



Programme – Commercial Development

Project – Portobello Road Enabling Works

Document Reference – RPT-EST-M176-5201034

Portobello Road Enabling Works Feasibility Study for M176/EM4

Signature

Date

Prepared by

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I accept this deliverable as the person accountable for its delivery and believe to the best of my knowledge that the above entities have undertaken and fulfilled their legal obligations as required with regard to this product.

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Consulted

Name	Position



Document History

Revision	Date	Summary of Changes
0.1	17/01/2020	First Draft - Issued for information and comment
1.0	05/03/2020	First Issue - Addition of A. Aravinthan, N. Saffari, F. McIlroy comments
2.0	17/03/2020	Second Issue – updated F. McIlroy comments

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1 Introduction

The Transport for London (TfL) Earth Structures & Geotechnical Team (Consultant) has been commissioned by the TfL Commercial Development Team (Client) to carry out a feasibility study.

The objective of the study is to determine the feasibility of cutting into an existing London Underground (LU) embankment in order to provide space for commercial development. This feasibility study will investigate the provision of a suitable retaining structure to support the LU operation and track infrastructure as well as the associated cost of the retaining structure.

The embankment under consideration is asset M176/EM4 and supports the Hammersmith & City Line, between the Ladbroke Grove Station and Westbourne Park Station in West London. It is approximately 215m long, on average 21.4m wide and up to 5.5m in height with embankment slope angles around 18°.

As per the Cost Time Resource proposal (CTR) issued on the 15th October 2018, this study shall address the following two activities:

- An outline design of suitable retaining wall options.
- An estimate of the cost required to implement each of the options to 25% accuracy.

2 Related Documents

The documents used and referred to in the preparation of this study are listed in Table 1 below.

Table 1: Documents used in the preparation of this study.

Reference	Document title	Issue date
May 2015 Principal Inspection Report	Earth Structures Principal Inspection Report (Chainage M176/HWB0475-0693), M176 EM4, M176-EM4-PI-150515-FMC, Rev 01	15 th May 2015
August 2005 Assessment Report includes the January 2005 Ground Investigation	Trans4m, Earth Structures Assessment Report M176 EM4 (Chainage M176/HWB0475-0693), RPT-EST-M176-5030011, Rev 01	25 th August 2005.
May 2003 Principal Inspection Report	Inspection Report M176 EM4 (Chainage M176/HWB 0420-0693)	22 nd May 2003
May 2001 Principal Inspection Report	Inspection Report M176 EM4 (Chainage M176/HWB0420-0693), M176 0000301182	6 th May 2001
December 1998 Principal Inspection Report	Inspection Report M176 EM4 (Chainage M176/HWB0475-0693)	2 nd December 1998

3 Name of Design Organisation

The design organisation is Transport for London – Earth Structures & Geotechnical.

TfL Earth Structures – Profession Head

Contact Name: Nader Saffari

TfL Earth Structures - Senior Geotechnical Engineer

Contact Name: Andrew James

4 Identification of Structure

The design scheme of this report relates to embankment M176/EM4 located on the Hammersmith & City Line, between the Ladbroke Grove Station and Westbourne Park Station in West London.

The local asset reference number and location coding system chainage for the earth structure is as detailed in Table 2 below.

Table 2: Asset code and chainage.

Asset	Chainage
Embankment M176/EM4	M176/HWB0475-0693

5 Title of Scheme

The title of the scheme is: **Portobello Road Enabling Works Feasibility Study for M176/EM4.**

6 Name of Supplier or Outside Party

The sponsor is Transport for London – Commercial Development

TfL Commercial Development – Civil Engineer

Contact Name: Francis McIlroy

TfL Commercial Development – Development Manager

Contact Name: Jess Conway

7 Brief Description of Existing Conditions

7.1 Site Location and Description

The site is located along the Hammersmith & City Line between Ladbroke Grove Station and Westbourne Park Station in West London. Its position can be found between chainages M176/HWB0475-0693 and at Grid Reference 524250E 191250N, see Appendix B.

The site comprises the southern slope of the embankment belonging to asset M176/EM4. It is approximately 215m long, on average 21.4m wide and between 3.6 and 5.5m in height with slope angles around 18°. It is vegetated with a moderate covering of brambles and semi-mature trees. Historically the toe area of part of the embankment adjoining the school was used as an allotment. Currently it is used as a playground and leased by Notting Hill Preparatory School.

The site is bounded to the west and east by Ladbroke Grove Road and Portobello Road respectively as well as the wingwalls (Assets W682 and W678) of the Ladbroke Grove underbridge (Asset HC3) and Portobello Road underbridge (Asset HC2/2A) respectively. The site is bounded to the north by the Hammersmith & City Line and to the south by third party structures such as the Notting Hill Preparatory School, the Isaac Newton Centre and a number of commercial buildings. Lancaster Road runs parallel, around 50m south of the site.

The site is roughly rectangular in shape with its long axis aligned in an approximate west to east direction. The topography rises from west to east. For this study, the site is separated into two embankment areas, referred to as the West and Main embankments:

- The West embankment is a relatively narrow embankment located at the western extent of the site behind the Notting Hill Preparatory School, between chainages M176/HWB0660-0693. The embankment slope is retained along its toe by a 2.2m high concrete retaining wall (asset W683) which cuts perpendicular into the slope at chainage M176/HWB0660. The West embankment is approximately 33m long and 9m wide, with an approximate area of 270m².

Following a site visit on the 28th November 2019 by the Client and Consultant, the West embankment was observed to be partly occupied by a cable run and agreed impractical to develop. Going forward the West embankment shall be excluded from this study.

- The Main embankment is the remaining larger portion of the site, between chainages M176/HWB0475-0660. The Main embankment is approximately 185m long and on average 21.4m wide, with an approximate area of 3,960m².

The general ground level rises from approximately 114mATD at the Ladbroke Grove Road to approximately 116mATD at the Portobello Road. The crest of the embankment/track rises from approximately 119.5mATD at chainage M176/HWB0660 to 121.0mATD at chainage M176/HWB0475.

Note the width of the embankment is an average width. It is measured from 3m from the outer track (nearest running rail) to the nearest LUL boundary fence at the toe of the embankment. The 3m corridor from the outer track is left for operational, maintenance and safety purposes as per The LU Engineering Standard S1054-A5.

As a precaution, the retaining wall along the back of the Notting Hill Preparatory School (Asset W683) was observed to be tilting up to 200mm and anecdotally said to be a recent effect. The weepholes along the base of the wall were observed to be blocked. There are monitoring targets along the wall. It is advised that further inspection is undertaken.

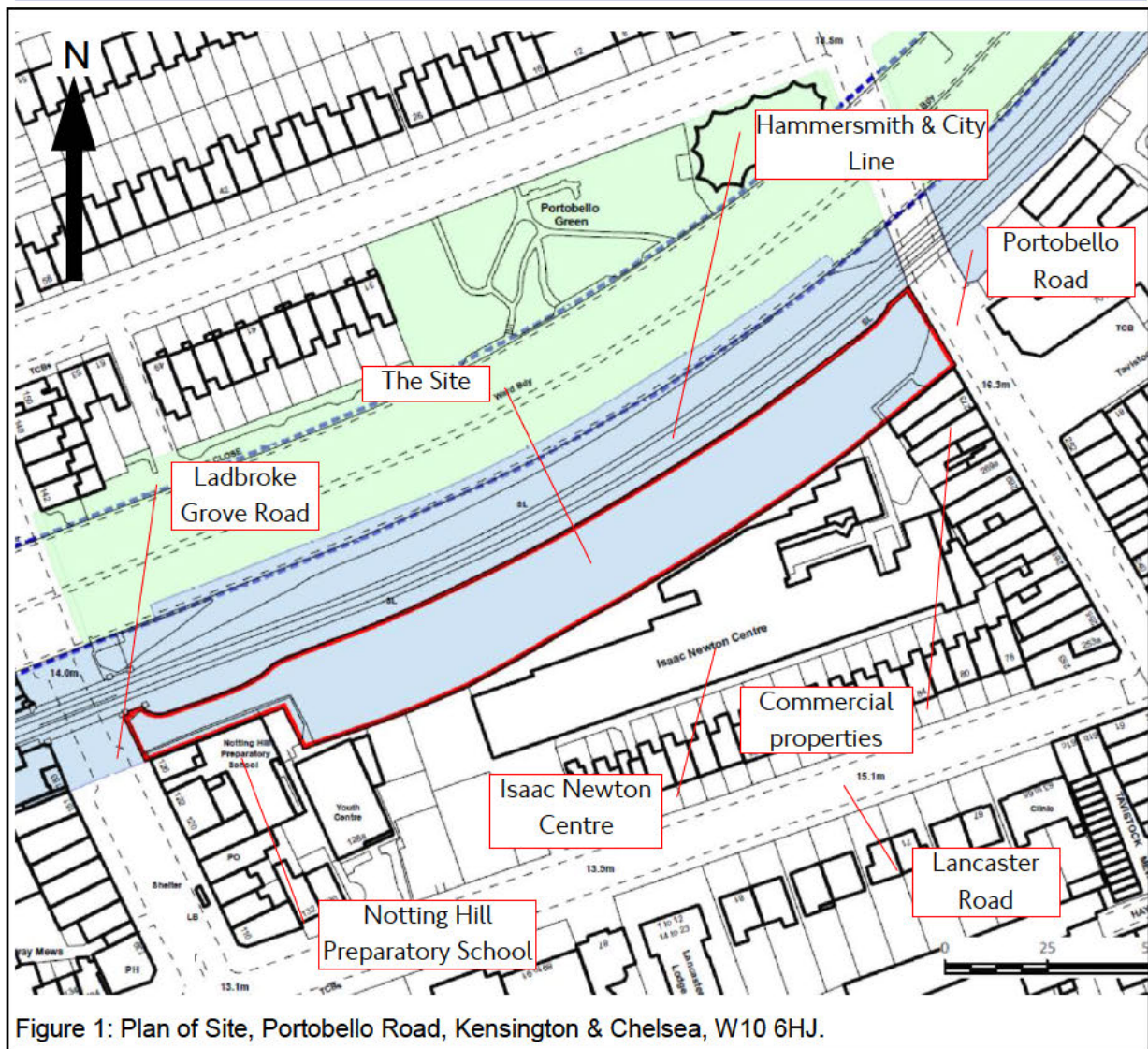


Figure 1: Plan of Site, Portobello Road, Kensington & Chelsea, W10 6HJ.

7.2 Topography

At present a full topographical survey of the site has not been carried out. However, for the purpose of this study the transect survey carried out for the August 2005 Assessment Report has been used for the purpose of analysis and estimate of the development area.

This provides only an approximate estimate for the development area which is considered to be adequate for this stage of study.

Further detailed topographical survey will be required in future stages of the project.

7.3 Existing Structures

A summary of the existing structures on and surrounding the embankment is presented in Appendix B.

7.4 Drainage

The LU GIS shows a number of catch pits and buried drainage pipes running parallel and perpendicular (downslope) to the embankment. It is understood that the drainage was installed circa 2003 as a remedial measure for wet bed problems.

The LU GIS shows drainage catch pits and pipes located in the 6-foot, cess and at the toe of slope. Catch pits along the 6-foot and cess have been confirmed, see Appendix A. However, the catch pits along the toe of the slope have not been confirmed. The outfall or outfalls for the drainage system are unknown.

It is recommended that a connectivity survey of the existing drainage system is undertaken to confirm what drainage exists and where it connects. Additionally, a topographical survey should confirm the location of each catch pit.

7.5 Vegetation and Wildlife

The embankment is moderately vegetated with brambles and semi-mature trees. The vegetation may be acting to improve the stability of the slope through root cohesion and drawdown of the groundwater level.

There appears to be no ecological survey of the site.

It is recommended that an ecological survey of the site is undertaken to confirm if there are any protected species, habitats or dangerous flora.

7.6 Services

Cable Run

Currently, a cable route runs parallel to the track. The cable run is assumed to be offset at 2.44m from the outer track to the face of the cable post.

This cable run has recently been installed, potentially for the 4LM project, and currently carries no cables.

Third Party Services

There appears to be no a recent statutory services search.

It is recommended that a service/utility search is procured to confirm what third party services exist on or near to the site.

7.7 Existing Site Access

The site can only be accessed through pedestrian gates. The two known pedestrian gates are through the Notting Hill Preparatory School and require permission. The August 2005 Assessment Report mentions that the ground investigation accessed the site through a car park between the Notting Hill Preparatory School and Isaac Newton Centre. This access appears to now be occupied by a building.

There is an option to access the site along Portobello Road by removing a brick wall topped with a palisade fence (Asset W678), see Appendix A. Behind this wall appears to be a small area that can be used by a contractor for welfare, laydown and possibly small delivery vehicles. Temporary works may be required to enlarge this area. Deliveries to site may require a designated lane and/or traffic management plan.

This option appears to be the most obvious and most suitable for this site but it may impact traffic on Portobello Road and will likely require a traffic management plan.

7.8 Ground Investigation

One known ground investigation of embankment M176/EM4 was undertaken in January 2005 and is included in the August 2005 Assessment Report. The ground investigation was used to contribute towards the development of the ground model and soil parameter derivation for this study. The ground investigation is summarised in Table 3 below.

Table 3: Summary of historical Ground Investigation of embankment M176 EM4.

Ground investigation	Exploratory holes (Depth)	Installations & Monitoring	Laboratory tests
Richies (January 2005)	13no. Window Samples to between 2.0m and 7.0m depth, 2no. Windowless Samples to 6.95m and 8.5m, 5no. Observation pits to between 1.3m and 2.0m.	11no. piezometers, and 3no. geo-piezometers. Piezometers were read daily during the ground investigation and were planned to be monitored by the ground investigation contractor monthly for the following year.	NMC, Atterberg limits, PSD, consolidated undrained triaxial compression tests

7.9 Ground Model

The ground model was interpreted from the August 2005 Assessment Report which includes the January 2005 Ground Investigation.

In simplicity, the site geology is up to 6.5m of Made Ground overlying between 50.0m and 55.0m of London Clay.

The embankment is generally classified as Made Ground but for this study it has been split into the two dominant factions of Ash (ASH) and Embankment Fill Cohesive (EFC) which vary in proportion along the length of the embankment. The ground investigation occasionally describes Glacial Till and Alluvium deposits, these have been reclassified as EFC. The top 7m of London Clay has been classified as Weathered London Clay (WLC) since the ground investigation did not explore deep enough to confidently delineate the weathered from unweathered London Clay and the nearest historical BGS borehole shows a 7.6m thick layer of WLC. Below the WLC is the London Clay (LC). The existing site geology used to develop the ground model is summarised in Table 4 below.

The typical ground model of the asset for conceptual design is shown in Figure 2 below. The ground model excludes relatively thin layers of soil that are not adverse to the design such as a thin layer of ash, ballast or topsoil. As mentioned in Section 7.2, a supplementary topographical survey will be

carried out which will allow the most onerous ground profile to be adopted during detailed design stage.

Table 4: Description of existing site geology used to develop the ground model.

