	-80	55	-1	74	-1
18	15.00	0.004	0.000	18	-29	25	-40	47	-0	64	-0
19	14.40	0.003	0.000	24	-5	32	-6	36	-0	49	-0
20	13.80	0.003	0.000	23	-1	31	-2	20	-6	27	-8
21	13.20	0.002	0.000	25	-1	33	-1	2	-11	3	-15
22	12.60	0.002	0.000	18	-0	25	-0	1	-15	1	-21
23	12.00	0.002	0.000	8	-0	10	-0	0	-17	0	-23
24	11.69	0.001	0.000	3	-0	4	-0	0	-13	0	-17
25	11.38	0.001	-0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_CONTIG 1_ULS1
Tottenham Court Road
CONTIG 1, 750mm Contig PROPPED

Sheet No.
Date:27-05-2022
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. min.		max. elev.	min. elev.	max. min.	
	kN.m/m	kN.m/m	kN.m/m		kN/m	kN/m	kN/m	
1	0 12.60	-0 15.60	0 -0		0 21.98	-0 21.50	0 -0	
2	0 21.98	-8 18.00	0 -11		2 15.60	-4 19.00	3 -5	
3	0 21.98	-8 18.00	0 -11		2 15.60	-4 19.00	3 -5	
4	7 19.40	-0 13.80	10 -0		5 20.28	-3 18.50	7 -4	
5	No calculation at this stage							
6	20 14.40	-85 18.50	28 -114		62 16.43	-42 21.50	84 -57	
7	21 14.40	-86 18.50	28 -117		64 16.33	-43 21.50	86 -58	
8	21 14.40	-87 18.50	29 -117		65 16.33	-43 21.50	87 -58	
9	No calculation at this stage							
10	24 14.40	-87 18.50	32 -117		65 16.33	-40 21.78	88 -54	
11	18 13.20	-138 18.00	25 -186		55 15.96	-55 21.78	74 -74	
12	25 13.20	-130 18.00	33 -176		57 15.96	-52 21.78	77 -71	

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum elev.	minimum elev.			
	m	m			
1	0.000 15.96	-0.000 11.38			Change EI of wall to 485571kN.m2/m run
2	0.000 16.43	0.000 21.98			Apply surcharge no.1 at elev. 21.98
3	0.000 16.43	0.000 21.98			Apply water pressure profile no.1
4	0.001 21.98	0.000 21.98			Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003 18.50	0.000 21.98			Excav. to elev. 16.43 on RIGHT side
7	0.003 18.50	0.000 21.98			Excav. to elev. 16.33 on RIGHT side
8	0.003 18.50	0.000 21.98			Fill to elev. 16.43 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.003 18.50	0.000 21.98			Remove prop no.1 at elev. 21.50
11	0.004 18.00	0.000 21.98			Change soil type 4 to soil type 6
12	0.005 18.00	0.000 21.98			Change EI of wall to 346836kN.m2/m run

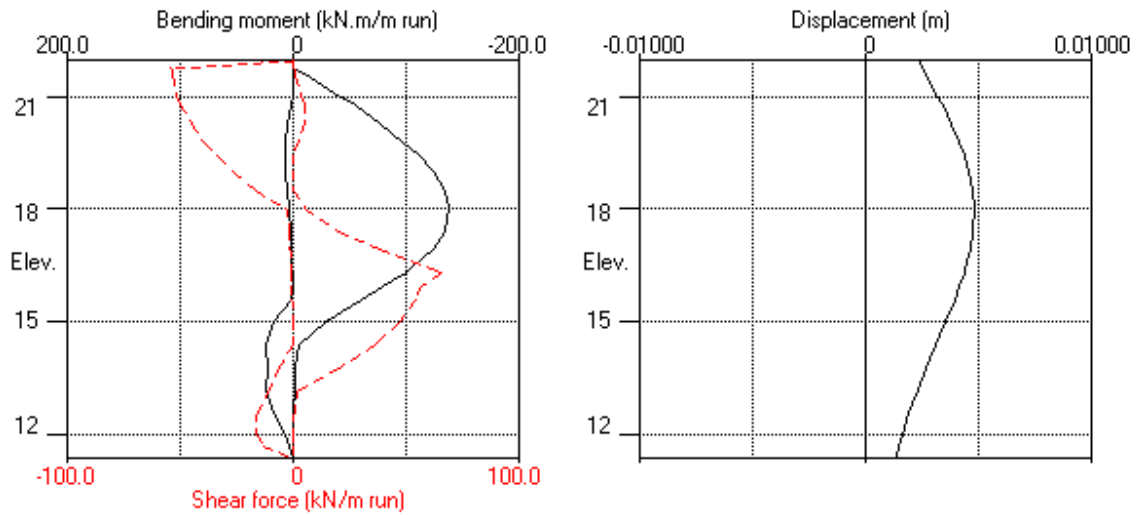
Prop forces at each stage (horizontal components)

Stage no.	Prop no. 1			Prop no. 2		
	at elev. 21.50			at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
6	43	43	58	---	---	---
7	44	44	59	---	---	---
8	44	44	59	---	---	---
10	---	---	---	40	40	54
11	---	---	---	55	55	74
12	---	---	---	53	53	71

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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

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	MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2	Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3	SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5	Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6	LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7	CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

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	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	16.33	16.33	0.0	1	16.33	16.33	0.0

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2	Equiv. soil type	Partial factor/ Category
1	21.98	0.50(L)	50.00	20.00	=	N/A 1.30 Var
2	15.90	-0.00(R)	50.00	55.00	=	N/A 1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 16.43 on RIGHT side
7	Excavate to elevation 16.33 on RIGHT side
8	Fill to elevation 16.43 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run
	Allow wall to relax with new modulus value

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) = 10.63 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m

Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m

Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

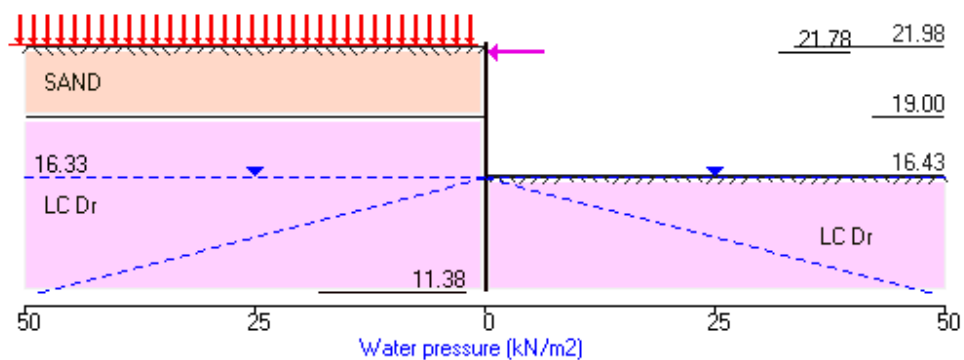
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 16.43 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 16.33 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 16.43 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
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Sheet No.
 Job No. 2176
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Stage No.12 Change EI of wall to 346836kN.m2/m run



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 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

Overall								
				FoS for toe elev. = 11.38		Toe elev. for FoS = 1.000		
<u>Stage No.</u>	<u>Ground Act.</u>	<u>level Pass.</u>	<u>Prop Elev.</u>	<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetr -ation</u>	<u>Direction of failure</u>
1	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
4	21.98	20.75	Cant.	5.281	12.22	19.57	1.18	L to R
5	21.98	20.75		No analysis at this stage				
6	21.98	16.43	21.50	2.938	n/a	16.11	0.32	L to R
7	21.98	16.33	21.50	2.887	n/a	15.99	0.34	L to R
8	21.98	16.43	21.50	2.919	n/a	16.00	0.43	L to R
9	21.98	16.43		No analysis at this stage				
10	21.98	16.43	21.78	2.901	n/a	15.99	0.44	L to R
11	21.98	16.43	21.78	1.096	n/a	12.28	4.15	L to R
12	21.98	16.43	21.78	1.096	n/a	12.28	4.15	L to R

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Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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	21.98	0.003	0.000	0.0	-0.0	0.0	0.0
2	21.78	0.003	0.000	0.0	-0.0	0.2	-91.3
3	21.50	0.004	0.000	0.2	-25.4	0.9	-90.5
4	21.00	0.005	0.000	1.3	-70.0	4.2	-87.2
5	20.75	0.005	0.000	2.7	-91.5	6.7	-84.7
6	20.28	0.006	0.000	6.9	-129.8	7.9	-78.5
7	19.80	0.007	0.000	9.9	-165.4	5.2	-70.6
8	19.40	0.008	0.000	11.6	-192.1	3.4	-62.9
9	19.00	0.008	0.000	12.7	-215.5	2.0	-54.1
10	18.50	0.009	0.000	12.9	-239.0	0.7	-39.1
11	18.00	0.009	0.000	12.0	-252.1	10.0	-21.9
12	17.40	0.009	0.000	10.0	-258.1	24.7	-3.6
13	16.92	0.009	0.000	8.1	-252.1	41.5	-3.8
14	16.43	0.009	0.000	6.3	-235.2	65.1	-3.6
15	16.33	0.009	0.000	5.9	-230.3	68.9	-3.5
16	15.96	0.009	0.000	4.7	-209.6	62.5	-3.2
17	15.60	0.008	-0.000	12.6	-185.9	69.4	-2.8
18	15.00	0.008	-0.000	27.2	-143.4	74.6	-2.0
19	14.40	0.007	-0.000	31.1	-100.0	72.1	-1.4
20	13.80	0.006	-0.000	27.8	-60.5	61.8	-9.1
21	13.20	0.005	-0.000	20.2	-27.0	43.8	-13.8
22	12.60	0.004	-0.000	11.2	-8.1	23.5	-14.0
23	12.00	0.003	-0.000	3.4	-0.5	6.1	-9.6
24	11.69	0.002	-0.000	2.5	-0.0	0.3	-6.8
25	11.38	0.002	-0.000	0.0	-0.0	0.0	-0.0

Run ID. 2176_TCR_CONTIG 1_ULS2
Tottenham Court Road
CONTIG 1, 750mm Contig PROPPED

Sheet No.
Date: 27-05-2022
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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	0.0	17.40	-0.0	20.28	0.0	21.98	-0.0	21.50
2	0.0	21.98	-8.4	18.00	2.2	15.60	-4.0	19.00
3	0.0	21.98	-8.1	18.00	2.1	15.60	-3.5	19.00
4	12.9	18.50	-0.0	21.98	7.9	20.28	-3.8	16.92
5	No calculation at this stage							
6	26.6	14.40	-83.7	18.50	65.1	16.43	-46.7	21.50
7	27.3	14.40	-86.1	18.50	66.8	16.33	-47.5	21.50
8	27.9	14.40	-86.3	18.50	67.5	16.33	-47.6	21.50
9	No calculation at this stage							
10	31.1	14.40	-87.5	18.50	68.9	16.33	-44.6	21.78
11	0.5	11.69	-258.1	17.40	73.8	15.00	-91.3	21.78
12	2.9	12.00	-255.3	17.40	74.6	15.00	-90.5	21.78

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u> m	<u>elev.</u>	<u>minimum</u> m	<u>elev.</u>	
1	0.000	21.98	-0.000	14.40	Change EI of wall to 485571kN.m2/m run
2	0.000	16.43	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	16.43	0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003	19.00	0.000	21.98	Excav. to elev. 16.43 on RIGHT side
7	0.003	19.00	0.000	21.98	Excav. to elev. 16.33 on RIGHT side
8	0.003	19.00	0.000	21.98	Fill to elev. 16.43 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.003	19.00	0.000	21.98	Remove prop no.1 at elev. 21.50
11	0.007	17.40	0.000	21.98	Change soil type 4 to soil type 6
12	0.009	17.40	0.000	21.98	Change EI of wall to 346836kN.m2/m run

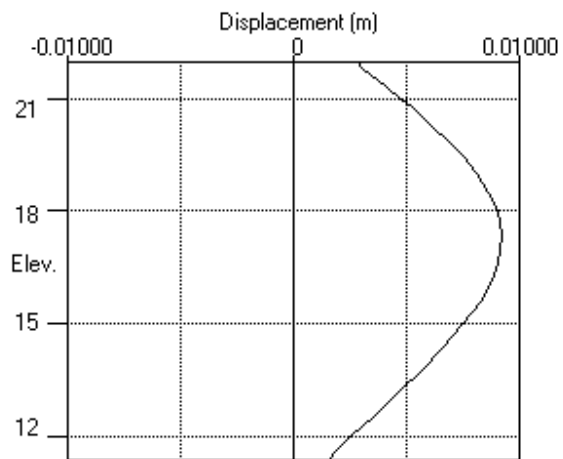
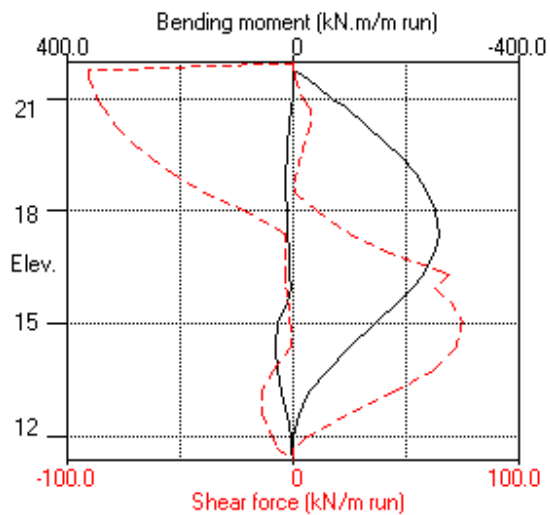
Prop forces at each stage (horizontal components)

Stage no.	Strut no. 1		Strut no. 2	
	at elev. 21.50	at elev. 21.78	at elev. 21.50	at elev. 21.78
	kN/m run	kN/prop	kN/m run	kN/prop
6	47.62	47.62	---	---
7	48.40	48.40	---	---
8	48.50	48.50	---	---
10	---	---	44.71	44.71
11	---	---	91.39	91.39
12	---	---	90.66	90.66

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 Soil properties file: 2176_TCR SOILS_01.dat
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 CONTIG 1, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
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Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 CONTIG 2 LIFT PIT, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3 SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5 Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6 LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7 CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

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 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Left side					Right side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	16.33	16.33	0.0	1	15.03	15.03	0.0	

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 9.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 kN.m2/m run
 Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	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/m2		Equiv. soil type	Partial factor/ Category
					Near edge	Far edge		
1	21.98	2.00(L)	50.00	50.00	20.00	=	N/A	1.00 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	=	N/A	1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.13 on RIGHT side
7	Install strut or anchor no.2 at elevation 21.78
8	Remove strut or anchor no.1 at elevation 21.50
9	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
10	Change EI of wall to 346836 kN.m2/m run Allow wall to relax with new modulus value

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) = 12.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
 Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
 Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

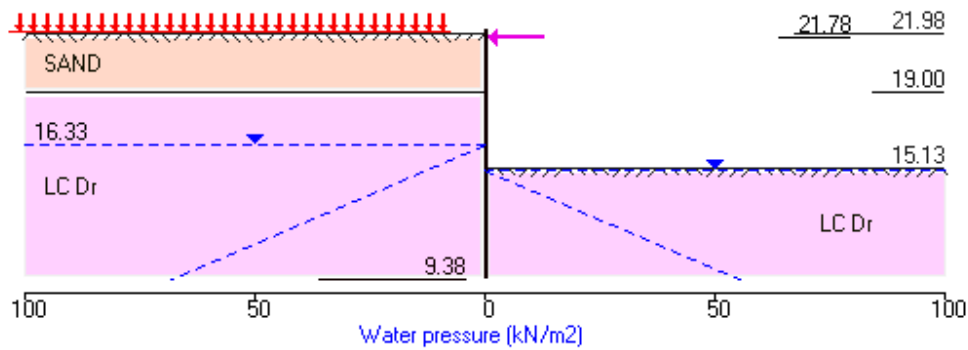
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.13 on RIGHT side	Yes	Yes	Yes
7	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
8	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
9	Change soil type 4 to soil type 6	Yes	Yes	Yes
10	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Stage No.10 Change EI of wall to 346836kN.m2/m run



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Sheet No.
 Job No. 2176
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 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

				FoS for toe		Toe elev. for			
				elev. = 9.38		FoS = 1.000			
<u>Stage</u>	<u>Ground</u>	<u>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 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	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>					
2	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>					
3	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>					
4	21.98	20.75	Cant.	11.131	10.24	20.14	0.61	L to R	
5	21.98	20.75		No analysis at this stage					
6	21.98	15.13	21.50	4.017	n/a	14.84	0.29	L to R	
7	21.98	15.13		No analysis at this stage					
8	21.98	15.13	21.78	4.000	n/a	14.83	0.30	L to R	
9	21.98	15.13	21.78	1.289	n/a	11.83	3.30	L to R	
10	21.98	15.13	21.78	1.289	n/a	11.83	3.30	L to R	

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Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	0.000	0	0	0	0	0	0	0	0
2	21.78	0.003	0.000	0	0	0	0	0	-73	0	-98
3	21.50	0.003	0.000	0	-20	0	-27	1	-72	1	-97
4	21.00	0.004	0.000	1	-56	1	-76	2	-70	3	-95
5	20.75	0.005	0.000	1	-73	2	-99	3	-69	5	-93
6	20.28	0.006	0.000	4	-105	5	-142	4	-66	5	-89
7	19.80	0.006	0.000	5	-136	6	-183	1	-61	2	-83
8	19.40	0.007	0.000	5	-159	7	-215	0	-57	0	-76
9	19.00	0.008	0.000	4	-181	5	-244	0	-51	0	-69
10	18.50	0.008	0.000	3	-204	3	-275	0	-42	0	-57
11	18.00	0.009	0.000	1	-222	2	-300	0	-31	0	-42
12	17.40	0.009	0.000	0	-236	0	-319	6	-15	8	-21
13	16.87	0.009	0.000	0	-240	0	-324	19	-1	26	-2
14	16.33	0.009	0.000	0	-231	0	-312	34	-1	45	-1
15	15.73	0.009	0.000	0	-212	0	-286	55	-0	75	-1
16	15.13	0.008	0.000	0	-177	0	-239	86	-0	116	-0
17	15.03	0.008	0.000	0	-169	0	-228	80	0	108	0
18	14.72	0.008	0.000	0	-144	1	-194	85	0	115	0
19	14.40	0.007	0.000	18	-117	24	-158	89	0	120	0
20	13.80	0.007	0.000	38	-66	51	-89	87	0	118	0
21	13.20	0.006	0.000	45	-19	60	-25	75	0	101	0
22	12.60	0.005	0.000	43	-2	58	-2	52	-8	70	-10
23	12.00	0.004	0.000	58	-1	79	-1	27	-15	36	-20
24	11.40	0.003	0.000	63	-1	85	-1	1	-18	1	-24
25	10.80	0.003	0.000	52	-0	71	-0	0	-32	1	-43
26	10.20	0.002	0.000	29	-0	39	-0	0	-42	0	-56
27	9.79	0.002	0.000	13	-0	17	-0	0	-37	0	-50
28	9.38	0.002	0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_CONTIG_2_SLS
Tottenham Court Road
CONTIG 2 LIFT PIT, 750mm Contig PROPPED

| Sheet No.
| Date:27-05-2022
| 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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	11.40	-0	15.73	0	-0	0	21.98
2	0	21.78	-5	16.87	0	-7	1	14.40
3	0	21.78	-5	16.87	0	-7	1	13.80
4	5	19.40	-2	15.03	7	-2	4	20.28
5	No calculation at this stage							
6	42	13.20	-122	17.40	56	-164	85	15.13
7	No calculation at this stage							
8	45	13.20	-122	17.40	60	-165	86	15.13
9	51	11.40	-240	16.87	69	-324	87	14.40
10	63	11.40	-232	16.87	85	-313	89	14.40

Maximum and minimum displacement at each stage

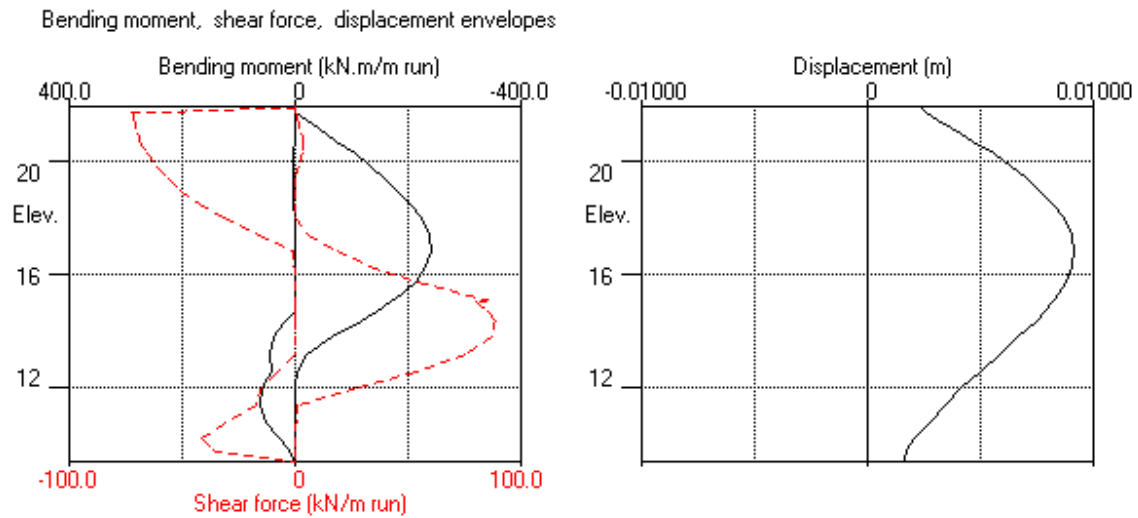
Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	9.38	0.000	21.98	Change EI of wall to 485571kN.m2/m run
2	0.000	13.80	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.004	17.40	0.000	21.98	Excav. to elev. 15.13 on RIGHT side
7	No calculation at this stage				Install prop no.2 at elev. 21.78
8	0.004	17.40	0.000	21.98	Remove prop no.1 at elev. 21.50
9	0.008	16.87	0.000	21.98	Change soil type 4 to soil type 6
10	0.009	16.87	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

Stage no.	Prop no. 1			Prop no. 2		
	at elev. 21.50			at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per	kN per	kN per	kN per	kN per	kN per
	m run	prop	prop	m run	prop	prop
6	49	49	66	---	---	---
8	---	---	---	46	46	62
9	---	---	---	73	73	98
10	---	---	---	71	71	96

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Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
CONTIG 2 LIFT PIT, 750mm Contig PROPPED

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 CONTIG 2 LIFT PIT, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3 SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5 Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6 LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7 CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

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 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Left side					Right side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	16.33	16.33	0.0	1	15.03	15.03	0.0	

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 9.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.98	2.00(L)	50.00	50.00	20.00 =	N/A	1.10 Var
2	15.90	-0.00(R)	50.00	50.00	55.00 =	N/A	1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.13 on RIGHT side
7	Excavate to elevation 15.03 on RIGHT side
8	Fill to elevation 15.13 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
 Water pressures : Moderately Conservative
 Partial factor on C' = 1.000
 Partial factor on Phi' = 1.000
 Partial factor on Cu = 1.000
 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 = 1.100
 Design factor on calculated Bending Moments = 1.350

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) = 12.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

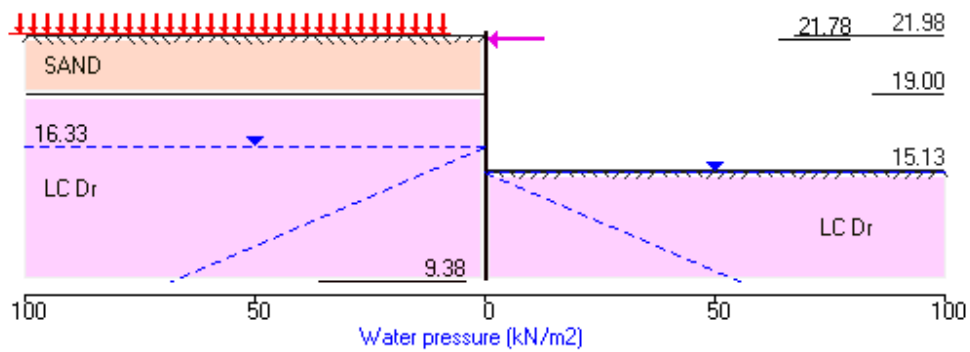
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.13 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 15.03 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 15.13 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 CONTIG 2 LIFT PIT, 750mm Contig PROPPED

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Stage No.12 Change EI of wall to 346836kN.m2/m run



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 Job No. 2176
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 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	0.000	0	-0	0	-0	0	0	0	0
2	21.78	0.003	0.000	0	0	0	0	0	-75	0	-101
3	21.50	0.003	0.000	0	-21	0	-28	1	-74	1	-100
4	21.00	0.004	0.000	1	-58	1	-78	2	-73	3	-98
5	20.75	0.005	0.000	1	-76	2	-102	4	-71	5	-96
6	20.28	0.006	0.000	4	-109	5	-147	4	-68	5	-92
7	19.80	0.007	0.000	5	-140	6	-189	1	-64	2	-86
8	19.40	0.007	0.000	5	-164	6	-222	0	-59	0	-79
9	19.00	0.008	0.000	4	-187	5	-252	0	-53	0	-72
10	18.50	0.009	0.000	2	-211	3	-285	0	-44	0	-60
11	18.00	0.009	0.000	1	-230	1	-311	0	-33	0	-44
12	17.40	0.009	0.000	0	-245	0	-331	5	-17	7	-23
13	16.87	0.010	0.000	0	-250	0	-337	18	-1	25	-2
14	16.33	0.010	0.000	0	-242	0	-326	33	-1	44	-1
15	15.73	0.009	0.000	0	-223	0	-301	54	-0	73	-1
16	15.13	0.009	0.000	0	-188	0	-254	85	-0	115	-0
17	15.03	0.009	0.000	0	-180	0	-244	89	0	120	0
18	14.72	0.008	0.000	0	-155	0	-209	87	0	118	0
19	14.40	0.008	0.000	16	-127	22	-172	91	0	123	0
20	13.80	0.007	0.000	39	-74	52	-100	90	0	122	0
21	13.20	0.006	0.000	47	-25	64	-34	79	0	106	0
22	12.60	0.005	0.000	46	-2	62	-2	57	-8	76	-10
23	12.00	0.004	0.000	56	-1	76	-2	30	-16	40	-21
24	11.40	0.004	0.000	63	-1	85	-1	2	-19	2	-25
25	10.80	0.003	0.000	54	-0	73	-0	0	-30	1	-41
26	10.20	0.002	0.000	30	-0	41	-0	0	-43	0	-58
27	9.79	0.002	0.000	13	-0	18	-0	0	-39	0	-52
28	9.38	0.002	0.000	0	-0	0	-0	0	-0	0	-0

Run ID: 2176_TCR_CONTIG_2_ULS1
Tottenham Court Road
CONTIG 2 LIFT PIT, 750mm Contig PROPPED

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.

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	11.40	-0	15.73	0	-0	0	21.98	0	21.98	0	0
2	0	21.78	-6	16.87	0	-8	1	14.40	-2	19.00	2	-3
3	0	21.78	-5	16.87	0	-7	1	13.80	-2	19.00	2	-3
4	5	19.40	-2	15.13	6	-3	4	20.28	-3	19.00	5	-5
5	No calculation at this stage											
6	42	13.20	-122	17.40	57	-165	85	15.13	-49	21.50	115	-66
7	43	13.20	-125	17.40	58	-169	87	15.03	-49	21.50	118	-66
8	44	13.20	-126	17.40	59	-169	88	15.03	-49	21.50	119	-67
9	No calculation at this stage											
10	47	13.20	-126	17.40	64	-170	89	15.03	-47	21.78	120	-63
11	50	11.40	-250	16.87	68	-337	89	14.40	-75	21.78	120	-101
12	63	11.40	-242	16.87	85	-327	91	14.40	-73	21.78	123	-98

Maximum and minimum displacement at each stage

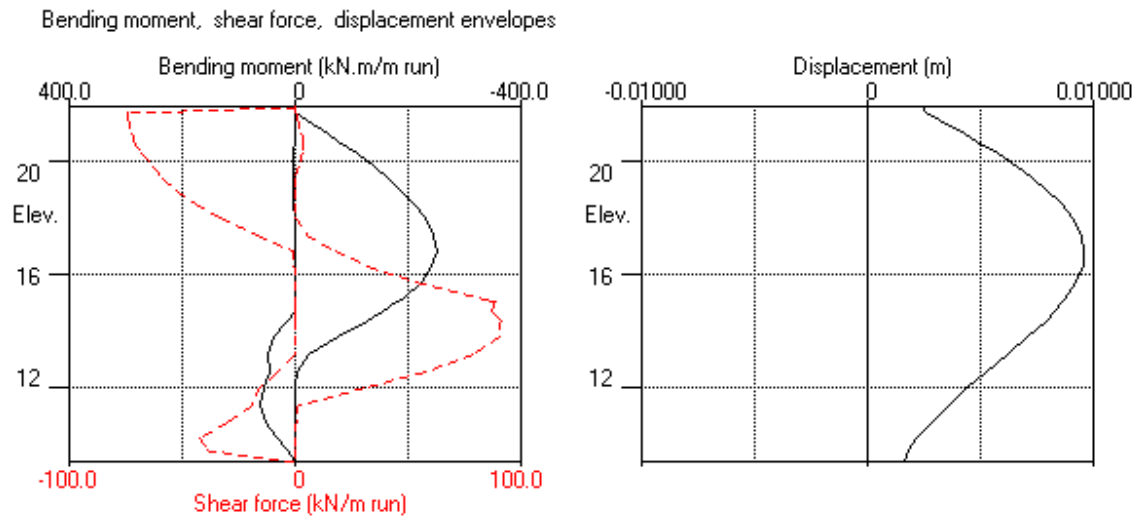
Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	9.38	0.000	21.98	Change EI of wall to 485571kN.m2/m run
2	0.000	13.80	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.004	17.40	0.000	21.98	Excav. to elev. 15.13 on RIGHT side
7	0.004	17.40	0.000	21.98	Excav. to elev. 15.03 on RIGHT side
8	0.004	17.40	0.000	21.98	Fill to elev. 15.13 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.004	17.40	0.000	21.98	Remove prop no.1 at elev. 21.50
11	0.008	16.87	0.000	21.98	Change soil type 4 to soil type 6
12	0.010	16.87	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

Stage no.	Prop no. 1			Prop no. 2		
	at elev. 21.50			at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per	kN per	kN per	kN per	kN per	kN per
	m run	prop	prop	m run	prop	prop
6	49	49	66	---	---	---
7	50	50	67	---	---	---
8	50	50	67	---	---	---
10	---	---	---	47	47	63
11	---	---	---	75	75	101
12	---	---	---	73	73	99

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Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND	3 SAND	
2	19.00	4 LC UnDr	4 LC UnDr	

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

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	MG	18.00	10000	0.500	OC	0.292	4.369	
2	Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
3	SAND	19.00	60000	0.426	OC	0.235	6.084	
4	LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
5	Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
6	LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
7	CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
8	LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u

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	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Left side					Right side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	16.33	16.33	0.0	1	15.03	15.03	0.0	

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 9.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 kN.m2/m run
 Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	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/m2		Equiv. soil type	Partial factor/ Category
					Near edge	Far edge		
1	21.98	2.00(L)	50.00	50.00	20.00	=	N/A	1.30 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	=	N/A	1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.13 on RIGHT side
7	Excavate to elevation 15.03 on RIGHT side
8	Fill to elevation 15.13 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run
	Allow wall to relax with new modulus value

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) = 12.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m

Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m

Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

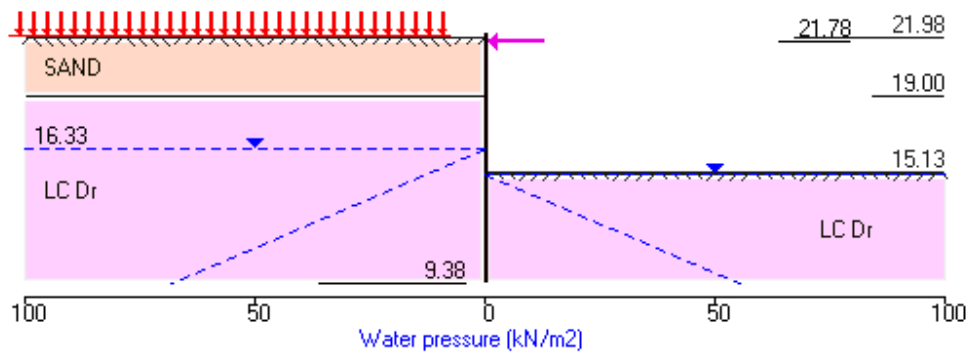
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.13 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 15.03 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 15.13 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 CONTIG 2 LIFT PIT, 750mm Contig PROPPED

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Stage No.12 Change EI of wall to 346836kN.m2/m run



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Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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 Φ' = 1.250
 Partial factor on C_u = 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

Overall								
				FoS for toe		Toe elev. for		
				elev. = 9.38		FoS = 1.000		
<u>Stage</u>	<u>Ground</u>	<u>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 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	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
2	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
3	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
4	21.98	20.75	Cant.	7.490	10.16	19.80	0.95	L to R
5	21.98	20.75		No analysis at this stage				
6	21.98	15.13	21.50	2.790	n/a	14.69	0.44	L to R
7	21.98	15.03	21.50	2.749	n/a	14.58	0.45	L to R
8	21.98	15.13	21.50	2.774	n/a	14.59	0.54	L to R
9	21.98	15.13		No analysis at this stage				
10	21.98	15.13	21.78	2.763	n/a	14.58	0.55	L to R
11	21.98	15.13	21.78	1.014	n/a	9.54	5.59	L to R
12	21.98	15.13	21.78	1.014	n/a	9.54	5.59	L to R

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 CONTIG 2 LIFT PIT, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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	21.98	0.003	0.000	0.0	0.0	0.0	0.0
2	21.78	0.003	0.000	0.0	0.0	0.1	-132.9
3	21.50	0.005	0.000	0.1	-37.1	0.7	-132.3
4	21.00	0.007	0.000	0.9	-102.8	2.8	-130.1
5	20.75	0.009	0.000	1.9	-135.1	4.5	-128.5
6	20.28	0.011	0.000	4.7	-194.8	5.1	-124.1
7	19.80	0.013	0.000	6.6	-252.4	2.9	-118.2
8	19.40	0.015	0.000	7.5	-298.5	1.3	-111.9
9	19.00	0.017	0.000	7.7	-341.9	0.0	-104.6
10	18.50	0.019	0.000	7.3	-391.2	0.0	-92.2
11	18.00	0.020	0.000	6.2	-433.6	0.0	-77.3
12	17.40	0.022	0.000	4.6	-473.8	7.9	-56.1
13	16.87	0.023	0.000	3.1	-498.1	20.9	-34.3
14	16.33	0.024	0.000	1.7	-506.3	35.3	-9.8
15	15.73	0.024	0.000	0.4	-502.9	56.1	-2.0
16	15.13	0.023	0.000	0.0	-479.1	87.6	-1.4
17	15.03	0.023	0.000	0.0	-472.9	91.7	-1.3
18	14.72	0.023	0.000	3.3	-450.2	79.1	-0.9
19	14.40	0.022	0.000	22.7	-423.5	90.6	-0.6
20	13.80	0.021	0.000	45.0	-364.8	106.7	-0.1
21	13.20	0.019	0.000	52.6	-298.7	115.2	0.0
22	12.60	0.017	0.000	50.0	-229.6	116.0	-9.6
23	12.00	0.015	0.000	41.1	-162.3	109.2	-17.5
24	11.40	0.012	0.000	29.0	-101.3	94.6	-20.4
25	10.80	0.009	0.000	16.7	-51.2	72.4	-18.9
26	10.20	0.007	0.000	6.3	-16.9	42.4	-13.6
27	9.79	0.005	0.000	1.8	-3.0	19.4	-7.7
28	9.38	0.003	0.000	0.0	-0.0	0.0	-0.0

Run ID. 2176_TCR_CONTIG_2_ULS2
Tottenham Court Road
CONTIG 2 LIFT PIT, 750mm Contig PROPPED

Sheet No.
Date: 27-05-2022
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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>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	11.40	-0.0	15.73	0.0	21.98	0.0	21.98
2	0.0	21.78	-6.6	16.87	1.4	14.40	-2.8	19.00
3	0.0	21.78	-6.4	16.87	1.4	13.80	-2.8	19.00
4	7.7	19.00	-1.4	13.80	5.1	20.28	-2.9	17.40
5	No calculation at this stage							
6	46.6	13.20	-122.4	17.40	87.6	15.13	-52.5	21.50
7	48.1	13.20	-125.2	17.40	89.6	15.03	-53.2	21.50
8	48.9	13.20	-125.6	17.40	90.3	15.03	-53.3	21.50
9	No calculation at this stage							
10	52.6	13.20	-127.1	18.00	91.7	15.03	-50.6	21.78
11	0.0	21.78	-506.3	16.33	115.9	12.60	-132.9	21.78
12	0.0	21.78	-505.8	16.33	116.0	12.60	-132.8	21.78