Stratigraphy	General description	Layer thickness [m]	Comment
ASH	Black, silty sandy gravel Ash to sandy gravelly Ash. Gravel is subangular to sub rounded with slag, brick and occasional flint.	0.0 to 2.5	Overlies EFC and thickest along the western extent of the embankment.
EFC	Soft to very stiff, brown to orange brown and green to greyish greenish, silty CLAY to slightly sandy slightly gravelly CLAY. Gravel ranges from angular to rounded fragments of flint, brick and some chalk.	4.0 to 6.0	Thickest along the eastern extent of the embankment.
WLC	Firm to very stiff, brown to brown grey and mottled greenish grey to orange grey veined, CLAY with pockets of fine sand and rootlets.	~7.6 (from historical BGS borehole)	Top level varies between 113mATD at the western extent to 116mATD at the eastern extent of the embankment.
LC	Generally blue grey slightly silty CLAY	unproven	Top level from base of WLC

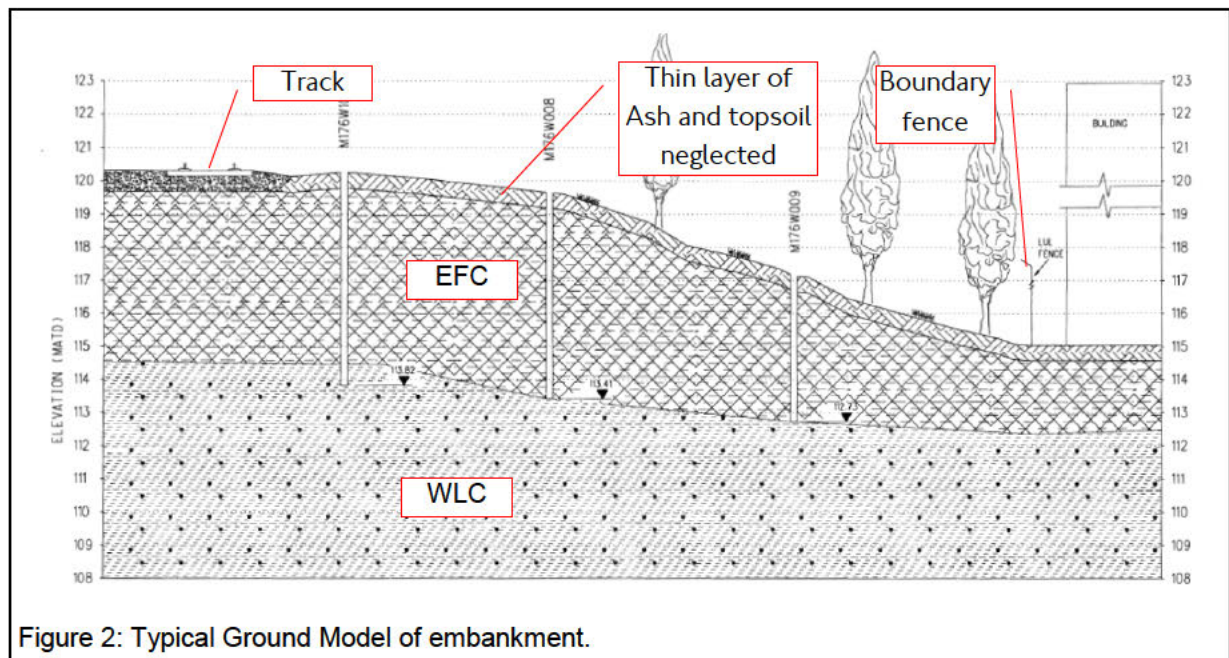


Figure 2: Typical Ground Model of embankment.

7.10 Geotechnical Parameters

Soil parameters have been reviewed based on the various ground investigation findings, in-situ and laboratory test results and LU Engineering Standard S1054-A5 and Guidance Document G0054B-A4. Appendix C shows the in-situ and laboratory test results and the derivation of the soil parameters.

For the EFC, WLC and LC, the soil parameters were derived from site specific data using correlations with Liquid Limit (LL), Clay Fraction (CF), natural moisture content (NMC) and liquidity Index (IL) as outlined in the Guidance Document G0054B-A4.

ASH

Due to insufficient laboratory test data a general approach was adopted for Ash that assumes soil parameters as recommended in the LU Engineering Standard S1054-A5, Table 6 under Section 3.5.4.4.

EFC

The characteristic angle of shearing resistance (ϕ'_k) of the EFC is based on a characteristic LL of 75% and a CF > 45%, resulting in a ϕ'_k of 21°. The peak cohesion (c'_p) is based on a NMC of 33% and LL of 75%, giving a c'_p of 5kN/m². These values are typical cautious peak strengths for EFC sourced from London Clay material.

The characteristic undrained and drained horizontal stiffness (E_{hu} & E_h') is based on a characteristic undrained strength of 30kN/m² and the correlation given in the Mott MacDonald, LUL Research Stage II Assessment of Clay Fill, of $E_{hu} = 400C_u$ and $E_h' = 0.8E_{hu}$, resulting in an $E_{hu} = 12,000$ kN/m² and $E_h' = 9,600$ kN/m².

WLC

The characteristic angle of shearing resistance (ϕ'_k) of the WLC is based on a characteristic LL of 75% and a CF > 45%, resulting in a ϕ'_k of 21°. The peak cohesion (c'_p) is based on a NMC of 33% and LL of 75%, giving a c'_p of 5kN/m².

The characteristic undrained and drained horizontal stiffness (E_{hu} & E_h') is based on a characteristic undrained strength of 80kN/m² and the recommended correlations of $E_{hu} = 400C_u$ and $E_h' = 0.8E_{hu}$, resulting in an $E_{hu} = 32,000$ kN/m² and $E_h' = 25,600$ kN/m².

LC

Due the limited depth of the ground investigation, the characteristic angle of shearing resistance (ϕ'_k) of the LC is based on engineering judgement of a ϕ'_k of 25° and a c'_p of 4kN/m².

The characteristic undrained and drained horizontal stiffness (E_{hu} & E_h') is based on engineering judgement of 8kN/m² for every meter of depth taken from 80kN/m² and the correlation given in CIRIA C760 of $E_{hu} = 1000C_u$ and $E_h' = 0.8E_{hu}$, resulting in a $E_{hu} = 80000 + 8000z$ kN/m² and $E_h' = 64000 + 6400z$ kN/m².

These parameters will be revised once further investigation is undertaken.

Table 5: Characteristic parameters used in the ground model.

Stratigraphy	γ_{bulk} [kN/m ³]	Drained strength [deg; kN/m ²]		Undrained strength [kN/m ²]	Youngs Modulus [kN/m ²]		Poissons ratio ν	Wall friction a/c or δ/ϕ	At-rest earth pressure k_0	Earth pressure			
		ϕ'	c'		E_{uh}	E_h'				K_a	K_{ac}	K_p	K_{pc}
ASH	11	35	0			5000	0.3	0.67	0.43	0.229	0.00	6.52	0.00
EFC (Drained)	19	21	5			9600	0.2	0.67	0.58	0.42	1.52	2.73	4.50
EFC (Undrained)	19			30	12000		0.5	0.5	1.00	1.00	2.39	1.00	2.39
WLC (Drained)	19	21	5			25600	0.2	0.67	1.00	0.42	1.52	2.73	4.50
WLC (Undrained)	19			80	32000		0.5	0.5	1.00	1.00	2.39	1.00	2.39
LC (Drained)	19	25	4			64000+6 400z	0.2	0.67	1.00	0.35	1.39	3.42	5.20
LC (Undrained)	19			80+8z	80000+8 000z		0.5	0.5	1.00	1.00	2.39	1.00	2.39
Reinforced Concrete	24	500			30GPa (Short-term) 15GPa (Long-term)								
Sheetpile (G355)		355 (Yield strength)			200GPa								

7.11 Groundwater

The groundwater level was interpreted from the August 2005 Assessment Report.

During the January 2005 Ground Investigation fourteen piezometers were installed along the M176/EM4 embankment. Out of the twelve planned monthly ground water readings, two readings were taken prior to the issue of the August 2005 Assessment Report, in May and June 2005. These two readings are unlikely to reveal the variance in groundwater level. Therefore, the worst credible water level of 117.5mATD has been assumed as the design level for this study.

It is recommended that a ground investigation is undertaken and that piezometers are installed within the embankment and monitored for at least 6 months. However, the August 2005 Assessment Report mentions that twelve post GI readings were planned which means there are ten outstanding groundwater measurement that may exist with the GI contractor. Additionally, although not guaranteed, it is may be possible to locate and measuring the existing piezometers.

7.12 Soil Chemistry

In accordance with the BRE Special Digest 1 (SD1:2005), results for soil chemistry testing undertaken on six samples from M176/M4 indicate that:

- pH values range from 7.5 to 8.0 with a characteristic pH of 7.6
- Water-soluble sulphate as SO₄ analysed from 2:1 soil:water extract ranges from 0.04 to 2.10 g/l with a characteristic value of 2.1 g/l
- Magnesium content was not carried out as the SO₄ in the water/soil extracts was less than 3.7g/l

Based on the above test results, the aggressive chemical environment for concrete (ACEC) classification for this site is AC-3 with a design sulphate class of DS-3. For classification purposes the site has been treated as brownfield due to its use in a railway environment. It has been assumed that groundwater at the site is likely to be mobile.

7.13 Principal Inspections

The latest Principal Inspection of embankment M176/EM4 was undertaken in May 2015 by the LU Earth Structures Inspection Team. It scored the embankment an Asset Condition Rating (ACR) of 100%A and in serviceable condition with no major concerns. The current recommended inspection cycle is every 10 years.

Previous Principal Inspections undertaken in December 1998, May 2001 and May 2003 observed slip scars and tension cracks along a moderate extent of the embankment and typically offset between 6m and 17m from the slope shoulder. The severity was noted as minor (non-urgent) between chainages M176/HWB0475-0600 and heavy (unacceptable) between chainages M176/HWB0600-0693. Recommendations for monitoring, speed restrictions and topographic survey were given as a medium priority. It is unknown if the recommendations were carried out.

The reviewed condition ratings from the May 2015 Principal Inspection, for the relevant chainages along M176/EM4 are presented in Table 6 below.

Table 6: Principal Inspection Condition Ratings from May 2015 Principal Inspection.

Chainage	Reviewed condition rating
M176/HWB0480	90
M176/HWB0580	90
M176/HWB0675	90

7.14 Existing Slope Stability Analysis

The stability of the existing slope was modelled using Slope/W which is a limit equilibrium software that predicts the likelihood of failure. The stability of the existing slope is useful information to a contractor planning to modify or surcharge the slope.

Three sections were analysed. The analysed factor of safety (FoS) is shown and compared with the previous FoS in Table 7 below. The Slope/W output is shown in Appendix F. The previous stability analysis was taken from the August 2005 Assessment Report.

The comparison shows all factors of safety are sufficiently above 1.25 as per the minimum requirement of the LU Engineering Standard S1054-A5 and BS EN1997-1. All failure surfaces are deep seated and daylight in the cess.

It is noted that previous Principal Inspections mention tension cracks and slip scars between 6 and 17m from the slope shoulder. These fall inside the development area and will likely be removed during excavation.

Based on this information the existing slope, in its current condition, is stable. However, if there is a change from the current condition i.e. cutting, filling, surcharging, the stability should be reassessed.

Table 7: Comparison of the existing and August 2005 Assessment Report stability analyses

Section	Chainage	August 2005 Assessment Report	January 2020 Feasibility Study
		FoS	FoS
Section A*	M176/MWB0650	2.15 (Section 2*)	>1.7
Section B*	M176/MWB0550	2.04 (Section 3*)	>2.0
Section C*	M176/MWB0480	1.99 (Section 4*)	>2.1

* For location of sections refer to Figure 3 below.

8 Proposed Design

The objective of this study is to design a suitable retaining structure that supports the embankment to provide space for commercial development. This section presents the analysis undertaken to address the following two activities:

- Design options for suitable retaining structures that meet the study objective, and
- Estimate the cost required to implement each of the options (to 25% accuracy).

8.1 Design Criteria

The design options should aim to achieve the following criteria:

- Minimise impact to nearby TfL assets and neighbours,
- Maximise development space,
- Minimise construction costs and
- Minimise maintenance cost and the need for future access for maintenance.

The retaining wall shall act as an independent structure. Neither the retaining wall nor the future development shall rely upon the other for support.

A 3m exclusion zone should be provided from the outer track (nearest running rail), in accordance with the requirements of LU Engineering Standard S1054-A5.

Where possible, deformations shall be kept to within reasonable limits such that the relevant track maintenance targets (Level 1) as defined in LU Engineering Standard S1159 are not exceeded. This requires that the differential settlement of the outer rail be limited to 1:500 along any 10m length of track with a limit of 1:300 across the rails. It should be noted that track deformation may be completely unrelated to the earth structure and related to other factors such as the condition of ballast, trackbed formation and track drainage.

The proposed retaining wall shall be designed to ensure that it has adequate stability against failure, excessive deformation of the ground and structure in accordance with BS EN1997-1, the NA to BS EN1997-1 and the LU Guidance Document G0054B-A4.

The Construction Design Management (CDM) 2015 regulations state that designers must eliminate foreseeable health and safety risks to anyone affected by the project and take steps to reduce or control any risks that cannot be eliminated. During this feasibility stage the above CDM requirements are implicit within the design. A designer's risk assessment will form part of the subsequent design stages.

8.2 Exclusion Zone (Design Clearances)

The LU Engineering Standard S1054-A5, Clause 3.2.15 and 3.2.16 requests that an exclusion zone measured from the outer track is left for operational, maintenance and safety purposes.

Currently, a cable route runs parallel to the track. The cable run is assumed to be offset at 2.44m from the outer track to the face of the cable post.

Additional to this, the LU Engineering Standard S1800-A3, Clause 3.1.4 suggest that a clear gangway of between 0.6 and 1.5m is left from the cable run to the fence for theft protection and maintenance purposes. For this study the Client has requested that the minimum clear gangway of 0.6m is used.

Therefore for this study a minimum exclusion zone of 3m (approximately 2.4m cable run offset + 0.6m clear gangway) shall be left between outer track and fence or back of the retaining wall.

8.3 Retaining Structure Design

The proposed retaining structure has been classified as Geotechnical Category 3. This is due to it supporting the Hammersmith & City Line which is considered critical infrastructure.

The most suitable retaining structure was judged to be an embedded cantilever retaining wall. Other retaining structures considered were a kingpost retaining wall, a gravity retaining wall and steepening the embankment slope. These were judged less effective at achieving the design criteria and discounted. The benefit of an embedded cantilever retaining wall is its relatively compact geometry that maximises the development area. More importantly, it is installed prior to excavation which helps minimise ground movements and improves the speed of construction.

The advantage of a cantilever retaining wall reduces the need for support from anchors, props or berms. The advantages are its reduced construction and maintenance costs. The disadvantages are its limited retaining height and a deeper embedment length. However, for this site the maximum retained height is 5.5m which according to CIRIA C760 is just within the capability of many types of cantilever embedded retaining walls.

The design formation level was advised by the Client to be the general local ground level. This is approximately 114mATD at the Ladbroke Grove Road rising to 116mATD at the Portobello Road. Figure shows the assumed formation levels and top of embankment levels.

The retaining wall is anticipated to support approximately 195m of embankment. This includes 185m length of embankment and a 10m length of re-entrant wall towards the western end of the site.