Maximum and minimum displacement at each stage

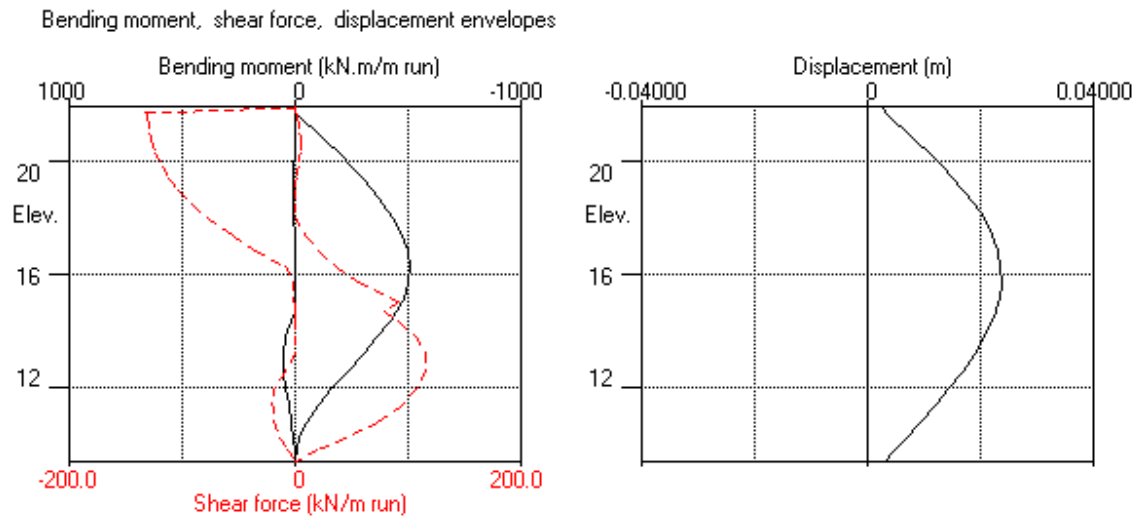
Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	9.38	0.000	21.98	Change EI of wall to 485571kN.m2/m run
2	0.000	13.80	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.004	17.40	0.000	21.98	Excav. to elev. 15.13 on RIGHT side
7	0.004	17.40	0.000	21.98	Excav. to elev. 15.03 on RIGHT side
8	0.004	17.40	0.000	21.98	Fill to elev. 15.13 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.004	18.00	0.000	21.98	Remove prop no.1 at elev. 21.50
11	0.018	15.73	0.000	21.98	Change soil type 4 to soil type 6
12	0.024	15.73	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

Stage no.	Strut no. 1		Strut no. 2	
	at elev. 21.50		at elev. 21.78	
	kN/m run	kN/prop	kN/m run	kN/prop
6	53.20	53.20	---	---
7	53.89	53.89	---	---
8	54.01	54.01	---	---
10	---	---	50.71	50.71
11	---	---	132.99	132.99
12	---	---	132.88	132.88

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 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :



Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
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INPUT DATA

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	21.98	3 SAND	3 SAND
2	19.00	4 LC UnDr	4 LC UnDr

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	MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2	Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3	SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5	Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6	LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7	CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

		--- parameters for Ka ---			--- parameters for Kp ---		
		Soil	Wall	Back-	Soil	Wall	Back-
----- Soil type -----		friction	adhesion	fill	friction	adhesion	fill
No.	Description	angle	coeff.	angle	angle	coeff.	angle
1	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

Water press. profile no.	Left side				Right side				MC+WC
	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	1	16.33	16.33	0.0	1	15.83	15.83	

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	21.98	2.00(L)	50.00	50.00	20.00	=	N/A	1.00 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	=	N/A	1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.93 on RIGHT side
7	Install strut or anchor no.2 at elevation 21.78
8	Remove strut or anchor no.1 at elevation 21.50
9	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
10	Change EI of wall to 346836 kN.m2/m run Allow wall to relax with new modulus value

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) = 10.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 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	Output options		
		Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
7	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
8	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
9	Change soil type 4 to soil type 6	Yes	Yes	Yes
10	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

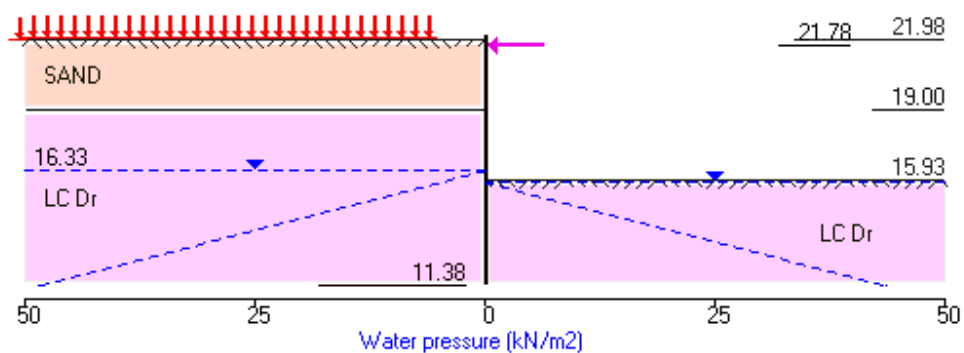
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Units: kN,m

Stage No.10 Change EI of wall to 346836kN.m²/m run



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 Tottenham Court Road
 CONTIG 3, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

			FoS for toe elev. = 11.38		Toe elev. for FoS = 1.000			
<u>Stage No.</u>	<u>Ground Act.</u>	<u>level Pass.</u>	<u>Prop Elev.</u>	<u>Factor of Safety</u>	<u>Moment at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetr -ation</u>	<u>Direction of failure</u>
1	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	21.98	21.98	Cant.	<u>Conditions not suitable for FoS calc.</u>				
4	21.98	20.75	Cant.	10.070	12.15	20.14	0.61	L to R
5	21.98	20.75		No analysis at this stage				
6	21.98	15.93	21.50	4.107	n/a	15.69	0.24	L to R
7	21.98	15.93		No analysis at this stage				
8	21.98	15.93	21.78	4.086	n/a	15.69	0.24	L to R
9	21.98	15.93	21.78	1.278	n/a	13.38	2.55	L to R
10	21.98	15.93	21.78	1.278	n/a	13.38	2.55	L to R

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Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	-0.000	0	-0	0	-0	0	0	0	0
2	21.78	0.002	-0.000	0	-0	0	-0	0	-55	0	-74
3	21.50	0.002	-0.000	0	-15	0	-21	1	-54	1	-74
4	21.00	0.003	0.000	1	-42	1	-57	2	-53	3	-71
5	20.75	0.003	0.000	2	-55	2	-74	3	-51	5	-69
6	20.28	0.004	0.000	4	-78	6	-105	4	-48	5	-65
7	19.80	0.004	0.000	6	-100	8	-134	1	-44	1	-59
8	19.40	0.005	0.000	5	-116	7	-157	2	-39	2	-53
9	19.00	0.005	0.000	4	-131	5	-177	5	-33	7	-45
10	18.50	0.005	0.000	1	-146	2	-197	4	-24	5	-33
11	18.00	0.005	0.000	1	-156	2	-210	2	-13	3	-18
12	17.40	0.005	0.000	2	-159	3	-215	14	-2	18	-2
13	16.87	0.005	0.000	2	-151	3	-204	28	-1	38	-1
14	16.33	0.005	0.000	2	-136	3	-183	48	-0	65	-0
15	15.93	0.005	0.000	2	-118	3	-159	68	-1	91	-1
16	15.83	0.005	0.000	2	-112	3	-151	63	-1	85	-1
17	15.42	0.004	0.000	2	-89	2	-120	60	-1	81	-1
18	15.00	0.004	0.000	11	-65	15	-87	58	-1	79	-1
19	14.40	0.004	-0.000	22	-33	29	-44	47	-1	64	-1
20	13.80	0.003	-0.000	23	-9	31	-12	33	-3	45	-4
21	13.20	0.003	-0.000	18	-1	24	-1	16	-10	22	-14
22	12.60	0.002	-0.000	16	-1	22	-1	1	-12	1	-17
23	12.00	0.002	-0.000	7	-0	10	-0	0	-16	1	-22
24	11.69	0.001	-0.000	3	-0	4	-0	0	-13	0	-17
25	11.38	0.001	-0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_CONTIG_3_SLS
Tottenham Court Road
CONTIG 3, 750mm Contig PROPPED

| Sheet No.
| Date:27-05-2022
| 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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	2	16.87	-3	19.80	3	-3	5	19.00
2	0	21.98	-4	19.40	0	-6	3	19.00
3	1	20.28	-5	16.87	1	-7	1	14.40
4	6	19.80	-3	16.33	8	-4	4	20.28
5	No calculation at this stage							
6	21	13.80	-92	18.00	28	-125	66	15.93
7	No calculation at this stage							
8	23	13.80	-93	18.00	31	-126	68	15.93
9	10	12.60	-159	17.40	13	-215	58	15.42
10	16	12.60	-152	17.40	22	-206	60	15.42

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	21.98	-0.000	13.20	Change EI of wall to 485571kN.m2/m run
2	0.000	15.00	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	-0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003	18.00	0.000	21.98	Excav. to elev. 15.93 on RIGHT side
7	No calculation at this stage				Install prop no.2 at elev. 21.78
8	0.003	18.00	0.000	21.98	Remove prop no.1 at elev. 21.50
9	0.005	17.40	0.000	21.98	Change soil type 4 to soil type 6
10	0.005	17.40	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

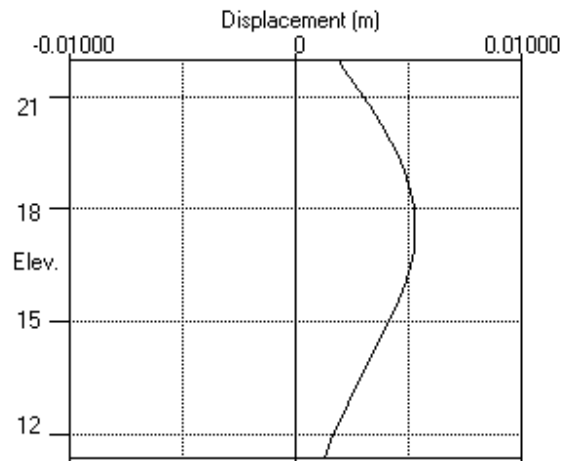
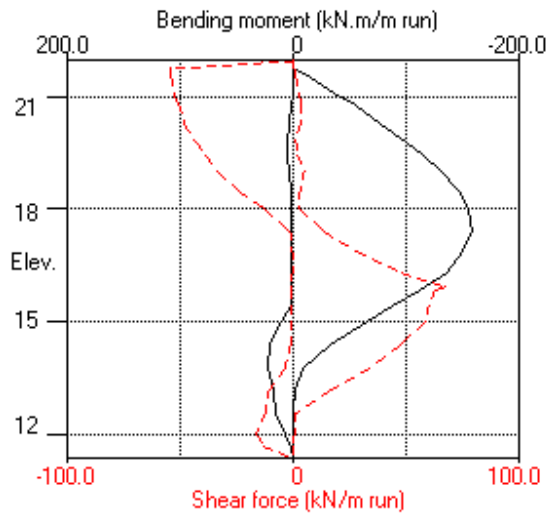
Stage no.	Prop no. 1			Prop no. 2		
	at elev. 21.50			at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per	kN per	kN per	kN per	kN per	kN per
	m run	prop	prop	m run	prop	prop
6	41	41	55	---	---	---
8	---	---	---	38	38	51
9	---	---	---	55	55	74
10	---	---	---	53	53	72

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Bending moment, shear force, displacement envelopes



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INPUT DATA

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	21.98	3 SAND		3 SAND
2	19.00	4 LC UnDr		4 LC UnDr

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	MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2	Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3	SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5	Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6	LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7	CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

		--- parameters for Ka ---			--- parameters for Kp ---		
----- Soil type -----		Soil friction	Wall adhesion	Back-fill	Soil friction	Wall adhesion	Back-fill
No.	Description	angle	coeff.	angle	angle	coeff.	angle
1	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Left side				Right side				MC+WC
	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	1	16.33	16.33	0.0	1	15.83	15.83	

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2	Equiv. soil type	Partial factor/ Category
1	21.98	2.00(L)	50.00	50.00	20.00	= N/A 1.10 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	= N/A 1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.93 on RIGHT side
7	Excavate to elevation 15.83 on RIGHT side
8	Fill to elevation 15.93 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run
	Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
 Water pressures : Moderately Conservative
 Partial factor on C' = 1.000
 Partial factor on Phi' = 1.000
 Partial factor on Cu = 1.000
 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 = 1.100
 Design factor on calculated Bending Moments = 1.350

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m3
 Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 10.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 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 Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 15.83 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 15.93 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

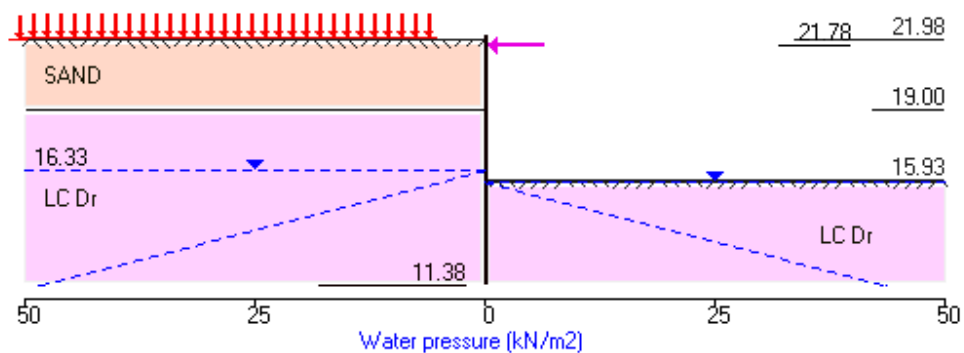
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Stage No.12 Change EI of wall to 346836kN.m²/m run



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Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 20.00 from wall

Right side 20.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	21.98	0.002	-0.000	0	-0	0	-0	0	0	0	0
2	21.78	0.002	-0.000	0	-0	0	-0	0	-57	0	-77
3	21.50	0.002	-0.000	0	-16	0	-21	1	-56	1	-76
4	21.00	0.003	0.000	1	-43	1	-59	2	-55	3	-74
5	20.75	0.003	0.000	2	-57	2	-77	4	-53	5	-72
6	20.28	0.004	0.000	4	-81	6	-109	4	-50	5	-68
7	19.80	0.004	0.000	6	-103	8	-140	1	-46	1	-61
8	19.40	0.005	0.000	5	-121	7	-163	2	-41	2	-55
9	19.00	0.005	0.000	4	-136	5	-184	5	-35	7	-48
10	18.50	0.005	0.000	1	-152	1	-205	4	-26	5	-35
11	18.00	0.005	0.000	1	-163	2	-220	2	-15	3	-20
12	17.40	0.005	0.000	2	-164	3	-221	13	-2	17	-2
13	16.87	0.005	0.000	2	-158	3	-214	27	-1	36	-1
14	16.33	0.005	0.000	2	-144	3	-194	47	-0	63	-0
15	15.93	0.005	0.000	2	-126	3	-170	67	-1	90	-1
16	15.83	0.005	0.000	2	-121	3	-163	70	-1	95	-1
17	15.42	0.005	0.000	2	-96	2	-130	63	-1	84	-1
18	15.00	0.004	0.000	10	-71	14	-96	61	-1	82	-1
19	14.40	0.004	-0.000	23	-38	30	-51	50	-1	67	-1
20	13.80	0.003	-0.000	24	-12	33	-17	36	-3	48	-4
21	13.20	0.003	-0.000	19	-1	26	-2	18	-11	24	-15
22	12.60	0.002	-0.000	15	-1	21	-1	1	-13	1	-18
23	12.00	0.002	-0.000	7	-0	9	-0	0	-16	1	-21
24	11.69	0.001	-0.000	3	-0	3	-0	0	-12	0	-17
25	11.38	0.001	-0.000	0	-0	0	-0	0	-0	0	-0

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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. 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	2	16.87	-3	19.80	3	-3	5	19.00	-2	20.75	7	-3
2	0	21.98	-4	19.40	0	-6	3	19.00	-3	20.28	4	-4
3	1	20.28	-5	16.87	1	-7	1	14.40	-3	19.00	2	-5
4	6	19.80	-3	16.33	8	-4	4	20.28	-5	19.00	5	-6
5	No calculation at this stage											
6	21	13.80	-93	18.00	28	-126	67	15.93	-41	21.50	90	-55
7	21	13.80	-96	18.00	29	-130	69	15.83	-42	21.50	93	-56
8	22	13.80	-96	18.00	30	-130	69	15.83	-42	21.50	94	-56
9	No calculation at this stage											
10	24	13.80	-97	18.00	33	-131	70	15.83	-39	21.78	95	-53
11	9	12.60	-164	17.40	12	-221	60	15.42	-57	21.78	82	-77
12	15	12.60	-156	18.00	21	-211	63	15.42	-55	21.78	84	-74

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.000	21.98	-0.000	13.20	Change EI of wall to 485571kN.m2/m run
2	0.000	15.00	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	-0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003	18.00	0.000	21.98	Excav. to elev. 15.93 on RIGHT side
7	0.003	18.00	0.000	21.98	Excav. to elev. 15.83 on RIGHT side
8	0.003	18.00	0.000	21.98	Fill to elev. 15.93 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.003	18.00	0.000	21.98	Remove prop no.1 at elev. 21.50
11	0.005	17.40	0.000	21.98	Change soil type 4 to soil type 6
12	0.005	17.40	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

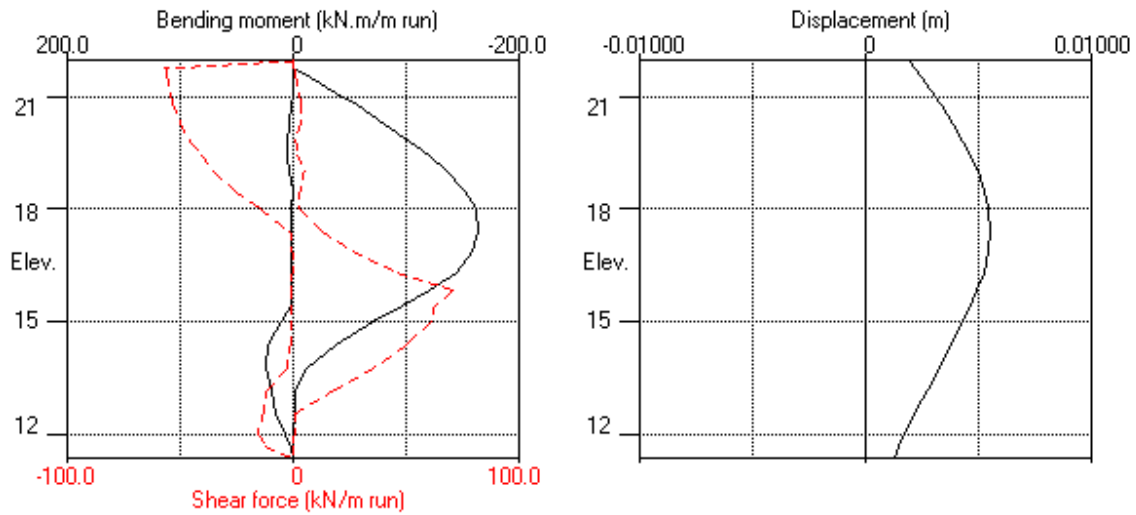
Stage no.	Prop no. 1 at elev. 21.50			Prop no. 2 at elev. 21.78		
	--Calculated--		Factored	--Calculated--		Factored
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
6	41	41	56	---	---	---
7	42	42	57	---	---	---
8	42	42	57	---	---	---
10	---	---	---	39	39	53
11	---	---	---	57	57	77
12	---	---	---	55	55	74

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 Tottenham Court Road
 CONTIG 3, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
Checked :

INPUT DATA

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	21.98	3 SAND	3 SAND
2	19.00	4 LC UnDr	4 LC UnDr

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	MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2	Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3	SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5	Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6	LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7	CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8	LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

		--- parameters for Ka ---			--- parameters for Kp ---		
		Soil	Wall	Back-	Soil	Wall	Back-
----- Soil type -----		friction	adhesion	fill	friction	adhesion	fill
No.	Description	angle	coeff.	angle	angle	coeff.	angle
1	MG	30.00	0.500	0.00	30.00	0.500	0.00
2	Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3	SAND	35.00	0.500	0.00	35.00	0.500	0.00
4	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5	Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6	LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7	CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8	LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

Water press. profile no.	Left side				Right side				MC+WC
	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
	1	1	16.33	16.33	0.0	1	15.83	15.83	

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 11.38
 Maximum finite element length = 0.60 m
 Youngs modulus of wall E = 2.8000E+07 kN/m2
 Moment of inertia of wall I = 0.024774 m4/m run
 E.I = 693672 kN.m2/m run
 Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	21.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	21.78	1.00	0.400000	2.100E+07	30.00	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/m2		Equiv. soil type	Partial factor/ Category
					Near edge	Far edge		
1	21.98	2.00(L)	50.00	50.00	20.00	=	N/A	1.30 Var
2	15.90	-0.00(R)	50.00	50.00	55.00	=	N/A	1.00 P/U

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	Change EI of wall to 485571 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 21.98
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 20.75 on RIGHT side
5	Install strut or anchor no.1 at elevation 21.50
6	Excavate to elevation 15.93 on RIGHT side
7	Excavate to elevation 15.83 on RIGHT side
8	Fill to elevation 15.93 on RIGHT side with soil type 1
9	Install strut or anchor no.2 at elevation 21.78
10	Remove strut or anchor no.1 at elevation 21.50
11	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
12	Change EI of wall to 346836 kN.m2/m run
	Allow wall to relax with new modulus value

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) = 10.60 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 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 Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 485571kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 21.98	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 20.75 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 21.50	Yes	Yes	Yes
6	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 15.83 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 15.93 on RIGHT side	Yes	Yes	Yes
9	Install prop no.2 at elev. 21.78	Yes	Yes	Yes
10	Remove prop no.1 at elev. 21.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Change EI of wall to 346836kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

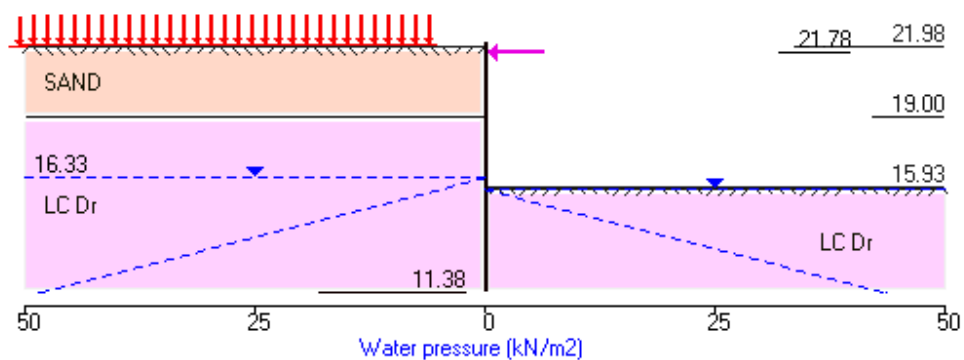
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 Tottenham Court Road
 CONTIG 3, 750mm Contig PROPPED

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 Date: 27-05-2022
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Units: kN,m

Stage No.12 Change EI of wall to 346836kN.m²/m run



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 CONTIG 3, 750mm Contig PROPPED

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 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

Overall								
Stage No.	Ground Act.	level Pass.	Prop Elev.	FoS for toe elev. = 11.38		Toe elev. for FoS = 1.000		Direction of failure
				Factor of Safety	Moment of equilb. at elev.	Toe elev.	Wall Penetr -ation	
1	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
2	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
3	21.98	21.98	Cant.	Conditions not suitable for FoS calc.				
4	21.98	20.75	Cant.	6.848	12.07	19.80	0.95	L to R
5	21.98	20.75		No analysis at this stage				
6	21.98	15.93	21.50	2.848	n/a	15.57	0.36	L to R
7	21.98	15.83	21.50	2.799	n/a	15.46	0.37	L to R
8	21.98	15.93	21.50	2.828	n/a	15.47	0.46	L to R
9	21.98	15.93		No analysis at this stage				
10	21.98	15.93	21.78	2.814	n/a	15.46	0.47	L to R
11	21.98	15.93	21.78	1.003	n/a	11.41	4.52	L to R
12	21.98	15.93	21.78	1.003	n/a	11.41	4.52	L to R

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 Tottenham Court Road
 CONTIG 3, 750mm Contig PROPPED

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: 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	21.98	0.002	-0.000	0.0	-0.0	0.0	0.0
2	21.78	0.002	-0.000	0.0	-0.0	0.1	-93.9
3	21.50	0.003	0.000	0.1	-26.2	0.7	-93.4
4	21.00	0.005	0.000	1.2	-72.2	2.8	-91.2
5	20.75	0.005	0.000	2.2	-94.7	4.5	-89.5
6	20.28	0.007	0.000	5.3	-135.8	5.1	-85.1
7	19.80	0.008	0.000	7.3	-174.7	2.6	-79.2
8	19.40	0.009	0.000	7.9	-205.2	1.7	-73.0
9	19.00	0.010	0.000	7.3	-233.2	5.1	-65.7
10	18.50	0.010	0.000	5.7	-263.5	3.5	-53.3
11	18.00	0.011	0.000	4.1	-286.8	3.3	-38.3
12	17.40	0.012	0.000	2.4	-303.8	16.1	-17.2
13	16.87	0.012	0.000	2.2	-304.1	29.9	-2.1
14	16.33	0.012	0.000	2.1	-295.2	49.0	-1.7
15	15.93	0.012	0.000	1.9	-279.5	68.9	-1.3
16	15.83	0.012	0.000	1.9	-274.3	72.4	-1.2
17	15.42	0.011	0.000	1.6	-248.9	67.5	-0.9
18	15.00	0.011	0.000	16.9	-219.0	76.5	-0.8
19	14.40	0.010	-0.000	28.1	-171.3	83.0	-0.8
20	13.80	0.009	-0.000	28.4	-122.0	81.9	-5.2
21	13.20	0.008	-0.000	22.0	-75.7	73.0	-13.3
22	12.60	0.006	-0.000	12.7	-37.0	56.4	-15.2
23	12.00	0.005	-0.000	4.0	-10.7	32.0	-11.0
24	11.69	0.004	-0.000	1.1	-2.3	16.2	-6.4
25	11.38	0.004	-0.000	0.0	-0.0	0.0	-0.0

Run ID. 2176_TCR_CONTIG_3_ULS2
Tottenham Court Road
CONTIG 3, 750mm Contig PROPPED

Sheet No.
Date: 27-05-2022
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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>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	2.2	16.87	-2.5	19.80	5.1	19.00	-2.4	20.75
2	0.0	21.98	-4.5	19.40	2.6	19.00	-3.4	20.28
3	1.0	20.28	-6.1	16.87	1.4	14.40	-3.8	19.00
4	7.9	19.40	-1.1	14.40	5.1	20.28	-2.7	18.00
5	No calculation at this stage							
6	24.5	13.80	-92.8	18.00	68.9	15.93	-44.2	21.50
7	25.4	13.80	-95.5	18.00	70.7	15.83	-45.0	21.50
8	25.9	13.80	-95.9	18.00	71.4	15.83	-45.1	21.50
9	No calculation at this stage							
10	28.4	13.80	-96.4	18.00	72.4	15.83	-42.4	21.78
11	0.0	21.98	-304.1	16.87	83.0	14.40	-93.9	21.78
12	0.0	21.98	-304.0	16.87	83.0	14.40	-93.9	21.78

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	21.98	-0.000	13.20	Change EI of wall to 485571kN.m2/m run
2	0.000	14.40	0.000	21.98	Apply surcharge no.1 at elev. 21.98
3	0.000	13.80	-0.000	21.98	Apply water pressure profile no.1
4	0.001	21.98	0.000	21.98	Excav. to elev. 20.75 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 21.50
6	0.003	18.00	0.000	21.98	Excav. to elev. 15.93 on RIGHT side
7	0.003	18.00	0.000	21.98	Excav. to elev. 15.83 on RIGHT side
8	0.003	18.00	0.000	21.98	Fill to elev. 15.93 on RIGHT side
9	No calculation at this stage				Install prop no.2 at elev. 21.78
10	0.003	18.50	0.000	21.98	Remove prop no.1 at elev. 21.50
11	0.009	16.87	0.000	21.98	Change soil type 4 to soil type 6
12	0.012	16.87	0.000	21.98	Change EI of wall to 346836kN.m2/m run

Prop forces at each stage (horizontal components)

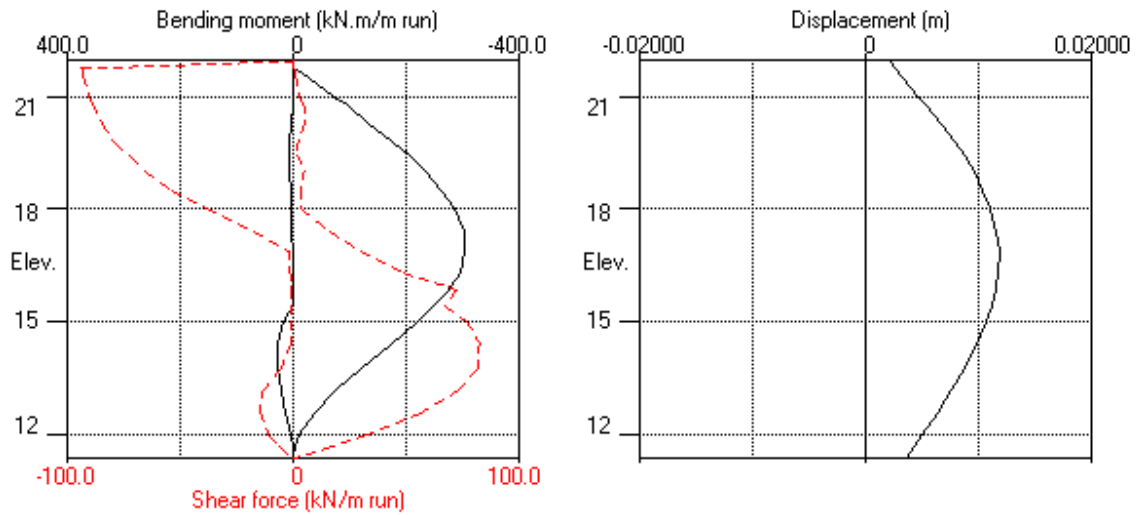
Stage no.	Strut no. 1		Strut no. 2	
	at elev. 21.50		at elev. 21.78	
	kN/m run	kN/prop	kN/m run	kN/prop
6	44.84	44.84	---	---
7	45.63	45.63	---	---
8	45.74	45.74	---	---
10	---	---	42.47	42.47
11	---	---	94.05	94.05
12	---	---	94.05	94.05

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Units: kN,m

Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil		Wall	Back-	Soil		Wall	Back-
friction angle		adhesion coeff.	fill angle	friction angle		adhesion coeff.	fill angle
----- Soil type -----							
No. Description							
1 MG		30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr		0.00	0.500	0.00	0.00	0.500	0.00
3 SAND		35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr		24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr		25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE		40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 18.38
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2		Equiv. soil type	Partial factor/ Category
	Elev.			Near edge	Far edge		
1	26.70	0.50(L)	50.00	20.00	25.00	=	N/A 1.00 Var
2	20.93	-0.00(R)	50.00	20.00	53.00	=	N/A 1.00 P/U

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	Change EI of wall to 450887 kN.m2/m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.93 on RIGHT side
7	Fill to elevation 21.98 on RIGHT side with soil type 7
8	Install strut or anchor no.3 at elevation 21.50
9	Install strut or anchor no.2 at elevation 26.50
10	Remove strut or anchor no.1 at elevation 25.50
11	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
12	Apply surcharge no.2 at elevation 20.93
13	Apply water pressure profile no.2 (Mod. Conserv.)
14	Change EI of wall to 322062 kN.m2/m run Allow wall to relax with new modulus value

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) = 8.320 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m

Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m

Distance to rigid boundary on Right side = 25.00 m

OUTPUT OPTIONS

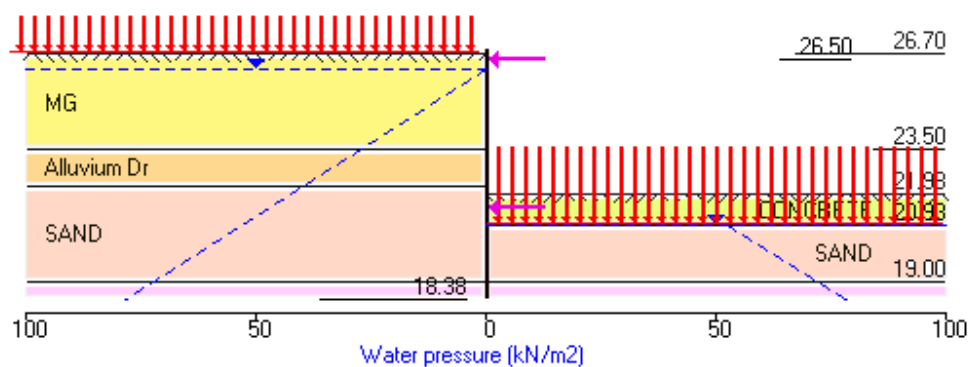
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m ² /m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
7	Fill to elev. 21.98 on RIGHT side	Yes	Yes	Yes
8	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
9	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
10	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
11	Change soil type 4 to soil type 6	Yes	Yes	Yes
12	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
13	Apply water pressure profile no.2	Yes	Yes	Yes
14	Change EI of wall to 322062kN.m ² /m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Stage No.14 Change EI of wall to 322062kN.m²/m run



Sheet No.
Job No. 2176
Made by : JRM

Date: 27-05-2022
Checked :

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

Stage No.	Ground Act.	level Pass.	Prop Elev.	FoS for toe elev. = 18.38		Toe elev. for FoS = 1.000		Direction of failure
				Factor of Safety	Moment of equilib. at elev.	Toe elev.	Wall Penetr -ation	
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	25.00	Cant.	2.709	19.18	23.35	1.65	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	20.93	25.50	1.492	n/a	19.03	1.90	L to R
7	26.70	21.98	25.50	3.603	n/a	21.91	0.07	L to R
8	26.70	21.98		No analysis at this stage				
All	remaining stages have more than one prop - FoS calculation n/a							

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall
 Right side 25.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.005	-0.000	0	-0	0	-0	0	-81	0	-109
3	26.20	0.005	-0.000	0	-24	0	-33	1	-80	1	-108
4	25.85	0.006	-0.000	1	-52	1	-70	3	-78	4	-105
5	25.50	0.006	-0.000	2	-78	3	-106	6	-73	8	-99
6	25.00	0.006	-0.000	7	-113	9	-152	12	-67	16	-91
7	24.50	0.006	-0.000	14	-141	19	-191	15	-60	21	-81
8	24.00	0.006	-0.000	22	-163	30	-220	16	-51	22	-68
9	23.50	0.006	-0.000	30	-176	41	-237	18	-40	24	-54
10	23.00	0.006	0.000	37	-177	50	-239	19	-22	25	-30
11	22.63	0.006	0.000	41	-169	56	-228	43	-6	58	-8
12	22.25	0.005	0.000	44	-150	59	-202	73	0	98	0
13	21.98	0.005	0.000	45	-130	61	-175	88	0	118	0
14	21.50	0.005	0.000	44	-116	59	-157	95	-7	128	-9
15	21.00	0.004	0.000	39	-96	52	-129	52	-12	71	-17
16	20.93	0.004	0.000	38	-92	51	-125	55	-13	74	-18
17	20.83	0.004	0.000	36	-87	49	-117	56	-14	76	-19
18	20.42	0.004	0.000	30	-63	41	-86	58	-16	78	-22
19	20.00	0.003	0.000	23	-40	31	-54	53	-17	71	-23
20	19.50	0.003	0.000	14	-16	19	-21	36	-18	49	-24
21	19.00	0.002	0.000	5	-3	7	-4	16	-17	22	-23
22	18.69	0.002	0.000	1	-0	2	-0	5	-9	7	-12
23	18.38	0.002	0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_SW01-A_900_SLS
Tottenham Court Road
SW01-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	21.98	-0	19.50	0	-0	0	26.70
2	7	21.50	-1	25.00	9	-1	3	23.50
3	6	21.50	-1	25.00	9	-1	3	23.50
4	45	21.98	-0	18.38	61	-0	18	23.50
5	No calculation at this stage							
6	2	25.50	-133	22.63	3	-180	57	20.42
7	2	25.50	-136	22.63	3	-184	58	20.42
8	No calculation at this stage							
9	No calculation at this stage							
10	0	18.69	-136	23.00	0	-184	49	20.42
11	0	18.69	-136	23.00	0	-184	49	20.42
12	0	18.69	-146	23.00	0	-197	56	20.42
13	1	18.69	-177	23.00	1	-239	94	21.50
14	2	19.00	-157	23.50	2	-212	95	21.50