8.4 Design Loads

The design considers the ultimate and serviceability limit states of the structure and adjacent structures under long-term equilibrium conditions. The design of the retaining wall takes into account all permanent and loads (actions) as outlined in Table 8 below.

Table 8: Design actions.

Type	Action
Variable Unfavourable	The track surcharge according to LU Engineering Standard S1054-A5 is 30kN/m ² and has been applied as a uniform vertical live load across the length of the sleepers.
Variable Unfavourable	A 5kN/m ² surcharge will be applied outside of the 3m exclusion zone for potential future surcharging through maintenance and other railway upgrade activities.
Variable Unfavourable	Horizontal handrail loading according to the National Annex to BS EN 1991-1-1:2002 Table NA8 is 0.36 kN/m applied at 1.1m above the walkway level.

8.5 Design Soil Parameters and Groundwater Condition

The soil parameters adopted for this study are presented in Table 5 above. They have been based on LU Engineering Standard S1054-A5, the Guidance Document G0054B-A4 and the results of a ground investigation and laboratory tests. Design groundwater conditions are described in Section 7.11.

8.6 Design Life

The proposed retaining wall shall be designed to achieve a design life of 120 years. Long term conditions have been considered in the design in order to take into account the most onerous requirements over the service life of the structure.

8.7 Design Constraints

There are a number of design constraints at this urban site, particularly relating to the Hammersmith & City Line which is considered critical infrastructure. Appendix B lists the existing assets, the third party structures and the expected design constraints. The text highlighted in orange represent the design

constraints that may be impacted by construction. Most of the presented information is available on the LU GIS system.

With respect to the design and construction constraints near third party structures, the Party wall Act 1996 may apply if:

- The proposed retaining wall or excavation occurs within the notifiable zone of the any third party structures and
- The future development or basement occurs within the notifiable zone of the proposed retaining wall or other TfL assets.

8.8 Retaining Structure Analysis

The retaining structure was analysed using WALLAP, an embedded retaining wall programme in accordance with BS EN1997. This analysis provides the shear force, bending moment and deformation of the retaining system. The minimum length of the piles was determined using limit equilibrium principles of balancing the passive pressure with the active pressure.

Two wall sections were modelled, namely Section A at chainage M176/HWB0652 and Section B at chainage M176/HWB0561. Section A is typical of the conditions along the western extent of the Main embankment, approximately between chainages M176/HWB0600-0660 where a deep layer of ASH overlies EFC. Section B is typical of the conditions along the majority of the Main embankment, approximately between chainages M176/HWB0475-0600 where the entire retained height is assumed to be of EFC.

At each design section the retaining wall was analysed at three offsets, namely 3.0m, 4.5m and 6.0m. The wall offset is measured from the outer track to the back of the retaining wall. A plan of the embankment, the approximate pile line and design sections are shown on Figure 3 below

The analysis modelled the relationship between the wall stiffness (IE) and wall deflection for the two sections at each of the three wall offsets. The IE is the Second Moment of Area (I) multiplied by the Young's Modulus (E). The I dependent on the cross sectional area of the wall and E is dependent on what material the wall is constructed from. The IE was varied between 60,000 and 3,000,000kNm² per meter, to model a range of flexible (i.e. sheetpile walls) to stiff retaining (i.e. pile walls) structures.

For the purpose of this study only the drained (Long-term) condition was assessed as this will result in the largest deflections, structural forces and impact on the track. As per BS EN1997-1, the Serviceability Limit State (SLS) and Design Approach 1 Combination 2 (DA1C2 or ULS2) were analysed and were judged to have sufficient variance to bound the design. Along with the prescribed partial factors, both SLS and DA1C2 modelled worst credible groundwater conditions and DA1C2 included 0.5m of unplanned excavation (over-dig) as recommended by CIRIA C760.

A general design section is shown on Figure 4 below and the results of the retaining wall analysis are given in Table 9 below followed by a summary of the findings.

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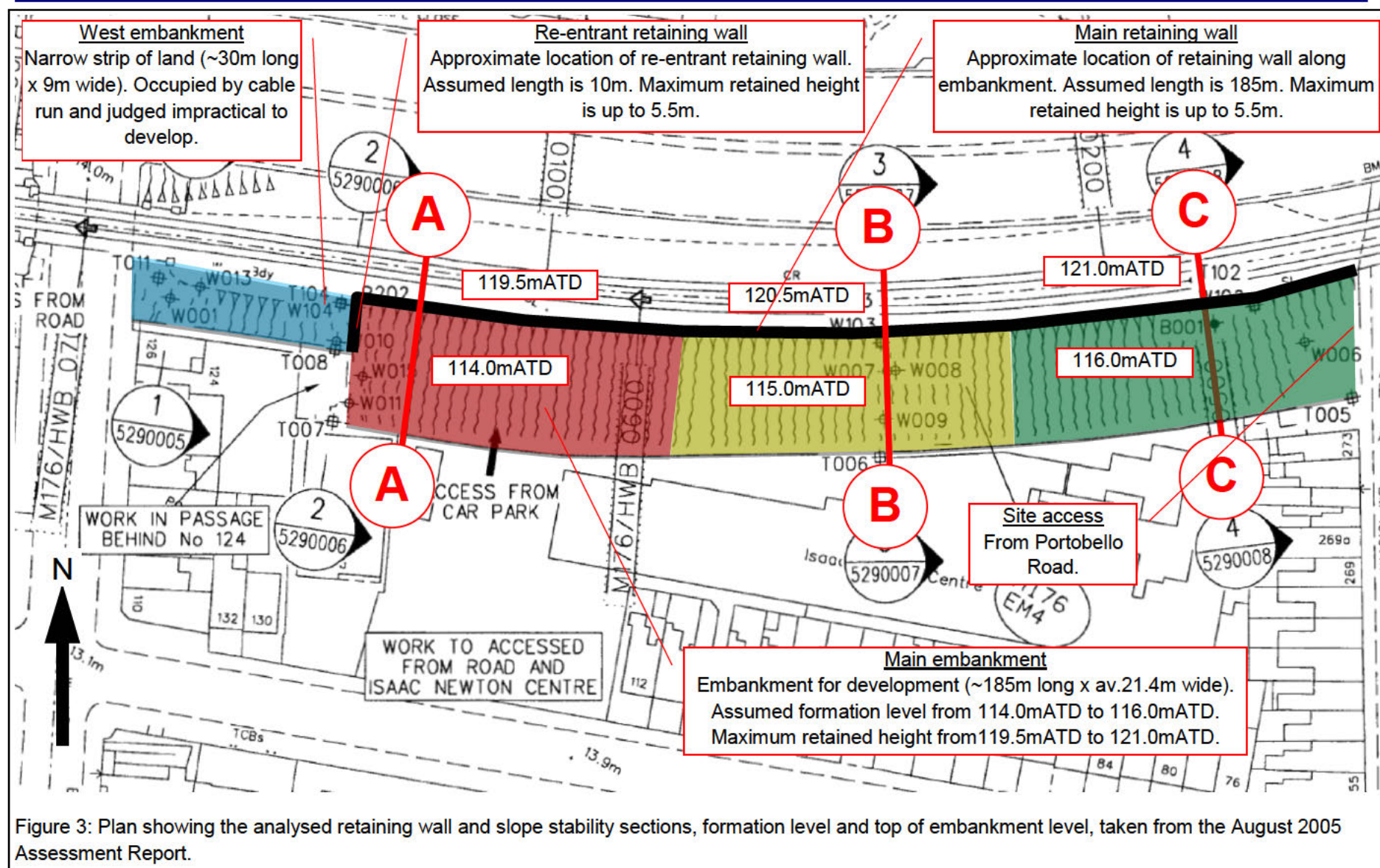


Figure 3: Plan showing the analysed retaining wall and slope stability sections, formation level and top of embankment level, taken from the August 2005 Assessment Report.

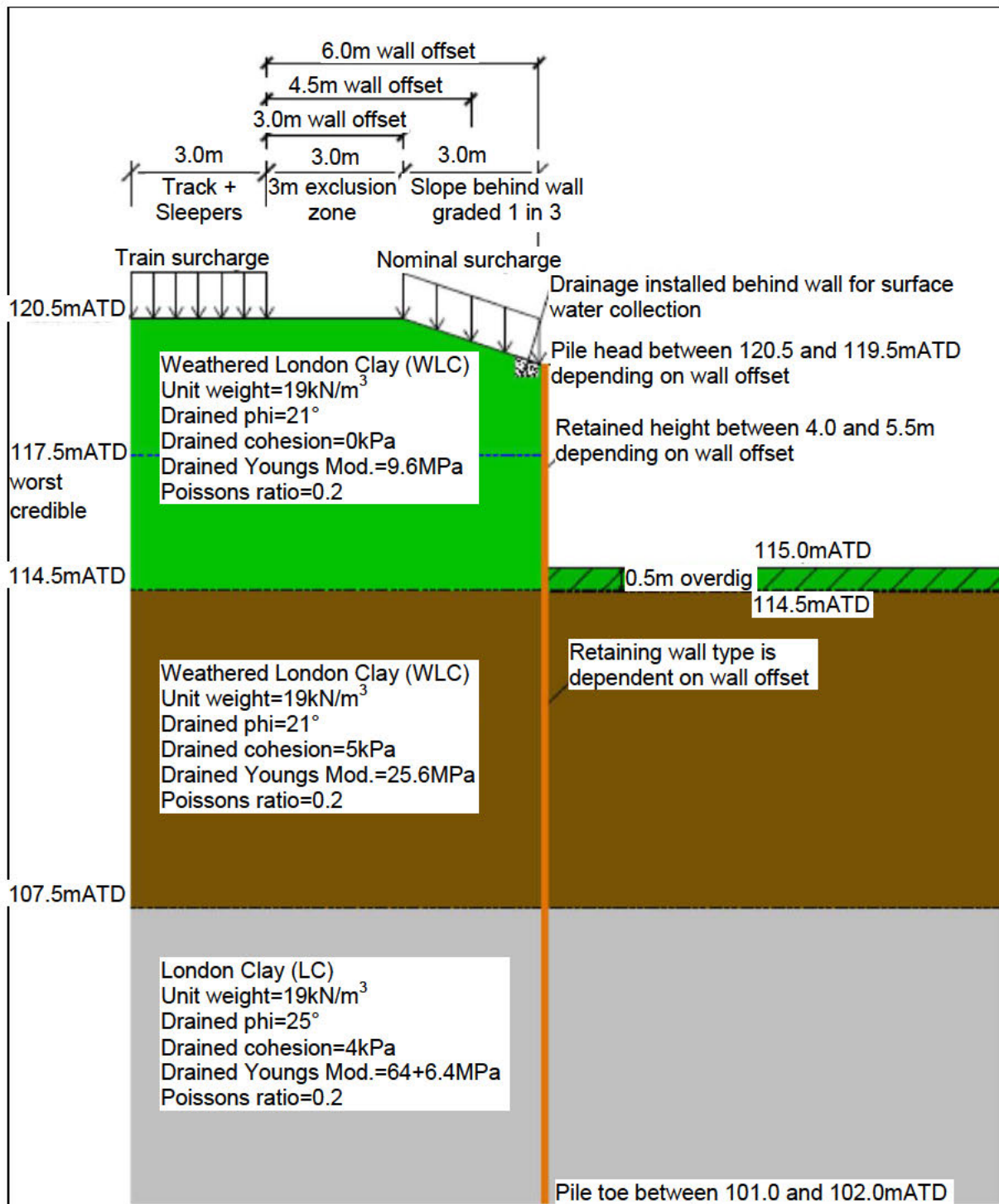


Figure 4: Sketch of general wall section, equivalent to Section B at a 6.0m wall offset.

Table 9: Results of retaining wall analysis.

Wall offset* [m]	Section**	Design Retained height [m]	Embedded length [m]	Total length [m]	Retained height: Embedment length ratio
3.0	A	5.5	13.0	18.5	2.4
	B		15.0	20.5	2.7
4.5	A	5.0	12.5	17.5	2.5
	B		14.0	19.0	2.8
6.0	A	4.5	12.0	16.5	2.7
	B		13.0	17.5	2.9

* Wall offset is measured from the outer track to the back of the proposed retaining wall.

** Refer to Figure 3 above

Findings

- As the wall stiffness increases the wall deflection decreases but with diminishing returns. Generally, wall stiffness greater than $1,500,000\text{kNm}^2$ per meter becomes less effective. For comparison, a long-term wall stiffness of $1,500,000\text{kNm}^2$ per meter is equivalent to a 1350mm diameter concrete pile wall. The limit of a sheetpile wall is around $180,000\text{kNm}^2$ per meter.
- As the wall offset increases the wall deflection decreases. This is because the wall moves further down the embankment slope which reduces its retained height and increases its distance from the 30kPa train surcharge. The increased offset acts to reduce the active pressure behind the wall. Up to a 6.0m wall offset, Section B will experience larger wall deflections than Section A. Beyond a 6.0m wall offset Section A and Section B have approximately the same wall deflections.
- As the wall offset increases the impact on the track decreases. This is because the ground settlement profile becomes less severe further away from the wall.
- There is always a deflection at the head of the cantilever pile, irrelevant of wall stiffness or wall offset. The findings show for a 3m wall offset with the maximum IE of $3,000,000\text{kNm}^2$ per meter the head of the pile deflects between 50mm and 60mm. This goes to show that a very stiff cantilever wall, offset very close to the track will have a sizeable wall deflection. These deflections could be reduced at the expense of applying additional support to the wall such as props or anchors.

8.9 Ground Settlements

Appendix D shows the graphic results of the ground settlement analysis. Each settlement profile represents a different IE and wall offset.

The ground settlement, behind the wall, was predicted using the semi-empirical relationship given in CIRIA C760. This is done by rotating the WALLAP wall deflection profile horizontally and then halving its deflections. Since the wall is cantilevering the maximum ground settlement is likely to occur directly behind the wall and reduce to zero at a distance away from the wall approximately 1.5 times the total length of the wall, refer to CIRIA C760. There are a number of limitations to this method but for this study it is judged adequate to give an understanding of the potential ground movements.

It should be noted that additional ground movement may occur during pile installation and excavation. However, for the purpose of this study these additional movements are assumed to roughly cancel out

one another. Nevertheless, these movements should be included in the design as part of the ground movement assessment to understand the impact to nearby TfL assets and neighbouring structures.

The predicted ground settlements are long-term settlements and likely to be upperbound predictions due to the cautious estimates taken on strength. The time taken for primary consolidation maybe relatively short due to the slight amount of silt, sand and gravel within the retained fill that will allow porewater pressure to equalize fairly quickly. As a rough estimate, based on the rate of one dimensional consolidation calculation, assuming a Coefficient of consolidation of $10^{-3} \text{ cm}^2/\text{s}$ (normally consolidated clay), then it is likely that the majority of settlement will occur within 5 years.

8.10 Suitable Retaining Wall Options

For each wall offset a suitable retaining wall was determined from the graphs shown in Appendix D. A suitable retaining wall is considered as one that best achieves the design criteria, given in Section 8.1. Options of suitable types of embedded retaining walls and installation methods are given in Table 10 below.