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	18.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.003	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.005	24.00	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
7	0.005	24.00	0.000	26.70	Fill to elev. 21.98 on RIGHT side
8	No calculation at this stage				Install prop no.3 at elev. 21.50
9	No calculation at this stage				Install prop no.2 at elev. 26.50
10	0.006	24.50	0.000	26.70	Remove prop no.1 at elev. 25.50
11	0.006	24.50	0.000	26.70	Change soil type 4 to soil type 6
12	0.006	24.50	0.000	26.70	Apply surcharge no.2 at elev. 20.93
13	0.006	24.00	0.000	26.70	Apply water pressure profile no.2
14	0.006	24.00	0.000	26.70	Change EI of wall to 322062kN.m2/m run

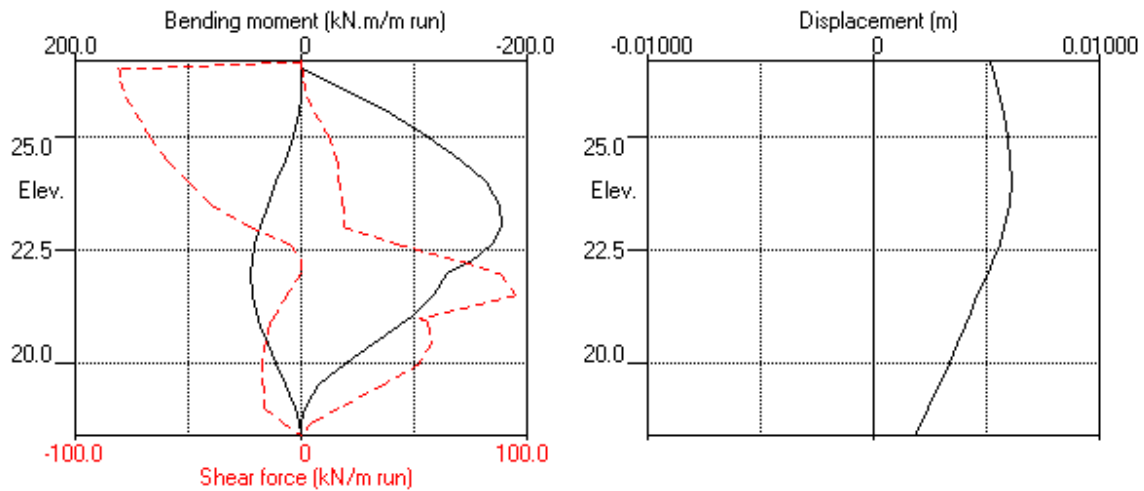
Prop forces at each stage (horizontal components)

Stage no.	Prop no. 1			Prop no. 2			Prop no. 3		
	at elev. 25.50			at elev. 26.50			at elev. 21.50		
	--Calculated--	Factored		--Calculated--	Factored		--Calculated--	Factored	
	kN per	kN per	kN per	kN per	kN per	kN per	kN per	kN per	kN per
	m run	prop	prop	m run	prop	prop	m run	prop	prop
6	78	78	106	---	---	---	---	---	---
7	79	79	107	---	---	---	---	---	---
10	---	---	---	58	58	79	21	21	28
11	---	---	---	58	58	79	21	21	28
12	---	---	---	61	61	82	6	6	9
13	---	---	---	81	81	109	75	75	102
14	---	---	---	73	73	98	92	92	124

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

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Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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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	26.70	1 MG	1 MG
2	23.50	5 Alluvium Dr	5 Alluvium Dr
3	22.25	3 SAND	3 SAND
4	19.00	4 LC UnDr	4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---		
Soil	Wall	Back-		Soil	Wall	Back-
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle
1 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Water press. 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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 18.38
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 -----		Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	20.00	25.00	=	N/A 1.10 Var
2	20.93	-0.00(R)	50.00	20.00	53.00	=	N/A 1.00 P/U

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	Change EI of wall to 450887 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.93 on RIGHT side
7	Excavate to elevation 20.83 on RIGHT side
8	Fill to elevation 20.93 on RIGHT side with soil type 1
9	Fill to elevation 21.98 on RIGHT side with soil type 7
10	Install strut or anchor no.3 at elevation 21.50
11	Install strut or anchor no.2 at elevation 26.50
12	Remove strut or anchor no.1 at elevation 25.50
13	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
14	Apply surcharge no.2 at elevation 20.93
15	Apply water pressure profile no.2 (Mod. Conserv.)
16	Change EI of wall to 322062 kN.m2/m run
	Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
Water pressures : Moderately Conservative
Partial factor on C' = 1.000
Partial factor on Phi' = 1.000
Partial factor on Cu = 1.000
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 = 1.100
Design factor on calculated Bending Moments = 1.350

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) = 8.320 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m
Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m
Distance to rigid boundary on Right side = 25.00 m

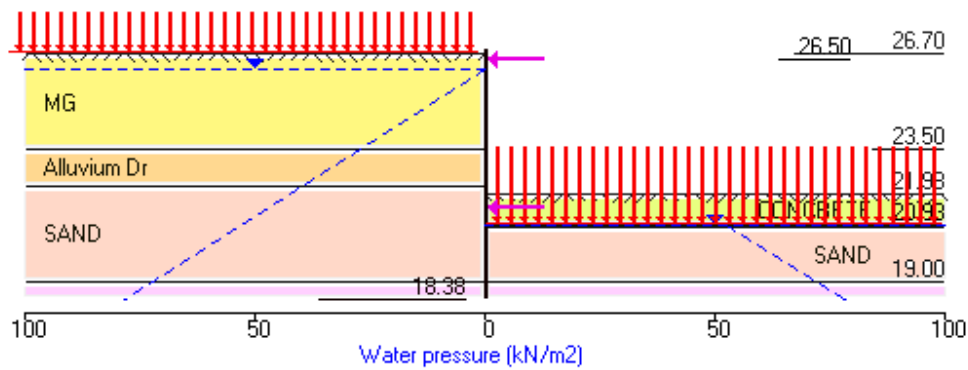
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 20.83 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 20.93 on RIGHT side	Yes	Yes	Yes
9	Fill to elev. 21.98 on RIGHT side	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
11	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
12	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
13	Change soil type 4 to soil type 6	Yes	Yes	Yes
14	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
16	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

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 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.16 Change EI of wall to 322062kN.m²/m run



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall
 Right side 25.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.005	-0.000	0	-0	0	-0	0	-84	0	-113
3	26.20	0.006	-0.000	0	-25	0	-34	1	-83	1	-112
4	25.85	0.006	-0.000	1	-54	1	-73	3	-81	4	-109
5	25.50	0.006	-0.000	2	-81	3	-110	6	-77	8	-104
6	25.00	0.006	-0.000	7	-117	9	-158	12	-71	17	-96
7	24.50	0.006	-0.000	15	-147	20	-198	16	-63	22	-85
8	24.00	0.006	-0.000	23	-170	31	-229	17	-54	23	-73
9	23.50	0.006	-0.000	31	-184	42	-248	18	-43	25	-58
10	23.00	0.006	0.000	39	-185	52	-250	17	-26	23	-35
11	22.63	0.006	0.000	43	-177	58	-239	41	-9	56	-13
12	22.25	0.006	0.000	46	-159	61	-215	70	0	94	0
13	21.98	0.005	0.000	47	-141	63	-191	85	0	115	0
14	21.50	0.005	0.000	45	-130	61	-176	92	-7	124	-9
15	21.00	0.005	0.000	40	-111	54	-150	49	-13	66	-17
16	20.93	0.005	0.000	39	-108	53	-146	51	-13	69	-18
17	20.83	0.004	0.000	38	-103	51	-139	53	-14	72	-19
18	20.42	0.004	0.000	31	-80	42	-108	59	-17	80	-22
19	20.00	0.004	0.000	24	-55	32	-74	59	-18	80	-24
20	19.50	0.003	0.000	15	-26	20	-35	48	-18	64	-25
21	19.00	0.003	0.000	6	-7	8	-9	29	-17	39	-24
22	18.69	0.002	0.000	1	-1	2	-2	11	-9	15	-12
23	18.38	0.002	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW01-A_900_ULS1
Tottenham Court Road
SW01-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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. 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	0	21.98	-0	19.50	0	-0	0	26.70	0	26.70	0	0
2	7	21.50	-1	25.00	10	-2	4	23.50	-4	19.00	5	-6
3	7	21.50	-1	25.00	10	-2	4	23.50	-4	19.00	5	-5
4	47	21.98	0	26.70	63	0	18	23.50	-18	19.50	25	-25
5	No calculation at this stage											
6	2	25.50	-134	22.63	3	-181	58	20.42	-74	25.50	78	-99
7	2	25.50	-142	22.63	3	-192	59	20.42	-76	25.50	79	-103
8	2	25.50	-142	22.63	3	-192	59	20.42	-76	25.50	79	-103
9	2	25.50	-145	22.25	3	-196	59	20.42	-77	25.50	80	-104
10	No calculation at this stage											
11	No calculation at this stage											
12	0	26.50	-144	23.00	0	-194	51	20.00	-61	26.50	69	-82
13	0	26.50	-144	23.00	0	-194	51	20.00	-61	26.50	69	-82
14	0	26.50	-154	23.00	0	-208	57	20.42	-64	26.50	77	-86
15	0	26.50	-185	23.00	0	-250	91	21.50	-84	26.50	123	-113
16	0	18.69	-163	23.50	0	-220	92	21.50	-75	26.50	124	-101

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.000	18.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.003	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.005	24.00	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
7	0.006	23.50	0.000	26.70	Excav. to elev. 20.83 on RIGHT side
8	0.006	23.50	0.000	26.70	Fill to elev. 20.93 on RIGHT side
9	0.006	24.00	0.000	26.70	Fill to elev. 21.98 on RIGHT side
10	No calculation at this stage				Install prop no.3 at elev. 21.50
11	No calculation at this stage				Install prop no.2 at elev. 26.50
12	0.006	24.00	0.000	26.70	Remove prop no.1 at elev. 25.50
13	0.006	24.00	0.000	26.70	Change soil type 4 to soil type 6
14	0.006	24.00	0.000	26.70	Apply surcharge no.2 at elev. 20.93
15	0.006	24.00	0.000	26.70	Apply water pressure profile no.2
16	0.006	24.00	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW01-A_900_ULS1
Tottenham Court Road
SW01-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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.

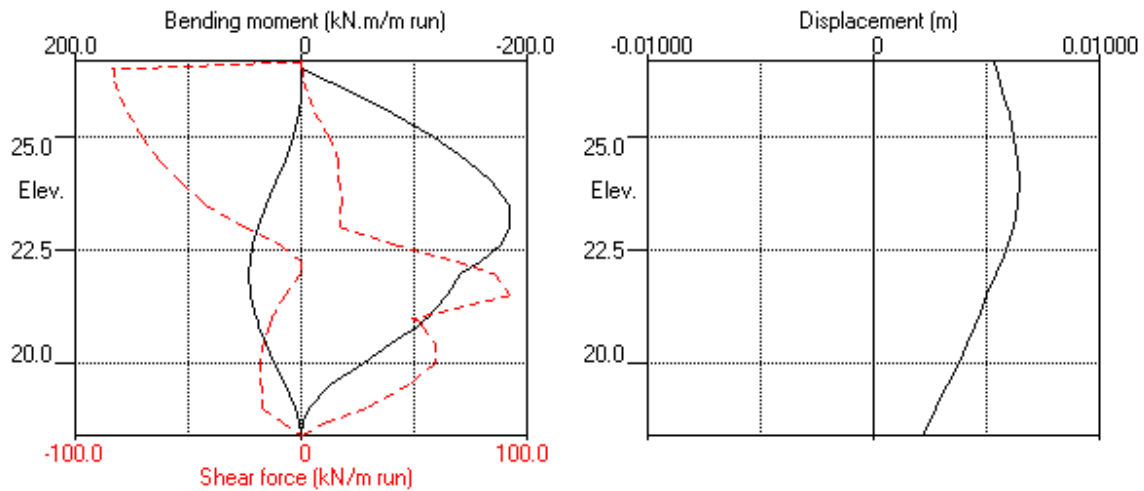
Prop forces at each stage (horizontal components)

Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.50		
	--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	kN per m run	kN per prop	kN per prop
6	80	80	108	---	---	---	---	---	---
7	82	82	111	---	---	---	---	---	---
8	82	82	111	---	---	---	---	---	---
9	83	83	113	---	---	---	---	---	---
12	---	---	---	61	61	83	22	22	30
13	---	---	---	61	61	83	22	22	30
14	---	---	---	64	64	86	7	7	9
15	---	---	---	84	84	113	76	76	103
16	---	---	---	75	75	102	94	94	127

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil		Wall	Back-	Soil		Wall	Back-
friction angle		adhesion coeff.	fill angle	friction angle		adhesion coeff.	fill angle
----- Soil type -----							
No. Description							
1 MG		30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr		0.00	0.500	0.00	0.00	0.500	0.00
3 SAND		35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr		24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr		25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE		40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Water press. 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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 18.38
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2		Equiv. soil type	Partial factor/ Category
	Elev.			Near edge	Far edge		
1	26.70	0.50(L)	50.00	20.00	25.00	=	N/A 1.30 Var
2	20.93	-0.00(R)	50.00	20.00	53.00	=	N/A 1.00 P/U

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	Change EI of wall to 450887 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.93 on RIGHT side
7	Excavate to elevation 20.83 on RIGHT side
8	Fill to elevation 20.93 on RIGHT side with soil type 1
9	Fill to elevation 21.98 on RIGHT side with soil type 7
10	Install strut or anchor no.3 at elevation 21.50
11	Install strut or anchor no.2 at elevation 26.50
12	Remove strut or anchor no.1 at elevation 25.50
13	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
14	Apply surcharge no.2 at elevation 20.93
15	Apply water pressure profile no.2 (Worst Cred.)
16	Change EI of wall to 322062 kN.m2/m run
	Allow wall to relax with new modulus value

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) = 8.320 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m

Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m

Distance to rigid boundary on Right side = 25.00 m

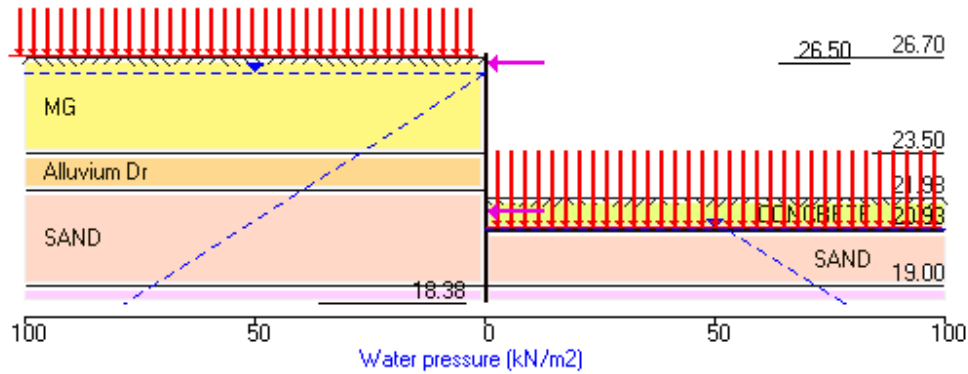
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 20.83 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 20.93 on RIGHT side	Yes	Yes	Yes
9	Fill to elev. 21.98 on RIGHT side	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
11	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
12	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
13	Change soil type 4 to soil type 6	Yes	Yes	Yes
14	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
16	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
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Stage No.16 Change EI of wall to 322062kN.m2/m run



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 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

Overall								
				FoS for toe		Toe elev. for		
				elev. = 18.38		FoS = 1.000		
<u>Stage</u>	<u>Ground</u>	<u>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 elev.</u>		<u>-ation</u>	<u>failure</u>
1	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
4	26.70	25.00	Cant.	2.017	19.21	22.37	2.63	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	20.93	25.50	1.113	n/a	18.59	2.34	L to R
7	26.70	20.83	25.50	1.076	n/a	18.51	2.32	L to R
8	26.70	20.93	25.50	1.111	n/a	18.59	2.34	L to R
9	26.70	21.98	25.50	2.700	n/a	21.84	0.14	L to R
10	26.70	21.98		No analysis at this stage				

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

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 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall
 Right side 25.00 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	26.70	0.007	-0.000	0.0	-0.0	0.0	0.0
2	26.50	0.007	-0.000	0.0	-0.0	0.2	-98.3
3	26.20	0.007	-0.000	0.2	-29.3	1.2	-97.3
4	25.85	0.008	-0.000	1.1	-62.9	3.9	-94.1
5	25.50	0.008	-0.000	3.1	-95.0	8.2	-100.7
6	25.00	0.008	-0.000	9.2	-136.5	16.4	-92.5
7	24.50	0.008	-0.000	19.3	-171.1	21.6	-82.1
8	24.00	0.008	-0.000	30.3	-197.2	22.7	-69.7
9	23.50	0.008	-0.000	42.0	-212.6	24.0	-55.3
10	23.00	0.008	0.000	52.1	-214.3	20.7	-35.1
11	22.63	0.008	0.000	56.4	-205.4	45.7	-18.4
12	22.25	0.008	0.000	59.0	-194.2	73.2	-0.3
13	21.98	0.008	0.000	59.5	-193.0	90.0	-0.2
14	21.50	0.007	0.000	57.3	-184.5	100.3	-10.4
15	21.00	0.007	0.000	51.4	-166.2	48.7	-14.9
16	20.93	0.007	0.000	50.3	-162.8	51.5	-15.8
17	20.83	0.007	0.000	48.7	-157.5	55.3	-16.9
18	20.42	0.006	0.000	40.9	-132.0	67.9	-20.6
19	20.00	0.006	0.000	31.7	-101.9	76.7	-23.0
20	19.50	0.005	0.000	19.8	-62.7	79.7	-23.8
21	19.00	0.004	0.000	7.9	-24.0	74.6	-22.8
22	18.69	0.004	0.000	2.3	-5.0	35.1	-12.7
23	18.38	0.004	0.000	0.0	-0.0	0.0	0.0

Run ID. 2176_TCR_SW01-A_900_ULS2
Tottenham Court Road
SW01-A, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
Checked :

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	0.0	21.98	-0.0	19.50	0.0	26.70	0.0	26.70
2	10.0	21.50	-0.7	25.50	4.9	23.50	-5.7	19.00
3	9.9	21.50	-0.6	25.50	4.9	23.50	-4.9	19.00
4	59.5	21.98	0.0	26.70	24.0	23.50	-23.8	19.50
5	No calculation at this stage							
6	3.1	25.50	-181.8	22.25	72.0	20.00	-96.8	25.50
7	3.1	25.50	-191.2	22.25	78.6	19.50	-99.7	25.50
8	3.1	25.50	-191.4	22.25	78.7	19.50	-99.8	25.50
9	3.1	25.50	-194.2	22.25	79.7	19.50	-100.7	25.50
10	No calculation at this stage							
11	No calculation at this stage							
12	0.0	26.50	-188.6	23.00	70.3	19.50	-79.9	26.50
13	0.0	26.50	-173.5	23.00	57.0	20.00	-75.9	26.50
14	0.0	26.50	-183.3	23.00	61.3	20.00	-78.5	26.50
15	0.0	26.50	-214.3	23.00	99.0	21.50	-98.3	26.50
16	0.0	26.50	-187.3	23.50	100.3	21.50	-87.2	26.50

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	0.000	18.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.004	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.007	23.50	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
7	0.008	23.50	0.000	26.70	Excav. to elev. 20.83 on RIGHT side
8	0.008	23.50	0.000	26.70	Fill to elev. 20.93 on RIGHT side
9	0.008	23.50	0.000	26.70	Fill to elev. 21.98 on RIGHT side
10	No calculation at this stage				Install prop no.3 at elev. 21.50
11	No calculation at this stage				Install prop no.2 at elev. 26.50
12	0.008	23.50	0.000	26.70	Remove prop no.1 at elev. 25.50
13	0.008	23.50	0.000	26.70	Change soil type 4 to soil type 6
14	0.008	24.00	0.000	26.70	Apply surcharge no.2 at elev. 20.93
15	0.008	24.00	0.000	26.70	Apply water pressure profile no.2
16	0.008	24.00	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW01-A_900_ULS2
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

| Sheet No.
 | Date:27-05-2022
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Summary of results (continued)

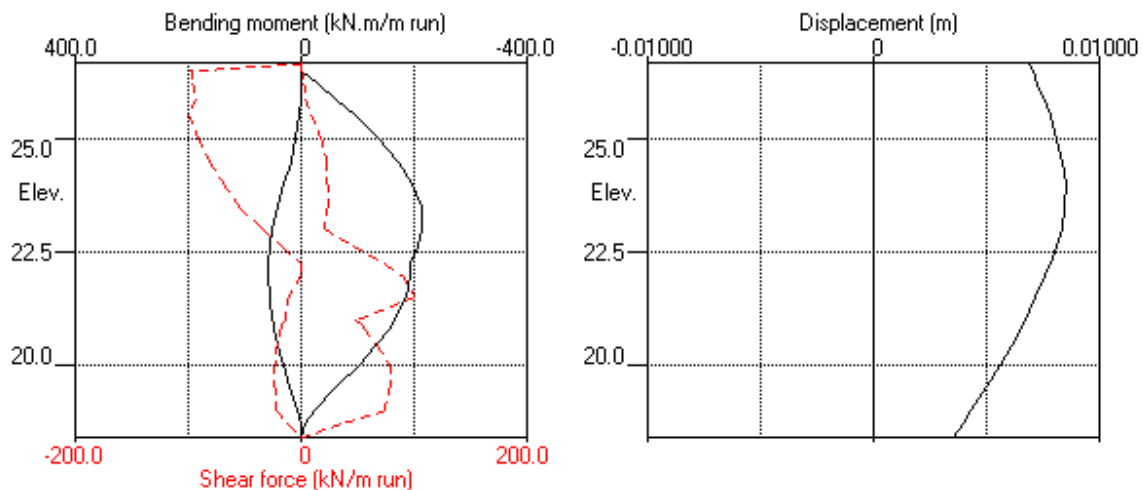
Prop forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 25.50		--- Strut no. 2 --- at elev. 26.50		--- Strut no. 3 --- at elev. 21.50	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
6	104.96	104.96	---	---	---	---
7	107.85	107.85	---	---	---	---
8	107.93	107.93	---	---	---	---
9	108.89	108.89	---	---	---	---
12	---	---	80.09	80.09	29.64	29.64
13	---	---	76.02	76.02	36.38	36.38
14	---	---	78.66	78.66	21.60	21.60
15	---	---	98.47	98.47	89.59	89.59
16	---	---	87.42	87.42	110.79	110.79

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types
		Left side Right side
1	26.70	1 MG 1 MG
2	23.50	5 Alluvium Dr 5 Alluvium Dr
3	22.25	3 SAND 3 SAND
4	19.00	4 LC UnDr 4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3 SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5 Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6 LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7 CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 15.88
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch-arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2		Equiv. soil type	Partial factor/Category
	Elev.			Near edge	Far edge		
1	26.66	0.50(L)	50.00	20.00	25.00	=	N/A 1.00 Var
2	20.93	-0.00(R)	50.00	20.00	53.00	=	N/A 1.00 P/U
3	22.25	1.00(L)	50.00	1.00	485.00	=	N/A 1.00 P/U
4	22.25	1.00(L)	50.00	1.00	111.00	=	N/A 1.00 Var
5	22.25	0.50(L)	50.00	20.00	35.00	=	N/A 1.00 P/U
6	22.25	0.50(L)	50.00	20.00	7.50	=	N/A 1.00 Var

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.93 on RIGHT side
10	Fill to elevation 21.98 on RIGHT side with soil type 7
11	Install strut or anchor no.3 at elevation 21.50
12	Install strut or anchor no.2 at elevation 26.50
13	Remove strut or anchor no.1 at elevation 25.50
14	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
15	Apply surcharge no.2 at elevation 20.93
16	Apply water pressure profile no.2 (Mod. Conserv.)
17	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 10.78 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m
Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m
Distance to rigid boundary on Right side = 25.00 m

OUTPUT OPTIONS

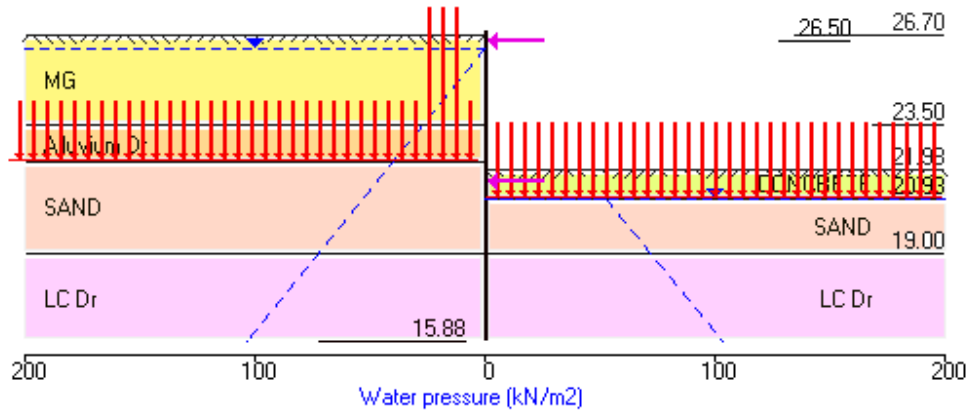
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
10	Fill to elev. 21.98 on RIGHT side	Yes	Yes	Yes
11	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
12	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
13	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
14	Change soil type 4 to soil type 6	Yes	Yes	Yes
15	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
16	Apply water pressure profile no.2	Yes	Yes	Yes
17	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
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 Date: 27-05-2022
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Stage No.17 Change EI of wall to 322062kN.m2/m run



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 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

			FoS for toe		Toe elev. for			
			elev. = 15.88		FoS = 1.000			
<u>Stage</u>	<u>Ground</u>	<u>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 equil.</u>	<u>elev.</u>	<u>Penetr</u>	<u>of</u>
				<u>Safety</u>	<u>at elev.</u>		<u>-ation</u>	<u>failure</u>
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
5	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
6	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
7	26.70	25.00	Cant.	Conditions not suitable for FoS calc.				
8	26.70	25.00		No analysis at this stage				
9	26.70	20.93	25.50	1.458	n/a	18.49	2.44	L to R
10	26.70	21.98	25.50	2.112	n/a	21.91	0.07	L to R
11	26.70	21.98		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall
 Right side 25.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.003	-0.001	0	-0	0	-0	0	0	0	0
2	26.50	0.003	-0.001	0	-0	0	-0	0	-83	1	-111
3	26.20	0.004	-0.001	0	-25	0	-33	2	-82	2	-111
4	25.85	0.004	-0.000	1	-53	2	-72	3	-80	4	-108
5	25.50	0.005	-0.000	3	-81	4	-109	5	-81	7	-110
6	25.00	0.005	-0.000	6	-118	8	-159	11	-78	14	-105
7	24.63	0.006	-0.000	11	-142	14	-192	13	-74	18	-100
8	24.25	0.006	-0.000	16	-164	21	-222	14	-69	19	-94
9	23.88	0.006	-0.000	21	-182	28	-246	14	-64	19	-86
10	23.50	0.007	-0.000	26	-195	36	-264	15	-58	20	-78
11	23.19	0.007	-0.000	30	-202	41	-273	11	-49	14	-66
12	22.88	0.007	-0.000	33	-204	45	-276	13	-38	17	-52
13	22.56	0.007	-0.000	34	-201	47	-271	32	-26	43	-35
14	22.25	0.007	-0.000	35	-191	47	-258	54	-13	72	-17
15	21.98	0.007	-0.000	33	-190	44	-257	67	-13	91	-17
16	21.50	0.007	-0.000	25	-190	33	-256	80	-23	108	-31
17	21.00	0.007	-0.000	11	-180	15	-243	33	-30	45	-40
18	20.93	0.007	-0.000	9	-178	13	-240	37	-30	51	-41
19	20.83	0.007	-0.000	6	-174	9	-235	43	-31	58	-41
20	20.32	0.007	-0.000	0	-147	0	-198	64	-31	86	-41
21	19.80	0.006	-0.000	0	-112	0	-151	74	-30	100	-40
22	19.40	0.006	0.000	0	-83	0	-112	73	-29	99	-39
23	19.00	0.006	0.000	0	-61	0	-82	64	-30	86	-40
24	18.50	0.006	0.000	0	-61	0	-82	44	-0	60	-1
25	18.00	0.005	0.000	0	-53	0	-71	35	0	47	0
26	17.40	0.005	0.000	5	-35	6	-47	32	0	43	0
27	16.80	0.004	0.000	5	-16	6	-21	28	-3	38	-4
28	16.34	0.004	0.000	2	-5	3	-6	17	-5	24	-7
29	15.88	0.003	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW01-B_900_SLS
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	18.00	-0	16.34	0	26.70	0	26.70
2	9	22.88	-43	18.50	23	17.40	-18	20.93
3	11	22.88	-53	18.50	28	17.40	-23	20.93
4	14	22.88	-59	18.50	31	17.40	-25	20.93
5	15	22.88	-60	18.50	32	17.40	-26	20.93
6	15	22.88	-61	18.50	32	17.40	-26	20.93
7	35	22.25	-55	18.50	29	17.40	-31	20.32
8	No calculation at this stage							
9	2	16.80	-189	21.50	72	19.80	-81	25.50
10	4	16.80	-190	21.98	74	19.80	-81	25.50
11	No calculation at this stage							
12	No calculation at this stage							
13	4	16.80	-177	22.56	67	19.80	-62	26.50
14	1	16.34	-166	22.56	54	19.80	-59	26.50
15	2	16.80	-180	22.56	60	19.80	-63	26.50
16	3	16.80	-204	22.88	74	21.50	-83	26.50
17	5	17.40	-173	23.19	80	21.50	-71	26.50

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	15.88	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.002	15.88	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.002	15.88	-0.001	26.70	Apply surcharge no.4 at elev. 22.25
4	0.003	15.88	-0.001	26.70	Apply surcharge no.5 at elev. 22.25
5	0.003	15.88	-0.001	26.70	Apply surcharge no.6 at elev. 22.25
6	0.003	15.88	-0.001	26.70	Apply water pressure profile no.1
7	0.003	15.88	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.007	21.50	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
10	0.007	21.50	0.000	26.70	Fill to elev. 21.98 on RIGHT side
11	No calculation at this stage				Install prop no.3 at elev. 21.50
12	No calculation at this stage				Install prop no.2 at elev. 26.50
13	0.007	21.98	0.000	26.70	Remove prop no.1 at elev. 25.50
14	0.007	21.50	0.000	26.70	Change soil type 4 to soil type 6
15	0.007	21.98	0.000	26.70	Apply surcharge no.2 at elev. 20.93
16	0.007	22.25	0.000	26.70	Apply water pressure profile no.2
17	0.007	22.25	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW01-B_900_SLS
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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.

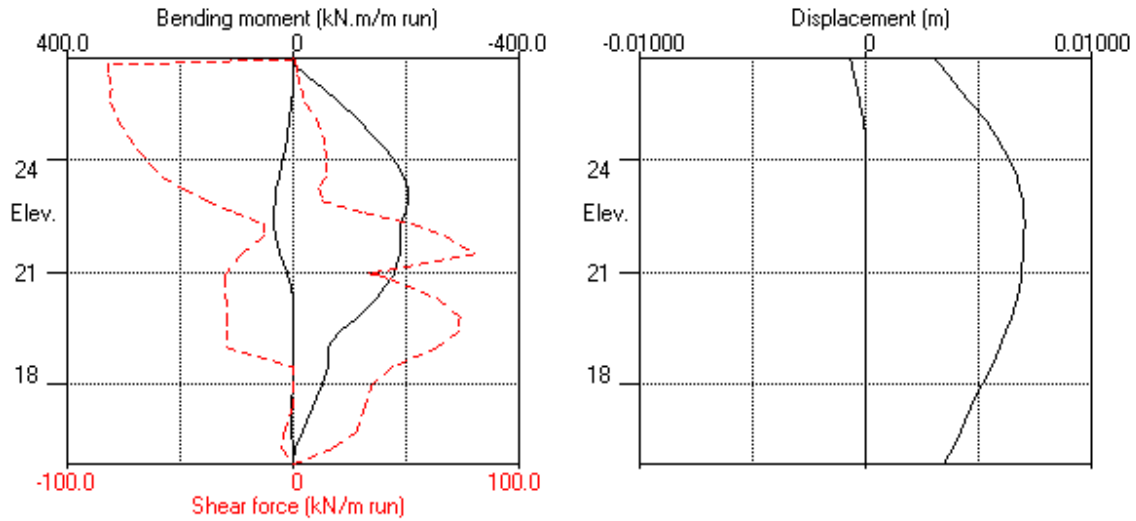
Prop forces at each stage (horizontal components)

Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.50		
	--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	kN per m run	kN per prop	kN per prop
9	84	84	114	---	---	---	---	---	---
10	85	85	115	---	---	---	---	---	---
13	---	---	---	62	62	84	21	21	29
14	---	---	---	60	60	80	35	35	47
15	---	---	---	63	63	85	15	15	20
16	---	---	---	83	83	112	83	83	112
17	---	---	---	71	71	96	102	102	137

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil		Wall	Back-	Soil		Wall	Back-
friction angle		adhesion coeff.	fill angle	friction angle		adhesion coeff.	fill angle
----- Soil type -----							
No. Description							
1 MG		30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr		0.00	0.500	0.00	0.00	0.500	0.00
3 SAND		35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr		24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr		25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE		40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr		0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 15.88
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 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 (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	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/m2		Equiv. soil type	Partial factor/Category
1	26.66	0.50(L)	50.00	20.00	Near edge	Far edge	N/A	1.10 Var
2	20.93	-0.00(R)	50.00	20.00	25.00	=	N/A	1.00 P/U
3	22.25	1.00(L)	50.00	1.00	53.00	=	N/A	1.00 P/U
4	22.25	1.00(L)	50.00	1.00	485.00	=	N/A	1.10 Var
5	22.25	0.50(L)	50.00	20.00	111.00	=	N/A	1.00 P/U
6	22.25	0.50(L)	50.00	20.00	35.00	=	N/A	1.10 Var
					7.50	=	N/A	

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.93 on RIGHT side
10	Excavate to elevation 20.83 on RIGHT side
11	Fill to elevation 20.93 on RIGHT side with soil type 1
12	Fill to elevation 21.98 on RIGHT side with soil type 7
13	Install strut or anchor no.3 at elevation 21.50
14	Install strut or anchor no.2 at elevation 26.50
15	Remove strut or anchor no.1 at elevation 25.50
16	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
17	Apply surcharge no.2 at elevation 20.93
18	Apply water pressure profile no.2 (Mod. Conserv.)
19	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
Water pressures : Moderately Conservative
Partial factor on C' = 1.000
Partial factor on Phi' = 1.000
Partial factor on Cu = 1.000
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 = 1.100
Design factor on calculated Bending Moments = 1.350

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.78 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m
Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m
Distance to rigid boundary on Right side = 25.00 m

OUTPUT OPTIONS

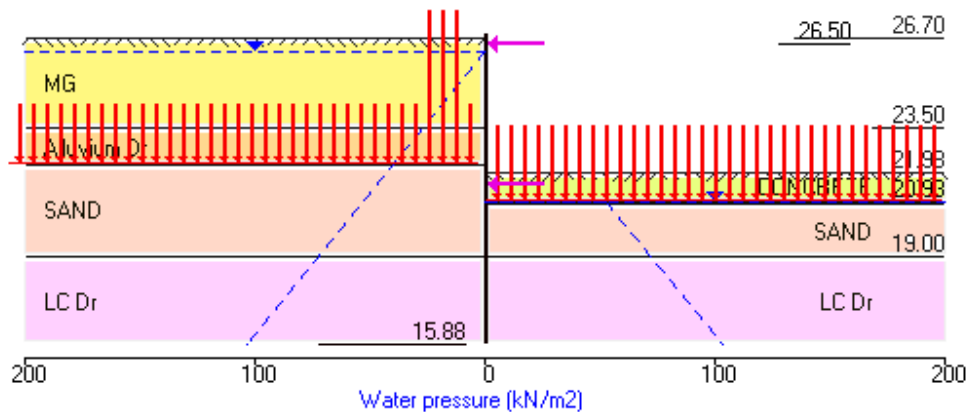
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
10	Excav. to elev. 20.83 on RIGHT side	Yes	Yes	Yes
11	Fill to elev. 20.93 on RIGHT side	Yes	Yes	Yes
12	Fill to elev. 21.98 on RIGHT side	Yes	Yes	Yes
13	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
14	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
15	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
16	Change soil type 4 to soil type 6	Yes	Yes	Yes
17	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
18	Apply water pressure profile no.2	Yes	Yes	Yes
19	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

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Stage No.19 Change EI of wall to 322062kN.m2/m run



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 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall

Right side 25.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.003	-0.001	0	-0	0	-0	0	0	0	0
2	26.50	0.003	-0.001	0	-0	0	-0	0	-84	1	-114
3	26.20	0.004	-0.001	0	-25	0	-34	2	-84	2	-113
4	25.85	0.004	-0.000	1	-54	2	-73	3	-82	5	-111
5	25.50	0.005	-0.000	3	-83	4	-111	5	-85	7	-115
6	25.00	0.005	-0.000	6	-120	8	-162	11	-81	14	-110
7	24.63	0.006	-0.000	11	-146	14	-197	13	-77	18	-105
8	24.25	0.006	-0.000	16	-168	21	-227	14	-73	19	-98
9	23.88	0.007	-0.000	21	-187	28	-252	14	-68	19	-91
10	23.50	0.007	-0.000	26	-201	36	-271	15	-62	20	-83
11	23.19	0.007	-0.000	30	-209	41	-282	11	-53	14	-72
12	22.88	0.007	-0.000	33	-212	45	-286	11	-43	14	-58
13	22.56	0.007	-0.000	34	-209	47	-282	29	-32	39	-43
14	22.25	0.007	-0.000	34	-201	46	-271	50	-19	68	-26
15	21.98	0.007	-0.000	33	-205	44	-277	64	-13	87	-18
16	21.50	0.007	-0.000	24	-207	33	-280	77	-31	104	-42
17	21.00	0.007	-0.000	11	-201	15	-271	30	-30	41	-41
18	20.93	0.007	-0.000	9	-199	12	-269	34	-31	46	-42
19	20.83	0.007	-0.000	6	-196	8	-264	40	-31	54	-42
20	20.32	0.007	-0.000	0	-170	0	-229	65	-31	88	-42
21	19.80	0.007	-0.000	0	-133	0	-179	82	-30	110	-40
22	19.40	0.007	0.000	0	-100	0	-135	86	-29	116	-40
23	19.00	0.006	0.000	0	-75	0	-102	81	-30	110	-40
24	18.50	0.006	0.000	0	-62	0	-84	55	-0	75	-0
25	18.00	0.005	0.000	0	-54	0	-73	44	0	59	0
26	17.40	0.005	0.000	6	-36	9	-48	33	0	44	0
27	16.80	0.004	0.000	6	-16	8	-22	29	-3	39	-5
28	16.34	0.004	0.000	3	-5	4	-6	18	-6	24	-9
29	15.88	0.004	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW01-B_900_ULS1
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

Sheet No.
Date:27-05-2022
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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. min.		max. elev.	min. elev.	max. min.	
	kN.m/m	kN.m/m	kN.m/m		kN/m	kN/m	kN/m	
1	0 18.00	-0 16.34	0 -0		0 26.70	0 26.70	0 0	
2	9 22.88	-43 18.50	13 -58		23 17.40	-18 20.93	31 -25	
3	12 22.88	-54 18.50	16 -72		28 17.40	-23 20.93	38 -31	
4	15 22.88	-60 18.50	20 -81		32 17.40	-26 20.93	43 -34	
5	15 22.88	-61 18.50	21 -83		32 17.40	-26 20.93	44 -35	
6	15 22.88	-62 18.50	20 -84		33 17.40	-27 20.93	44 -36	
7	34 22.56	-56 18.50	47 -75		30 17.40	-31 20.83	40 -42	
8	No calculation at this stage							
9	2 16.80	-191 21.50	3 -258		72 19.80	-81 25.50	97 -109	
10	4 16.80	-207 21.50	6 -279		83 19.40	-84 25.50	112 -114	
11	4 16.80	-207 21.50	6 -280		83 19.40	-84 25.50	112 -114	
12	6 16.80	-207 21.50	8 -280		86 19.40	-85 25.50	116 -115	
13	No calculation at this stage							
14	No calculation at this stage							
15	6 17.40	-189 22.25	9 -255		79 19.40	-65 26.50	106 -87	
16	2 16.34	-174 22.56	2 -235		59 19.40	-61 26.50	80 -83	
17	3 16.80	-189 22.25	5 -255		63 19.80	-65 26.50	85 -87	
18	4 16.80	-212 22.88	6 -286		70 21.50	-84 26.50	95 -114	
19	6 16.80	-177 22.88	8 -239		77 21.50	-72 26.50	104 -97	

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.000	15.88	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.002	15.88	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.002	15.88	-0.001	26.70	Apply surcharge no.4 at elev. 22.25
4	0.003	15.88	-0.001	26.70	Apply surcharge no.5 at elev. 22.25
5	0.003	15.88	-0.001	26.70	Apply surcharge no.6 at elev. 22.25
6	0.003	15.88	-0.001	26.70	Apply water pressure profile no.1
7	0.003	15.88	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.007	21.50	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
10	0.007	21.50	0.000	26.70	Excav. to elev. 20.83 on RIGHT side
11	0.007	21.50	0.000	26.70	Fill to elev. 20.93 on RIGHT side
12	0.007	21.50	0.000	26.70	Fill to elev. 21.98 on RIGHT side
13	No calculation at this stage				Install prop no.3 at elev. 21.50
14	No calculation at this stage				Install prop no.2 at elev. 26.50
15	0.007	21.50	0.000	26.70	Remove prop no.1 at elev. 25.50
16	0.007	21.50	0.000	26.70	Change soil type 4 to soil type 6
17	0.007	21.50	0.000	26.70	Apply surcharge no.2 at elev. 20.93
18	0.007	21.98	0.000	26.70	Apply water pressure profile no.2
19	0.007	22.25	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW01-B_900_ULS1
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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.

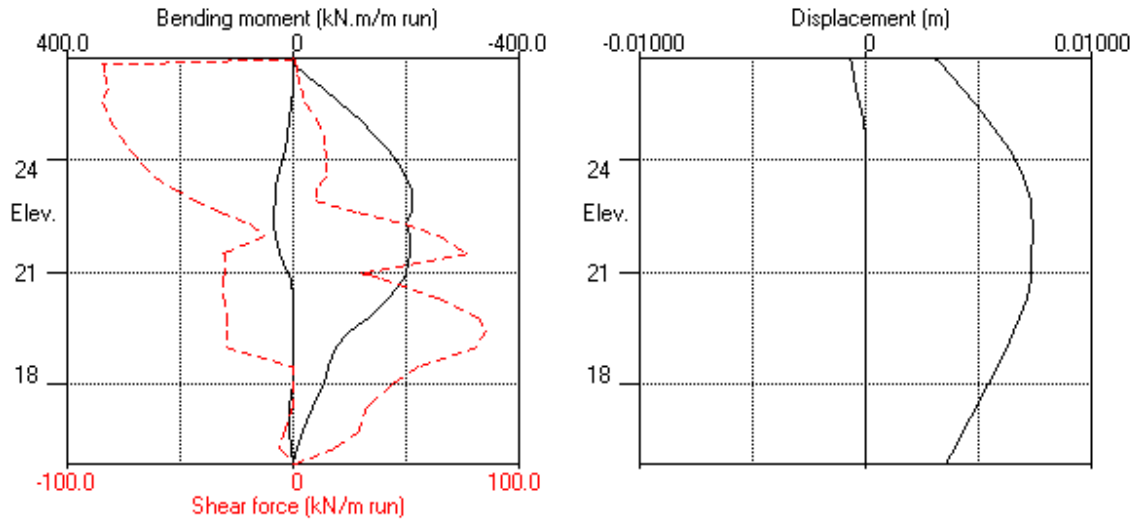
Prop forces at each stage (horizontal components)

Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.50		
	--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	kN per m run	kN per prop	kN per prop
9	85	85	114	---	---	---	---	---	---
10	88	88	119	---	---	---	---	---	---
11	88	88	119	---	---	---	---	---	---
12	89	89	120	---	---	---	---	---	---
15	---	---	---	65	65	87	22	22	30
16	---	---	---	61	61	83	40	40	54
17	---	---	---	65	65	87	19	19	26
18	---	---	---	85	85	114	87	87	118
19	---	---	---	72	72	98	108	108	145

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 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
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 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	20.83	20.83	0.0 MC+WC
	2	26.20	26.20	0.0	1	20.93	20.93	0.0 MC+WC
					2	20.93	26.20	52.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 15.88
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.50	1.00	1.000000	2.100E+07	30.00	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/m2 -----		Equiv. soil type	Partial factor/ Category
					Near edge	Far edge		
1	26.66	0.50(L)	50.00	20.00	25.00	=	N/A	1.30 Var
2	20.93	-0.00(R)	50.00	20.00	53.00	=	N/A	1.00 P/U
3	22.25	1.00(L)	50.00	1.00	485.00	=	N/A	1.00 P/U
4	22.25	1.00(L)	50.00	1.00	111.00	=	N/A	1.30 Var
5	22.25	0.50(L)	50.00	20.00	35.00	=	N/A	1.00 P/U
6	22.25	0.50(L)	50.00	20.00	7.50	=	N/A	1.30 Var

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Worst Cred.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.93 on RIGHT side
10	Excavate to elevation 20.83 on RIGHT side
11	Fill to elevation 20.93 on RIGHT side with soil type 1
12	Fill to elevation 21.99 on RIGHT side with soil type 7
13	Install strut or anchor no.3 at elevation 21.50
14	Install strut or anchor no.2 at elevation 26.50
15	Remove strut or anchor no.1 at elevation 25.50
16	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
17	Apply surcharge no.2 at elevation 20.93
18	Apply water pressure profile no.2 (Worst Cred.)
19	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 10.78 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m

Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m

Distance to rigid boundary on Right side = 25.00 m

OUTPUT OPTIONS

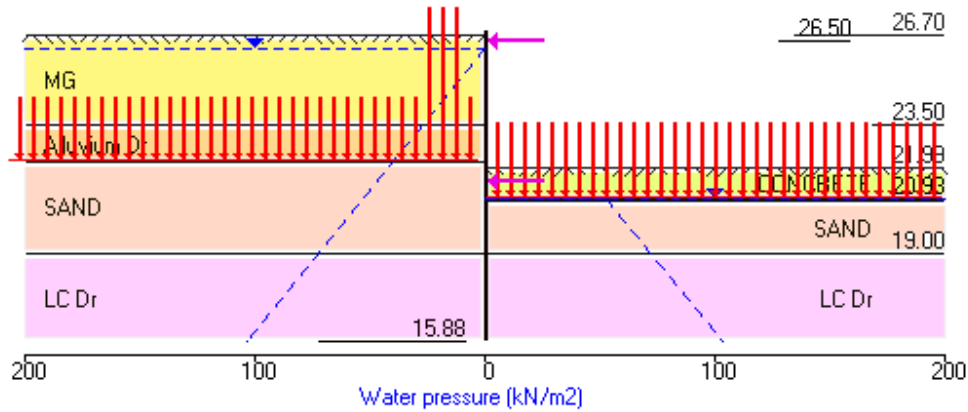
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.93 on RIGHT side	Yes	Yes	Yes
10	Excav. to elev. 20.83 on RIGHT side	Yes	Yes	Yes
11	Fill to elev. 20.93 on RIGHT side	Yes	Yes	Yes
12	Fill to elev. 21.99 on RIGHT side	Yes	Yes	Yes
13	Install prop no.3 at elev. 21.50	Yes	Yes	Yes
14	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
15	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
16	Change soil type 4 to soil type 6	Yes	Yes	Yes
17	Apply surcharge no.2 at elev. 20.93	Yes	Yes	Yes
18	Apply water pressure profile no.2	Yes	Yes	Yes
19	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Data filename/Run ID: 2176_TCR_SW01-B_900_ULS2
 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.19 Change EI of wall to 322062kN.m2/m run



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 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

Overall								
				FoS for toe		Toe elev. for		
				elev. = 15.88		FoS = 1.000		
<u>Stage</u>	<u>Ground</u>	<u>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 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	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
4	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
5	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
6	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
7	26.70	25.00	Cant.	<u>Conditions not suitable for FoS calc.</u>				
8	26.70	25.00		No analysis at this stage				
9	26.70	20.93	25.50	1.037	n/a	16.25	4.68	L to R
10	26.70	20.83	25.50	1.023	n/a	16.13	4.70	L to R
11	26.70	20.93	25.50	1.036	n/a	16.25	4.68	L to R
12	26.70	21.99	25.50	1.552	n/a	21.84	0.15	L to R
13	26.70	21.99		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall

Right side 25.00 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	26.70	0.004	-0.001	0.0	-0.0	0.0	0.0
2	26.50	0.004	-0.001	0.0	-0.0	0.4	-113.6
3	26.20	0.005	-0.000	0.3	-34.0	1.7	-112.9
4	25.85	0.006	-0.000	1.1	-73.2	2.9	-110.9
5	25.50	0.007	-0.000	2.3	-111.4	4.7	-132.8
6	25.00	0.008	-0.000	5.6	-162.9	9.5	-128.0
7	24.63	0.009	-0.000	9.8	-198.5	11.6	-123.4
8	24.25	0.010	-0.000	14.1	-230.6	11.3	-117.8
9	23.88	0.010	-0.000	18.3	-258.4	11.0	-111.2
10	23.50	0.011	-0.000	22.4	-281.2	10.6	-103.8
11	23.19	0.012	-0.000	24.7	-295.6	4.5	-95.1
12	22.88	0.012	-0.000	25.1	-305.1	0.0	-85.5
13	22.56	0.012	-0.000	23.6	-323.1	15.9	-75.2
14	22.25	0.012	-0.000	19.9	-344.8	35.4	-64.2
15	21.99	0.013	-0.000	14.9	-360.4	49.7	-57.4
16	21.50	0.013	-0.000	0.0	-383.9	69.7	-69.1
17	21.00	0.013	-0.000	0.0	-395.7	0.0	-38.9
18	20.93	0.013	-0.000	0.0	-396.0	4.9	-38.5
19	20.83	0.013	-0.000	0.0	-395.8	12.5	-37.7
20	20.32	0.013	-0.000	0.0	-381.9	49.3	-30.5
21	19.80	0.012	-0.000	0.0	-348.3	84.2	-20.7
22	19.40	0.012	0.000	0.0	-310.9	106.1	-13.1
23	19.00	0.012	0.000	0.0	-266.2	122.4	-7.5
24	18.50	0.011	0.000	0.0	-204.3	124.8	0.0
25	18.00	0.010	0.000	0.0	-142.5	119.3	0.0
26	17.40	0.009	0.000	0.0	-78.5	97.9	0.0
27	16.80	0.008	0.000	0.0	-32.6	61.5	0.0
28	16.34	0.007	0.000	0.0	-6.3	33.7	0.0
29	15.88	0.006	0.000	0.0	-0.0	0.0	0.0

Run ID. 2176_TCR_SW01-B_900_ULS2
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	18.00	-0.0	16.34	0.0	26.70	0.0	26.70
2	7.5	23.19	-47.4	19.00	24.0	17.40	-22.2	21.00
3	7.0	23.50	-65.0	19.00	31.5	17.40	-29.7	21.00
4	7.9	23.50	-74.1	19.00	35.3	17.40	-33.7	21.00
5	8.1	23.50	-76.6	19.00	36.4	17.40	-34.9	21.00
6	7.9	23.50	-77.5	19.00	36.5	17.40	-35.6	21.00
7	25.1	22.88	-67.2	19.00	32.9	17.40	-38.9	21.00
8	No calculation at this stage							
9	1.9	25.50	-365.0	21.00	115.7	18.50	-125.4	25.50
10	1.9	25.50	-396.0	20.93	124.7	18.50	-132.2	25.50
11	1.9	25.50	-395.9	20.93	124.7	18.50	-132.2	25.50
12	1.9	25.50	-394.8	20.93	124.8	18.50	-132.8	25.50
13	No calculation at this stage							
14	No calculation at this stage							
15	0.0	26.70	-361.5	20.83	117.4	18.50	-100.5	26.50
16	0.0	26.70	-308.5	20.83	101.3	18.00	-90.7	26.50
17	0.0	26.70	-315.2	20.93	98.4	18.00	-93.9	26.50
18	0.0	26.70	-309.2	22.56	94.9	18.00	-113.6	26.50
19	0.0	26.70	-246.6	22.88	74.1	18.00	-92.8	26.50

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	15.88	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.002	17.40	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.002	17.40	-0.001	26.70	Apply surcharge no.4 at elev. 22.25
4	0.003	17.40	-0.001	26.70	Apply surcharge no.5 at elev. 22.25
5	0.003	17.40	-0.001	26.70	Apply surcharge no.6 at elev. 22.25
6	0.003	17.40	-0.001	26.70	Apply water pressure profile no.1
7	0.004	18.00	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.012	21.00	0.000	26.70	Excav. to elev. 20.93 on RIGHT side
10	0.013	21.00	0.000	26.70	Excav. to elev. 20.83 on RIGHT side
11	0.013	21.00	0.000	26.70	Fill to elev. 20.93 on RIGHT side
12	0.013	21.00	0.000	26.70	Fill to elev. 21.99 on RIGHT side
13	No calculation at this stage				Install prop no.3 at elev. 21.50
14	No calculation at this stage				Install prop no.2 at elev. 26.50
15	0.013	21.50	0.000	26.70	Remove prop no.1 at elev. 25.50
16	0.013	20.93	0.000	26.70	Change soil type 4 to soil type 6
17	0.013	21.00	0.000	26.70	Apply surcharge no.2 at elev. 20.93
18	0.013	21.00	0.000	26.70	Apply water pressure profile no.2
19	0.013	21.00	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW01-B_900_ULS2
 Tottenham Court Road
 SW01-B, 900mm Secant 1400mm c/c

| Sheet No.
 | Date:27-05-2022
 | Checked :

Summary of results (continued)

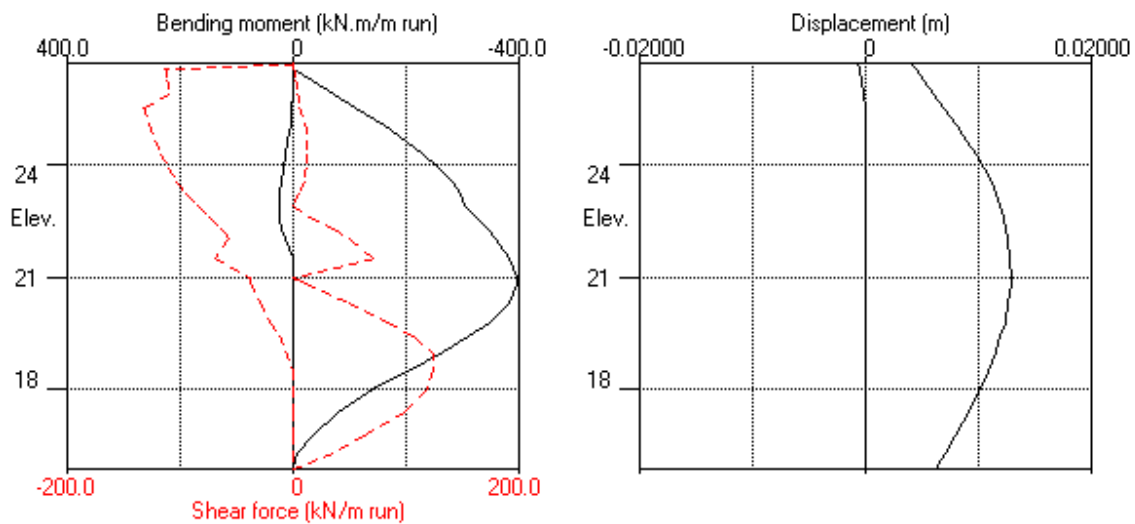
Prop forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 25.50		--- Strut no. 2 --- at elev. 26.50		--- Strut no. 3 --- at elev. 21.50	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
9	130.08	130.08	---	---	---	---
10	136.90	136.90	---	---	---	---
11	136.94	136.94	---	---	---	---
12	137.50	137.50	---	---	---	---
15	---	---	100.60	100.60	35.34	35.34
16	---	---	90.85	90.85	57.37	57.37
17	---	---	94.07	94.07	36.85	36.85
18	---	---	113.72	113.72	104.12	104.12
19	---	---	93.00	93.00	138.75	138.75

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Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW01-B, 900mm Secant 1400mm c/c

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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW02-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	18.58	18.58	0.0 MC+WC
2	1	26.20	26.20	0.0	1	18.68	18.68	0.0 MC+WC
					2	18.68	26.20	75.2

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 14.38
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.86	1.00	0.250000	2.100E+07	30.00	0.00	0	Strut	No	R
4	19.23	1.00	1.000000	2.100E+07	30.00	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/m2	Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	20.00	25.00	N/A 1.00 Var
2	18.68	-0.00(R)	50.00	20.00	76.00	N/A 1.00 P/U

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	Change EI of wall to 450887 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 18.68 on RIGHT side
7	Excavate to elevation 18.58 on RIGHT side
8	Fill to elevation 18.68 on RIGHT side with soil type 1
9	Fill to elevation 19.73 on RIGHT side with soil type 7
10	Install strut or anchor no.4 at elevation 19.23
11	Install strut or anchor no.3 at elevation 21.86
12	Install strut or anchor no.2 at elevation 26.50
13	Remove strut or anchor no.1 at elevation 25.50
14	Change properties of soil type 4 to soil type 6
	Ko pressures will not be reset
15	Apply surcharge no.2 at elevation 18.68
16	Apply water pressure profile no.2 (Mod. Conserv.)
17	Change EI of wall to 322062 kN.m2/m run
	Allow wall to relax with new modulus value

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) = 12.32 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m

Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m

Distance to rigid boundary on Right side = 25.00 m

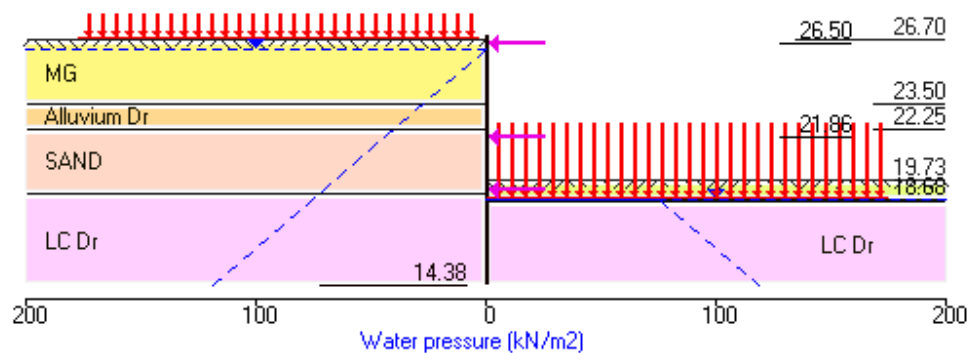
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m ² /m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 18.68 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 18.58 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 18.68 on RIGHT side	Yes	Yes	Yes
9	Fill to elev. 19.73 on RIGHT side	Yes	Yes	Yes
10	Install prop no.4 at elev. 19.23	Yes	Yes	Yes
11	Install prop no.3 at elev. 21.86	Yes	Yes	Yes
12	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
13	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
14	Change soil type 4 to soil type 6	Yes	Yes	Yes
15	Apply surcharge no.2 at elev. 18.68	Yes	Yes	Yes
16	Apply water pressure profile no.2	Yes	Yes	Yes
17	Change EI of wall to 322062kN.m ² /m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW02-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Stage No.17 Change EI of wall to 322062kN.m²/m run



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Job No. 2176
Made by : JRM

Date: 27-05-2022
Checked :

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

Stage No.	Ground Act.	level Pass.	Prop. Elev.	FoS for toe elev. = 14.38		Toe elev. for FoS = 1.000		Direction of failure
				Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	25.00	Cant.	4.113	15.57	23.34	1.66	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	18.68	25.50	2.370	n/a	18.04	0.64	L to R
7	26.70	18.58	25.50	2.335	n/a	17.93	0.65	L to R
8	26.70	18.68	25.50	2.353	n/a	17.94	0.74	L to R
9	26.70	19.73	25.50	3.303	n/a	19.58	0.15	L to R
10	26.70	19.73		No analysis at this stage				

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

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW02-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall
 Right side 25.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.005	-0.000	0	-0	0	-0	0	-93	0	-126
3	26.20	0.006	-0.000	0	-28	0	-37	1	-92	1	-125
4	25.85	0.006	-0.000	1	-60	1	-81	3	-90	4	-121
5	25.50	0.007	-0.000	2	-90	3	-122	6	-91	8	-122
6	25.00	0.007	-0.000	7	-131	9	-177	12	-85	16	-114
7	24.63	0.008	-0.000	12	-158	16	-213	15	-79	20	-107
8	24.25	0.008	-0.000	18	-181	24	-244	16	-73	21	-98
9	23.88	0.008	-0.000	24	-199	32	-269	17	-65	23	-88
10	23.50	0.008	-0.000	30	-213	41	-287	18	-57	25	-77
11	23.19	0.008	-0.000	36	-219	48	-295	15	-48	21	-64
12	22.88	0.008	-0.000	40	-220	54	-297	17	-36	23	-49
13	22.56	0.008	-0.000	43	-215	59	-291	37	-23	50	-31
14	22.25	0.008	-0.000	46	-204	63	-276	59	-8	80	-11
15	21.86	0.008	-0.000	49	-194	66	-262	81	-57	110	-77
16	21.43	0.008	-0.000	48	-193	64	-261	18	-31	24	-42
17	21.00	0.008	-0.000	44	-194	59	-261	31	-11	41	-15
18	20.40	0.007	0.000	35	-173	48	-233	58	-16	78	-22
19	20.07	0.007	0.000	30	-149	40	-201	84	-18	114	-24
20	19.73	0.006	0.000	24	-118	32	-160	112	-18	151	-24
21	19.23	0.006	0.000	15	-74	21	-100	143	-15	193	-21
22	19.00	0.005	0.000	12	-50	16	-68	116	-14	157	-19
23	18.68	0.005	0.000	8	-20	11	-28	136	-11	183	-15
24	18.58	0.005	0.000	13	-11	17	-14	142	-10	192	-14
25	17.99	0.004	0.000	71	-2	96	-2	71	-6	96	-8
26	17.40	0.004	0.000	93	-1	125	-2	32	-3	44	-4
27	16.80	0.003	0.000	88	-2	119	-2	1	-22	1	-30
28	16.20	0.003	0.000	70	-1	94	-2	1	-42	1	-57
29	15.60	0.002	0.000	41	-1	56	-1	1	-47	1	-64
30	15.00	0.002	0.000	13	-0	18	-0	1	-36	1	-48
31	14.69	0.002	0.000	4	-0	5	-0	0	-21	0	-29
32	14.38	0.001	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW02-A_900_SLS
Tottenham Court Road
SW02-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	
1	0	17.99	-0	15.00	0	-0	0	26.70	0	26.70	0	0
2	9	21.00	-2	16.80	12	-2	4	22.25	-5	19.00	5	-7
3	6	21.86	-3	19.23	8	-5	4	23.50	-6	20.40	5	-8
4	49	21.86	-2	16.80	66	-2	18	23.50	-18	20.07	25	-24
5	No calculation at this stage											
6	81	17.40	-185	21.86	109	-250	131	18.68	-88	25.50	177	-119
7	81	17.40	-190	21.86	110	-257	134	18.58	-89	25.50	181	-121
8	82	17.40	-191	21.86	110	-257	135	18.58	-90	25.50	182	-121
9	90	17.40	-194	21.86	122	-262	142	18.58	-91	25.50	192	-122
10	No calculation at this stage											
11	No calculation at this stage											
12	No calculation at this stage											
13	93	17.40	-185	22.56	125	-250	138	18.58	-71	26.50	186	-96
14	66	16.80	-181	22.56	89	-244	103	19.23	-70	26.50	140	-94
15	72	16.80	-183	22.56	97	-247	101	18.58	-70	26.50	136	-95
16	87	16.80	-220	22.88	117	-297	143	19.23	-93	26.50	193	-126
17	84	16.80	-184	23.19	114	-249	124	19.23	-80	26.50	167	-108

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	14.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.003	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.007	22.25	0.000	26.70	Excav. to elev. 18.68 on RIGHT side
7	0.008	22.25	0.000	26.70	Excav. to elev. 18.58 on RIGHT side
8	0.008	22.25	0.000	26.70	Fill to elev. 18.68 on RIGHT side
9	0.007	22.25	0.000	26.70	Fill to elev. 19.73 on RIGHT side
10	No calculation at this stage				Install prop no.4 at elev. 19.23
11	No calculation at this stage				Install prop no.3 at elev. 21.86
12	No calculation at this stage				Install prop no.2 at elev. 26.50
13	0.008	22.56	0.000	26.70	Remove prop no.1 at elev. 25.50
14	0.008	22.56	0.000	26.70	Change soil type 4 to soil type 6
15	0.008	22.56	0.000	26.70	Apply surcharge no.2 at elev. 18.68
16	0.008	22.88	0.000	26.70	Apply water pressure profile no.2
17	0.008	22.88	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW02-A_900_SLS
Tottenham Court Road
SW02-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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)

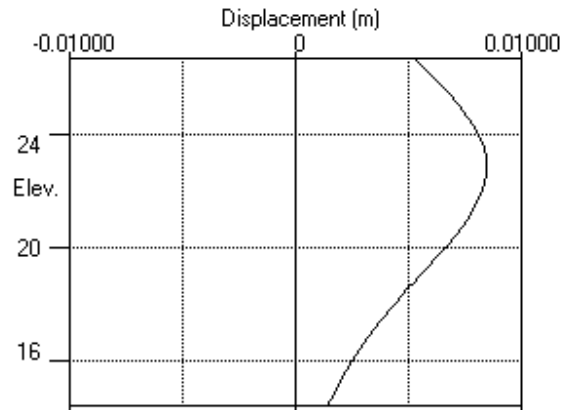
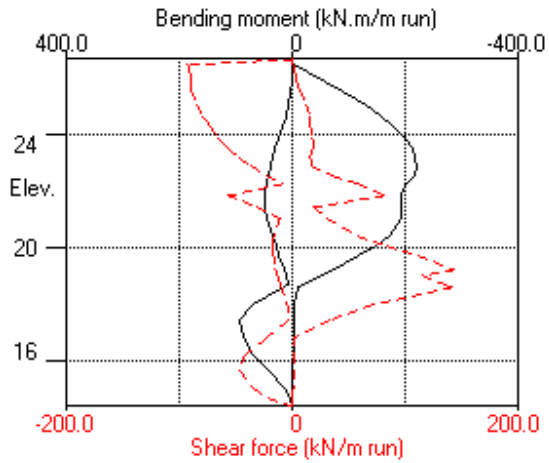
Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.86		
	--Calculated-- Factored			--Calculated-- Factored			--Calculated-- Factored		
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
6	94	94	127	---	---	---	---	---	---
7	95	95	129	---	---	---	---	---	---
8	95	95	129	---	---	---	---	---	---
9	97	97	130	---	---	---	---	---	---
13	---	---	---	71	71	96	26	26	35
14	---	---	---	70	70	95	21	21	28
15	---	---	---	71	71	95	27	27	37
16	---	---	---	93	93	126	111	111	149
17	---	---	---	80	80	108	139	139	187

Stage no.	----- Prop no. 4 ----- at elev. 19.23		
	--Calculated-- Factored		
	kN per m run	kN per prop	kN per prop
13	slack	slack	slack
14	61	61	82
15	33	33	45
16	84	84	114
17	77	77	104

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Tottenham Court Road
SW02-A, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	26.70	1 MG	1 MG
2	23.50	5 Alluvium Dr	5 Alluvium Dr
3	22.25	3 SAND	3 SAND
4	19.00	4 LC UnDr	4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---		
Soil	Wall	Back-		Soil	Wall	Back-
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle
1 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

Automatic water pressure balancing at toe of wall : No

Water press. 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	21.00	21.00	0.0	1	18.58	18.58	0.0 MC+WC
2	1	26.20	26.20	0.0	1	18.68	18.68	0.0 MC+WC
					2	18.68	26.20	75.2

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 14.38
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 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	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.86	1.00	0.250000	2.100E+07	30.00	0.00	0	Strut	No	R
4	19.23	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall Elev.	Length parallel to wall 0.50(L) 50.00	Width perpend. to wall 20.00	Surcharge ----- kN/m2 ----- Near edge 25.00	Far edge =	Equiv. soil type N/A	Partial factor/ Category 1.10 Var 1.00 P/U
1	26.70	0.50(L)	50.00	20.00	25.00	=	N/A
2	18.68	-0.00(R)	50.00	20.00	76.00	=	N/A

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	Change EI of wall to 450887 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 18.68 on RIGHT side
7	Excavate to elevation 18.58 on RIGHT side
8	Fill to elevation 19.73 on RIGHT side with soil type 7
9	Install strut or anchor no.4 at elevation 19.23
10	Install strut or anchor no.3 at elevation 21.86
11	Install strut or anchor no.2 at elevation 26.50
12	Remove strut or anchor no.1 at elevation 25.50
13	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
14	Apply surcharge no.2 at elevation 18.68
15	Apply water pressure profile no.2 (Mod. Conserv.)
16	Change EI of wall to 322062 kN.m2/m run Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
Water pressures : Moderately Conservative
Partial factor on C' = 1.000
Partial factor on Phi' = 1.000
Partial factor on Cu = 1.000
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 = 1.100
Design factor on calculated Bending Moments = 1.350

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) = 12.32 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m
Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m
Distance to rigid boundary on Right side = 25.00 m

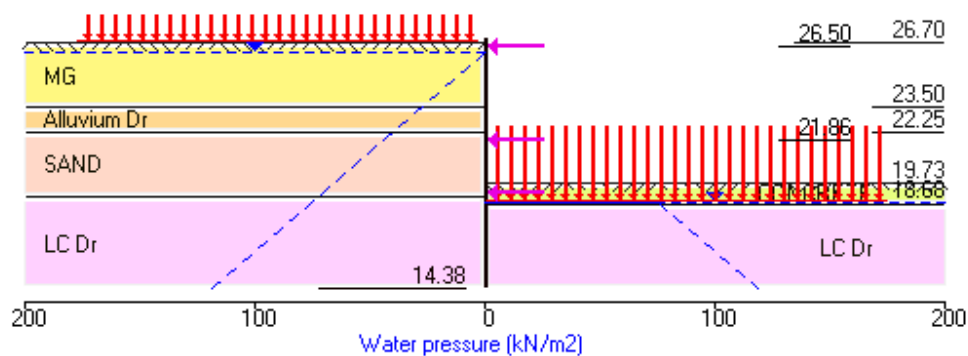
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 18.68 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 18.58 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 19.73 on RIGHT side	Yes	Yes	Yes
9	Install prop no.4 at elev. 19.23	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.86	Yes	Yes	Yes
11	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
12	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
13	Change soil type 4 to soil type 6	Yes	Yes	Yes
14	Apply surcharge no.2 at elev. 18.68	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
16	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
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 Date: 27-05-2022
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Stage No.16 Change EI of wall to 322062kN.m2/m run