Table 10: Suitable types of embedded retaining walls and installation methods

Wall offset* [m]	Selected long-term wall stiffness [kNm ² per meter]	Type of embedded pile wall	Wall description	Installation method
3.0	1,200,000	Contiguous bored pile wall	Diameter:1200mm Spacing c/c:1400mm Retained: 5.5m Length:20.5m	Full height rotary bore piling (TPA** required for drilling rig)
4.5	500,000	Contiguous bored pile wall	Diameter:900mm Spacing c/c:1000mm Retained: 5.0m Length:19.0m	Low headroom rotary bore piling (Restricted access piling 3.5m height, reinforcement cages <3.5m long)
6.0	125,000	Sheetpile wall	Section: AZ36-700N Width: 700mm Depth: 500mm Thick: 15mm Mass: 118.6kg/m Retained: 4.5m Length:17.5m	GIKEN silent piler (TPA** required for sheetpiles >3.5m long) MOVAX (TPA** required for sheetpiles >3.5m long)

* Wall offset is measured from the outer track to the back of the proposed retaining wall.

** TPA = LU Tall Plant Approval for working near track, see Section 10 below.

8.11 Contiguous Bored Pile Wall

The gaps exposed between the contiguous piles will expose soil. For this site it is assumed the retained soil will temporarily stay intact but this will be confirmed by a ground investigation. It is envisaged that following excavation, a concrete facing wall will be required to cover the gap and provide a smooth surface. The benefit of this is that it reduces cost and programme. This is opposed to a secant pile wall that uses a pile to infill the gaps.

A capping beam is required for a cantilever contiguous pile wall to connect the piles together and help distribute load laterally. This is a sizeable cost in proportion to the cost of the piles.

An advantage of a contiguous pile wall is it that they can be installed in hard ground and through minor obstructions. A disadvantage is that they require fresh concrete and bulky reinforcement cages that will require constant deliveries which may be a hindrance on this small site in an urban area.

The envisaged method of installation is rotary bore piling. This method is not particularly well suited due to the difficult access up the embankment slope to reach the pile line. In order to improve the suitability of this method a low headroom (restricted access) rotary bore rig is recommended but this comes at a higher cost and from a specialist piling contractor.

For contiguous piles less than 1050mm diameter a low headroom rotary bore rig is recommended which can have a mast height of 3.5m and can bore up to 40m depth (MP4001 Martello restricted access rig). Using a low headroom rig may overcome the constraints of working near an operating track. For pile diameters greater than 1050mm a full height rotary bore rig may be the only option which will require a TPA.

Both methods will require access to reach the pile line from a ramp and must operate from a sturdy and wide engineered piling platform. The temporary works for this method will play a significant part and may even be prohibitive to this site. It is recommended that a specialist temporary works designer is consulted on this matter.

Other installation methods are Continuous Flight Auger (CFA) and Segmental Flight Auger (SFA). Depending on the wall offset, these methods are unlikely to achieve the required pile diameters or are less suitable than the envisaged rotary bore methods.

8.12 Sheet Pile Wall

Sheetpiles are generally limited to a stiffness (IE) up to around $180,000\text{kNm}^2$ per meter (assumed section modulus of 4950cm^3 including reduction for corrosion) which is significantly less than what a contiguous pile wall can achieve. They are susceptible to corrosion and a loss of stiffness and strength over time. The ArcelorMittal Steel Foundation Solution Catalogue suggests a corrosion rate of 0.05mm per year is recommended (6mm over the 120 year design life).

Their lengths are usually limited by their installation weight or the length of the delivery vehicle. At this site sheetpiles may need to be welded together to reach the required design embedment.

A capping beam may not be required due to the interlock connection between the sheetpiles however it is recommended for a cantilever wall of this height. This is a sizeable cost in proportion to the cost of the piles.

Depending on ground conditions they can be installed quicker than contiguous piles. In ground with SPT's greater than 20 or with minor obstructions an impact hammer or pre-augering may be required, which will incur additional cost. At this site it is likely that below the weathered London Clay the ground will have an SPT greater than 20 which is likely to make installing sheetpiles slow and difficult. This can be confirmed by a ground investigation.

There are a number of methods to install sheetpiles; two have been envisaged for this site, namely the GIKEN silent piler and the MOVAX methods.

The GIKEN method is a self-contained piling system. It is mounted on the pile wall from which it reacts against to press in the piles. This method is suited to this site due to the long length of the retaining wall and the difficult access to the pile line. The GIKEN's strength is its silence and ability to operate from the wall which eliminates the need for a piling platform which would potentially have a significant impact on cost, programme and the local environment.

The MOVAX method is an excavator mounted piling system that is commonly used in the UK. This method is suited to this site due to its ability to access the pile line without a significant amount of temporary works. The strength of this method is that a sheetpile can be installed from a distance and from below the level of the head of the pile.

8.13 Construction Sequence

The following construction sequence is envisaged for the proposed design options:

1. Implement traffic management system,
2. Mobilise to site,
3. Divert all services, protect track assets and third party structures (if necessary) and carry out Tall Plant Approvals (if necessary),
4. Install monitoring instrumentation and undertake baseline readings,
5. Prepare site for construction and undertake temporary works to gain access to pile line,
6. Construct guidewall,
7. Construct proposed retaining wall and install monitoring instrumentation,
8. Construct capping beam,
9. Excavate to formation and monitor,
10. Construct facing (if necessary) and prepare site for handover and
11. Demobilise but continue to monitor.

8.14 Excavation Volumes

The volumes were calculated using three embankment profiles from the August 2005 Assessment Report. The assumed length of the main embankment is 185m. The expected volume of material to be excavated for each wall offset is summarised in Table 11 below.

Note that where removal of soil from site is required, the chemical properties of the soil will need to be determined by lab testing, so that it can be classified in accordance with the Waste Acceptance Criteria procedure. This feasibility study assumes that the excavated material is not contaminated.

Table 11: Excavation volumes for each wall offset, accurate to +/-25%.

Wall offset [m]	Excavation volume (+/-25%) [m ³]
3.0	10,900
4.5	9,450
6.0	8,050

** Wall offset is measured from the outer track to the back of the retaining wall.*

8.15 Development Space

For the purpose of this study the Transect survey carried out for the August 2005 Assessment Report has been used to calculate the development area. This provides only an approximate estimate for the development area which is considered to be adequate for this stage of study. The calculation of development space includes the depth of the proposed retaining wall. It does not include an LU inspection and maintenance corridor in front of the retaining wall. The expected development space for each wall offset is given in Table 12 below.

Table 12: Approximate development space for each wall offset and retaining wall.

Wall offset * [m]	Type of embedded pile wall	LU Inspection and maintenance corridor [m]	Wall diameter/ depth [m]	Average site width [m]	Length of cut slope [m]	Approximate development space** [m ²]	Reduction in space from max. area
3.0	Contiguous bored pile wall	1.0	1.2	21.4	185	3,737 (max. area)	0%
4.5	Contiguous bored pile wall	1.0	0.9	19.9	185	3,515	5.9%
6.0	Sheetpile wall	1.0	0.5	18.4	185	3,312	11.4%

* Wall offset is measured from the outer track to the back of the proposed retaining wall.

** The development space is approximate, refer to Section 7.2.

8.16 Cost

The expected cost required to implement each option is given in Table 13 below. The cost has been split into the following three items:

- **Temporary works costs:** includes vegetation clearance, protection of cable run, diversion of drainage system, earthworks for haul road and piling platform and removal or temporary works.
- **Construction costs:** includes site preliminaries, mobilisation and demobilisation, provision of materials and Installation of wall and capping beam.
- **Excavation costs:** includes excavation and disposal of earth (assuming excavation is not contaminated)

Additional costs separate from the implementation costs are given in Table 14 below. These should be added to the total cost.

Table 13: Summary of cost, time and development space, accurate to +/-25%.

Wall offset* [m]	Type of embedded pile wall	Wall description	Selected long-term wall stiffness [kNm ² per meter]	Installation method	Cost of temporary works [£]	Cost for construction [£]	Cost for excavation [£]	Total implementation cost (+25%) [£]	Approximate development space** [m ²]
3.0	Contiguous bored pile wall	Diameter:1200mm Spacing c/c:1400mm Retained height: 5.5m Length:20.5m	1,200,000	Full height rotary bore piling (TPA** required for drilling rig)	762,000	3,015,000	573,000	4,350,000	3,737
4.5	Contiguous bored pile wall	Diameter:900mm Spacing c/c:1000mm Retained height: 5.0m Length:19.0m	500,000	Low headroom rotary bore piling (Restricted access piling 3.5m height, reinforcement cages <3.5m long)	686,000	3,060,000	497,000	4,243,000	3,515
6.0	Sheetpile wall	Section :AZ36-700N Width: 700mm Depth: 500mm Thick: 15mm Mass: 118.6kg/m Retained height: 4.5m Length:17.5m	125,000	GIKEN silent piler (TPA** required for sheetpiles >3.5m long)	295,000	1,948,000	423,000	2,666,000	3,312
				MOVAX (TPA** required for sheetpiles >3.5m long)	401,000	2,197,000	423,000	3,021,000	3,312

* Wall offset is measured from the outer track to the back of the proposed retaining wall.

** The development space is approximate, refer to Section 7.2.

Table 14: Additional costs.

Additional costs	Assumptions	Cost
Further investigation	May include utility search, Topographical survey, Connectivity survey, Condition surveys, ground investigation	See Section 9
Design costs (including post construction reports and handovers)	From Conceptual to Detailed design undertaken by the TfL Earth Structures team.	5 to 10% of the total cost
Site supervision	Attendance by competent geotechnical engineer from the TfL Earth Structures team during the construction phase.	£500 per day
Instrumentation and Monitoring	Instrumentation may include inclinometers in piles wall or targets on sheetpiles, targets along the capping beam, targets on surrounding structures, levelling studs on surrounding pavements. Monitoring may be undertaken prior (baseline), during and after construction.	£150,000

8.17 Retaining Wall Slope Stability

The stability of the retained embankment slope was modelled using Slope/W. The analyses considered the following:

- Shallow slope failures above the wall and
- Global stability.

Understanding the slope stability above the wall is important to prevent material failing into the development below as well as make sure the track will not be affected by slope instability. Understanding the global stability is an equilibrium requirement of Eurocode 7.

Three sections were analysed. The analysed factors of safety (FoS) are shown in Table 15 below and the Slope/W output is shown in Appendix F. It shows all factors of safety are sufficiently above 1.25 as per the minimum requirement of the LU Engineering Standard S1054-A5 and BS EN1997-1.

It should be noted that for this analysis the global stability was reasoned using inspection. This is because the failure surface corresponding to the minimum FoS is above 1.25 is at a shallower depth than that of a global failure surface.

Based on this information the retained slope is likely to be stable.

Table 15: Summary of slope stability factors of safety for the retained embankment slope.

Section*	Chainage	January 2020 Feasibility Study
		FoS
Section A	M176/MWB0650	>1.8
Section B	M176/MWB0550	>2.0
Section C	M176/MWB0480	>1.9

* Refer to Figure 3 above

9 Additional Investigations and Surveys

It is advised that the following additional investigations and surveys undertaken:

- Ground Investigation
- Ecological survey
- UXO survey
- Utility search (i.e. <https://www.groundwise.com/>)
- Topographical survey of the full embankment and immediate surrounding area,
- Connectivity survey of the existing drainage system
- Asbestos survey
- Condition survey of TfL assets and third party structures
- Inspection of the retaining wall along the back of the Notting Hill Preparatory School (Asset W683)

10 Working Near a Track

A major constraint at this site is working near an operational track. The rule is plant or materials (i.e. sheetpiles, reinforcement cages) taller than 3.5m are classed as "tall plant" and will need to operate at least 1.15x its height away from the critical boundary. For this site the critical boundary is assumed to

be the cable run at around 2.44m from the outer track. For example, a 5m high piling rig or excavator should operate 5.75m away from the critical boundary or 8.2m away from the outer track. If this rule cannot be achieved then Tall Plant Approval (TPA) will be required. A TPA may include:

- Installing a barrier between the plant and the track,
- A risk based approach that may involve vetting of the contractor, onerous method statements, fulltime site supervision etc.,
- Operating during engineering hours,
- Gaining possession of the track, etc.

11 Drainage & Groundwater

The installation of the retaining wall and excavation will result in the loss of part of the existing drainage system. Prior to installing the proposed retaining wall the existing drainage system will need to be decommissioned and some drainage pipes diverted and, depending on their current condition and capacity, may require strengthening. A drainage review and design will be required as per LU Engineering Standard S1052.

In order to maintain the stability and performance of the proposed retaining wall, groundwater should not be allowed to build up behind the wall above the assumed design groundwater level. To relieve water pressure behind the wall weepholes will be installed through the retaining wall. Additionally, the wall shall be designed to have negligible impact on the local groundwater flow. To achieve this, sheetpiles can occasionally be reduced in embedment to allow groundwater to flow beneath. In the case of contiguous piles, the pile spacing is sufficient to allow groundwater to flow.

12 Maintenance Requirements

The proposed cantilever retaining wall has been designed for minimal maintenance. Inspection periods should be as per the LU Engineering Standard S1042. The wall will perform better under regular maintenance such as maintaining the:

- water pressure behind the wall to a minimum by keeping the surface drains and weepholes free of debris,
- exposed areas of the retaining wall protected to slow down corrosion,
- area immediately behind the wall to apply minimum surcharge on the wall and
- ground in front of the wall at its intended level and strength.

It is likely that the track will experience vertical and horizontal movement and may require minor realignment. As a rough estimate, a portion of the ground movement may occur at the time of installing the wall but the majority is likely to occur potentially within 5 years, once the wall and soil have relaxed and crept and the pore water pressures have largely stabilised.

The Portobello Road Bridge, abutment and retaining wall may experience some movement. In the extreme case they may experience cracking but more likely the interface between the bridge and the track may need some realignment.

The surrounding third party assets may experience some movement. It is advised that a condition survey of these structures is taken prior to construction and monitored during construction and that necessary Party Wall agreements are undertaken in accordance with the Material and Workmanship Specification T0007.

13 Conclusion

The study area excludes a narrow length of embankment behind the Notting Hill Preparatory school since a cable run occupies part of this embankment. It was agreed with the Client that this embankment is impractical to develop.

There are a number of design constraints at this site. The most critical being the Hammersmith & City Line which is susceptible to ground movement. Additionally, the Portobello Road Bridge, abutment and embankment retaining wall may conflict with the retaining wall alignment and are also susceptible to ground movement. The drainage system on the embankment slope will be demolished during excavation and will need to be diverted. The surrounding structures, including the Notting Hill Primary School and the Isaac Newton Centre may have shallow foundations that may restrict the final excavation level and may require noise and vibration restrictions.

The LU Engineering Standard S1054-A5 specifies an exclusion zone between the outer track and the back of the retaining wall for operational, maintenance and safety purposes. For this site, due to the presence of a cable run this exclusion zone is taken as 3.0m, hence the minimum wall offset is 3.0m.

In order to enable this site for development the table below summarises three outline designs for suitable retaining walls with estimates of total construction cost and approximate development space.

Table 16: Summary of suitable retaining wall options, cost estimate and approximate development space.