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall

Right side 25.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.006	-0.000	0	-0	0	-0	0	-94	0	-127
3	26.20	0.006	-0.000	0	-28	0	-38	1	-93	1	-126
4	25.85	0.006	-0.000	1	-60	1	-82	3	-91	4	-123
5	25.50	0.007	-0.000	2	-91	3	-123	6	-92	8	-124
6	25.00	0.007	-0.000	7	-132	10	-179	12	-86	17	-116
7	24.63	0.008	-0.000	12	-159	17	-215	15	-80	21	-108
8	24.25	0.008	-0.000	18	-183	25	-246	16	-73	22	-99
9	23.88	0.008	-0.000	25	-201	33	-272	17	-66	23	-89
10	23.50	0.008	-0.000	31	-215	42	-290	19	-57	26	-78
11	23.19	0.009	-0.000	37	-220	50	-298	16	-48	21	-64
12	22.88	0.009	-0.000	41	-222	56	-299	18	-37	24	-49
13	22.56	0.009	-0.000	45	-217	61	-293	37	-24	50	-32
14	22.25	0.008	-0.000	48	-206	65	-278	59	-9	80	-12
15	21.86	0.008	-0.000	50	-196	68	-265	82	-57	111	-77
16	21.43	0.008	-0.000	49	-195	67	-263	18	-31	24	-42
17	21.00	0.008	-0.000	46	-195	61	-263	31	-11	42	-16
18	20.40	0.007	0.000	37	-173	49	-234	59	-17	79	-23
19	20.07	0.007	0.000	31	-149	42	-201	85	-18	115	-24
20	19.73	0.006	0.000	25	-119	33	-161	113	-18	153	-24
21	19.23	0.006	0.000	16	-74	22	-100	144	-16	195	-22
22	19.00	0.006	0.000	12	-50	17	-67	117	-15	158	-20
23	18.68	0.005	0.000	8	-19	11	-26	138	-12	186	-16
24	18.58	0.005	0.000	14	-9	19	-13	145	-11	195	-15
25	17.99	0.004	0.000	73	-2	99	-2	72	-7	98	-9
26	17.40	0.004	0.000	95	-2	128	-2	32	-3	44	-4
27	16.80	0.003	0.000	90	-2	121	-2	1	-23	1	-31
28	16.20	0.003	0.000	71	-2	96	-2	1	-43	1	-58
29	15.60	0.002	0.000	42	-1	57	-1	1	-48	2	-65
30	15.00	0.002	0.000	14	-0	18	-0	1	-36	1	-49
31	14.69	0.002	0.000	4	-0	5	-0	0	-22	1	-29
32	14.38	0.001	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW02-A_900_ULS1
Tottenham Court Road 1400mm c/c
SW02-A, 900mm Secant

| Sheet No.
| Date:27-05-2022
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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. 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	0	17.99	-0	15.00	0	-0	0	26.70	0	26.70	0	0
2	10	21.00	-2	16.80	13	-2	4	22.25	-6	19.00	6	-8
3	7	21.86	-3	19.00	9	-4	4	23.50	-6	20.40	5	-8
4	50	21.86	-2	16.80	68	-2	19	23.50	-18	19.73	26	-24
5	No calculation at this stage											
6	83	17.40	-187	21.86	112	-252	133	18.68	-89	25.50	179	-121
7	83	17.40	-192	21.86	112	-259	136	18.58	-91	25.50	183	-122
8	92	17.40	-196	21.86	124	-265	145	18.58	-92	25.50	195	-124
9	No calculation at this stage											
10	No calculation at this stage											
11	No calculation at this stage											
12	95	17.40	-187	22.56	128	-252	140	18.58	-72	26.50	189	-97
13	67	16.80	-182	22.56	91	-246	105	19.23	-71	26.50	141	-96
14	74	16.80	-184	22.56	99	-249	102	18.58	-72	26.50	138	-97
15	88	16.80	-222	22.88	119	-299	144	19.23	-94	26.50	195	-127
16	85	16.80	-186	23.19	115	-251	125	19.23	-81	26.50	168	-109

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum m	elev.	minimum m	elev.	
1	0.000	14.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.003	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.008	22.25	0.000	26.70	Excav. to elev. 18.68 on RIGHT side
7	0.008	22.25	0.000	26.70	Excav. to elev. 18.58 on RIGHT side
8	0.008	22.56	0.000	26.70	Fill to elev. 19.73 on RIGHT side
9	No calculation at this stage				Install prop no.4 at elev. 19.23
10	No calculation at this stage				Install prop no.3 at elev. 21.86
11	No calculation at this stage				Install prop no.2 at elev. 26.50
12	0.008	22.88	0.000	26.70	Remove prop no.1 at elev. 25.50
13	0.008	22.88	0.000	26.70	Change soil type 4 to soil type 6
14	0.008	22.88	0.000	26.70	Apply surcharge no.2 at elev. 18.68
15	0.008	22.88	0.000	26.70	Apply water pressure profile no.2
16	0.009	22.88	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW02-A_900_ULS1
Tottenham Court Road 1400mm c/c
SW02-A, 900mm Secant

| Sheet No.
| Date:27-05-2022
| 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)

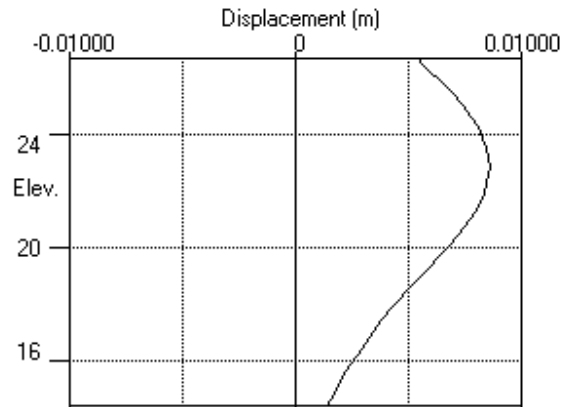
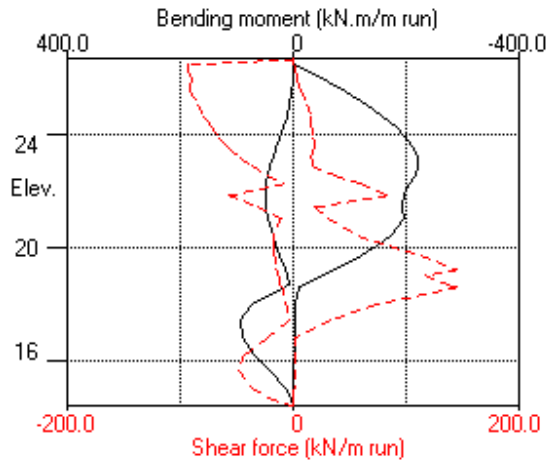
Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.86		
	--Calculated-- Factored			--Calculated-- Factored			--Calculated-- Factored		
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
6	96	96	129	---	---	---	---	---	---
7	97	97	131	---	---	---	---	---	---
8	98	98	132	---	---	---	---	---	---
12	---	---	---	72	72	98	27	27	36
13	---	---	---	71	71	96	21	21	29
14	---	---	---	72	72	97	28	28	38
15	---	---	---	94	94	127	111	111	150
16	---	---	---	81	81	109	139	139	188

Stage no.	----- Prop no. 4 ----- at elev. 19.23		
	--Calculated-- Factored		
	kN per m run	kN per prop	kN per prop
12	slack	slack	slack
13	61	61	83
14	33	33	45
15	86	86	116
16	78	78	105

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	18.58	18.58	0.0 MC+WC
2	1	26.20	26.20	0.0	1	18.68	18.68	0.0 MC+WC
					2	18.68	26.20	75.2

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 14.38
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.86	1.00	0.250000	2.100E+07	30.00	0.00	0	Strut	No	R
4	19.23	1.00	1.000000	2.100E+07	30.00	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/m2	Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	20.00	25.00	N/A 1.30 Var
2	18.68	-0.00(R)	50.00	20.00	76.00	N/A 1.00 P/U

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	Change EI of wall to 450887 kN.m2/m run
	Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 18.68 on RIGHT side
7	Excavate to elevation 18.58 on RIGHT side
8	Fill to elevation 19.73 on RIGHT side with soil type 7
9	Install strut or anchor no.4 at elevation 19.23
10	Install strut or anchor no.3 at elevation 21.86
11	Install strut or anchor no.2 at elevation 26.50
12	Remove strut or anchor no.1 at elevation 25.50
13	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
14	Apply surcharge no.2 at elevation 18.68
15	Apply water pressure profile no.2 (Worst Cred.)
16	Change EI of wall to 322062 kN.m2/m run Allow wall to relax with new modulus value

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) = 12.32 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 25.00 m

Width of excavation on Right side of wall = 25.00 m

Distance to rigid boundary on Left side = 25.00 m

Distance to rigid boundary on Right side = 25.00 m

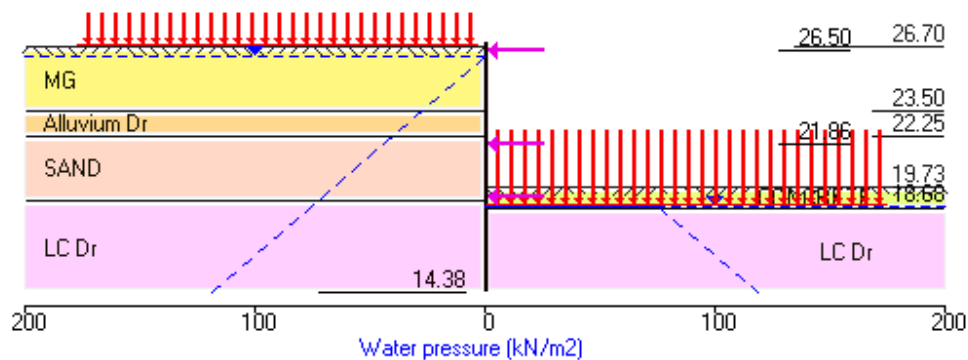
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 18.68 on RIGHT side	Yes	Yes	Yes
7	Excav. to elev. 18.58 on RIGHT side	Yes	Yes	Yes
8	Fill to elev. 19.73 on RIGHT side	Yes	Yes	Yes
9	Install prop no.4 at elev. 19.23	Yes	Yes	Yes
10	Install prop no.3 at elev. 21.86	Yes	Yes	Yes
11	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
12	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
13	Change soil type 4 to soil type 6	Yes	Yes	Yes
14	Apply surcharge no.2 at elev. 18.68	Yes	Yes	Yes
15	Apply water pressure profile no.2	Yes	Yes	Yes
16	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.16 Change EI of wall to 322062kN.m2/m run



Sheet No.
Job No. 2176
Made by : JRM

Date: 27-05-2022
Checked :

Summary of results

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

Factor of safety on soil strength

Overall								
			FoS for toe elev. = 14.38		Toe elev. for FoS = 1.000			
Stage	Ground level		Prop	Factor of Safety	Moment of equilb. at elev.	Toe elev.	Wall Penetr -ation	Direction of failure
No.	Act.	Pass.	Elev.					
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	25.00	Cant.	2.968	15.48	22.37	2.63	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	18.68	25.50	1.649	n/a	17.56	1.12	L to R
7	26.70	18.58	25.50	1.625	n/a	17.45	1.13	L to R
8	26.70	19.73	25.50	2.407	n/a	19.47	0.26	L to R
9	26.70	19.73		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 25.00 from wall

Right side 25.00 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	26.70	0.007	-0.000	0.0	-0.0	0.0	0.0
2	26.50	0.007	-0.000	0.0	-0.0	0.2	-111.7
3	26.20	0.008	-0.000	0.2	-33.3	1.2	-110.6
4	25.85	0.008	-0.000	1.0	-71.6	3.9	-107.5
5	25.50	0.009	-0.000	3.1	-108.3	8.2	-116.1
6	25.00	0.009	-0.000	9.2	-156.5	16.4	-107.9
7	24.63	0.010	-0.000	16.4	-188.3	20.5	-100.2
8	24.25	0.010	-0.000	24.3	-215.5	21.7	-91.4
9	23.88	0.010	-0.000	32.7	-237.3	23.1	-81.6
10	23.50	0.010	-0.000	41.6	-252.8	24.4	-70.6
11	23.19	0.010	-0.000	48.6	-259.9	19.3	-58.3
12	22.88	0.011	-0.000	53.9	-261.3	20.0	-45.1
13	22.56	0.010	-0.000	57.9	-256.2	41.0	-31.0
14	22.25	0.010	-0.000	60.9	-244.4	63.7	-15.9
15	21.86	0.010	-0.000	62.7	-248.1	88.6	-44.8
16	21.43	0.010	-0.000	61.8	-245.6	35.1	-15.5
17	21.00	0.009	-0.000	58.3	-236.0	52.3	-11.2
18	20.40	0.009	0.000	49.3	-209.1	83.9	-17.6
19	20.07	0.008	0.000	43.0	-186.4	113.4	-19.7
20	19.73	0.008	0.000	36.3	-157.5	144.5	-20.5
21	19.23	0.007	0.000	26.1	-102.7	179.1	-19.6
22	19.00	0.007	0.000	21.7	-72.9	142.7	-18.3
23	18.68	0.006	0.000	16.3	-25.1	157.7	-15.5
24	18.58	0.006	0.000	14.8	-10.0	162.8	-14.7
25	17.99	0.005	0.000	76.6	-2.2	96.6	-9.9
26	17.40	0.005	0.000	111.9	-2.2	35.6	-6.0
27	16.80	0.004	0.000	121.4	-2.3	4.0	-21.2
28	16.20	0.003	0.000	94.5	-1.8	1.1	-55.5
29	15.60	0.003	0.000	54.8	-1.0	1.2	-64.0
30	15.00	0.002	0.000	17.6	-0.3	0.9	-47.1
31	14.69	0.002	0.000	5.3	-0.1	0.5	-28.1
32	14.38	0.001	0.000	0.0	-0.0	0.0	-0.0

Run ID. 2176_TCR_SW02-A_900_ULS2
Tottenham Court Road 1400mm c/c
SW02-A, 900mm Secant

| Sheet No.
| Date: 27-05-2022
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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>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	17.99	-0.0	15.00	0.0	26.70	0.0	26.70
2	12.7	21.43	-2.3	16.80	5.5	23.50	-7.5	19.00
3	10.1	21.86	-2.5	18.58	5.2	23.50	-6.9	20.40
4	62.7	21.86	-0.4	15.60	24.4	23.50	-20.5	19.73
5	No calculation at this stage							
6	109.9	16.80	-236.2	21.86	152.7	18.68	-112.7	25.50
7	111.5	16.80	-243.9	21.86	154.0	18.58	-114.8	25.50
8	119.4	16.80	-248.1	21.86	162.8	18.58	-116.1	25.50
9	No calculation at this stage							
10	No calculation at this stage							
11	No calculation at this stage							
12	121.4	16.80	-234.2	22.56	157.3	18.58	-91.8	26.50
13	49.8	16.80	-222.7	22.56	142.6	19.23	-89.2	26.50
14	56.0	16.80	-224.9	22.56	135.2	19.23	-89.7	26.50
15	70.2	16.80	-261.3	22.88	179.1	19.23	-111.7	26.50
16	68.6	16.80	-219.5	23.19	156.0	19.23	-95.8	26.50

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	14.38	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.004	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.009	22.56	0.000	26.70	Excav. to elev. 18.68 on RIGHT side
7	0.010	22.25	0.000	26.70	Excav. to elev. 18.58 on RIGHT side
8	0.010	22.56	0.000	26.70	Fill to elev. 19.73 on RIGHT side
9	No calculation at this stage				Install prop no.4 at elev. 19.23
10	No calculation at this stage				Install prop no.3 at elev. 21.86
11	No calculation at this stage				Install prop no.2 at elev. 26.50
12	0.010	22.88	0.000	26.70	Remove prop no.1 at elev. 25.50
13	0.010	22.88	0.000	26.70	Change soil type 4 to soil type 6
14	0.010	22.88	0.000	26.70	Apply surcharge no.2 at elev. 18.68
15	0.010	22.88	0.000	26.70	Apply water pressure profile no.2
16	0.011	22.88	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW02-A_900_ULS2
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

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 | Date: 27-05-2022
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Summary of results (continued)

Prop forces at each stage (horizontal components)

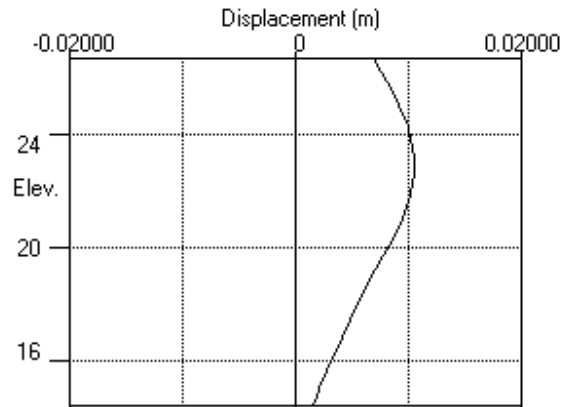
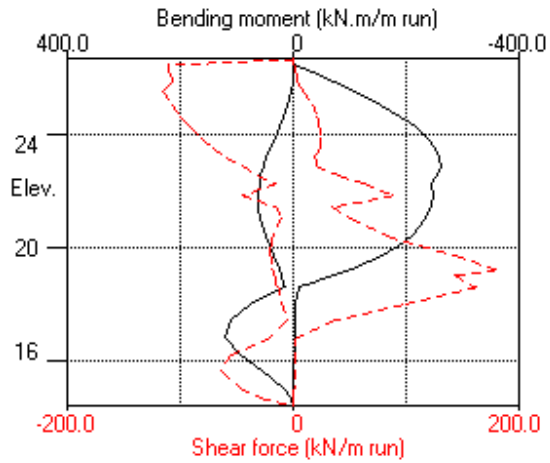
Stage no.	--- Strut no. 1 --- at elev. 25.50		--- Strut no. 2 --- at elev. 26.50		--- Strut no. 3 --- at elev. 21.86	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
6	120.81	120.81	---	---	---	---
7	122.94	122.94	---	---	---	---
8	124.22	124.22	---	---	---	---
12	---	---	91.91	91.91	34.77	34.77
13	---	---	89.34	89.34	14.83	14.83
14	---	---	89.83	89.83	21.43	21.43
15	---	---	111.82	111.82	100.77	100.77
16	---	---	96.00	96.00	133.32	133.32

Stage no.	--- Strut no. 4 --- at elev. 19.23	
	kN/m run	kN/prop
12	slack	slack
13	148.66	148.66
14	120.75	120.75
15	169.88	169.88
16	158.56	158.56

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road 1400mm c/c
 SW02-A, 900mm Secant

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types
		Left side Right side
1	26.70	1 MG 1 MG
2	23.50	5 Alluvium Dr 5 Alluvium Dr
3	22.25	3 SAND 3 SAND
4	19.00	4 LC UnDr 4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC (0.200)	0.292 (0.000)	4.369 (0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	50.00u
3 SAND	19.00	60000	0.426	OC (0.200)	0.235 (0.000)	6.084 (0.000)	
4 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (7.813)
5 Alluvium Dr	19.00	30000	1.000	OC (0.200)	0.376 (1.401)	3.077 (4.665)	0.0d
6 LC Dr (19.00)	20.00	68000 (6250)	1.000	OC (0.200)	0.361 (1.370)	3.253 (4.831)	5.000d
7 CONCRETE	24.00	200000	1.000	OC (0.300)	0.217 (0.933)	4.599 (4.289)	300.0d
8 LC UnDr (19.00)	20.00	85000 (7813)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	85.00u (6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	14.73	14.73	0.0	MC+WC
2	1	26.20	26.20	0.0	1	16.38	16.38	0.0	MC+WC
					2	16.38	26.16	97.8	

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 12.38
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 -----		Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	25.00	25.00 =	N/A	1.00 Var
2	16.38	-0.00(R)	50.00	25.00	100.00 =	N/A	1.00 P/U

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.50 on RIGHT side
7	Install strut or anchor no.5 at elevation 21.00
8	Excavate to elevation 16.48 on RIGHT side Toe of berm at elevation 14.83 Width of top of berm = 0.90 Width of toe of berm = 2.60
9	Fill to elevation 17.48 on RIGHT side with soil type 7
10	Install strut or anchor no.4 at elevation 17.00
11	Install strut or anchor no.3 at elevation 21.78
12	Remove strut or anchor no.5 at elevation 21.00
13	Install strut or anchor no.2 at elevation 26.50
14	Remove strut or anchor no.1 at elevation 25.50
15	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
16	Apply surcharge no.2 at elevation 16.38
17	Apply water pressure profile no.2 (Mod. Conserv.)
18	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 14.32 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

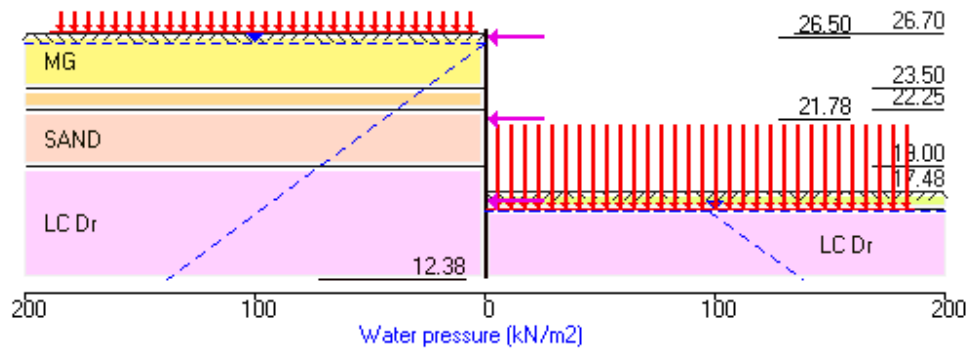
Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
7	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
8	Excav. to elev. 16.48 on RIGHT side	Yes	Yes	Yes
9	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
10	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
11	Install prop no.3 at elev. 21.78	Yes	Yes	Yes
12	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
13	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
14	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
15	Change soil type 4 to soil type 6	Yes	Yes	Yes
16	Apply surcharge no.2 at elev. 16.38	Yes	Yes	Yes
17	Apply water pressure profile no.2	Yes	Yes	Yes
18	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Stage No.18 Change EI of wall to 322062kN.m²/m run



Sheet No.
Job No. 2176
Made by : JRM

Date: 27-05-2022
Checked :

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

Stage No.	Ground Act.	level Pass.	Prop Elev.	FoS for toe elev. = 12.38		Toe elev. for FoS = 1.000		Direction of failure
				Factor of Safety	Moment equilib. at elev.	Toe elev.	Wall Penetr -ation	
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	25.00	Cant.	4.717	13.73	23.39	1.61	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	20.50	25.50	3.406	n/a	19.06	1.44	L to R
7	26.70	20.50		No analysis at this stage				

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 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.005	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.005	-0.000	0	-0	0	-0	1	-72	1	-97
3	26.20	0.006	-0.000	1	-21	1	-29	3	-70	4	-94
4	25.50	0.007	-0.000	5	-67	7	-91	9	-77	12	-105
5	25.00	0.007	-0.000	7	-96	9	-130	12	-72	16	-97
6	24.25	0.008	-0.000	19	-128	25	-173	18	-60	24	-80
7	23.50	0.009	-0.000	33	-142	44	-191	20	-44	28	-60
8	22.88	0.009	-0.000	43	-141	59	-191	42	-23	56	-31
9	22.25	0.010	0.000	51	-147	69	-199	83	0	112	0
10	21.78	0.010	0.000	54	-142	72	-192	110	-189	148	-255
11	21.00	0.011	0.000	49	-187	66	-253	52	-139	71	-187
12	20.50	0.011	0.000	41	-245	56	-331	69	-102	93	-138
13	19.75	0.011	0.000	28	-291	37	-393	69	-42	93	-57
14	19.00	0.010	0.000	40	-295	54	-398	47	-15	63	-21
15	18.24	0.009	0.000	63	-243	85	-328	110	-10	148	-13
16	17.48	0.008	0.000	68	-127	92	-172	198	-5	268	-7
17	17.00	0.007	0.000	65	-72	88	-97	233	-9	315	-12
18	16.48	0.006	0.000	59	-10	79	-14	146	-15	198	-20
19	16.38	0.006	0.000	57	-3	77	-4	130	-16	176	-21
20	15.61	0.005	0.000	81	-3	110	-4	52	-19	70	-26
21	14.83	0.004	0.000	90	-2	121	-3	12	-18	17	-25
22	14.73	0.004	0.000	90	-2	121	-3	7	-18	9	-24
23	14.17	0.004	0.000	77	-1	104	-2	1	-38	2	-52
24	13.60	0.003	0.000	50	-1	68	-1	1	-50	1	-67
25	12.99	0.002	0.000	18	-0	24	-0	1	-41	1	-56
26	12.38	0.002	0.000	0	0	0	0	0	-0	0	-0

Run ID. 2176_TCR_SW03-A_900_SLS
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
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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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	17.48	-0	14.17	0	-0	0	26.70
2	9	21.00	-3	16.48	12	-3	4	22.25
3	6	21.78	-3	19.00	9	-4	4	23.50
4	54	21.78	-3	16.38	72	-4	20	23.50
5	No calculation at this stage							
6	68	17.48	-135	22.88	92	-183	69	19.75
7	No calculation at this stage							
8	73	14.73	-181	19.00	99	-244	137	16.48
9	80	14.73	-187	19.00	108	-252	146	16.48
10	No calculation at this stage							
11	No calculation at this stage							
12	87	14.83	-213	19.75	118	-288	136	16.48
13	No calculation at this stage							
14	87	14.83	-202	19.75	117	-273	137	16.48
15	67	14.73	-208	19.75	90	-280	175	17.00
16	74	14.73	-218	19.00	100	-295	168	17.00
17	90	14.73	-295	19.00	121	-398	233	17.00
18	90	14.83	-262	19.00	121	-353	220	17.00

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	14.17	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.004	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.006	23.50	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
7	No calculation at this stage				Install prop no.5 at elev. 21.00
8	0.009	20.50	0.000	26.70	Excav. to elev. 16.48 on RIGHT side
9	0.009	20.50	0.000	26.70	Fill to elev. 17.48 on RIGHT side
10	No calculation at this stage				Install prop no.4 at elev. 17.00
11	No calculation at this stage				Install prop no.3 at elev. 21.78
12	0.010	20.50	0.000	26.70	Remove prop no.5 at elev. 21.00
13	No calculation at this stage				Install prop no.2 at elev. 26.50
14	0.010	21.00	0.000	26.70	Remove prop no.1 at elev. 25.50
15	0.010	20.50	0.000	26.70	Change soil type 4 to soil type 6
16	0.010	20.50	0.000	26.70	Apply surcharge no.2 at elev. 16.38
17	0.010	20.50	0.000	26.70	Apply water pressure profile no.2
18	0.011	20.50	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW03-A_900_SLS
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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)

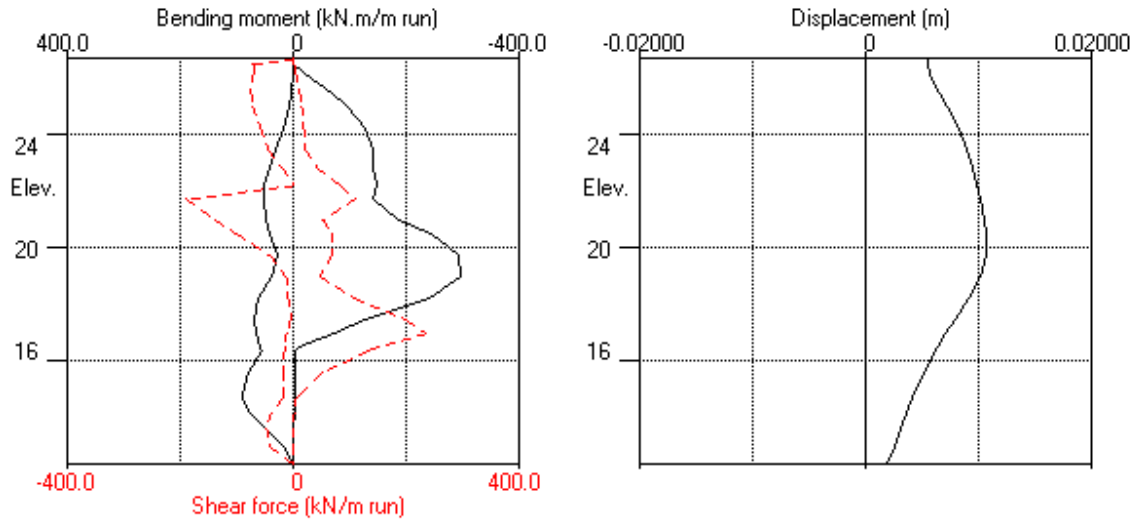
Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.78		
	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop
6	81	81	109	---	---	---	---	---	---
8	85	85	115	---	---	---	---	---	---
9	86	86	116	---	---	---	---	---	---
12	85	85	115	---	---	---	86	86	116
14	---	---	---	62	62	84	113	113	152
15	---	---	---	60	60	81	122	122	164
16	---	---	---	60	60	80	129	129	174
17	---	---	---	72	72	98	282	282	380
18	---	---	---	60	60	81	299	299	404

Stage no.	----- Prop no. 4 ----- at elev. 17.00			----- Prop no. 5 ----- at elev. 21.00		
	--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
8	---	---	---	111	111	150
9	---	---	---	111	111	149
12	23	23	30	---	---	---
14	19	19	25	---	---	---
15	162	162	218	---	---	---
16	132	132	179	---	---	---
17	199	199	269	---	---	---
18	202	202	272	---	---	---

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Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	26.70	1 MG	1 MG
2	23.50	5 Alluvium Dr	5 Alluvium Dr
3	22.25	3 SAND	3 SAND
4	19.00	4 LC UnDr	4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---		
Soil	Wall	Back-		Soil	Wall	Back-
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle
1 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	14.73	14.73	0.0 MC+WC
	2	26.20	26.20	0.0	1	16.38	16.38	0.0 MC+WC
					2	16.38	26.16	97.8

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 12.38
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 -----		Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	25.00	25.00 =	N/A	1.10 Var
2	16.38	-0.00(R)	50.00	25.00	100.00 =	N/A	1.00 P/U

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.50 on RIGHT side
7	Install strut or anchor no.5 at elevation 21.00
8	Excavate to elevation 16.48 on RIGHT side Toe of berm at elevation 14.83 Width of top of berm = 0.90 Width of toe of berm = 2.60
9	Excavate to elevation 16.38 on RIGHT side Toe of berm at elevation 14.73 Width of top of berm = 0.90 Width of toe of berm = 2.60
10	Fill to elevation 17.48 on RIGHT side with soil type 7
11	Install strut or anchor no.4 at elevation 17.00
12	Install strut or anchor no.3 at elevation 21.78
13	Remove strut or anchor no.5 at elevation 21.00
14	Install strut or anchor no.2 at elevation 26.50
15	Remove strut or anchor no.1 at elevation 25.50
16	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
17	Apply surcharge no.2 at elevation 16.38
18	Apply water pressure profile no.2 (Mod. Conserv.)
19	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
Water pressures : Moderately Conservative
Partial factor on C' = 1.000
Partial factor on Phi' = 1.000
Partial factor on Cu = 1.000
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 = 1.100
Design factor on calculated Bending Moments = 1.350

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) = 14.32 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m
Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m
Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

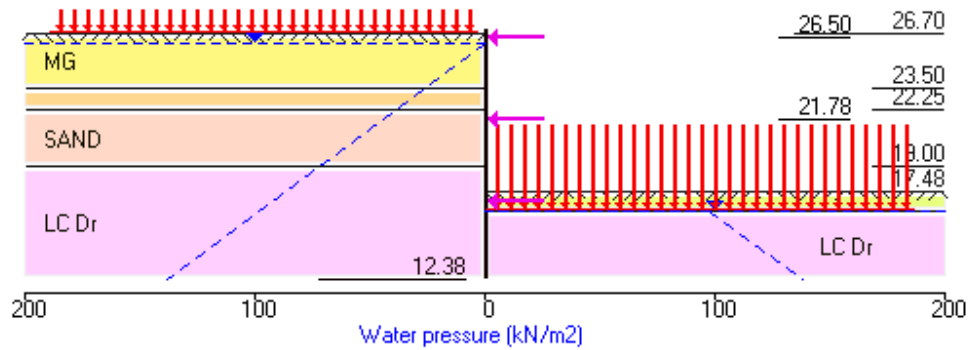
Stage no.	Stage description	Output options		
		Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
7	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
8	Excav. to elev. 16.48 on RIGHT side	Yes	Yes	Yes
9	Excav. to elev. 16.38 on RIGHT side	Yes	Yes	Yes
10	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
11	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
12	Install prop no.3 at elev. 21.78	Yes	Yes	Yes
13	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
14	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
15	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
16	Change soil type 4 to soil type 6	Yes	Yes	Yes
17	Apply surcharge no.2 at elev. 16.38	Yes	Yes	Yes
18	Apply water pressure profile no.2	Yes	Yes	Yes
19	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.19 Change EI of wall to 322062kN.m2/m run



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 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.006	-0.000	0	-0	0	-0	0	0	0	0
2	26.50	0.006	-0.000	0	-0	0	-0	1	-72	1	-98
3	26.20	0.006	-0.000	1	-21	1	-29	3	-70	4	-95
4	25.50	0.007	-0.000	5	-68	7	-92	9	-78	13	-105
5	25.00	0.007	-0.000	7	-97	9	-131	12	-72	16	-97
6	24.25	0.008	-0.000	20	-128	26	-173	18	-60	25	-80
7	23.50	0.009	-0.000	34	-142	46	-191	21	-44	29	-59
8	22.88	0.010	-0.000	45	-141	61	-190	42	-23	57	-30
9	22.25	0.010	0.000	53	-147	71	-198	84	0	113	0
10	21.78	0.010	0.000	55	-141	75	-191	111	-192	149	-259
11	21.00	0.011	0.000	51	-189	68	-255	53	-141	72	-191
12	20.50	0.011	0.000	43	-248	58	-335	70	-105	94	-141
13	19.75	0.011	0.000	29	-296	39	-400	70	-44	94	-59
14	19.00	0.010	0.000	42	-302	56	-407	47	-16	64	-22
15	18.24	0.010	0.000	65	-251	88	-339	108	-10	146	-14
16	17.48	0.008	0.000	70	-137	94	-184	197	-5	266	-7
17	17.00	0.007	0.000	67	-86	90	-116	232	-10	314	-13
18	16.48	0.007	0.000	60	-27	81	-36	140	-15	188	-21
19	16.38	0.006	0.000	58	-13	79	-18	147	-16	199	-22
20	15.61	0.005	0.000	75	-3	101	-5	55	-20	75	-26
21	14.83	0.004	0.000	85	-2	114	-3	20	-19	27	-25
22	14.73	0.004	0.000	85	-2	115	-3	15	-18	21	-25
23	14.17	0.004	0.000	75	-1	101	-2	1	-35	2	-47
24	13.60	0.003	0.000	50	-1	68	-1	1	-48	2	-64
25	12.99	0.003	0.000	18	-0	24	-0	1	-41	1	-56
26	12.38	0.002	0.000	0	0	0	0	0	-0	0	-0

Run ID. 2176_TCR_SW03-A_900_ULS1
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
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.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0	17.48	-0	14.17	0	26.70	0	26.70
2	10	21.00	-3	16.48	5	22.25	-6	19.00
3	7	21.78	-3	19.00	4	23.50	-6	20.50
4	55	21.78	-3	16.38	21	23.50	-19	19.75
5	No calculation at this stage							
6	70	17.48	-136	22.88	94	19.75	-76	25.50
7	No calculation at this stage							
8	73	14.73	-182	19.00	137	16.48	-78	25.50
9	70	14.73	-187	19.00	137	16.38	-77	25.50
10	77	14.73	-194	19.00	147	16.38	-78	25.50
11	No calculation at this stage							
12	No calculation at this stage							
13	84	14.73	-219	19.75	137	16.38	-77	25.50
14	No calculation at this stage							
15	84	14.73	-208	19.75	138	16.38	-79	21.78
16	62	14.73	-213	19.75	174	17.00	-85	21.78
17	69	14.73	-226	19.00	167	17.00	-92	21.78
18	85	14.73	-302	19.00	232	17.00	-187	21.78
19	85	14.73	-267	19.00	220	17.00	-192	21.78

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	14.17	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.004	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.006	23.50	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
7	No calculation at this stage				Install prop no.5 at elev. 21.00
8	0.009	20.50	0.000	26.70	Excav. to elev. 16.48 on RIGHT side
9	0.010	20.50	0.000	26.70	Excav. to elev. 16.38 on RIGHT side
10	0.010	20.50	0.000	26.70	Fill to elev. 17.48 on RIGHT side
11	No calculation at this stage				Install prop no.4 at elev. 17.00
12	No calculation at this stage				Install prop no.3 at elev. 21.78
13	0.010	20.50	0.000	26.70	Remove prop no.5 at elev. 21.00
14	No calculation at this stage				Install prop no.2 at elev. 26.50
15	0.010	20.50	0.000	26.70	Remove prop no.1 at elev. 25.50
16	0.010	20.50	0.000	26.70	Change soil type 4 to soil type 6
17	0.010	20.50	0.000	26.70	Apply surcharge no.2 at elev. 16.38
18	0.011	20.50	0.000	26.70	Apply water pressure profile no.2
19	0.011	20.50	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW03-A_900_ULS1
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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)

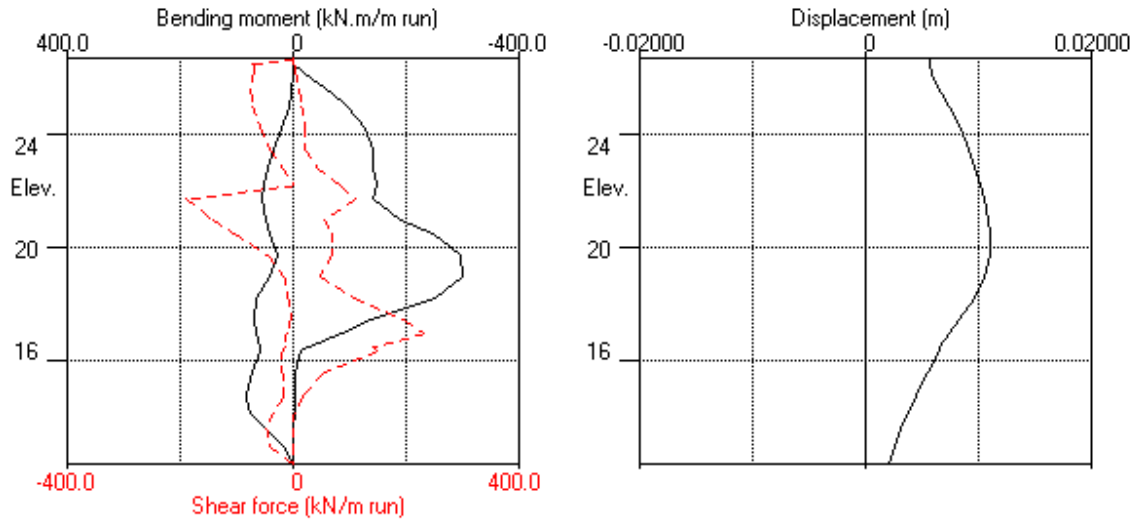
Stage no.	----- Prop no. 1 ----- at elev. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.78		
	--Calculated--	Factored		--Calculated--	Factored		--Calculated--	Factored	
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
6	82	82	110	---	---	---	---	---	---
8	86	86	117	---	---	---	---	---	---
9	86	86	116	---	---	---	---	---	---
10	87	87	118	---	---	---	---	---	---
13	86	86	117	---	---	---	90	90	122
15	---	---	---	63	63	85	118	118	159
16	---	---	---	61	61	82	126	126	170
17	---	---	---	60	60	81	133	133	180
18	---	---	---	73	73	99	286	286	386
19	---	---	---	61	61	82	303	303	409