Wall offset* [m]	Type of embedded pile wall	Wall description	Installation method	Total implementation cost (+/-25%) [£]	Approximate development space [m ²]
3.0	Contiguous bored pile wall	Diameter:1200mm Spacing c/c:1400mm Retained height: 5.5m	Full height rotary bore piling (TPA** required for drilling rig)	4,350,000	3,737
4.5	Contiguous bored pile wall	Diameter:900mm Spacing c/c:1000mm Retained height: 5.0m	Low headroom rotary bore piling (Restricted access piling 3.5m height, reinforcement cages <3.5m long)	4,243,000	3,515
6.0	Sheetpile wall	Section: AZ36-700N Depth: 500mm Retained height: 4.5m	GIKEN silent piler (TPA** required for sheetpiles >3.5m long)	2,666,000	3,312
			MOVAX (TPA** required for sheetpiles >3.5m long)	3,021,000	3,312

* Wall offset is measured from the outer track to the back of the proposed retaining wall.

** TPA = LU Tall Plant Approval for working near track, see Section 10 above.

Note the proposed development space does not include space for a corridor in front of the retaining wall which is required by LU for inspection and maintenance.

Note the given total cost is for implementation only and excludes the costs for further investigations and surveys, design and site supervision, instrumentation and monitoring etc.

It is advised that the following further investigations and surveys undertaken:

-
- Ground Investigation
 - Ecological survey
 - UXO survey
 - Utility search (i.e. <https://www.groundwise.com/>)
 - Topographical survey of the full embankment and immediate surrounding area,
 - Connectivity survey of the existing drainage system
 - Asbestos survey
 - Condition survey of TfL assets and third party structures
 - Inspection of the retaining wall along the back of the Notting Hill Preparatory School (Asset W683)

14 Recommendation

The 6.0m wall offset option presents a low risk to the track operation, performance and maintenance. It is also likely to be the most simple in terms of design and construction and the most economical. Hence, based on the above this may be considered as the most feasible option.

Depending on the buildability and access constraints a sheetpile wall or a contiguous bored pile wall can be considered at this offset. At present the option of a sheetpile wall has been shown in Table 16. Based on the ease of installation the sheet piling option may present the most feasible option. This option would potentially require minimal temporary works to construct a piling platform which would have an impact on cost and programme of the project.

15 References

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2. Transport for London, Guidance Document, G0054B-A4 Earth Structures – Guidance for Slope Stability Analysis, A1, December 2014.
3. BS EN 1997-1:2004, BS EN1997-1: Geotechnical Design - Part 1 General rules.
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11. Transport for London, Infrastructure Systems Earth Structures Inspection Report for M176/EM4 (Chainage HWB0420-0693), 2 December 1998.
12. CIRIA C760, Guidance on Embedded Retaining Wall Design, London, 2017
13. Steel Foundation Solutions, ArcelorMittal, General Catalogue 2019

Appendix A – Site Photo

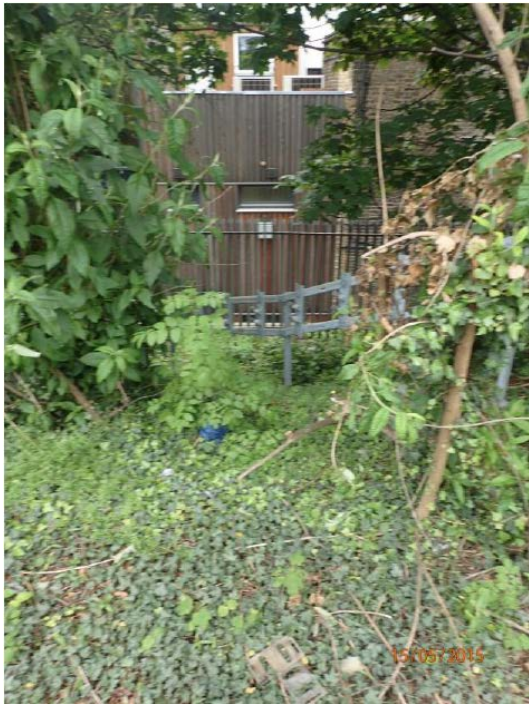


Photo 1: Chainage 675m looking south. Showing cable run aligned downslope of the West Embankment. Taken from Principal Inspection Report of EM4, 15 May 2015.



Photo 2: Chainage 580m, looking south. Showing catch pit (M176/CTP2011) located on the shoulder of the East Embankment. This catch pit may require diversion. Taken from Principal Inspection Report of EM4, 15 May 2015.



Photo 3: Chainage 480m looking east. Showing bridge (M176/HC2A) over Portobello Road, Signal Post (M176/SSP/A120A) and cable run located at the eastern extent of the East Embankment.

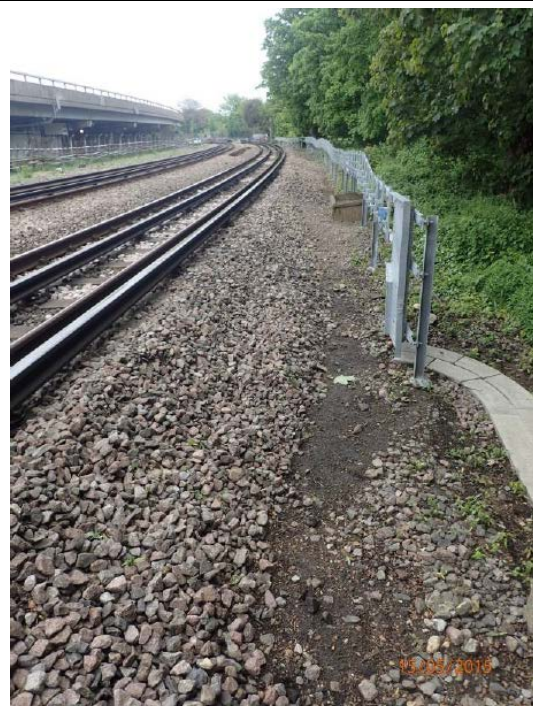


Photo 4: Chainage 580m looking east. Showing cable run offset approximately 2m from the track (not shown on LU GIS) and catch pit (M176/CTP2011). Taken from Principal Inspection Report of EM4, 15 May 2015.

Taken from Principal Inspection Report of EM4, 15 May 2015.	Report of EM4, 15 May 2015.
 <p>Photo 5: Chainage 600m looking west. Showing the width of the embankment shoulder (EM4), the westbound and eastbound Hammersmith & City Line tracks (M176/MWBLO) and signal post (M176/SGP/A120B). Taken from Earth Structures Inspection Report of EM4, 6 May 2001.</p>	 <p>Photo 6: Looking west. Showing the brick wall topped with a balustrade fence that could be potentially removed to create site access from Portobello Road. Taken during site visit on 28 November 2019.</p>

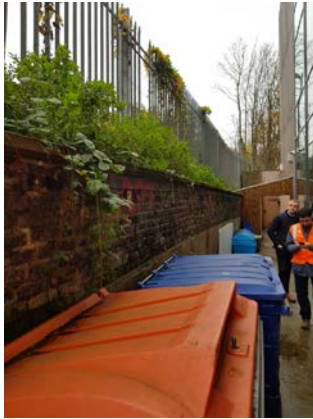


Photo 7: Chainage 690m looking east from behind Notting Hill Preparatory School. Showing the brick retaining wall with a balustrade fence that could be potentially removed to create site access from Portobello Road. Taken during site visit on 28 November 2019.



Photo 8: Chainage 640m looking north. Showing the brick retaining wall bordering Notting Hill Preparatory School. Likely to be partially demolished to create development space and to form a connection with the re-entrant length of the proposed retaining wall. Taken during site visit on 28 November 2019.



Photo 9: Looking west from Portobello Road. Showing Portobello Road bridge and embankment retaining wall. The embankment retaining wall may be partially demolished once the proposed retaining wall has been installed. The extent of demolition of this wall will depend on the line of the proposed retaining wall taken to avoid conflicting with the Portobello Road Bridge abutment foundations. Taken during site visit on 28 November 2019.



Photo 10: Looking east from Ladbroke Grove Station. Showing Ladbroke Grove bridge and embankment retaining wall. These are unlikely to be impacted by the enabling works. Taken during site visit on 28 November 2019.



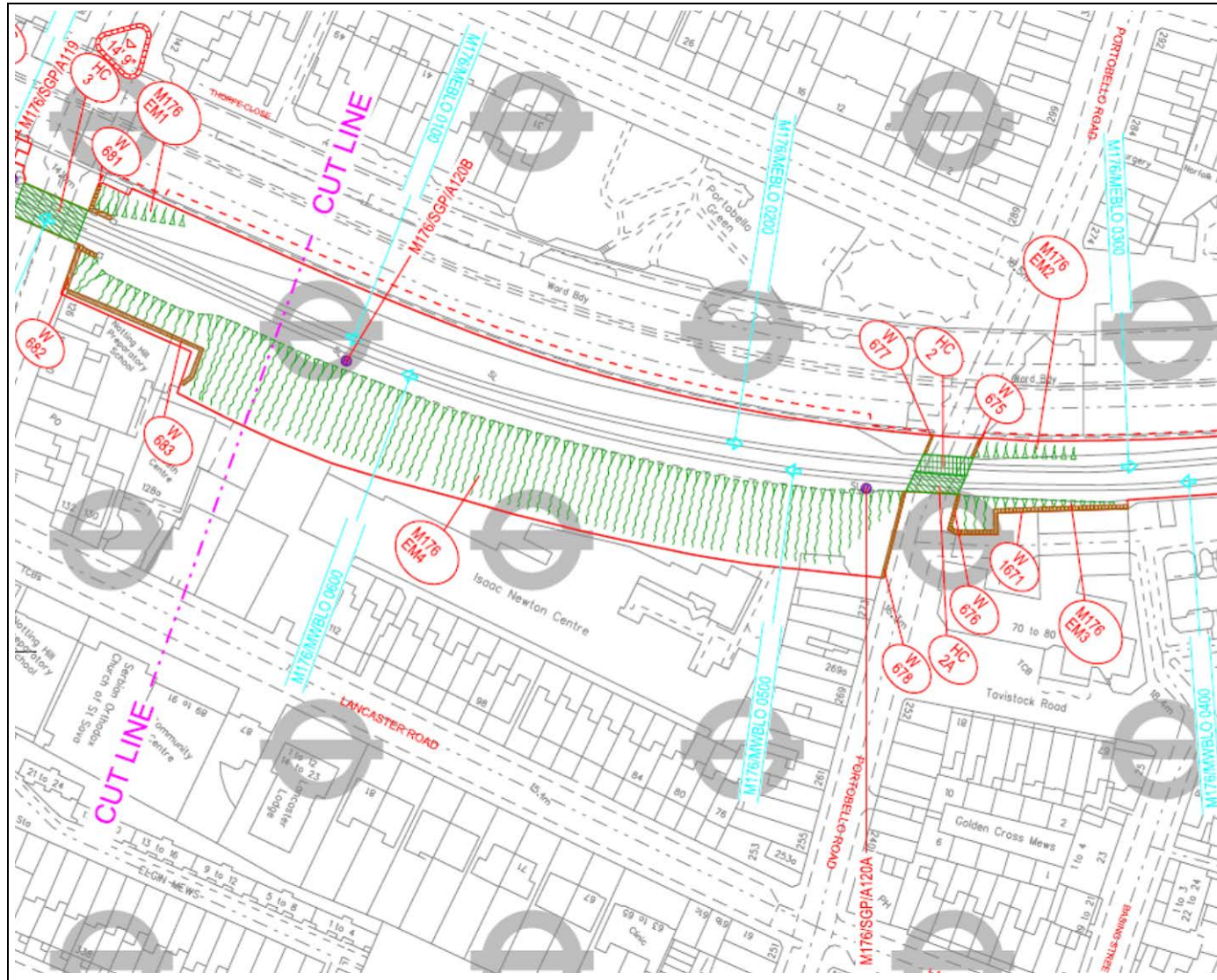
Photo 11: Chainage 600m looking east along Main embankment, Showing boundary fence on the left and toe of slope of the right with a moderate covering of vegetation. Taken during site visit on 28 November 2019.



Photo 12: Chainage 640m looking east along Main embankment. Showing boundary fence on the left and toe of slope on the right and a moderate covering of vegetation. Taken during site visit on 28 November 2019.

Appendix B – Asset Location Plan

Plan showing LU assets and surround buildings



Asset No.	Asset description	Asset Condition	Design Constraint
M176/MWBLO M176/MEBLO (see Appendix A)	<u>Hammersmith & City Line</u> Eastbound & Westbound track.		Working near an operating track. May require specialist equipment or a concession, see Section Error! Reference source not found. . Impact on the track is likely to occur from ground movement related to installation and deflection of the retaining wall and excavation, see Section 10.
M176/HC2 M176/HC2A (see Appendix A)	<u>Portobello Road Bridge</u> The bridges HC2 and HC2A comprise of: the adjacent brick abutments, the metal girder underbridge with a concrete floor carrying the east and west bound of track over Portobello Road. The bridge was originally constructed in 1864 but later re-constructed in 1950's	.Bus strikes causing minor damage at HC2 and seepage on abutment at HC2A have been recorded. Since 1950, the condition ratings have been recorded as 'good' or 'serviceable'. Principal report from 01/12/17 gave an overall score of 95.83%.	Potential conflict between the line of retaining wall and the bridge abutments and their foundations. Advised to be explored further through ground investigation, desk study and topographical survey. Impact on the bridge abutments and foundations may occur from ground movement related to installation and deflection of the retaining wall and excavation.
M176/HC3 (see Appendix A)	<u>Ladbroke Grove Bridge</u> The bridge comprises of: the brick abutment, the metal girder underbridge with a concrete floor carrying the Hammersmith and City Line over Ladbroke station. The bridge was probably constructed in 1864 and reconstructed in 1938 with general renovation work carried out on the abutments.	Inspections since 1940 have highlighted the development of fractures in the parapets and the east abutment being out of plumb. There have been several vehicle strikes in the 1960's but since 1952 the condition ratings have been recorded as 'good' to 'serviceable'. The overall score in the latest principal report from 28/11/17 was 96.25%.	Unlikely constraint due to its distance from the Main embankment.

Asset No.	Asset description	Asset Condition	Design Constraint
M176/W678 (see Appendix A)	<u>Portobello Road Bridge embankment retaining wall</u> 12.3m long stock brick wingwall to the bridge HC2A between 2.1m and 3.8m high.	Inspections records indicate some minor spalling and fractures and with a 25mm roadside lean recorded in 1993. The condition rating since 1950 have been recorded as 'serviceable', however, principal inspection from 08/12/17 revealed the overall score of the wall to be 93.75%.	Likely to be partially demolished once the proposed retaining wall has been installed. The extent of demolition of this wall will depend on the line of the proposed retaining wall taken to avoid conflicting with the Portobello Road Bridge abutment foundations. Advised to be explored further through ground investigation, desk study and topographical survey.
M176/W682 (see Appendix A)	<u>Ladbroke Grove Bridge embankment retaining wall</u> 11.4m long stock brick wingwall to the bridge HC3 between 2.0m and 4.4m high. The wall retains the southern end of embankment M176/EM4.	Principal Inspection records indicate that in 14/04/12, the overall score of the wall was 95%.	Unlikely constraint due to its distance from the Main embankment.
M176/W683 (see Appendix A)	<u>Retaining wall behind the Notting Hill Preparatory School</u> 44m long brick and concrete boundary wall between 2.4m and 3.0m high. The wall retains the southern boundary of embankment M176/EM4 from chainage HWB 0648 to 0693.	Remedial works were undertaken in 2001 with new concrete flashing but locally the wall is recorded to be out of plumb by 70mm. The condition ratings since 1945 have been recorded as 'serviceable' and the latest principal inspection from 09/12/17 scored the wall with 83.33%.	Likely to be partially demolished to create development space and to form a connection with the re-entrant length of the proposed retaining wall. Advised to be explored further through ground investigation, desk study and topographical survey. Observations and records show that this wall has already experienced movement and therefore may require additional support measures if a portion is removed.
M176/SSP/A120A M176/SGP/A120B (see Appendix A)	<u>Signal Post & Signs FE</u>		Minor impact on the signal posts is likely to occur from ground movement related to installation and deflection of the retaining wall and excavation.

Asset No.	Asset description	Asset Condition	Design Constraint
M176/SSP/V1 M176/SSP/V2 M176/SSP/V3 M176/SSP/V4	<u>Signal Post & Signs FE</u>	Disused	Disused
Cable run (Not shown on GIS) (see Appendix A)	<u>Cable run</u> Located between chainages 470m to 552m. Evident along cess during site visit and shown in the May 2015 principal inspection report. Potentially related to the LM4 project.		Minor impact on the cable run is likely to occur from ground movement related to installation and deflection of the retaining wall and excavation.
M176/CTP2006 M176/CTP2013 M176/CTP2014 M176/CTP2005 M176/CTP2011 M176/CTP2012 M176/CTP2004 M176/CTP2009 M176/CTP2010 (see Appendix A)	<u>Drainage pipes and catch pits</u> Located at chainage 555m. Aligned perpendicular to westbound track with collection at base of slope. Located at chainage 580m. Aligned perpendicular to westbound track with collection at base of slope. Located at chainage 610m. Aligned perpendicular to westbound track with collection at base of slope. A site walkover on 10th May 2005 confirmed several catch pits were located on the six foot at chainages 475m, 490m, 515m, 540m, 575m, 610m, 640m and 680m.		Damaged by the installation of the retaining wall and embankment excavation, see Sections 7.4 & 11

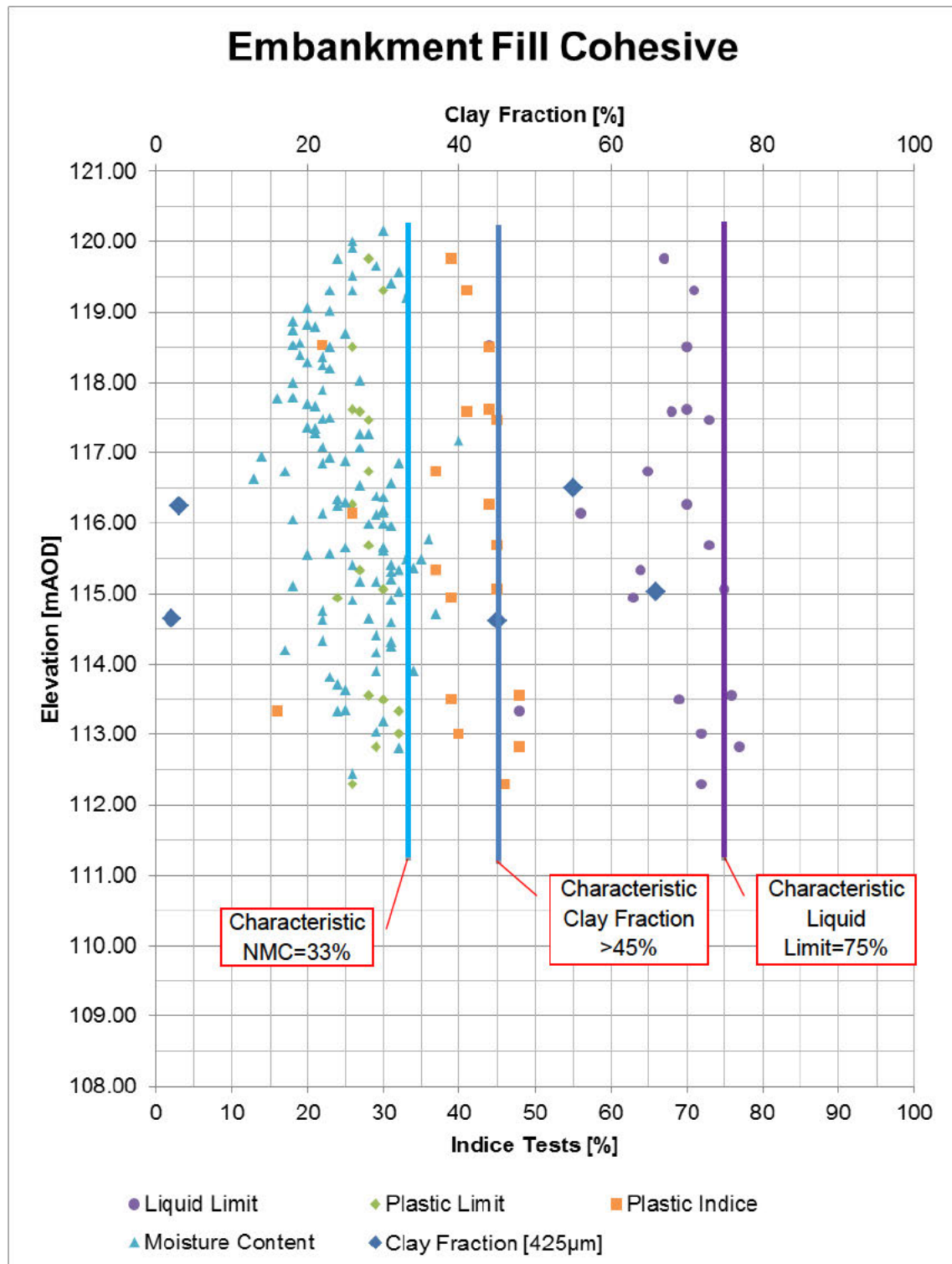
Asset No.	Asset description	Asset Condition	Design Constraint
M176/CTP0079A M176/CTP2003	Drainage pipes and catch pits Located between chainages 519m to 548m. Aligned parallel to westbound track.		Minor impact on the drainage pipes and catch pits behind the retaining wall likely to occur from ground movement related to installation and deflection of the retaining wall and excavation, see Sections 7.4 & 11.
M176/CTP0079 M176/CTP0078 M176/CTP0077	Located between chainages 470m to 552m. Aligned parallel to westbound track.		
M176/CTP0080 M176/CTP0079	Located between chainages 470m to 552m. Aligned parallel to westbound track. The May 2005 Principal Inspection on confirmed several catch pits were located on the six foot at chainages 475m, 490m, 515m, 540m, 575m, 610m, 640m and 680m.		
Third party structures	Notting Hill Preparatory School, Isaac Newton Centre and other adjacent buildings		Formation level of excavation constrained to the level and lateral extent of the foundations of the surrounding structures.. Advised to be explored further through ground investigation and topographical survey. Impact on the adjacent structures may occur from ground movement related to excavation. Working near a school, science center and residential area. May have restrictions on noise, vibration constraints and potentially working hours.

Appendix C – Derivation of Soil Parameters

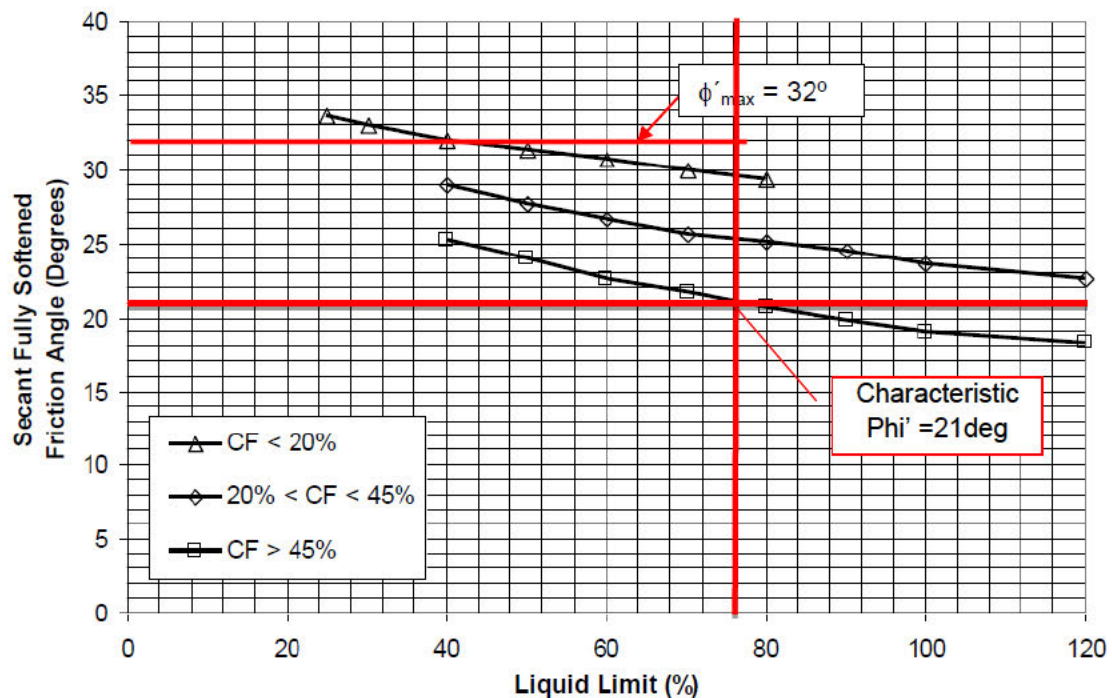
Minimum characteristic value of soil parameters for earth structures, taken from L U
Engineering S standard S 1054-A5.

Material	γ (kN/m ³)	c' (kN/m ²)	ϕ'
Alluvium	19	1	25
Ash	11	0	35
Ballast	18	0	40
Embankment fill: cohesive (see notes below)	19	1	21
Embankment fill: granular	18	0	35
London Clay (see notes below)	19	2	21
Reworked London Clay (see notes below)	19	2	18
Terrace gravels	19	0	35
Weathered London Clay (see notes below)	19	2	21

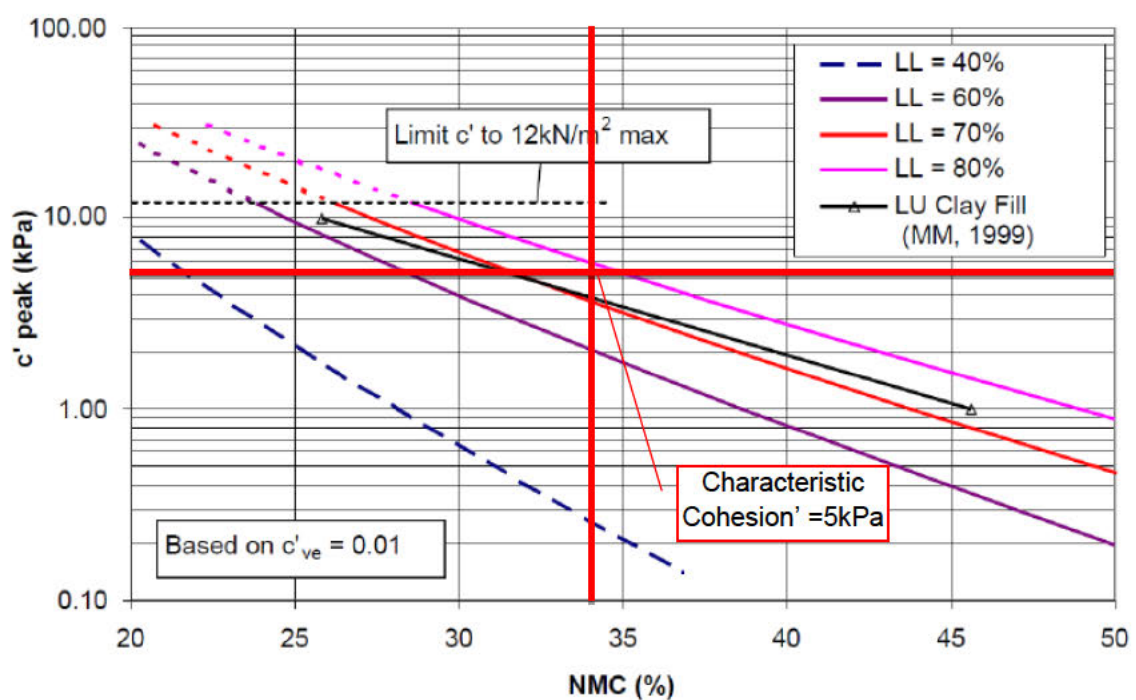
Factual data used determine the characteristic drained parameters for the embankment fill cohesive material, taken from the August 2005 Assessment Report



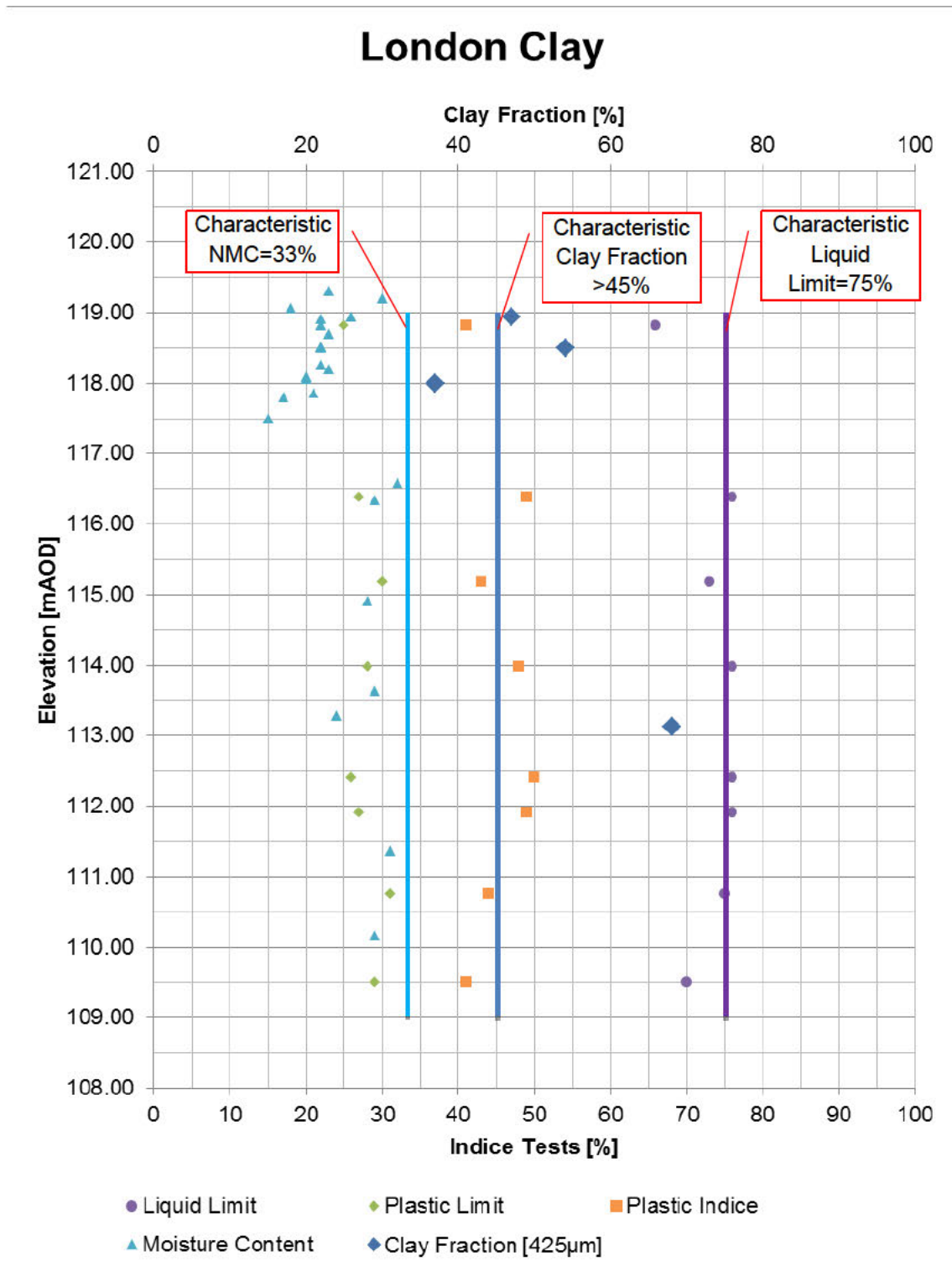
Variation of fully softened friction angle of internal resistance with liquid limit (Stark and Eid). Used in conjunction with the site factual data to determine the angle of internal resistance for the Embankment Fill Cohesive material, taken from LU Engineering Standard S 1054-A5