Stage no.	----- Prop no. 4 ----- at elev. 17.00			----- Prop no. 5 ----- at elev. 21.00		
	--Calculated--	Factored		--Calculated--	Factored	
	kN per m run	kN per prop	kN per prop	kN per m run	kN per prop	kN per prop
8	---	---	---	112	112	152
9	---	---	---	116	116	157
10	---	---	---	116	116	157
13	24	24	32	---	---	---
15	20	20	27	---	---	---
16	164	164	222	---	---	---
17	135	135	183	---	---	---
18	203	203	274	---	---	---
19	206	206	279	---	---	---

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Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
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Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---		
Soil	Wall	Back-		Soil	Wall	Back-
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle
1 MG	30.00	0.500	0.00	30.00	0.500	0.00
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	14.73	14.73	0.0	MC+WC
2	1	26.20	26.20	0.0	1	16.38	16.38	0.0	MC+WC
					2	16.38	26.16	97.8	

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 12.38
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross- section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre- stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.78	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R

SURCHARGE LOADS

Surch -arge no.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 -----		Equiv. soil type	Partial factor/ Category
1	26.70	0.50(L)	50.00	25.00	25.00 =	N/A	1.30 Var
2	16.38	-0.00(R)	50.00	25.00	100.00 =	N/A	1.00 P/U

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	Change EI of wall to 450887 kN.m ² /m run Allow wall to relax with new modulus value
2	Apply surcharge no.1 at elevation 26.70
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 25.00 on RIGHT side
5	Install strut or anchor no.1 at elevation 25.50
6	Excavate to elevation 20.50 on RIGHT side
7	Install strut or anchor no.5 at elevation 21.00
8	Excavate to elevation 16.48 on RIGHT side Toe of berm at elevation 14.83 Width of top of berm = 0.90 Width of toe of berm = 2.60
9	Excavate to elevation 16.38 on RIGHT side Toe of berm at elevation 14.73 Width of top of berm = 0.90 Width of toe of berm = 2.60
10	Fill to elevation 17.48 on RIGHT side with soil type 7
11	Install strut or anchor no.4 at elevation 17.00
12	Install strut or anchor no.3 at elevation 21.78
13	Remove strut or anchor no.5 at elevation 21.00
14	Install strut or anchor no.2 at elevation 26.50
15	Remove strut or anchor no.1 at elevation 25.50
16	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
17	Apply surcharge no.2 at elevation 16.38
18	Apply water pressure profile no.2 (Worst Cred.)
19	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 14.32 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 100.00 m

Width of excavation on Left side of wall = 50.00 m

Width of excavation on Right side of wall = 50.00 m

Distance to rigid boundary on Left side = 50.00 m

Distance to rigid boundary on Right side = 50.00 m

OUTPUT OPTIONS

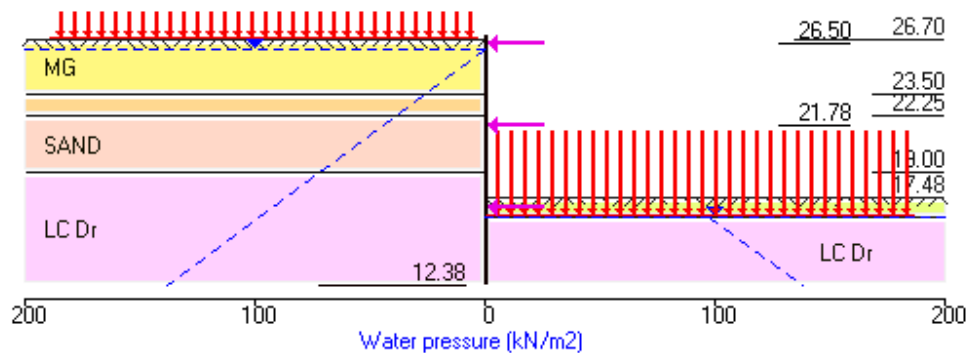
Stage no.	Stage description	Displacement Bending mom. Shear force	Output options Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.1 at elev. 26.70	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
5	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
6	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
7	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
8	Excav. to elev. 16.48 on RIGHT side	Yes	Yes	Yes
9	Excav. to elev. 16.38 on RIGHT side	Yes	Yes	Yes
10	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
11	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
12	Install prop no.3 at elev. 21.78	Yes	Yes	Yes
13	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
14	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
15	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
16	Change soil type 4 to soil type 6	Yes	Yes	Yes
17	Apply surcharge no.2 at elev. 16.38	Yes	Yes	Yes
18	Apply water pressure profile no.2	Yes	Yes	Yes
19	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.19 Change EI of wall to 322062kN.m2/m run



Sheet No.
Job No. 2176
Made by : JRM

Date: 27-05-2022
Checked :

Summary of results

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

Factor of safety on soil strength

Overall								
			FoS for toe elev. = 12.38		Toe elev. for FoS = 1.000			
<u>Stage No.</u>	<u>Ground Act.</u>	<u>level Pass.</u>	<u>Prop Elev.</u>	<u>Factor of Safety</u>	<u>Moment of equilib. at elev.</u>	<u>Toe elev.</u>	<u>Wall Penetr -ation</u>	<u>Direction of failure</u>
1	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
2	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
3	26.70	26.70	Cant.	Conditions not suitable for FoS calc.				
4	26.70	25.00	Cant.	3.330	13.62	22.44	2.56	L to R
5	26.70	25.00		No analysis at this stage				
6	26.70	20.50	25.50	2.345	n/a	18.57	1.93	L to R
7	26.70	20.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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 Tottenham Court Road
 SW03-A, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
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 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 100.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 50.00 from wall
 Right side 50.00 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	26.70	0.007	-0.000	0.0	-0.0	0.0	0.0
2	26.50	0.007	-0.000	0.0	-0.0	0.9	-87.1
3	26.20	0.007	-0.000	0.8	-25.7	3.8	-84.4
4	25.50	0.008	-0.000	6.6	-81.3	12.4	-94.7
5	25.00	0.009	-0.000	9.1	-115.7	16.2	-86.5
6	24.25	0.010	-0.000	25.6	-153.5	24.5	-70.1
7	23.50	0.011	-0.000	44.8	-170.0	26.9	-49.3
8	22.88	0.012	-0.000	58.9	-165.3	47.8	-23.9
9	22.25	0.012	0.000	66.8	-170.2	92.4	0.0
10	21.78	0.013	0.000	69.2	-164.3	122.3	-204.1
11	21.00	0.013	0.000	64.6	-222.6	56.5	-148.3
12	20.50	0.013	0.000	57.3	-277.5	78.3	-108.3
13	19.75	0.013	0.000	42.8	-330.6	94.6	-42.4
14	19.00	0.013	0.000	53.3	-327.4	83.9	-20.0
15	18.24	0.012	0.000	95.0	-268.9	126.2	-14.2
16	17.48	0.010	0.000	105.3	-175.9	226.4	-8.9
17	17.00	0.009	0.000	101.4	-133.8	265.4	-52.0
18	16.48	0.008	0.000	91.1	-77.1	130.1	-23.5
19	16.38	0.008	0.000	88.7	-64.8	135.8	-24.8
20	15.61	0.007	0.000	65.8	-4.3	62.3	-30.2
21	14.83	0.006	0.000	64.7	-2.2	43.1	-28.8
22	14.73	0.006	0.000	67.9	-2.2	40.1	-28.2
23	14.17	0.005	0.000	70.6	-1.5	8.0	-23.9
24	13.60	0.004	0.000	55.2	-0.8	1.1	-46.4
25	12.99	0.003	0.000	21.2	-0.2	0.7	-45.2
26	12.38	0.002	0.000	0.0	-0.0	0.0	-0.0

Run ID. 2176_TCR_SW03-A_900_ULS2
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
Checked :

Summary of results (continued)

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	17.48	-0.0	14.17	0.0	26.70	0.0	26.70
2	13.3	21.00	-3.5	16.48	5.7	23.50	-8.0	19.00
3	10.6	21.78	-2.2	18.24	5.3	23.50	-6.7	20.50
4	69.2	21.78	-2.4	15.61	26.9	23.50	-21.5	19.75
5	No calculation at this stage							
6	105.3	17.48	-160.6	22.25	94.6	19.75	-90.9	25.50
7	No calculation at this stage							
8	64.6	14.17	-220.7	19.00	124.9	16.48	-94.3	21.00
9	59.9	14.17	-226.9	19.00	125.6	16.38	-98.8	21.00
10	65.4	14.17	-233.3	19.00	135.8	16.38	-99.7	21.00
11	No calculation at this stage							
12	No calculation at this stage							
13	70.6	14.17	-269.7	19.75	122.0	16.38	-96.1	21.78
14	No calculation at this stage							
15	70.2	14.17	-256.0	19.75	122.6	16.38	-102.5	21.78
16	27.1	13.60	-252.9	19.75	207.8	17.00	-104.7	21.78
17	31.3	13.60	-262.0	19.75	201.1	17.00	-111.1	21.78
18	41.6	14.17	-330.6	19.75	265.4	17.00	-199.4	21.78
19	45.0	14.73	-286.4	19.75	250.8	17.00	-204.1	21.78

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	<u>maximum</u>	<u>elev.</u>	<u>minimum</u>	<u>elev.</u>	
	m		m		
1	0.000	14.17	-0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.001	26.70	0.000	26.70	Apply surcharge no.1 at elev. 26.70
3	0.001	26.70	0.000	26.70	Apply water pressure profile no.1
4	0.005	26.70	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
5	No calculation at this stage				Install prop no.1 at elev. 25.50
6	0.008	23.50	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
7	No calculation at this stage				Install prop no.5 at elev. 21.00
8	0.012	20.50	0.000	26.70	Excav. to elev. 16.48 on RIGHT side
9	0.012	20.50	0.000	26.70	Excav. to elev. 16.38 on RIGHT side
10	0.012	20.50	0.000	26.70	Fill to elev. 17.48 on RIGHT side
11	No calculation at this stage				Install prop no.4 at elev. 17.00
12	No calculation at this stage				Install prop no.3 at elev. 21.78
13	0.012	20.50	0.000	26.70	Remove prop no.5 at elev. 21.00
14	No calculation at this stage				Install prop no.2 at elev. 26.50
15	0.012	20.50	0.000	26.70	Remove prop no.1 at elev. 25.50
16	0.012	20.50	0.000	26.70	Change soil type 4 to soil type 6
17	0.012	20.50	0.000	26.70	Apply surcharge no.2 at elev. 16.38
18	0.013	20.50	0.000	26.70	Apply water pressure profile no.2
19	0.013	20.50	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW03-A_900_ULS2
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

| Sheet No.
| Date: 27-05-2022
| Checked :

Summary of results (continued)

Prop forces at each stage (horizontal components)

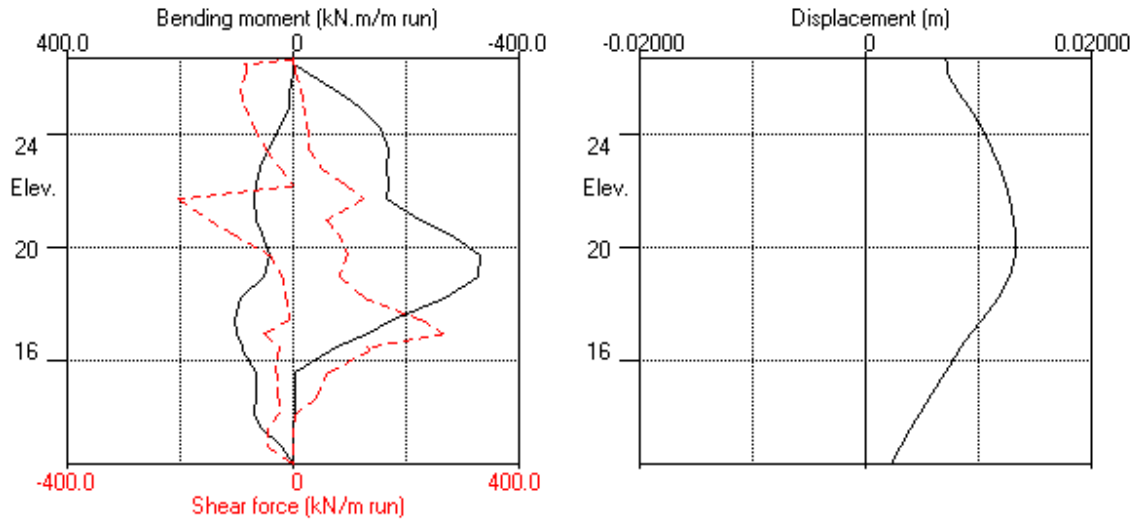
Stage no.	--- Strut no. 1 --- at elev. 25.50		--- Strut no. 2 --- at elev. 26.50		--- Strut no. 3 --- at elev. 21.78	
	kN/m run	kN/prop	kN/m run	kN/prop	kN/m run	kN/prop
6	98.89	98.89	---	---	---	---
8	105.80	105.80	---	---	---	---
9	105.45	105.45	---	---	---	---
10	106.46	106.46	---	---	---	---
13	105.65	105.65	---	---	118.71	118.71
15	---	---	77.11	77.11	153.14	153.14
16	---	---	75.60	75.60	156.98	156.98
17	---	---	74.80	74.80	164.10	164.10
18	---	---	87.98	87.98	307.98	307.98
19	---	---	73.94	73.94	326.40	326.40

Stage no.	--- Strut no. 4 --- at elev. 17.00		--- Strut no. 5 --- at elev. 21.00	
	kN/m run	kN/prop	kN/m run	kN/prop
8	---	---	145.67	145.67
9	---	---	150.68	150.68
10	---	---	150.56	150.56
13	31.46	31.46	---	---
15	26.72	26.72	---	---
16	259.80	259.80	---	---
17	230.64	230.64	---	---
18	294.41	294.41	---	---
19	295.97	295.97	---	---

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Data filename/Run ID: 2176_TCR_SW03-A_900_ULS2
Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW03-A, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
Checked :

Bending moment, shear force, displacement envelopes



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	15.83	15.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	15.93	15.93	0.0 MC+WC
					2	15.93	26.20	100.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 10.38
Maximum finite element length = 1.00 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.75	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	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/m2		Equiv. soil type	Partial factor/ Category
1	26.66	0.50(L)	50.00	25.00	Near edge	25.00 =	N/A	1.00 Var
2	15.93	-0.00(R)	50.00	25.00	Far edge	100.00 =	N/A	1.00 P/U
3	22.25	1.00(L)	40.00	1.00	Near edge	485.00 =	N/A	1.00 P/U
4	22.25	1.00(L)	40.00	1.00	Far edge	111.00 =	N/A	1.00 Var
5	22.25	0.50(L)	40.00	20.00	Near edge	35.00 =	N/A	1.00 P/U
6	22.25	0.50(L)	40.00	20.00	Far edge	7.50 =	N/A	1.00 Var

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	Change EI of wall to 450887 kN.m ² /m run Reset wall displacements to zero at this stage
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.50 on RIGHT side
10	Install strut or anchor no.5 at elevation 21.00
11	Excavate to elevation 15.93 on RIGHT side
12	Fill to elevation 17.48 on RIGHT side with soil type 7
13	Install strut or anchor no.4 at elevation 17.00
14	Install strut or anchor no.3 at elevation 21.75
15	Remove strut or anchor no.5 at elevation 21.00
16	Install strut or anchor no.2 at elevation 26.50
17	Remove strut or anchor no.1 at elevation 25.50
18	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
19	Apply surcharge no.2 at elevation 15.93
20	Apply water pressure profile no.2 (Mod. Conserv.)
21	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

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) = 16.33 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 200.00 m

Width of excavation on Left side of wall = 24.00 m
Width of excavation on Right side of wall = 24.00 m

Distance to rigid boundary on Left side = 24.00 m
Distance to rigid boundary on Right side = 24.00 m

OUTPUT OPTIONS

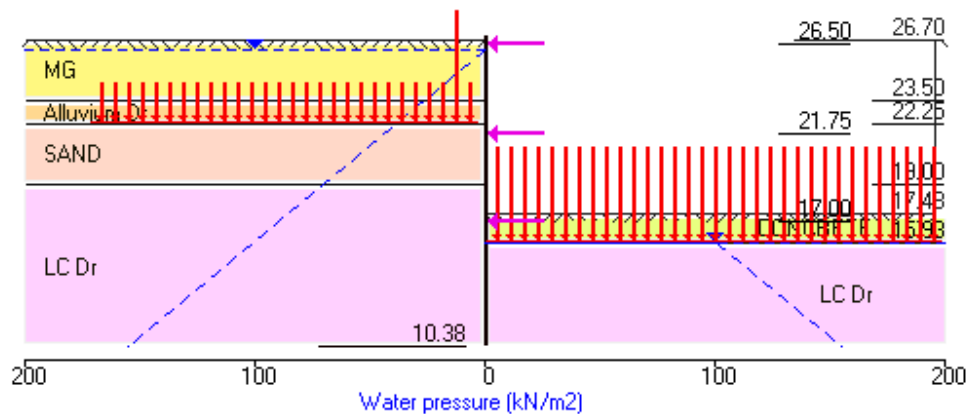
Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
10	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
11	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
12	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
13	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
14	Install prop no.3 at elev. 21.75	Yes	Yes	Yes
15	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
16	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
17	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
18	Change soil type 4 to soil type 6	Yes	Yes	Yes
19	Apply surcharge no.2 at elev. 15.93	Yes	Yes	Yes
20	Apply water pressure profile no.2	Yes	Yes	Yes
21	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.21 Change EI of wall to 322062kN.m²/m run



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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 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

				FoS for toe		Toe elev. for		
				elev. = 10.38		FoS = 1.000		
<u>Stage</u>	<u>Ground</u>	<u>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	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
2	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
3	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
4	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
5	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
6	26.70	26.70	Cant.	<u>Conditions not suitable for FoS calc.</u>				
7	26.70	25.00	Cant.	2.828	11.06	23.90	1.10	L to R
8	26.70	25.00		No analysis at this stage				
9	26.70	20.50	25.50	2.251	n/a	18.52	1.98	L to R
10	26.70	20.50		No analysis at this stage				
All remaining stages have more than one prop - FoS calculation n/a								

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

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 200.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 24.00 from wall
 Right side 24.00 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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.003	-0.001	0	-0	0	-0	0	0	0	0
2	26.50	0.004	-0.001	0	0	0	0	1	-87	2	-117
3	26.20	0.004	-0.000	1	-26	1	-34	4	-84	6	-113
4	25.50	0.006	-0.000	7	-81	9	-110	10	-91	13	-123
5	25.00	0.007	0.000	5	-118	7	-159	9	-88	12	-118
6	24.25	0.010	0.000	15	-164	20	-222	13	-79	18	-107
7	23.50	0.012	0.000	24	-195	33	-263	13	-68	17	-92
8	22.88	0.013	0.000	29	-205	39	-277	19	-53	25	-72
9	22.25	0.014	0.000	26	-222	35	-300	52	-36	70	-48
10	21.75	0.015	0.000	17	-237	22	-320	80	-262	107	-353
11	21.00	0.017	0.000	0	-355	0	-479	24	-203	32	-274
12	20.50	0.017	0.000	0	-432	0	-583	56	-159	76	-215
13	19.75	0.018	0.000	0	-509	0	-687	83	-100	112	-135
14	19.00	0.018	0.000	0	-511	0	-690	75	-36	102	-49
15	18.24	0.017	0.000	0	-461	0	-623	166	0	224	0
16	17.48	0.015	0.000	15	-376	20	-508	295	0	398	0
17	17.00	0.014	0.000	30	-288	41	-389	347	-45	468	-61
18	16.46	0.013	0.000	41	-160	56	-216	269	0	363	0
19	15.93	0.012	0.000	47	-50	64	-68	322	0	435	0
20	15.83	0.011	0.000	58	-39	78	-53	304	0	410	0
21	14.92	0.010	0.000	237	-12	320	-16	139	-3	187	-4
22	14.00	0.008	0.000	302	-0	407	-0	45	-10	61	-13
23	13.00	0.006	0.000	225	-0	304	-0	3	-95	4	-128
24	12.00	0.005	0.000	111	-0	150	-0	0	-102	0	-138
25	11.19	0.003	0.000	35	-0	47	-0	0	-68	0	-91
26	10.38	0.003	0.000	0	-0	0	-0	0	-0	0	-0

Run ID. 2176_TCR_SW03-B_900_SLS
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
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.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m	kN/m
1	0	17.48	-0	14.00	0	-0	0	26.70	0	26.70
2	10	13.00	-75	18.24	14	-102	26	16.46	-25	21.00
3	12	13.00	-93	18.24	17	-125	33	16.46	-31	21.00
4	11	13.00	-107	18.24	15	-145	36	16.46	-36	20.50
5	11	13.00	-111	18.24	15	-149	37	16.46	-37	20.50
6	12	13.00	-112	18.24	16	-151	37	16.46	-41	20.50
7	29	22.88	-103	18.24	39	-139	35	16.46	-45	20.50
8	No calculation at this stage									
9	48	15.83	-214	21.75	65	-289	83	19.75	-87	25.50
10	No calculation at this stage									
11	281	14.00	-465	19.00	379	-627	307	15.93	-190	21.00
12	296	14.00	-474	19.00	400	-640	322	15.93	-192	21.00
13	No calculation at this stage									
14	No calculation at this stage									
15	302	14.00	-499	19.00	407	-674	305	15.93	-180	21.75
16	No calculation at this stage									
17	301	14.00	-491	19.00	407	-663	306	15.93	-186	21.75
18	123	14.00	-430	19.75	165	-580	296	17.00	-160	21.75
19	139	14.00	-438	19.75	188	-592	287	17.00	-166	21.75
20	174	14.00	-511	19.00	235	-690	347	17.00	-257	21.75
21	161	14.00	-445	19.00	217	-600	328	17.00	-262	21.75

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum	elev.	minimum	elev.	
	m		m		
1	0.000	14.00	0.000	26.70	Change EI of wall to 450887kN.m ² /m run
2	0.002	18.24	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.003	18.24	-0.000	26.70	Apply surcharge no.4 at elev. 22.25
4	0.004	17.48	-0.001	26.70	Apply surcharge no.5 at elev. 22.25
5	0.004	17.48	-0.001	26.70	Apply surcharge no.6 at elev. 22.25
6	0.004	18.24	-0.001	26.70	Apply water pressure profile no.1
7	0.004	18.24	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.009	21.00	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
10	No calculation at this stage				Install prop no.5 at elev. 21.00
11	0.016	19.75	0.000	26.70	Excav. to elev. 15.93 on RIGHT side
12	0.016	19.75	0.000	26.70	Fill to elev. 17.48 on RIGHT side
13	No calculation at this stage				Install prop no.4 at elev. 17.00
14	No calculation at this stage				Install prop no.3 at elev. 21.75
15	0.017	19.75	0.000	26.70	Remove prop no.5 at elev. 21.00
16	No calculation at this stage				Install prop no.2 at elev. 26.50
17	0.017	19.75	0.000	26.70	Remove prop no.1 at elev. 25.50
18	0.017	19.75	0.000	26.70	Change soil type 4 to soil type 6
19	0.017	19.75	0.000	26.70	Apply surcharge no.2 at elev. 15.93
20	0.017	19.75	0.000	26.70	Apply water pressure profile no.2
21	0.018	19.75	0.000	26.70	Change EI of wall to 322062kN.m ² /m run

Run ID. 2176_TCR_SW03-B_900_SLS
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

| Sheet No.
 | Date:27-05-2022
 | 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. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.75		
	--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	kN per m run	kN per prop	kN per prop
9	91	91	123	---	---	---	---	---	---
11	99	99	134	---	---	---	---	---	---
12	100	100	136	---	---	---	---	---	---
15	100	100	135	---	---	---	158	158	213
17	---	---	---	73	73	98	190	190	257
18	---	---	---	76	76	102	162	162	219
19	---	---	---	75	75	101	168	168	227
20	---	---	---	88	88	118	316	316	426
21	---	---	---	68	68	91	341	341	460

Run ID. 2176_TCR_SW03-B_900_SLS
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

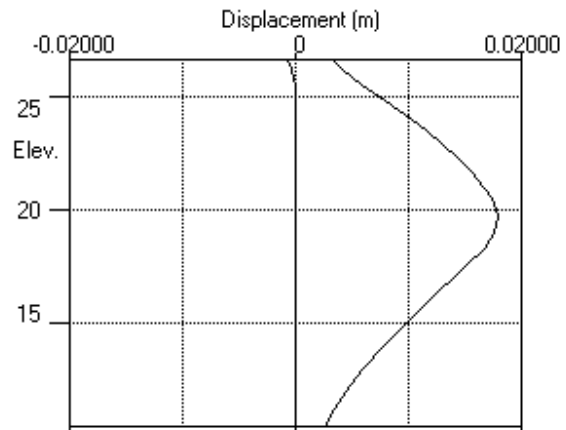
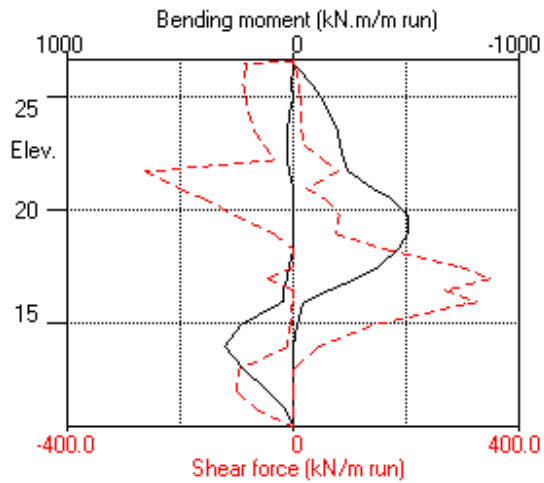
| Sheet No.
 | Date:27-05-2022
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Stage no.	----- Prop no. 4 ----- at elev. 17.00			----- Prop no. 5 ----- at elev. 21.00		
	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop	--Calculated-- kN per m run	Factored kN per prop	Factored kN per prop
11	---	---	---	200	200	269
12	---	---	---	200	200	269
15	41	41	56	---	---	---
17	37	37	49	---	---	---
18	320	320	432	---	---	---
19	290	290	392	---	---	---
20	357	357	482	---	---	---
21	373	373	504	---	---	---

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Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
Checked :

Bending moment, shear force, displacement envelopes



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 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	26.70	1 MG		1 MG
2	23.50	5 Alluvium Dr		5 Alluvium Dr
3	22.25	3 SAND		3 SAND
4	19.00	4 LC UnDr		4 LC UnDr

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil Properties File = 2176_TCR SOILS_01.dat

-- 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 MG	18.00	10000	0.500	OC	0.292	4.369	
				(0.200)	(0.000)	(0.000)	
2 Alluvium UnDr	19.00	40000	1.000	OC	1.000	1.000	50.00u
				(0.490)	(2.389)	(2.390)	
3 SAND	19.00	60000	0.426	OC	0.235	6.084	
				(0.200)	(0.000)	(0.000)	
4 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(7.813)
5 Alluvium Dr	19.00	30000	1.000	OC	0.376	3.077	0.0d
				(0.200)	(1.401)	(4.665)	
6 LC Dr	20.00	68000	1.000	OC	0.361	3.253	5.000d
(19.00)		(6250)		(0.200)	(1.370)	(4.831)	
7 CONCRETE	24.00	200000	1.000	OC	0.217	4.599	300.0d
				(0.300)	(0.933)	(4.289)	
8 LC UnDr	20.00	85000	1.000	OC	1.000	1.000	85.00u
(19.00)		(7813)		(0.490)	(2.389)	(2.390)	(6.750)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil	Wall	Back-		Soil	Wall	Back-	
friction angle	adhesion coeff.	fill angle		friction angle	adhesion coeff.	fill angle	
1 MG	30.00	0.500	0.00	30.00	0.500	0.00	
2 Alluvium UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
3 SAND	35.00	0.500	0.00	35.00	0.500	0.00	
4 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	
5 Alluvium Dr	24.00	0.500	0.00	24.00	0.500	0.00	
6 LC Dr	25.00	0.500	0.00	25.00	0.500	0.00	
7 CONCRETE	40.00	0.000	0.00	40.00	0.000	0.00	
8 LC UnDr	0.00	0.500	0.00	0.00	0.500	0.00	

GROUND WATER CONDITIONS

Density of water = 9.810 kN/m3

	Left side	Right side
Initial water table elevation	21.00	21.00

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	21.00	21.00	0.0	1	15.83	15.83	0.0 MC+WC
2	1	26.20	26.20	0.0	1	15.93	15.93	0.0 MC+WC
					2	15.93	26.20	100.7

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 10.38
Maximum finite element length = 1.00 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 0.023004 m4/m run
E.I = 644112 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Prop no.	Elev.	Prop spacing m	Cross-section area sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (deg)	Pre-stress /prop kN	Strut or Anchor	Allow tension ?	L/R
1	25.50	1.00	1.000000	30000	1.00	0.00	0	Strut	No	R
2	26.50	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
3	21.75	1.00	0.400000	2.100E+07	30.00	0.00	0	Strut	No	R
4	17.00	1.00	1.000000	2.100E+07	30.00	0.00	0	Strut	No	R
5	21.00	1.00	1.000000	30000	1.00	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/m2		Equiv. soil type	Partial factor/ Category
1	26.66	0.50(L)	50.00	25.00	Near edge	25.00 =	N/A	1.10 Var
2	15.93	-0.00(R)	50.00	25.00	Far edge	100.00 =	N/A	1.00 P/U
3	22.25	1.00(L)	40.00	1.00	Near edge	485.00 =	N/A	1.00 P/U
4	22.25	1.00(L)	40.00	1.00	Far edge	111.00 =	N/A	1.10 Var
5	22.25	0.50(L)	40.00	20.00	Near edge	35.00 =	N/A	1.00 P/U
6	22.25	0.50(L)	40.00	20.00	Far edge	7.50 =	N/A	1.10 Var

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	Change EI of wall to 450887 kN.m ² /m run Reset wall displacements to zero at this stage
2	Apply surcharge no.3 at elevation 22.25
3	Apply surcharge no.4 at elevation 22.25
4	Apply surcharge no.5 at elevation 22.25
5	Apply surcharge no.6 at elevation 22.25
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 25.00 on RIGHT side
8	Install strut or anchor no.1 at elevation 25.50
9	Excavate to elevation 20.50 on RIGHT side
10	Install strut or anchor no.5 at elevation 21.00
11	Excavate to elevation 15.93 on RIGHT side
12	Excavate to elevation 15.83 on RIGHT side
13	Fill to elevation 15.93 on RIGHT side with soil type 1
14	Fill to elevation 17.48 on RIGHT side with soil type 7
15	Install strut or anchor no.4 at elevation 17.00
16	Install strut or anchor no.3 at elevation 21.75
17	Remove strut or anchor no.5 at elevation 21.00
18	Install strut or anchor no.2 at elevation 26.50
19	Remove strut or anchor no.1 at elevation 25.50
20	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
21	Apply surcharge no.2 at elevation 15.93
22	Apply water pressure profile no.2 (Mod. Conserv.)
23	Change EI of wall to 322062 kN.m ² /m run Allow wall to relax with new modulus value

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1

Water pressures : Moderately Conservative

Partial factor on C' = 1.000

Partial factor on Phi' = 1.000

Partial factor on Cu = 1.000

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 = 1.100

Design factor on calculated Bending Moments = 1.350

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) = 16.33 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 200.00 m

Width of excavation on Left side of wall = 24.00 m

Width of excavation on Right side of wall = 24.00 m

Distance to rigid boundary on Left side = 24.00 m

Distance to rigid boundary on Right side = 24.00 m

OUTPUT OPTIONS

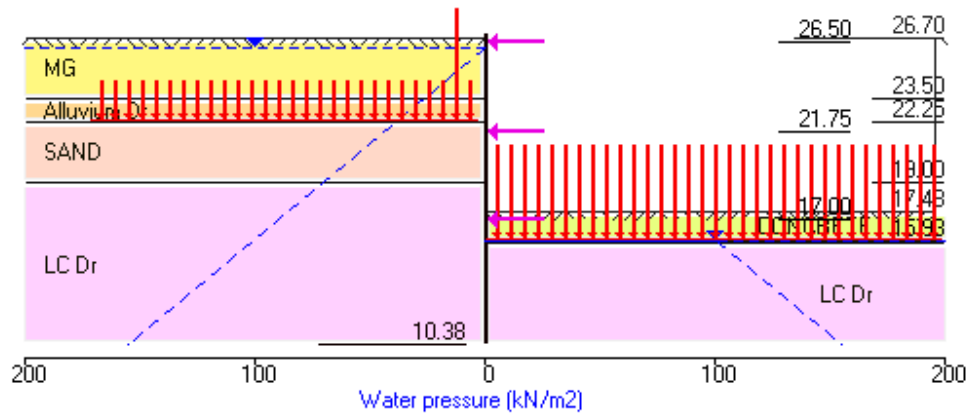
Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 450887kN.m2/m run	Yes	Yes	Yes
2	Apply surcharge no.3 at elev. 22.25	Yes	Yes	Yes
3	Apply surcharge no.4 at elev. 22.25	Yes	Yes	Yes
4	Apply surcharge no.5 at elev. 22.25	Yes	Yes	Yes
5	Apply surcharge no.6 at elev. 22.25	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 25.00 on RIGHT side	Yes	Yes	Yes
8	Install prop no.1 at elev. 25.50	Yes	Yes	Yes
9	Excav. to elev. 20.50 on RIGHT side	Yes	Yes	Yes
10	Install prop no.5 at elev. 21.00	Yes	Yes	Yes
11	Excav. to elev. 15.93 on RIGHT side	Yes	Yes	Yes
12	Excav. to elev. 15.83 on RIGHT side	Yes	Yes	Yes
13	Fill to elev. 15.93 on RIGHT side	Yes	Yes	Yes
14	Fill to elev. 17.48 on RIGHT side	Yes	Yes	Yes
15	Install prop no.4 at elev. 17.00	Yes	Yes	Yes
16	Install prop no.3 at elev. 21.75	Yes	Yes	Yes
17	Remove prop no.5 at elev. 21.00	Yes	Yes	Yes
18	Install prop no.2 at elev. 26.50	Yes	Yes	Yes
19	Remove prop no.1 at elev. 25.50	Yes	Yes	Yes
20	Change soil type 4 to soil type 6	Yes	Yes	Yes
21	Apply surcharge no.2 at elev. 15.93	Yes	Yes	Yes
22	Apply water pressure profile no.2	Yes	Yes	Yes
23	Change EI of wall to 322062kN.m2/m run	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 Soil properties file: 2176_TCR SOILS_01.dat
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
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Stage No.23 Change EI of wall to 322062kN.m2/m run



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 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

Sheet No.
 Job No. 2176
 Made by : JRM
 Date: 27-05-2022
 Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 200.00m
 Subgrade reaction model - Boussinesq Influence coefficients
 Soil deformations are elastic until the active or passive limit is reached
 Open Tension Crack analysis - No

Rigid boundaries: Left side 24.00 from wall
 Right side 24.00 from wall

Limit State: ULS DA1 Combination 1

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			
				Calculated		Factored		Calculated		Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	26.70	0.003	-0.001	0	-0	0	-0	0	0	0	0
2	26.50	0.004	-0.001	0	0	0	0	1	-87	2	-118
3	26.20	0.004	-0.000	1	-26	1	-35	4	-84	6	-114
4	25.50	0.006	-0.000	7	-81	9	-110	10	-91	14	-123
5	25.00	0.007	0.000	5	-118	7	-159	9	-87	12	-118
6	24.25	0.010	0.000	15	-164	20	-222	13	-79	18	-107
7	23.50	0.012	0.000	24	-195	33	-264	13	-68	17	-92
8	22.88	0.013	0.000	29	-206	39	-277	19	-53	25	-72
9	22.25	0.015	0.000	26	-221	35	-298	52	-35	70	-48
10	21.75	0.016	0.000	16	-236	22	-318	80	-267	108	-361
11	21.00	0.017	0.000	0	-361	0	-487	23	-208	31	-281
12	20.50	0.018	0.000	0	-441	0	-595	56	-171	75	-231
13	19.75	0.019	0.000	0	-522	0	-704	83	-111	113	-150
14	19.00	0.018	0.000	0	-528	0	-712	76	-42	103	-57
15	18.24	0.017	0.000	0	-490	0	-661	163	0	220	0
16	17.48	0.016	0.000	14	-410	19	-554	293	0	396	0
17	17.00	0.015	0.000	30	-324	40	-438	345	-53	466	-72
18	16.46	0.013	0.000	41	-198	56	-267	266	0	360	0
19	15.93	0.012	0.000	48	-80	64	-108	321	0	434	0
20	15.83	0.012	0.000	48	-67	65	-91	330	0	446	0
21	14.92	0.010	0.000	244	-12	329	-17	162	-3	219	-4
22	14.00	0.008	0.000	325	-0	439	-0	52	-9	70	-12
23	13.00	0.006	0.000	249	-0	336	-0	3	-99	4	-134
24	12.00	0.005	0.000	126	-0	170	-0	0	-112	0	-151
25	11.19	0.004	0.000	41	-0	56	-0	0	-77	0	-104
26	10.38	0.003	0.000	0	-0	0	-0	0	0	0	0

Run ID. 2176_TCR_SW03-B_900_ULS1
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

Sheet No.
Date: 27-05-2022
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. min.		max. elev.	min. elev.	max. min.	
	kN.m/m	kN.m/m	kN.m/m		kN/m	kN/m	kN/m	
1	0	17.48	-0	14.00	0	-0	0	26.70
2	10	13.00	-75	18.24	14	-102	26	16.46
3	13	13.00	-94	18.24	17	-127	33	16.46
4	12	13.00	-109	18.24	16	-147	37	16.46
5	11	13.00	-113	18.24	15	-152	38	16.46
6	12	13.00	-114	18.24	16	-154	38	16.46
7	29	22.88	-105	18.24	39	-141	36	16.46
8	No calculation at this stage							
9	48	15.83	-216	21.75	65	-292	83	19.75
10	No calculation at this stage							
11	294	14.00	-477	19.00	397	-645	311	15.93
12	304	14.00	-486	19.00	410	-656	314	15.83
13	304	14.00	-486	19.00	411	-656	315	15.83
14	320	14.00	-495	19.00	432	-669	330	15.83
15	No calculation at this stage							
16	No calculation at this stage							
17	325	14.00	-523	19.00	439	-706	312	15.83
18	No calculation at this stage							
19	325	14.00	-514	19.00	439	-694	313	15.83
20	130	13.00	-443	19.75	176	-598	294	17.00
21	144	13.00	-454	19.00	194	-613	285	17.00
22	174	14.00	-528	19.00	235	-712	345	17.00
23	162	14.00	-458	19.00	219	-619	327	17.00

Maximum and minimum displacement at each stage

Stage no.	Displacement				Stage description
	maximum elev.	minimum elev.			
	m	m			
1	0.000	14.00	0.000	26.70	Change EI of wall to 450887kN.m2/m run
2	0.002	18.24	-0.000	26.70	Apply surcharge no.3 at elev. 22.25
3	0.003	18.24	-0.000	26.70	Apply surcharge no.4 at elev. 22.25
4	0.004	17.48	-0.001	26.70	Apply surcharge no.5 at elev. 22.25
5	0.004	17.48	-0.001	26.70	Apply surcharge no.6 at elev. 22.25
6	0.004	18.24	-0.001	26.70	Apply water pressure profile no.1
7	0.004	18.24	0.000	26.70	Excav. to elev. 25.00 on RIGHT side
8	No calculation at this stage				Install prop no.1 at elev. 25.50
9	0.009	21.00	0.000	26.70	Excav. to elev. 20.50 on RIGHT side
10	No calculation at this stage				Install prop no.5 at elev. 21.00
11	0.017	19.00	0.000	26.70	Excav. to elev. 15.93 on RIGHT side
12	0.017	19.00	0.000	26.70	Excav. to elev. 15.83 on RIGHT side
13	0.017	19.00	0.000	26.70	Fill to elev. 15.93 on RIGHT side
14	0.017	19.00	0.000	26.70	Fill to elev. 17.48 on RIGHT side
15	No calculation at this stage				Install prop no.4 at elev. 17.00
16	No calculation at this stage				Install prop no.3 at elev. 21.75
17	0.018	19.75	0.000	26.70	Remove prop no.5 at elev. 21.00
18	No calculation at this stage				Install prop no.2 at elev. 26.50
19	0.018	19.75	0.000	26.70	Remove prop no.1 at elev. 25.50
20	0.017	19.75	0.000	26.70	Change soil type 4 to soil type 6
21	0.017	19.75	0.000	26.70	Apply surcharge no.2 at elev. 15.93
22	0.018	19.75	0.000	26.70	Apply water pressure profile no.2
23	0.019	19.75	0.000	26.70	Change EI of wall to 322062kN.m2/m run

Run ID. 2176_TCR_SW03-B_900_ULS1
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

| Sheet No.
| Date:27-05-2022
| 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. 25.50			----- Prop no. 2 ----- at elev. 26.50			----- Prop no. 3 ----- at elev. 21.75		
	--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	kN per m run	kN per prop	kN per prop
9	92	92	124	---	---	---	---	---	---
11	100	100	134	---	---	---	---	---	---
12	99	99	134	---	---	---	---	---	---
13	99	99	134	---	---	---	---	---	---
14	101	101	136	---	---	---	---	---	---
17	100	100	135	---	---	---	168	168	227
19	---	---	---	73	73	98	201	201	271
20	---	---	---	76	76	103	169	169	228
21	---	---	---	75	75	102	176	176	237
22	---	---	---	88	88	119	322	322	435
23	---	---	---	68	68	92	347	347	468

Run ID. 2176_TCR_SW03-B_900_ULS1
 Tottenham Court Road
 SW03-B, 900mm Secant 1400mm c/c

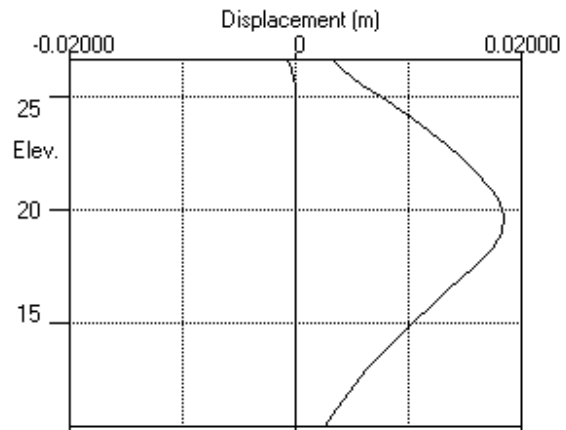
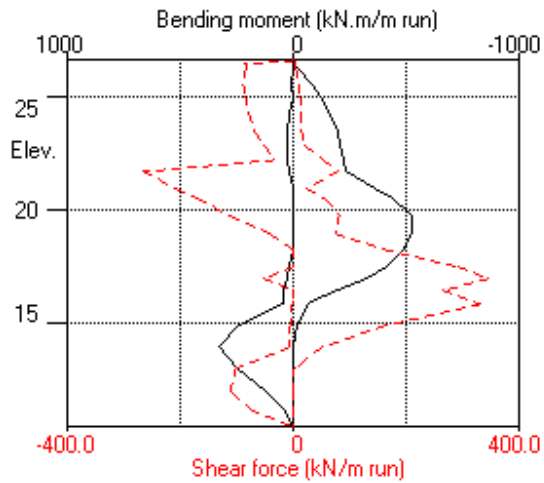
| Sheet No.
 | Date:27-05-2022
Checked :

Stage no.	----- Prop no. 4 ----- at elev. 17.00			----- Prop no. 5 ----- at elev. 21.00		
	--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
11	---	---	---	206	206	278
12	---	---	---	212	212	287
13	---	---	---	212	212	287
14	---	---	---	212	212	287
17	44	44	59	---	---	---
19	39	39	53	---	---	---
20	326	326	440	---	---	---
21	296	296	399	---	---	---
22	362	362	489	---	---	---
23	380	380	514	---	---	---

A-SQUARED STUDIO ENGINEERS LTD
Program: WALLAP Version 6.07 Revision A55.B74.R58
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Data filename/Run ID: 2176_TCR_SW03-B_900_ULS1
Soil properties file: 2176_TCR SOILS_01.dat
Tottenham Court Road
SW03-B, 900mm Secant 1400mm c/c

Sheet No.
Job No. 2176
Made by : JRM
Date: 27-05-2022
Checked :

Bending moment, shear force, displacement envelopes



	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix E: Axial Design Calculations

PROJECT NAME	TCR			PROJECT No	2176	
CLIENT				Document Number		
Produced By	JRM	Checked By		Revision & Status	0	0

General details

Pile Input Parameters		
Pile Type	CFA (circular)	mm
Pile dia	900	mm
Perimeter length	2.827	m
Base Area	0.636	m²
P.P.L	27.20	m OD
Cut-off	16.00	m OD

Eurocode Design			
Partial factors for Pile Resistance			
Combination 1		Combination 2	
+ Shaft	1.00	+ Shaft	1.6
Base	1.00	Base	2.0
- Shaft	1.00	- Shaft	2.0
Model factor			
1.4			

Eurocode Load Conversion Factors - ULS to SLS			
Load Type	Load Split	Com 1	Com 2
Eurocode Permanent	100%	1.35	1.0
Eurocode Variable	0%	1.50	1.3
NOTES:			

	Eurocode Partial Factors: Driven			Eurocode Partial Factors: Bored		
	No testing	Working tests	Preliminary tests	No testing	Working tests	Preliminary tests
Shaft (R _s)	1.5	1.3	1.3	1.6	1.4	1.4
Base (R _b)	1.7	1.5	1.5	2.0	1.7	1.7
Tension (R _{st})	2.0	1.7	1.7	2.0	1.7	1.7
Model factor	1.4	1.4	1.2	1.4	1.4	1.2

Ground Conditions > > >

Ground Conditions >>>					COHESIONLESS SOILS								COHESIVE SOILS						CHALK				ROCK					
Ground Stratum Ref	Stratum	Cohesive Or Cohesionless	top of stratum	bottom of stratum	Unit Weight yb	k value	limiting ϕ	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	limiting Nq	Limiting Base Stress	α	Cu at top of stratum	Cu at bottom of stratum	Cu gradient	Ending Bearing Nc	Max Avg Adhesion	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	Bearing (Qu/N)	Unconfined compressive strength	Rock Socket Correlation Factor	Adhesion Factor	Friction Angle		
			mOD	mOD	kN/m³		degrees	'N'	'N'		kN/m²	kN/m²		kN/m²	kN/m²	kN/m²		kN/m²	'N'	'N'			Co	β	α	ϕ	Nϕ =	
1	Made Ground	Cohesionless	27.20	23.50	18	0	0	0	0	0.00						0.00						0.00						0
2	Soft CLAY	Cohesive	23.5	22.25	19					0.00			0.45	50	50	0.00	9	140				0.00						0
3	SAND	Cohesionless	22.3	19.00	19	0.7	34	20	20	0.00	200					0.00						0.00						0
4	LC	Cohesive	19.0	3.00	20					0.00			0.5	85	210	7.81	9	140				0.00						0
5			3.0							0.00						0.00						0.00						0
6			0.0							0.00						0.00						0.00						0

Ground Water Level	21.00	mOD
Finished Ground Level	16.00	mOD

Level Increment	0.5	m
Overburden Unit Wt	18.00	kN/m³

Overburden Cap	0	kN
delta/phi	1.00	

PR11 or PG6?

							COHESIONLESS								COHESIVE				CHALK	PR11		ROCK											
Stratum Ref No.	from	to	SOIL TYPE	Bore (m)	Unit Wt. (kN/m³)	SPT N	delta	k	Nq	p.w.p.	σ _v	σ _v '	q _{us}	q _{ub}	Cohesion C _u	Adhesion	q _{us}	q _{ub}	Shaft factor	q _{us}	q _{ub}	q _{us}	q _{ub}	q _{us}	Q _{us}	Q _{ub}	Eurocode Design		Max Fact Loads kN				Toe
							(deg/s)			(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN/m²)	(kN)	(kN)	Rcd (Com 1) kN	Rcd (Com 2) kN	Compression	Tension	1.2 FoS on shaft
4	16.00	16.00	Cohesive	11.20	20.0	0.0	0.00	0.00	0	49	0.0	-49.1	0	0	108.4	54.2	0	976	0.45	0	0	0	0	0	0	443	222	0	0	0	16.00		
4	16.00	15.5	Cohesive	11.70	20.0	0.0	0.00	0.00	0	54	10.0	-44.0	0	0	112.3	55.2	55	1011	0.45	0	0	0	0	55	78	643	515	265	265	28	65	15.50	
4	15.5	15	Cohesive	12.20	20.0	0.0	0.00	0.00	0	59	20.0	-38.9	0	0	116.3	57.1	57	1046	0.45	0	0	0	0	57	159	666	589	309	309	57	132	15.00	
4	15	14.5	Cohesive	12.70	20.0	0.0	0.00	0.00	0	64	30.0	-33.8	0	0	120.2	59.1	59	1081	0.45	0	0	0	0	59	242	688	665	354	354	87	202	14.50	
4	14.5	14	Cohesive	13.20	20.0	0.0	0.00	0.00	0	69	40.0	-28.7	0	0	124.1	61.1	61	1117	0.45	0	0	0	0	61	329	710	742	400	400	117	274	14.00	
4	14	13.5	Cohesive	13.70	20.0	0.0	0.00	0.00	0	74	50.0	-23.6	0	0	128.0	63.0	63	1152	0.45	0	0	0	0	63	418	733	822	448	448	149	348	13.50	
4	13.5	13	Cohesive	14.20	20.0	0.0	0.00	0.00	0	78	60.0	-18.5	0	0	131.9	65.0	65	1187	0.45	0	0	0	0	65	510	755	903	497	497	182	425	13.00	
4	13	12.5	Cohesive	14.70	20.0	0.0	0.00	0.00	0	83	70.0	-13.4	0	0	135.8	66.9	67	1222	0.45	0	0	0	0	67	604	777	987	547	547	216	503	12.50	
4	12.5	12	Cohesive	15.20	20.0	0.0	0.00	0.00	0	88	80.0	-8.3	0	0	139.7	68.9	69	1257	0.45	0	0	0	0	69	702	800	1072	599	599	251	585	12.00	
4	12	11.5	Cohesive	15.70	20.0	0.0	0.00	0.00	0	93	90.0	-3.2	0	0	143.6	70.8	71	1292	0.45	0	0	0	0	71	802	822	1160	652	652	286	668	11.50	
4	11.5	11	Cohesive	16.20	20.0	0.0	0.00	0.00	0	98	100.0	1.9	0	0	147.5	72.8	73	1328	0.45	0	0	0	0	73	905	845	1249	705	705	323	754	11.00	
4	11	10.5	Cohesive	16.70	20.0	0.0	0.00	0.00	0	103	110.0	7.0	0	0	151.4	74.7	75	1363	0.45	0	0	0	0	75	1010	867	1341	761	761	361	842	10.50	
4	10.5	10	Cohesive	17.20	20.0	0.0	0.00	0.00	0	108	120.0	12.1	0	0	155.3	76.7	77	1398	0.45	0	0	0	0	77	1119	889	1434	817	817	400	932	10.00	
4	10	9.5	Cohesive	17.70	20.0	0.0	0.00	0.00	0	113	130.0	17.2	0	0	159.2	78.6	79	1433	0.45	0	0	0	0	79	1230	912	1530	875	875	439	1025	9.50	
4	9.5	9	Cohesive	18.20	20.0	0.0	0.00	0.00	0	118	140.0	22.3	0	0	163.1	80.6	81	1468	0.45	0	0	0	0	81	1344	934	1627	933	933	480	1120	9.00	
4	9	8.5	Cohesive	18.70	20.0	0.0	0.00	0.00	0	123	150.0	27.4	0	0	167.0	82.5	83	1503	0.45	0	0	0	0	83	1460	956	1726	994	994	522	1217	8.50	
4	8.5	8	Cohesive	19.20	20.0	0.0	0.00	0.00	0	128	160.0	32.5	0	0	170.9	84.5	84	1538	0.45	0	0	0	0	84	1580	979	1828	1055	1055	564	1317	8.00	
4	8	7.5	Cohesive	19.70	20.0	0.0	0.00	0.00	0	132	170.0	37.6	0	0	174.8	86.4	86	1574	0.45	0	0	0	0	86	1702	1001	1931	1117	1117	608	1418	7.50	
4	7.5	7	Cohesive	20.20	20.0	0.0	0.00	0.00	0	137	180.0	42.7	0	0	178.8	88.4	88	1609	0.45	0	0	0	0	88	1827	1023	2036	1181	1181	653	1523	7.00	
4	7	6.5	Cohesive	20.70	20.0	0.0	0.00	0.00	0	142	190.0	47.8	0	0	182.7	90.4	90	1644	0.45	0	0	0	0	90	1955	1046	2143	1246	1246	698	1629	6.50	
4	6.5	6	Cohesive	21.20	20.0	0.0	0.00	0.00	0	147	200.0	52.9	0	0	186.6	92.3	92	1679	0.45	0	0	0	0	92	2085	1068	2252	1312	1312	745	1738	6.00	
4	6	5.5	Cohesive	21.70	20.0	0.0	0.00	0.00	0	152	210.0	57.9	0	0	190.5	94.3	94	1714	0.45	0	0	0	0	94	2218	1091	2364	1380	1380	792	1849	5.50	
4	5.5	5	Cohesive	22.20	20.0	0.0	0.00	0.00	0	157	220.0	63.0	0	0	194.4	96.2	96	1749	0.45	0	0	0	0	96	2355	1113	2477	1449	1449	841	1962	5.00	
4	5	4.5	Cohesive	22.70	20.0	0.0	0.00	0.00	0	162	230.0	68.1	0	0	198.3	98.2	98	1785	0.45	0	0	0	0	98	2493	1135	2592	1519	1519	890	2078	4.50	
4	4.5	4	Cohesive	23.20	20.0	0.0	0.00	0.00	0	167	240.0	73.2	0	0	202.2	100.1	100	1820	0.45	0	0	0	0	100	2635	1158	2709	1590	1590	941	2196	4.00	
4	4	3.5	Cohesive	23.70	20.0	0.0	0.00	0.00	0	172	250.0	78.3	0	0	206.1	102.1	102	1855	0.45	0	0	0	0	102	2779	1180	2828	1662	1662	993	2316	3.50	
4	3.5	3	Cohesive	24.20	20.0	0.0	0.00	0.00	0	177	260.0	83.4	0	0	210.0	104.0	104	1890	0.45	0	0	0	0	104	2926	1202	2949	1736	1736	1045	2438	3.00	

PROJECT NAME	TCR			PROJECT No	2176	
CLIENT				Document Number		
Produced By	JRM	Checked By		Revision & Status	0	0

General details

Pile Input Parameters		
Pile Type	CFA (circular)	mm
Pile dia	900	mm
Perimeter length	2.827	m
Base Area	0.636	m²
P.P.L	27.20	m OD
Cut-off	21.00	m OD

Eurocode Design			
Partial factors for Pile Resistance			
Combination 1		Combination 2	
+ Shaft	1.00	+ Shaft	1.6
Base	1.00	Base	2.0
- Shaft	1.00	- Shaft	2.0
Model factor			
1.4			

Eurocode Load Conversion Factors - ULS to SLS			
Load Type	Load Split	Com 1	Com 2
Eurocode Permanent	100%	1.35	1.0
Eurocode Variable	0%	1.50	1.3
NOTES:			

	Eurocode Partial Factors: Driven			Eurocode Partial Factors: Bored		
	No testing	Working tests	Preliminary tests	No testing	Working tests	Preliminary tests
Shaft (R _s)	1.5	1.3	1.3	1.6	1.4	1.4
Base (R _b)	1.7	1.5	1.5	2.0	1.7	1.7
Tension (R _{st})	2.0	1.7	1.7	2.0	1.7	1.7
Model factor	1.4	1.4	1.2	1.4	1.4	1.2

Ground Conditions > > >

Ground Conditions > > >					COHESIONLESS SOILS								COHESIVE SOILS						CHALK				ROCK					
Ground Stratum Ref	Stratum	Cohesive Or Cohesionless	top of stratum	bottom of stratum	Unit Weight yb	k value	limiting ϕ	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	limiting Nq	Limiting Base Stress	α	Cu at top of stratum	Cu at bottom of stratum	Cu gradient	Ending Bearing Nc	Max Avg Adhesion	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	Bearing (Qu/N)	Unconfined compressive strength	Rock Socket Correlation Factor	Adhesion Factor	Friction Angle		
			mOD	mOD	kN/m³		degrees	'N'	'N'		kN/m²	kN/m²		kN/m²	kN/m²	kN/m²		kN/m²	'N'	'N'			Co	β	α	φ	Nφ =	
1	Made Ground	Cohesionless	27.20	23.50	18	0	0	0	0	0.00					0.00						0.00					0		
2	Soft CLAY	Cohesive	23.5	22.25	19					0.00			0.45	50	50	0.00	9	140			0.00					0		
3	SAND	Cohesionless	22.3	19.00	19	0.7	34	20	20	0.00	200				0.00						0.00					0		
4	LC	Cohesive	19.0	3.00	20					0.00			0.5	85	210	7.81	9	140			0.00					0		
5			3.0							0.00						0.00					0.00					0		
6			0.0							0.00						0.00					0.00					0		

Ground Water Level	21.00	mOD
Finished Ground Level	21.00	mOD

Level Increment	0.5	m
Overburden Unit Wt	18.00	kN/m³

Overburden Cap	0	kN
delta/phi	1.00	

PR11 or PG6?

							COHESIONLESS								COHESIVE				CHALK	PR11		ROCK											
Stratum Ref No.	from	to	SOIL TYPE	Bore	Unit Wt.	SPT	delta	k	Nq	p.w.p.	σ _v	σ _v '	q _{us}	q _{ub}	Cohesion C _u	Adhesion	q _{us}	q _{ub}	Shaft factor	q _{us}	q _{ub}	q _{us}	q _{ub}	q _{us}	Q _{us}	Q _{ub}	Eurocode Design		Max Fact Loads kN				Toe
				(m)	(kN/m ³)	N	(degs)			(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN)	(kN)	(kN)	Rcd (Com 1) kN	Rcd (Com 2) kN	Compression	Tension	1.2 FoS on shaft	m OD	
3	21.00	21.00	Cohesionless	6.20	19.0	20.0	33.00	0.70	55	0	0.0	0.0	0	0	0.0	0.0	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	21.00
3	21.00	20.5	Cohesionless	6.70	19.0	20.0	33.00	0.70	55	5	9.5	4.6	1	0	0.0	0.0	0	0	0.45	0	0	0	0	1	1	0	1	1	1	1	1	20.50	
3	20.5	20	Cohesionless	7.20	19.0	20.0	33.00	0.70	55	10	19.0	9.2	3	0	0.0	0.0	0	0	0.45	0	0	0	0	3	6	0	4	3	3	2	5	20.00	
3	20	19.5	Cohesionless	7.70	19.0	20.0	33.00	0.70	55	15	28.5	13.8	5	0	0.0	0.0	0	0	0.45	0	0	0	0	5	13	0	9	6	6	5	11	19.50	
3	19.5	19	Cohesionless	8.20	19.0	20.0	33.00	0.70	55	20	38.0	18.4	7	0	0.0	0.0	0	0	0.45	0	0	0	0	7	24	0	17	11	11	8	20	19.00	
4	19	18.5	Cohesive	8.70	20.0	0.0	0.00	0.00	0	25	48.0	23.5	0	0	88.9	43.5	43	800	0.45	0	0	0	0	43	85	509	424	220	220	30	71	18.50	
4	18.5	18	Cohesive	9.20	20.0	0.0	0.00	0.00	0	29	58.0	28.6	0	0	92.8	45.4	45	835	0.45	0	0	0	0	45	149	531	486	256	256	53	124	18.00	
4	18	17.5	Cohesive	9.70	20.0	0.0	0.00	0.00	0	34	68.0	33.7	0	0	96.7	47.4	47	870	0.45	0	0	0	0	47	216	554	550	294	294	77	180	17.50	
4	17.5	17	Cohesive	10.20	20.0	0.0	0.00	0.00	0	39	78.0	38.8	0	0	100.6	49.3	49	906	0.45	0	0	0	0	49	286	576	616	333	333	102	238	17.00	
4	17	16.5	Cohesive	10.70	20.0	0.0	0.00	0.00	0	44	88.0	43.9	0	0	104.5	51.3	51	941	0.45	0	0	0	0	51	359	598	684	374	374	128	299	16.50	
4	16.5	16	Cohesive	11.20	20.0	0.0	0.00	0.00	0	49	98.0	49.0	0	0	108.4	53.2	53	976	0.45	0	0	0	0	53	434	621	753	415	415	155	362	16.00	
4	16	15.5	Cohesive	11.70	20.0	0.0	0.00	0.00	0	54	108.0	54.0	0	0	112.3	55.2	55	1011	0.45	0	0	0	0	55	512	643	825	458	458	183	427	15.50	
4	15.5	15	Cohesive	12.20	20.0	0.0	0.00	0.00	0	59	118.0	59.1	0	0	116.3	57.1	57	1046	0.45	0	0	0	0	57	593	666	899	502	502	212	494	15.00	
4	15	14.5	Cohesive	12.70	20.0	0.0	0.00	0.00	0	64	128.0	64.2	0	0	120.2	59.1	59	1081	0.45	0	0	0	0	59	676	688	974	548	548	241	563	14.50	
4	14.5	14	Cohesive	13.20	20.0	0.0	0.00	0.00	0	69	138.0	69.3	0	0	124.1	61.1	61	1117	0.45	0	0	0	0	61	763	710	1052	594	594	272	635	14.00	
4	14	13.5	Cohesive	13.70	20.0	0.0	0.00	0.00	0	74	148.0	74.4	0	0	128.0	63.0	63	1152	0.45	0	0	0	0	63	852	733	1132	642	642	304	710	13.50	
4	13.5	13	Cohesive	14.20	20.0	0.0	0.00	0.00	0	78	158.0	79.5	0	0	131.9	65.0	65	1187	0.45	0	0	0	0	65	943	755	1213	691	691	337	786	13.00	
4	13	12.5	Cohesive	14.70	20.0	0.0	0.00	0.00	0	83	168.0	84.6	0	0	135.8	66.9	67	1222	0.45	0	0	0	0	67	1038	777	1297	741	741	371	865	12.50	
4	12.5	12	Cohesive	15.20	20.0	0.0	0.00	0.00	0	88	178.0	89.7	0	0	139.7	68.9	69	1257	0.45	0	0	0	0	69	1135	800	1382	793	793	405	946	12.00	
4	12	11.5	Cohesive	15.70	20.0	0.0	0.00	0.00	0	93	188.0	94.8	0	0	143.6	70.8	71	1292	0.45	0	0	0	0	71	1236	822	1470	845	845	441	1030	11.50	
4	11.5	11	Cohesive	16.20	20.0	0.0	0.00	0.00	0	98	198.0	99.9	0	0	147.5	72.8	73	1328	0.45	0	0	0	0	73	1338	845	1559	899	899	478	1115	11.00	
4	11	10.5	Cohesive	16.70	20.0	0.0	0.00	0.00	0	103	208.0	105.0	0	0	151.4	74.7	75	1363	0.45	0	0	0	0	75	1444	867	1651	954	954	516	1203	10.50	

PROJECT NAME	TCR			PROJECT No	2176	
CLIENT				Document Number		
Produced By	JRM	Checked By		Revision & Status	0	0

General details

Pile Input Parameters		
Pile Type	CFA (circular)	mm
Pile dia	900	mm
Perimeter length	2.827	m
Base Area	0.636	m²
P.P.L	27.20	m OD
Cut-off	21.00	m OD

Eurocode Design			
Partial factors for Pile Resistance			
Combination 1		Combination 2	
+ Shaft	1.00	+ Shaft	1.6
Base	1.00	Base	2.0
- Shaft	1.00	- Shaft	2.0
Model factor			
1.4			

Eurocode Load Conversion Factors - ULS to SLS			
Load Type	Load Split	Com 1	Com 2
Eurocode Permanent	100%	1.35	1.0
Eurocode Variable	0%	1.50	1.3
NOTES:			

	Eurocode Partial Factors: Driven			Eurocode Partial Factors: Bored		
	No testing	Working tests	Preliminary tests	No testing	Working tests	Preliminary tests
Shaft (R _s)	1.5	1.3	1.3	1.6	1.4	1.4
Base (R _b)	1.7	1.5	1.5	2.0	1.7	1.7
Tension (R _{st})	2.0	1.7	1.7	2.0	1.7	1.7
Model factor	1.4	1.4	1.2	1.4	1.4	1.2

Ground Conditions > > >

Ground Conditions > > >					COHESIONLESS SOILS								COHESIVE SOILS						CHALK				ROCK					
Ground Stratum Ref	Stratum	Cohesive Or Cohesionless	top of stratum	bottom of stratum	Unit Weight yb	k value	limiting ϕ	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	limiting Nq	Limiting Base Stress	α	Cu at top of stratum	Cu at bottom of stratum	Cu gradient	Ending Bearing Nc	Max Avg Adhesion	SPT 'N' at top of stratum	SPT 'N' at bottom of stratum	N Gradient	Bearing (Qu/N)	Unconfined compressive strength	Rock Socket Correlation Factor	Adhesion Factor	Friction Angle		
			mOD	mOD	kN/m³		degrees	'N'	'N'		kN/m²	kN/m²		kN/m²	kN/m²	kN/m²		kN/m²	'N'	'N'			Co	β	α	φ	Nφ =	
1	Made Ground	Cohesionless	27.20	23.50	18	0	0	0	0	0.00						0.00						0.00					0	
2	Soft CLAY	Cohesive	23.5	22.25	19					0.00			0.45	50	50	0.00	9	140				0.00					0	
3	SAND	Cohesionless	22.3	19.00	19	0.7	34	20	20	0.00	200					0.00						0.00					0	
4	LC	Cohesive	19.0	3.00	20					0.00			0.5	85	210	7.81	9	140				0.00					0	
5			3.0							0.00						0.00						0.00					0	
6			0.0							0.00						0.00						0.00					0	

Ground Water Level	21.00	mOD
Finished Ground Level	21.00	mOD

Level Increment	0.5	m
Overburden Unit Wt	18.00	kN/m³

Overburden Cap	0	kN
delta/phi	1.00	

PR11 or PG6?

							COHESIONLESS								COHESIVE				CHALK	PR11			ROCK											
Stratum Ref No.	from	to	SOIL TYPE	Bore	Unit Wt.	SPT	delta	k	Nq	p.w.p.	σ _v	σ _v '	q _{us}	q _{ub}	Cohesion C _u	Adhesion	q _{us}	q _{ub}	Shaft factor	q _{us}	q _{ub}	q _{us}	q _{ub}	q _{us}	Q _{us}	Q _{ub}	Eurocode Design		Max Fact Loads kN				Toe	
				(m)	(kN/m ³)	N	(degs)		(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN/m ²)	(kN)	(kN)	(kN)	Rcd (Com 1) kN	Rcd (Com 2) kN	Compression	Tension	1.2 FoS on shaft	m OD		
4	10.5	10	Cohesive	17.20	20.0	0.0	0.00	0.00	0	108	218.0	110.1	0	0	155.3	76.7	77	1398	0.45	0	0	0	0	77	1552	889	1744	1011	1011	554	1294	10.00		
4	10	9.5	Cohesive	17.70	20.0	0.0	0.00	0.00	0	113	228.0	115.2	0	0	159.2	78.6	79	1433	0.45	0	0	0	0	79	1664	912	1839	1068	1068	594	1386	9.50		
4	9.5	9	Cohesive	18.20	20.0	0.0	0.00	0.00	0	118	238.0	120.3	0	0	163.1	80.6	81	1468	0.45	0	0	0	0	81	1778	934	1937	1127	1127	635	1481	9.00		
4	9	8.5	Cohesive	18.70	20.0	0.0	0.00	0.00	0	123	248.0	125.4	0	0	167.0	82.5	83	1503	0.45	0	0	0	0	83	1894	956	2036	1187	1187	677	1579	8.50		
4	8.5	8	Cohesive	19.20	20.0	0.0	0.00	0.00	0	128	258.0	130.5	0	0	170.9	84.5	84	1538	0.45	0	0	0	0	84	2014	979	2137	1248	1248	719	1678	8.00		
4	8	7.5	Cohesive	19.70	20.0	0.0	0.00	0.00	0	132	268.0	135.6	0	0	174.8	86.4	86	1574	0.45	0	0	0	0	86	2136	1001	2241	1311	1311	763	1780	7.50		
4	7.5	7	Cohesive	20.20	20.0	0.0	0.00	0.00	0	137	278.0	140.7	0	0	178.8	88.4	88	1609	0.45	0	0	0	0	88	2261	1023	2346	1375	1375	807	1884	7.00		
4	7	6.5	Cohesive	20.70	20.0	0.0	0.00	0.00	0	142	288.0	145.8	0	0	182.7	90.4	90	1644	0.45	0	0	0	0	90	2389	1046	2453	1440	1440	853	1990	6.50		
4	6.5	6	Cohesive	21.20	20.0	0.0	0.00	0.00	0	147	298.0	150.9	0	0	186.6	92.3	92	1679	0.45	0	0	0	0	92	2519	1068	2562	1506	1506	900	2099	6.00		
4	6	5.5	Cohesive	21.70	20.0	0.0	0.00	0.00	0	152	308.0	155.9	0	0	190.5	94.3	94	1714	0.45	0	0	0	0	94	2652	1091	2673	1574	1574	947	2210	5.50		
4	5.5	5	Cohesive	22.20	20.0	0.0	0.00	0.00	0	157	318.0	161.0	0	0	194.4	96.2	96	1749	0.45	0	0	0	0	96	2788	1113	2787	1642	1642	996	2324	5.00		
4	5	4.5	Cohesive	22.70	20.0	0.0	0.00	0.00	0	162	328.0	166.1	0	0	198.3	98.2	98	1785	0.45	0	0	0	0	98	2927	1135	2902	1712	1712	1045	2439	4.50		
4	4.5	4	Cohesive	23.20	20.0	0.0	0.00	0.00	0	167	338.0	171.2	0	0	202.2	100.1	100	1820	0.45	0	0	0	0	100	3069	1158	3019	1783	1783	1096	2557	4.00		
4	4	3.5	Cohesive	23.70	20.0	0.0	0.00	0.00	0	172	348.0	176.3	0	0	206.1	102.1	102	1855	0.45	0	0	0	0	102	3213	1180	3138	1856	1856	1147	2677	3.50		
4	3.5	3	Cohesive	24.20	20.0	0.0	0.00	0.00	0	177	358.0	181.4	0	0	210.0	104.0	104	1890	0.45	0	0	0	0	104	3360	1202	3259	1929	1929	1200	2800	3.00		

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix F: Structural Calculations

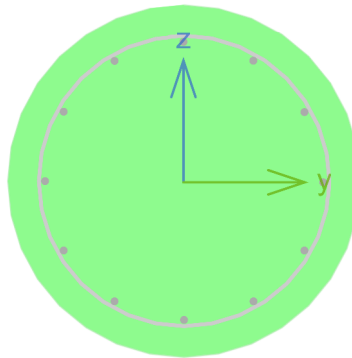
Job number 2176
Job title Tottenham Court Road
Subtitle Embedded Retaining Wall
By JRM

1 Design code

The following design code is used: Eurocode 2 (part 1), National Annex: UK

2 Sections

2.1 Section 1 (SW01-A)



<i>Definition</i>		<i>Reinforcement</i>	
<i>Material</i>	Concrete	<i>Type</i>	<i>Description</i>
<i>Grade</i>	C25/30	<i>LINK</i>	B10
<i>Profile</i>	STD C 900	<i>PERIMETER</i>	12B20
<i>Cover</i>	75mm		

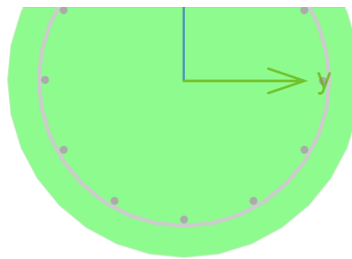
2.1.1 Analysis

2.1.1.1 ULS Results Summary

<i>Case</i>	<i>F_x (kN)</i>	<i>M_{yy} (kNm)</i>	<i>M_{zz} (kNm)</i>	<i>Utilisation</i>	<i>Status</i>
1	-699	350	0	36%	✓
2	0	350	0	63%	✓