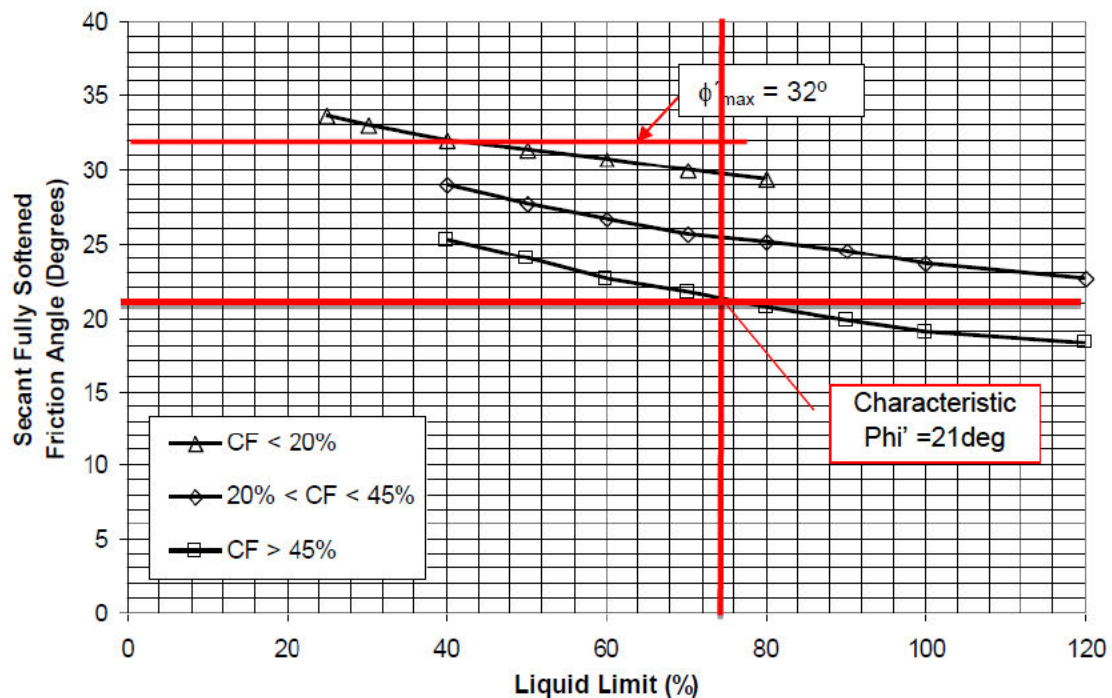
Variation of peak effective cohesion with moisture content. Used in conjunction with the site factual data to used determine the cohesion (C') for the Embankment Fill Cohesive material, taken from LU Engineering Standard S 1054-A5



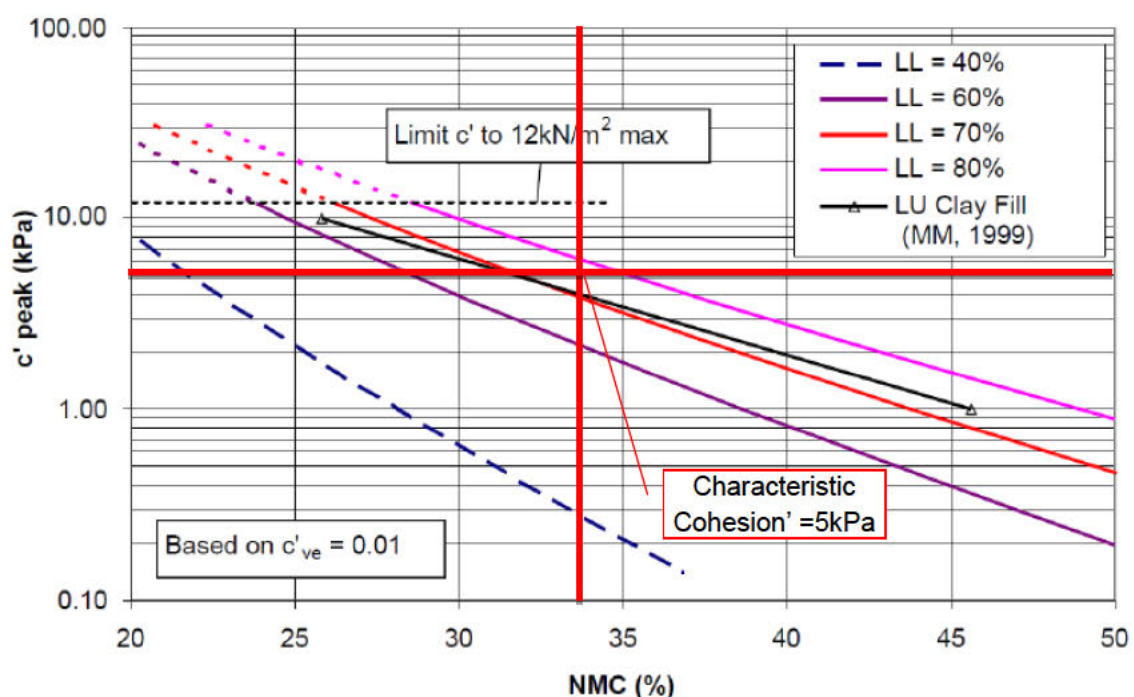
Factual data used determine the characteristic drained parameters for the weathered London Clay, taken from the August 2005 Assessment Report



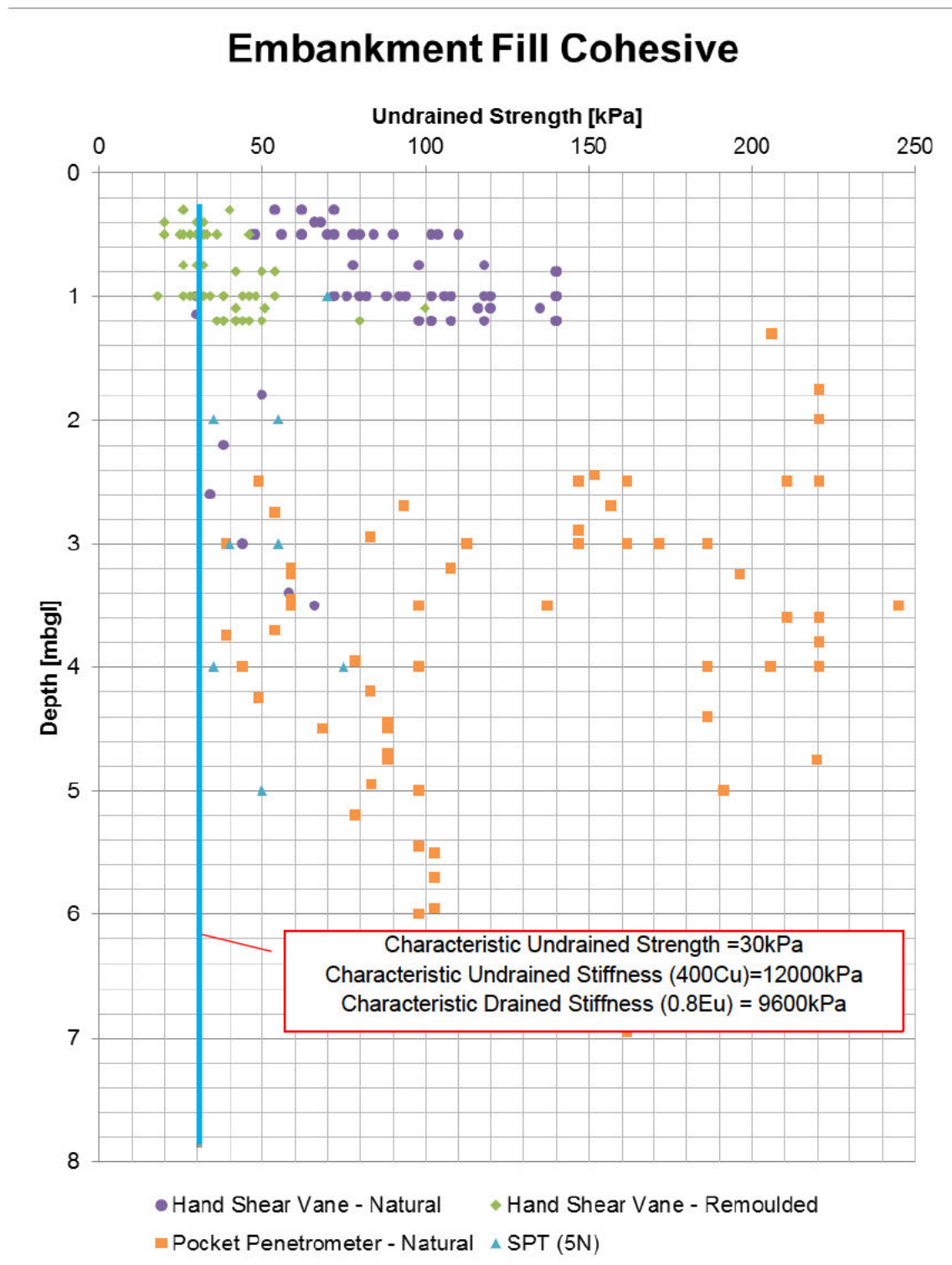
Variation of fully softened friction angle of internal resistance with liquid limit (Stark and Eid). Used in conjunction with the site factual data to determine the angle of internal resistance for the weathered London Clay, taken from LU Engineering Standard S1054-A5



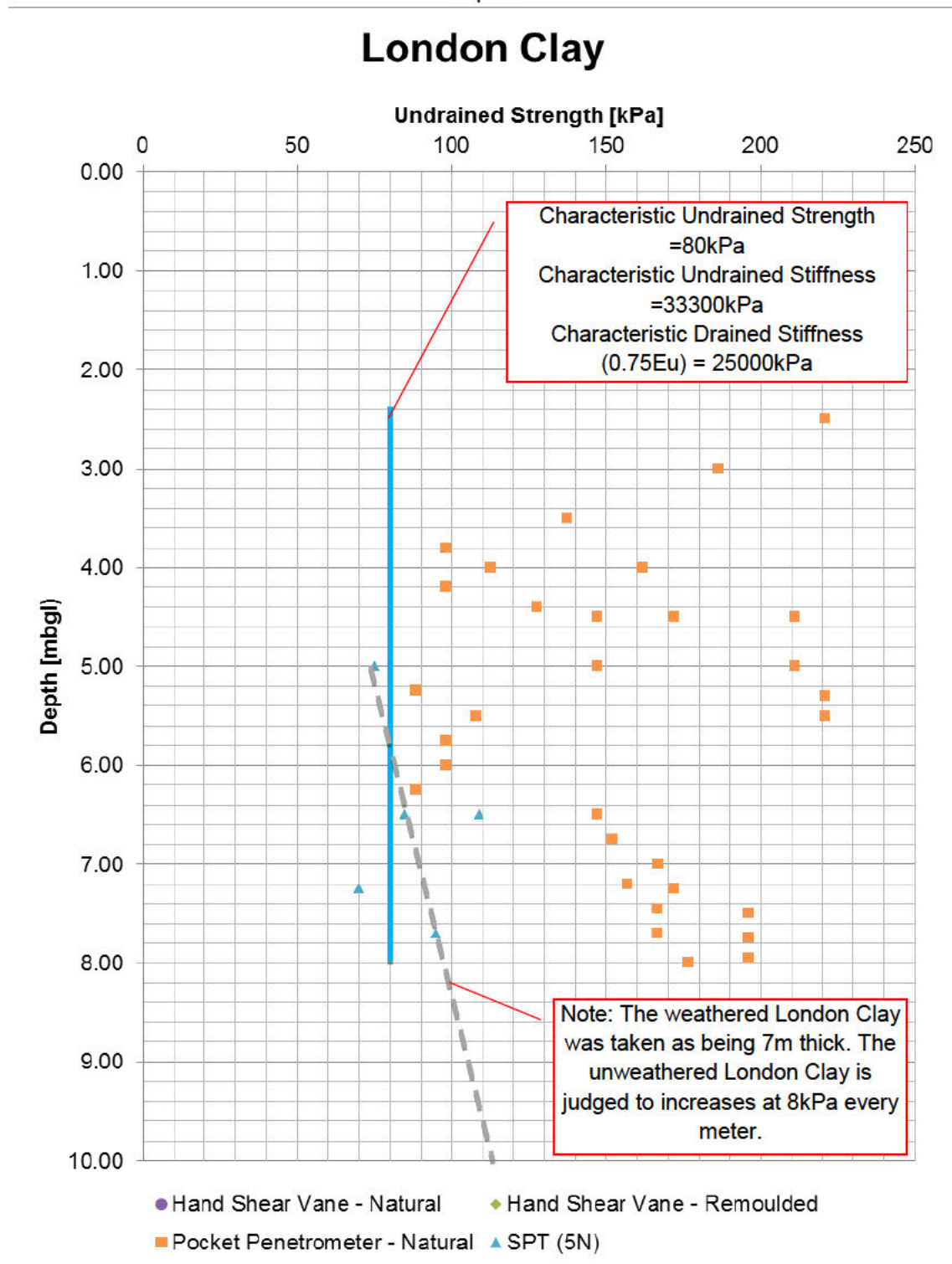
Variation of peak effective cohesion with moisture content. Used in conjunction with the site factual data to used determine the cohesion (C') for the weathered London Clay, taken from LU Engineering Standard S1054-A5



Factual data used determine the characteristic undrained strength and stiffness parameters for the embankment fill cohesive material, taken from the August 2005 Assessment Report