2.2 Section 2 (SW02-A)





Definition

<i>Material</i>	Concrete
<i>Grade</i>	C25/30
<i>Profile</i>	STD C 900
<i>Cover</i>	75mm

Reinforcement

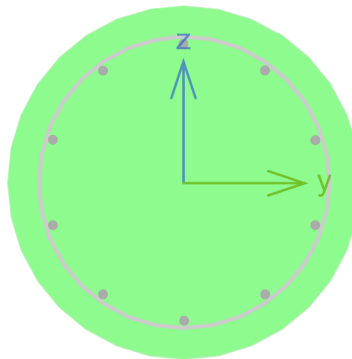
<i>Type</i>	<i>Description</i>
LINK	B10
PERIMETER	12B20

2.2.1 Analysis

2.2.1.1 ULS Results Summary

<i>Case</i>	<i>F_x (kN)</i>	<i>M_{yy} (kNm)</i>	<i>M_{zz} (kNm)</i>	<i>Utilisation</i>	<i>Status</i>
1	-846	419	0	43%	✓
2	0	419	0	76%	✓

2.3 Section 3 (SW03-A & SW04-A)



Definition

<i>Material</i>	Concrete
<i>Grade</i>	C25/30
<i>Profile</i>	STD C 900
<i>Cover</i>	75mm

Reinforcement

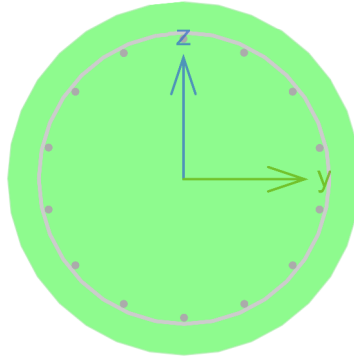
<i>Type</i>	<i>Description</i>
LINK	B10
PERIMETER	10B25

2.3.1 Analysis

2.3.1.1 ULS Results Summary

<i>Case</i>	F_x (kN)	M_{yy} (kNm)	M_{zz} (kNm)	<i>Utilisation</i>	<i>Status</i>
1	-1265	570	0	50%	✓
2	0	570	0	80%	✓

2.4 Section 4 (SW01-B)



Definition

<i>Material</i>	Concrete
<i>Grade</i>	C25/30
<i>Profile</i>	STD C 900
<i>Cover</i>	75mm

Reinforcement

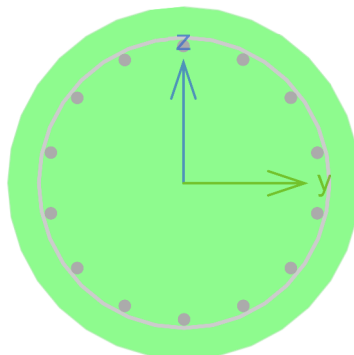
<i>Type</i>	<i>Description</i>
LINK	B10
PERIMETER	14B20

2.4.1 Analysis

2.4.1.1 ULS Results Summary

<i>Case</i>	F_x (kN)	M_{yy} (kNm)	M_{zz} (kNm)	<i>Utilisation</i>	<i>Status</i>
1	-699	554	0	62%	✓
2	0	554	0	87%	✓

2.5 Section 5 (SW03-B & SW05-B)



Definition

Reinforcement

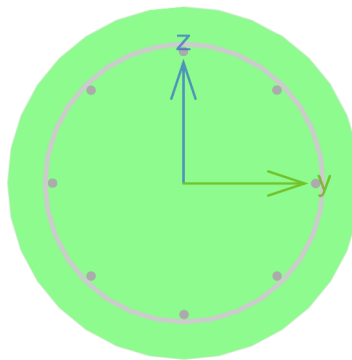
<i>Material</i>	Concrete	<i>Type</i>	<i>Description</i>
<i>Grade</i>	C25/30	<i>LINK</i>	B10
<i>Profile</i>	STD C 900	<i>PERIMETER</i>	14B32
<i>Cover</i>	75mm		

2.5.1 Analysis

2.5.1.1 ULS Results Summary

<i>Case</i>	<i>F_x (kN)</i>	<i>M_{yy} (kNm)</i>	<i>M_{zz} (kNm)</i>	<i>Utilisation</i>	<i>Status</i>
1	-1265	1375	0	86%	✓
2	0	1375	0	99%	✓

2.6 Section 6 (Contig 1)



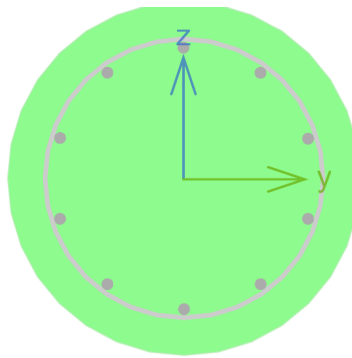
<i>Definition</i>		<i>Reinforcement</i>	
<i>Material</i>	Concrete	<i>Type</i>	<i>Description</i>
<i>Grade</i>	C25/30	<i>LINK</i>	B10
<i>Profile</i>	STD C 750	<i>PERIMETER</i>	8B20
<i>Cover</i>	75mm		

2.6.1 Analysis

2.6.1.1 ULS Results Summary

<i>Case</i>	<i>F_x (kN)</i>	<i>M_{yy} (kNm)</i>	<i>M_{zz} (kNm)</i>	<i>Utilisation</i>	<i>Status</i>
1	0	246	0	81%	✓
2	0	0	246	82%	✓

2.7 Section 7 (Contig 2)



Definition

Material	Concrete
Grade	C25/30
Profile	STD C 750
Cover	75mm

Reinforcement

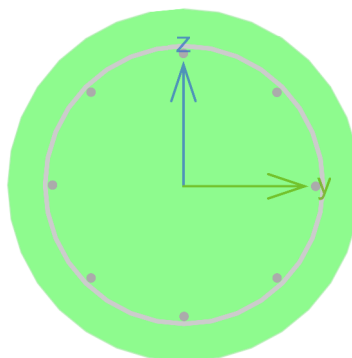
Type	Description
LINK	B10
PERIMETER	10B25

2.7.1 Analysis

2.7.1.1 ULS Results Summary

Case	F_x (kN)	M_{yy} (kNm)	M_{zz} (kNm)	Utilisation	Status
1	0	482	0	91%	✓
2	0	0	482	91%	✓

2.8 Section 8 (Contig 3)



Definition

Material	Concrete
Grade	C25/30
Profile	STD C 750
Cover	75mm

Reinforcement

Type	Description
LINK	B10
PERIMETER	8B20

2.8.1 Analysis

2.8.1.1 ULS Results Summary

<i>Case</i>	<i>F_x (kN)</i>	<i>M_{yy} (kNm)</i>	<i>M_{zz} (kNm)</i>	<i>Utilisation</i>	<i>Status</i>
1	0	290	0	96%	✓
2	0	0	290	96%	✓

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: <u>TCR</u> <u>SW01-A</u> 		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4 2.4.2.5 UKNA Table NA.1 3.1.6	Characteristic compressive cylinder strength of concrete		f_{ck} =	28	MPa			
	Characteristic compressive cube strength of concrete		$f_{ck,cube}$ =	35	MPa			
	Characteristic yield strength of reinforcement		f_{yk} =	500	MPa			
	Partial factors for materials:		For concrete	γ_c =	1.5			
			For reinforcing steel	γ_s =	1.15			
				k_f =	1.1			
			α_{cc} =	0.85				
Design value of concrete compressive strength		f_{cd} =	14.42	MPa				
Design yield strength of shear reinforcement		f_{ywd} =	434.78	MPa				
SECTION PROPERTIES								
2.3.4.2	Pile diameter (nominal)		nom pile dia =	900	mm			
	Pile constructed with permanent liner (Y/N)		permanent casing =	Y				
	Adjusted pile diameter		adjusted pile dia =	900	mm			
	Concrete cover to links		c =	75	mm			
	No. of main reinforcing bars		n =	12	nos.			
	Main reinforcement bar diameter		ϕ =	20	mm			
	Shear reinforcement type (circular / helical)			helical				
	Shear reinforcement arrangement		10mm @	250	mm c/c			
	Area of concrete		A_c =	636173				
	Area of main reinforcement		A_{sb} =	3770	mm ²			
Cross-sectional area of shear reinforcement		A_{sw} =	157	mm ²				
Effective depth		d =	671	mm				
Effective width		bw =	594	mm				
APPLIED ULTIMATE LOADS								
Ultimate shear resistance required		V_{Ed} =	174	kN				
Ultimate axial load (minimum compression or maximum tension)		N_{Ed} =	0	kN				
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2	Concrete Section:							
	Shear re Shear resistance without links (eqs 6.2a and 6.2b)		$V_{Rd,c}$ =	159.0	kN			
			$V_{Rd,c}$ <	V_{Ed}				
Shear Reinforcement Required to Resist Design Shear								
6.2.3 6.2.3	Shear Reinforcement:							
	Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$		$V_{Rd,s}$ =	298.1	kN			
Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$		$V_{Rd,max}$ =	812.8	kN				
Detailing check:								
9.2.2(5) 9.2.2(5) 9.2.2(6)	Minimum shear reinforcement ratio		ρ_{w_min} =	0.00085				
	Provided shear reinforcement ratio		ρ_w =	0.00106	Links OK			
	Maximum longitudinal shear reinf. spacing		$s_{l,max}$ =	503	mm			
Shear Reinforcement Meets Detailing Requirements								
Provide helical shear links B10mm @ 250 mm c/c								

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: <u>TCR</u> <u>SW02-A</u>		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4		Characteristic compressive cylinder strength of concrete	f_{ck}	=	28	MPa		
2.4.2.5		Characteristic compressive cube strength of concrete	$f_{ck,cube}$	=	35	MPa		
UKNA Table NA.1		Characteristic yield strength of reinforcement	f_{yk}	=	500	MPa		
3.1.6		Partial factors for materials:						
		For concrete	γ_c	=	1.5			
		For reinforcing steel	γ_s	=	1.15			
			k_f	=	1.1			
			α_{cc}	=	0.85			
		Design value of concrete compressive strength	f_{cd}	=	14.42	MPa		
		Design yield strength of shear reinforcement	f_{ywd}	=	434.78	MPa		
SECTION PROPERTIES								
2.3.4.2		Pile diameter (nominal)	nom pile dia	=	900	mm		
		Pile constructed with permanent liner (Y/N)	permanent casing	=	Y			
		Adjusted pile diameter	adjusted pile dia	=	900	mm		
		Concrete cover to links	c	=	75	mm		
		No. of main reinforcing bars	n	=	12	nos.		
		Main reinforcement bar diameter	ϕ	=	20	mm		
		Shear reinforcement type (circular / helical)			helical			
		Shear reinforcement arrangement	10mm @		250	mm c/c		
		Area of concrete	A_c	=	636173			
		Area of main reinforcement	A_{sb}	=	3770	mm ²		
		Cross-sectional area of shear reinforcement	A_{sw}	=	157	mm ²		
		Effective depth	d	=	671	mm		
		Effective width	bw	=	594	mm		
APPLIED ULTIMATE LOADS								
		Ultimate shear resistance required	V_{Ed}	=	273	kN		
		Ultimate axial load (minimum compression or maximum tension)	N_{Ed}	=	0	kN		
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2		Concrete Section:						
		Shear re Shear resistance without links (eqs 6.2a and 6.2b)	$V_{Rd,c}$	=	159.0	kN		
			$V_{Rd,c}$	<	V_{Ed}			
		Shear Reinforcement Required to Resist Design Shear						
6.2.3		Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$	$V_{Rd,s}$	=	298.1	kN		
6.2.3		Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$	$V_{Rd,max}$	=	812.8	kN		
		Detailing check:						
9.2.2(5)		Minimum shear reinforcement ratio	ρ_{w_min}	=	0.00085			
9.2.2(5)		Provided shear reinforcement ratio	ρ_w	=	0.00106	Links OK		
9.2.2(6)		Maximum longitudinal shear reinf. spacing	$s_{l,max}$	=	503	mm		
		Shear Reinforcement Meets Detailing Requirements						
Provide helical shear links B10mm @ 250 mm c/c								



A-squared Studio

Structural Design Sheet**Shear Calculation - Circular Section**

(Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)

PROJECT: TCR

SW03-A & SW04-A

Prepared

Date

Verified

Date

Ref. No.

Revision

Sheet

JRM

27-May-22

00

of

REFERENCE**GENERAL REFERENCE**

Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010

MATERIAL PROPERTIES

Characteristic compressive cylinder strength of concrete	f_{ck} =	28	MPa
Characteristic compressive cube strength of concrete	$f_{ck,cube}$ =	35	MPa
Characteristic yield strength of reinforcement	f_{yk} =	500	MPa
Partial factors for materials:			
For concrete	γ_c =	1.5	
For reinforcing steel	γ_s =	1.15	
	k_f =	1.1	
	α_{cc} =	0.85	
Design value of concrete compressive strength	f_{cd} =	14.42	MPa
Design yield strength of shear reinforcement	f_{ywd} =	434.78	MPa

SECTION PROPERTIES

Pile diameter (nominal)	nom pile dia =	900	mm
Pile constructed with permanent liner (Y/N)	permanent casing =	Y	
Adjusted pile diameter	adjusted pile dia =	900	mm
Concrete cover to links	c =	75	mm
No. of main reinforcing bars	n =	10	nos.
Main reinforcement bar diameter	ϕ =	25	mm
Shear reinforcement type (circular / helical)		helical	
Shear reinforcement arrangement	10mm @	150	mm c/c
Area of concrete	A_c =	636173	
Area of main reinforcement	A_{sb} =	4909	mm ²
Cross-sectional area of shear reinforcement	A_{sw} =	157	mm ²
Effective depth	d =	667	mm
Effective width	bw =	599	mm

APPLIED ULTIMATE LOADS

Ultimate shear resistance required	V_{Ed} =	441	kN
Ultimate axial load (minimum compression or maximum tension)	N_{Ed} =	0	kN

SHEAR REINFORCEMENT REQUIREMENTS**Concrete Section:**

Shear re Shear resistance without links (eqs 6.2a and 6.2b)	$V_{Rd,c}$ =	174.2	kN
	$V_{Rd,c}$ <	V_{Ed}	

Shear Reinforcement Required to Resist Design Shear**Shear Reinforcement:**

Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$	$V_{Rd,s}$ =	495.9	kN
Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$	$V_{Rd,max}$ =	815.8	kN

Detailing check:

Minimum shear reinforcement ratio	$\rho_{w,min}$ =	0.00085	
Provided shear reinforcement ratio	ρ_w =	0.00175	Links OK
Maximum longitudinal shear reinf. spacing	$s_{l,max}$ =	500	mm

Shear Reinforcement Meets Detailing Requirements

Provide helical shear links

B10mm @

150 mm c/c

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: <u>TCR</u> <u>SW01-B</u> 		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4 2.4.2.5 UKNA Table NA.1 3.1.6	Characteristic compressive cylinder strength of concrete		f_{ck} =	28	MPa			
	Characteristic compressive cube strength of concrete		$f_{ck,cube}$ =	35	MPa			
	Characteristic yield strength of reinforcement		f_{yk} =	500	MPa			
	Partial factors for materials:		For concrete	γ_c =	1.5			
			For reinforcing steel	γ_s =	1.15			
			k_f =	1.1				
			α_{cc} =	0.85				
	Design value of concrete compressive strength		f_{cd} =	14.42	MPa			
	Design yield strength of shear reinforcement		f_{ywd} =	434.78	MPa			
SECTION PROPERTIES								
2.3.4.2	Pile diameter (nominal)		nom pile dia =	900	mm			
	Pile constructed with permanent liner (Y/N)		permanent casing =	Y				
	Adjusted pile diameter		adjusted pile dia =	900	mm			
	Concrete cover to links		c =	75	mm			
	No. of main reinforcing bars		n =	14	nos.			
	Main reinforcement bar diameter		ϕ =	20	mm			
	Shear reinforcement type (circular / helical)			helical				
	Shear reinforcement arrangement		10mm @	250	mm c/c			
	Area of concrete		A_c =	636173				
	Area of main reinforcement		A_{sb} =	4398	mm ²			
Cross-sectional area of shear reinforcement		A_{sw} =	157	mm ²				
	Effective depth		d =	672	mm			
	Effective width		bw =	592	mm			
APPLIED ULTIMATE LOADS								
	Ultimate shear resistance required		V_{Ed} =	186	kN			
	Ultimate axial load (minimum compression or maximum tension)		N_{Ed} =	0	kN			
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2	Concrete Section:							
	Shear re Shear resistance without links (eqs 6.2a and 6.2b)		$V_{Rd,c}$ =	167.1	kN			
			$V_{Rd,c}$ <	V_{Ed}				
Shear Reinforcement Required to Resist Design Shear								
6.2.3	Shear Reinforcement:							
	Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$		$V_{Rd,s}$ =	298.7	kN			
6.2.3	Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$		$V_{Rd,max}$ =	811.6	kN			
Detailing check:								
9.2.2(5)	Minimum shear reinforcement ratio		ρ_{w_min} =	0.00085				
9.2.2(5)	Provided shear reinforcement ratio		ρ_w =	0.00106	Links OK			
9.2.2(6)	Maximum longitudinal shear reinf. spacing		$s_{l,max}$ =	504	mm			
Shear Reinforcement Meets Detailing Requirements								
Provide helical shear links B10mm @ 250 mm c/c								

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: <u>TCR</u> <u>SW03-B & SW05-B</u> 		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4 2.4.2.5 UKNA Table NA.1 3.1.6	Characteristic compressive cylinder strength of concrete		f_{ck} =	28	MPa			
	Characteristic compressive cube strength of concrete		$f_{ck,cube}$ =	35	MPa			
	Characteristic yield strength of reinforcement		f_{yk} =	500	MPa			
	Partial factors for materials:							
	For concrete		γ_c =	1.5				
	For reinforcing steel		γ_s =	1.15				
			k_f =	1.1				
			α_{cc} =	0.85				
Design value of concrete compressive strength		f_{cd} =	14.42	MPa				
Design yield strength of shear reinforcement		f_{ywd} =	434.78	MPa				
SECTION PROPERTIES								
2.3.4.2	Pile diameter (nominal)		nom pile dia =	900	mm			
	Pile constructed with permanent liner (Y/N)		permanent casing =	Y				
	Adjusted pile diameter		adjusted pile dia =	900	mm			
	Concrete cover to links		c =	75	mm			
	No. of main reinforcing bars		n =	14	nos.			
	Main reinforcement bar diameter		ϕ =	32	mm			
	Shear reinforcement type (circular / helical)			helical				
	Shear reinforcement arrangement		10mm @	100	mm c/c			
	Area of concrete		A_c =	636173				
	Area of main reinforcement		A_{sb} =	11259	mm ²			
Cross-sectional area of shear reinforcement		A_{sw} =	157	mm ²				
Effective depth		d =	668	mm				
Effective width		bw =	597	mm				
APPLIED ULTIMATE LOADS								
Ultimate shear resistance required		V_{Ed} =	652	kN				
Ultimate axial load (minimum compression or maximum tension)		N_{Ed} =	0	kN				
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2	Concrete Section:							
	Shear re Shear resistance without links (eqs 6.2a and 6.2b)		$V_{Rd,c}$ =	229.4	kN			
			$V_{Rd,c}$	<	V_{Ed}			
Shear Reinforcement Required to Resist Design Shear								
6.2.3 6.2.3	Shear Reinforcement:							
	Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$		$V_{Rd,s}$ =	746.3	kN			
Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$		$V_{Rd,max}$ =	814.7	kN				
Detailing check:								
9.2.2(5) 9.2.2(5) 9.2.2(6)	Minimum shear reinforcement ratio		ρ_{w_min} =	0.00085				
	Provided shear reinforcement ratio		ρ_w =	0.00263	Links OK			
	Maximum longitudinal shear reinf. spacing		$s_{l,max}$ =	501	mm			
Shear Reinforcement Meets Detailing Requirements								
Provide helical shear links B10mm @ 100 mm c/c								

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: TCR Contig 1 & 3		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4		Characteristic compressive cylinder strength of concrete	f_{ck}	=	28	MPa		
2.4.2.5		Characteristic compressive cube strength of concrete	$f_{ck,cube}$	=	35	MPa		
UKNA Table NA.1		Characteristic yield strength of reinforcement	f_{yk}	=	500	MPa		
3.1.6		Partial factors for materials:						
		For concrete	γ_c	=	1.5			
		For reinforcing steel	γ_s	=	1.15			
			k_f	=	1.1			
			α_{cc}	=	0.85			
		Design value of concrete compressive strength	f_{cd}	=	14.42	MPa		
		Design yield strength of shear reinforcement	f_{ywd}	=	434.78	MPa		
SECTION PROPERTIES								
2.3.4.2		Pile diameter (nominal)	nom pile dia	=	750	mm		
		Pile constructed with permanent liner (Y/N)	permanent casing	=	Y			
		Adjusted pile diameter	adjusted pile dia	=	750	mm		
		Concrete cover to links	c	=	75	mm		
		No. of main reinforcing bars	n	=	8	nos.		
		Main reinforcement bar diameter	ϕ	=	20	mm		
		Shear reinforcement type (circular / helical)			helical			
		Shear reinforcement arrangement	10mm @		250	mm c/c		
		Area of concrete	A_c	=	441786			
		Area of main reinforcement	A_{sb}	=	2513	mm ²		
		Cross-sectional area of shear reinforcement	A_{sw}	=	157	mm ²		
		Effective depth	d	=	544	mm		
		Effective width	bw	=	484	mm		
APPLIED ULTIMATE LOADS								
		Ultimate shear resistance required	V_{Ed}	=	90	kN		
		Ultimate axial load (minimum compression or maximum tension)	N_{Ed}	=	0	kN		
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2		Concrete Section:						
		Shear re Shear resistance without links (eqs 6.2a and 6.2b)	$V_{Rd,c}$	=	109.4	kN		
			$V_{Rd,c}$	>	V_{Ed}			
		Provide Minimum Shear Reinforcement						
6.2.3		Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$	$V_{Rd,s}$	=	N/A	kN		
6.2.3		Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$	$V_{Rd,max}$	=	N/A	kN		
		Detailing check:						
9.2.2(5)		Minimum shear reinforcement ratio	ρ_{w_min}	=	0.00085			
9.2.2(5)		Provided shear reinforcement ratio	ρ_w	=	0.00130	Links OK		
9.2.2(6)		Maximum longitudinal shear reinf. spacing	$s_{l,max}$	=	407	mm		
		Shear Reinforcement Meets Detailing Requirements						
Provide helical shear links B10mm @ 250 mm c/c								

 A-squared Studio		Structural Design Sheet Shear Calculation - Circular Section (Eurocode 2 - BS EN 1992-1-1:2002 and National Annex)						
PROJECT: <u>TCR</u> <u>Contig 2</u>		Prepared	Date	Verified	Date	Ref. No.	Revision	Sheet
		JRM	27-May-22				00	of
REFERENCE								
GENERAL REFERENCE Shear to BS EN 1992-1-1:2004 and the UK National Annex in conjunction with the technical paper by J. J. Orr et al, Shear Design of Circular Concrete Sections Using the Eurocode 2 Truss Model, The Structural Engineer 88 (23/24), December 2010								
MATERIAL PROPERTIES								
2.4.2.4		Characteristic compressive cylinder strength of concrete	f_{ck}	=	28	MPa		
		Characteristic compressive cube strength of concrete	$f_{ck,cube}$	=	35	MPa		
2.4.2.5		Characteristic yield strength of reinforcement	f_{yk}	=	500	MPa		
UKNA Table NA.1		Partial factors for materials:						
3.1.6		For concrete	γ_c	=	1.5			
		For reinforcing steel	γ_s	=	1.15			
			k_f	=	1.1			
			α_{cc}	=	0.85			
		Design value of concrete compressive strength	f_{cd}	=	14.42	MPa		
		Design yield strength of shear reinforcement	f_{ywd}	=	434.78	MPa		
SECTION PROPERTIES								
2.3.4.2		Pile diameter (nominal)	nom pile dia	=	750	mm		
		Pile constructed with permanent liner (Y/N)	permanent casing	=	Y			
		Adjusted pile diameter	adjusted pile dia	=	750	mm		
		Concrete cover to links	c	=	75	mm		
		No. of main reinforcing bars	n	=	10	nos.		
		Main reinforcement bar diameter	ϕ	=	25	mm		
		Shear reinforcement type (circular / helical)			helical			
		Shear reinforcement arrangement	10mm @		250	mm c/c		
		Area of concrete	A_c	=	441786			
		Area of main reinforcement	A_{sb}	=	4909	mm ²		
		Cross-sectional area of shear reinforcement	A_{sw}	=	157	mm ²		
		Effective depth	d	=	546	mm		
		Effective width	bw	=	481	mm		
APPLIED ULTIMATE LOADS								
		Ultimate shear resistance required	V_{Ed}	=	126	kN		
		Ultimate axial load (minimum compression or maximum tension)	N_{Ed}	=	0	kN		
SHEAR REINFORCEMENT REQUIREMENTS								
6.2.2		Concrete Section:						
		Shear re Shear resistance without links (eqs 6.2a and 6.2b)	$V_{Rd,c}$	=	136.5	kN		
			$V_{Rd,c}$	>	V_{Ed}			
		Provide Minimum Shear Reinforcement						
6.2.3		Design shear force sustained by yielding shear reinf. = $\lambda_1 \lambda_2 (A_{sw}/s) \cdot z \cdot f_{ywd} \cdot \cot \theta$	$V_{Rd,s}$	=	N/A	kN		
6.2.3		Concrete compression strut capacity = $\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd} / (\cot \theta + \tan \theta)$	$V_{Rd,max}$	=	N/A	kN		
		Detailing check:						
9.2.2(5)		Minimum shear reinforcement ratio	ρ_{w_min}	=	0.00085			
9.2.2(5)		Provided shear reinforcement ratio	ρ_w	=	0.00131	Links OK		
9.2.2(6)		Maximum longitudinal shear reinf. spacing	$s_{l,max}$	=	409	mm		
		Shear Reinforcement Meets Detailing Requirements						
Provide helical shear links B10mm @ 250 mm c/c								

PROJECT	TCR				
TITLE	EC2 structural Capacity Check		Orig.	Date	Verif.
Section			JRM		
				Date	Sheet

Based on EC2 Design
Maximum Structural Capacity for 900 mm diameter pile

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

$$f_{cd} = (a_{cc} * f_{ck}) / (\gamma_c * k_f) \quad \text{Clauses 2.4.2.5 \& 3.15}$$

Therefore for C 35 Concrete, characteristic cylinder strength = 28 N/mm²

Where:

$a_{cc} = 0.85$
 $f_{ck} = 28 \text{ N/mm}^2$
 $\gamma_c = 1.50$
 $k_f = 1.10$

Therefore
 $f_{cd} = 14.42 \text{ N/mm}^2$

Design Axial Resistance of 900 mm diameter pile

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

Where:

$d_{nom} = 855 \text{ mm}$
 $A_c = 574146 \text{ mm}^2$
 $f_{cd} = 14.42 \text{ N/mm}^2$
 $A_s = \text{Ignore}$
 $f_{yd} = \text{Ignore}$

Basing Design on Compressive Strength of Concrete Area alone

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

For a 900 mm diameter pile
 $A_c = 574146 \text{ mm}^2$

Therefore

$N_{rd} = 8282 \text{ kN}$

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

Partial Factors on Actions - A1 set of factors

$g_g = 1.35$
 $g_q = 1.50$
 $\psi = 0.50$

Total Action

$G_k = 770 \text{ kN}$ Permanent
 $Q_k = 90 \text{ kN}$ Variable
 $Q_{k,i} = 0 \text{ kN}$ Accompanying Variable (e.g. Wind)

$$F_{cd} = (G_k * g_g) + (Q_k * g_q) + (1.5 * \psi * Q_{k,i})$$

Therefore

$F_{cd} = 1175 \text{ kN}$ Total

$N_{rd} > F_{cd}$ therefore no additional compression steel required

	Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
	Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
	Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
	Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix G: Pile Wall Schedule

2176 - 247 Tottenham Court Road, London
Piled Wall Schedule - Secant & Contiguous
Rev 05

Wall Section	Pile Type	Primary / Secondary	Diameter (mm)	Max. pile spacing (mm)	Approximate Section length (ln.m.)	Approximate no. of piles	Piling Platform Level (mOD)	Max Top of Wall Level (mOD)	Cut-off Level (mOD)	Maximum formation level (mOD)	Approximate Retained Height (m)	Surcharge Type	Assumed Characteristic Pile Actions		Vertical Design Action		Pile Toe Level for Lateral Stability [mOD]	Pile Toe Level for Compression [mOD]	Final Pile Length (m)	Concrete length (m)	Cumulative Pile Concrete Length (m)	Reinforcement length for bending and shear from PPL (m)	Cage OD (mm)	Main reinforcement	Links	Approximate Deflection into the Basement (mm)
													Dead Load [kN/pile]	Live Load [kN/pile]	C1 [kN/pile]	C2 [kN/pile]										
SECANT SW01-A	CFA	Secondary	900	1400	95.0	69	+ 26.375	+ 26.700	+ 25.375	+ 20.930	5.8	A	458	54	699	528	+ 18.375	+ 14.500	11.9	11.9	819.4	8.0	750	12B20	B10 @ 250mm	6
	CFA	Primary	900	1400	95.0	69	+ 26.375	+ 26.700	+ 25.375	+ 20.930	5.8	A	-	-	-	-	+ 18.000	-	8.4	8.4	577.9	-	-	-	-	6
SECANT SW02-A	CFA	Secondary	900	1400	32.2	24	+ 26.375	+ 26.700	+ 25.375	+ 18.680	8.0	A	555	65	846	639	+ 14.375	+ 11.500	14.9	14.9	357.0	12.0	750	12B20	B10 @ 250mm	8
	CFA	Primary	900	1400	32.2	24	+ 26.375	+ 26.700	+ 25.375	+ 18.680	8.0	A	-	-	-	-	+ 18.000	-	8.4	8.4	201.0	-	-	-	-	8
SECANT SW03-A	CFA	Secondary	900	1400	21.0	15	+ 26.375	+ 26.700	+ 25.375	+ 14.830	11.9	A	829	97	1265	955	+ 12.375	+ 8.500	17.9	17.9	268.1	14.0	750	10B25	B10 @ 150mm	11
	CFA	Primary	900	1400	21.0	15	+ 26.375	+ 26.700	+ 25.375	+ 14.830	11.9	A	-	-	-	-	+ 18.000	-	8.4	8.4	125.6	-	-	-	-	11
SECANT SW04-A	CFA	Secondary	900	1400	5.1	4	+ 26.375	+ 26.700	+ 24.375	+ 14.830	11.9	A	829	97	1265	955	+ 12.375	+ 8.500	17.9	17.9	71.5	14.0	750	10B25	B10 @ 150mm	11
	CFA	Primary	900	1400	5.1	4	+ 26.375	+ 26.700	+ 24.375	+ 14.830	11.9	A	-	-	-	-	+ 18.000	-	8.4	8.4	33.5	-	-	-	-	11
SECANT SW01-B	CFA	Secondary	900	1400	5.7	5	+ 26.375	+ 26.700	+ 25.375	+ 20.930	5.8	B	458	54	699	528	+ 15.875	+ 14.500	11.9	11.9	59.4	10.5	750	14B20	B10 @ 250mm	7
	CFA	Primary	900	1400	5.7	5	+ 26.375	+ 26.700	+ 25.375	+ 20.930	5.8	B	-	-	-	-	+ 18.000	-	8.4	8.4	41.9	-	-	-	-	7
SECANT SW03-B	CFA	Secondary	900	1400	14.5	11	+ 26.375	+ 26.700	+ 25.375	+ 15.930	10.8	B	829	97	1265	955	+ 10.375	+ 8.500	17.9	17.9	196.6	16.0	750	14B32	B10 @ 100mm	18
	CFA	Primary	900	1400	14.5	11	+ 26.375	+ 26.700	+ 25.375	+ 15.930	10.8	B	-	-	-	-	+ 18.000	-	8.4	8.4	92.1	-	-	-	-	18
SECANT SW05-B	CFA	Secondary	900	1400	6.3	5	+ 26.375	+ 26.700	+ 24.375	+ 15.930	10.8	B	829	97	1265	955	+ 10.375	+ 8.500	17.9	17.9	89.4	16.0	750	14B32	B10 @ 100mm	18
	CFA	Primary	900	1400	6.3	5	+ 26.375	+ 26.700	+ 24.375	+ 15.930	10.8	B	-	-	-	-	+ 18.000	-	8.4	8.4	41.9	-	-	-	-	18
CONTIGUOUS 1 (B1 - B2) Propped	CFA	Secondary	750	950	46.41	50	+ 26.375	+ 21.980	-	+ 16.4	5.6	20kPa, 0.5m back from wall	-	-	-	-	+ 11.375	-	15.0	15.0	750.0	15.0	600	8B20	B10 @ 250mm	5
CONTIGUOUS 2 (Lift Pit) (B1 - B2) Propped	CFA	Secondary	750	950	10.0	11	+ 26.375	+ 21.980	-	+ 15.1	6.9	20kPa, 2.0m back from wall	-	-	-	-	+ 9.375	-	17.0	17.0	187.0	17.0	600	10B25	B10 @ 250mm	9
CONTIGUOUS 3 (B1 - B2) Propped	CFA	Secondary	750	950	10.0	11	+ 26.375	+ 21.980	-	+ 15.9	6.1	20kPa, 2.0m back from wall	-	-	-	-	+ 11.375	-	15.0	15.0	165.0	15.0	600	8B20	B10 @ 250mm	5

PROJECT NOTES:

- Ground parameters adopted in the design are based on geotechnical interpretation of borehole logs presented in the Ground Investigation Report, J20209A, May 2021, by Geotechnical & Environmental Associates Limited 2021
- Pile platform level of +26.375mOD has been used.
- Interpretation of Axial Loads used in the design are taken from Piling Layout drawing, 4190 AKT ZZ B2 DR S 20950 T6, AKTII. TBC be AKTII.
- Pile lengths provided are compliant to EC7 current standards
- All secant wall sections assumes the installation of basement and ground floor slabs, to support the wall in the long term
- This design has assumed an over-dig of 100mm as per CIRIA C760 (ULS only), therefore a controlled excavation must take place
- Surcharge type A and B used as per drawing 4190 AKT ZZ B2 DR S 20950 T6, AKTII. A surcharge of 20kPa has been assumed behind the contig wall (applied at a distance of 2.0m for contig sections 2 and 3).
- A short term GWL of +21.0mOD has been used in the design, with a long term GWL of 0.5m below the top of wall.
- Concrete C28/35.
- It has been assumed that **NO** imposed shear and moment loads are acting at the pile COL.
- The predicted deflection is based on WALLAP outputs.
- This design has not accounted for any sections of contig wall acting as buttress piles against the main secant. This would require an FE study using 3D modelling software.
- All secant wall sections are designed with a temporary prop at capping beam level, to be installed before the excavation to formation level begins. The "blue" wall sections have been designed with a second level of temporary propping.
- In order to install the contig wall the whole site (box) will need to be dewatered. GWL is at +21.0mOD.
- Secant wall primary piles are to be installed 1.0m below top of London Clay layer (+18.0mOD). This means wall sections SW03-A, SW04-A, SW03-B and SW05-B will effectively be hanging secant.
- The number of piles stated in the schedule is an estimate. This number will need confirming once a revised layout drawing has been produced.



Area of Project	Foundation Design	Prepared by	Jonathan Martin	Date	31.05.2022
Project Number	2176	Checked by	Tony Suckling	Date	31.05.2022
Project Name	The Fitzrovia, 247 Tottenham Court Road, London			Sheet	Appendix
Calculations Title	Pile Wall Design Calculations, Conforming Scheme			Revision	01

Appendix H: References

- Bond A & Harris A (2008) – Decoding Eurocode 7 – Taylor and Francis, London.
- BS EN 1990 (2002) + A1 (2005) – Eurocode: Basis of structural design, BSI, London.
- NA to BS EN 1990 (2002) + A1 (2005) – UK National Annex to Eurocode: Basis of structural design, BSI, London.
- BS EN 1992-1-1 (2004) – Eurocode 2: Design of Concrete Structures – Part 1-1: General rules and rules for Buildings, BSI, London.
- NA to BS EN 1992-1-1 (2004) - UK National Annex to Eurocode 2: Design of Concrete Structures – Part 1-1: General rules and rules for Buildings, BSI, London.
- BS EN 1997-1 (2004) – Eurocode 7: Geotechnical Design – Part 1 General Rules – BSI, London.
- NA to BS EN 1997 -1 (2004) – UK National Annex to Eurocode 7: Geotechnical Design – Part 1 General Rules – BSI, London.
- ICE Specification for Piling and Embedded Retaining Walls – 2nd Edition (2007), Thomas Telford.
- Tomlinson MJ (2001) – Foundation Design and Construction - 7th Edition, Prentice Hall.
- TRL Report 144 (1995): Design of reinforcement in piles.



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