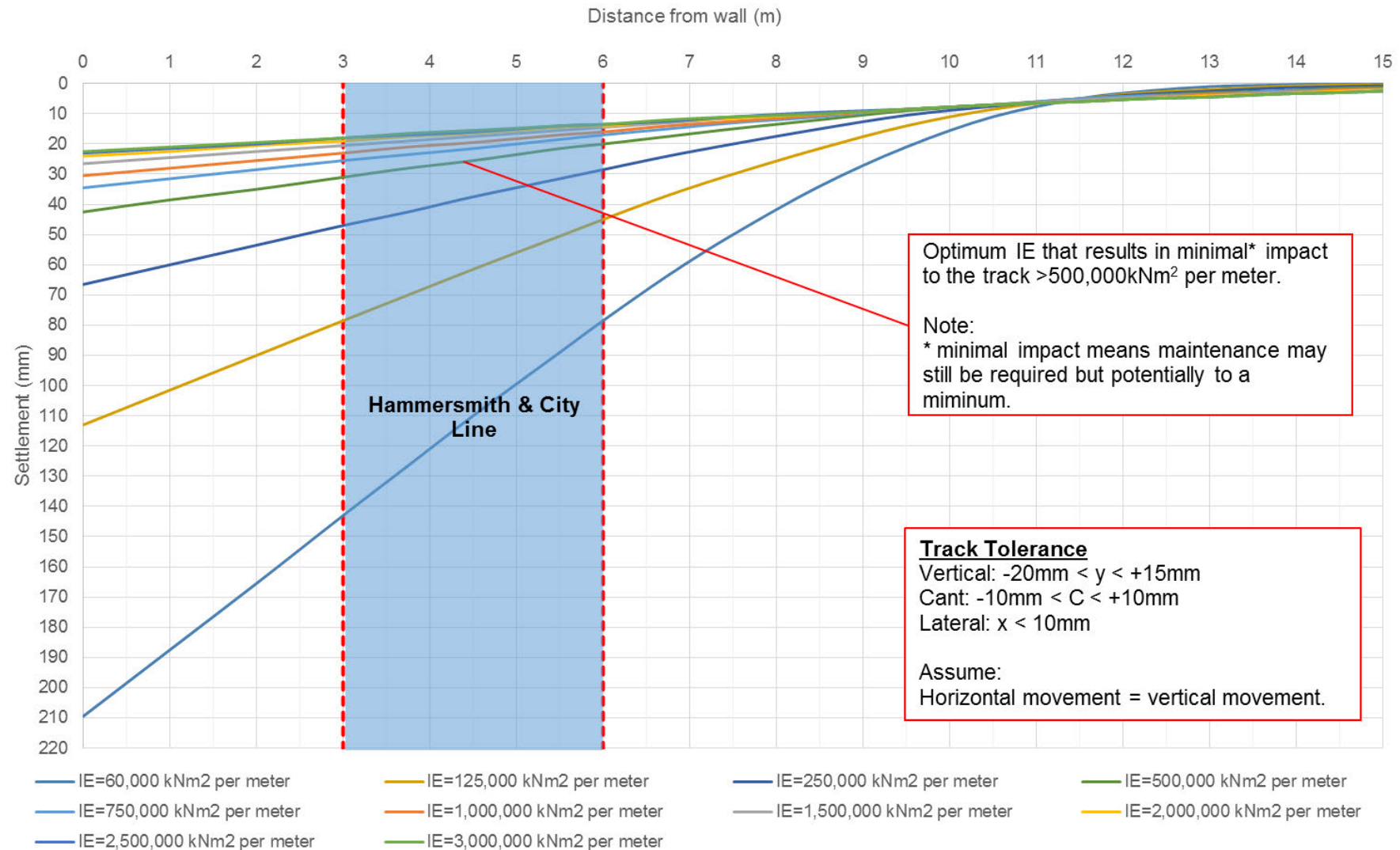


Factual data used determine the characteristic undrained strength and stiffness parameters for the weathered London Clay, taken from the August 2005 Assessment Report

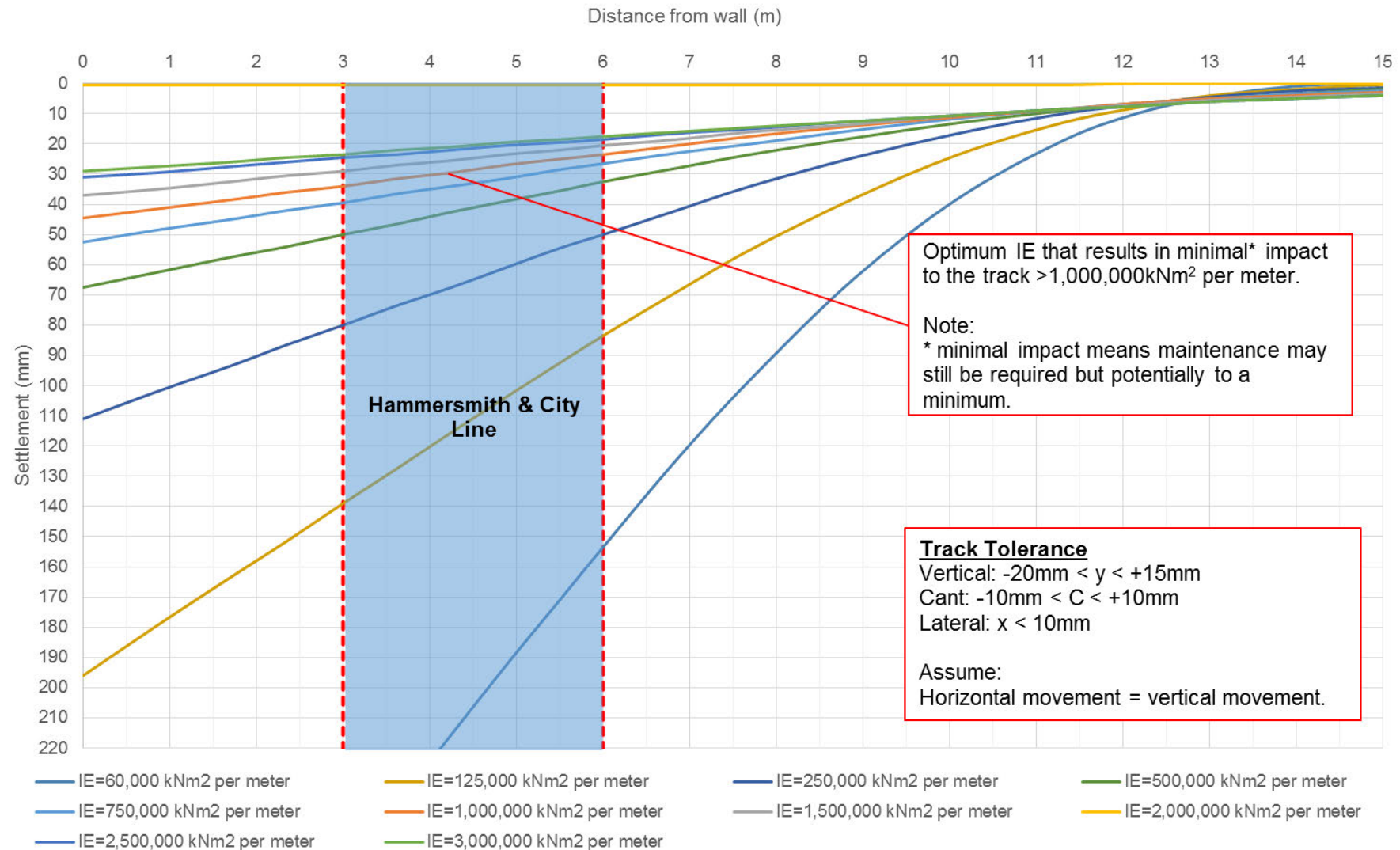


Appendix D – Ground Settlement Graphs

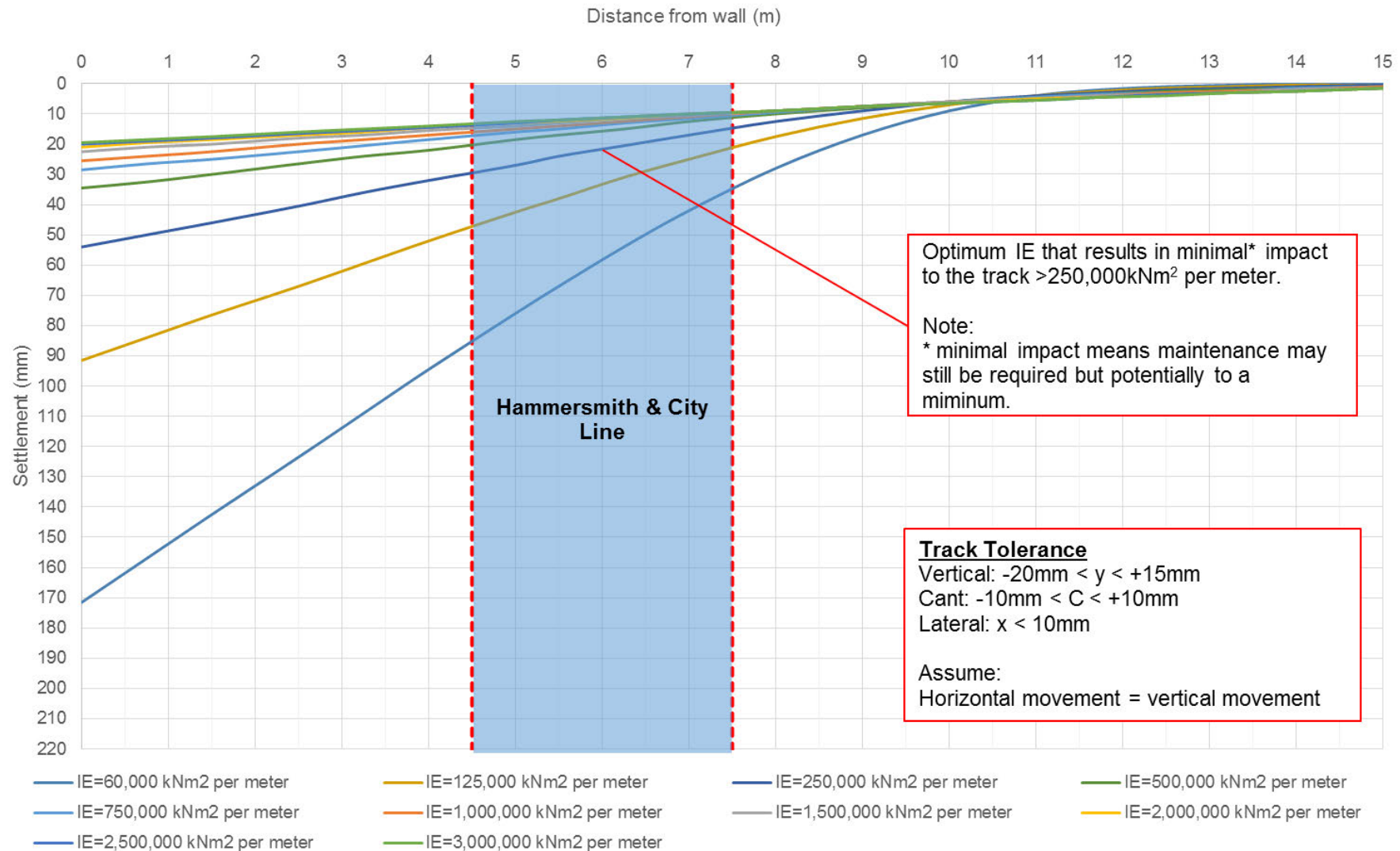
Section A - Predicted ground movement behind retaining wall - 3.0m track offset



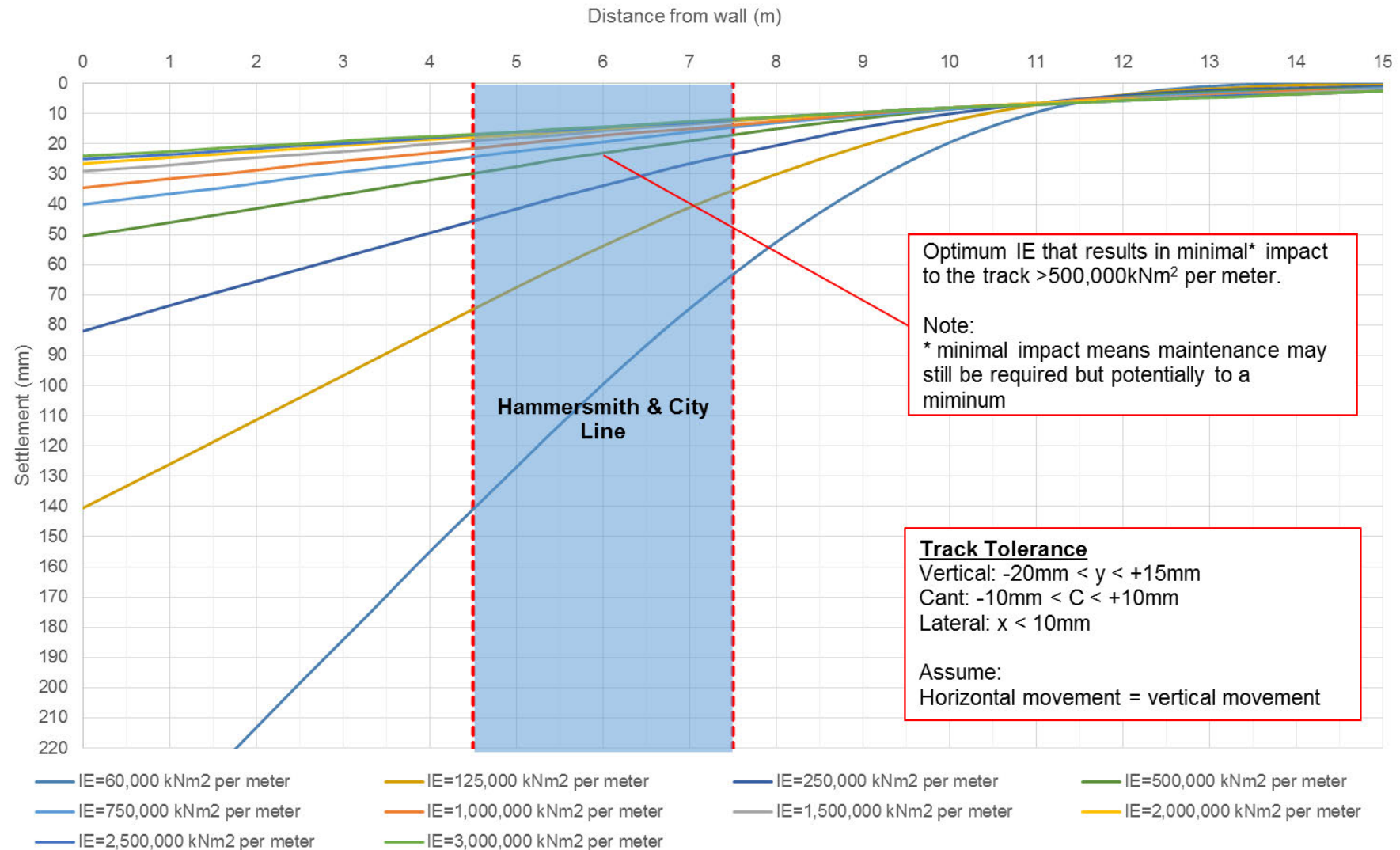
Section B - Predicted ground movement behind retaining wall - 3.0m track offset



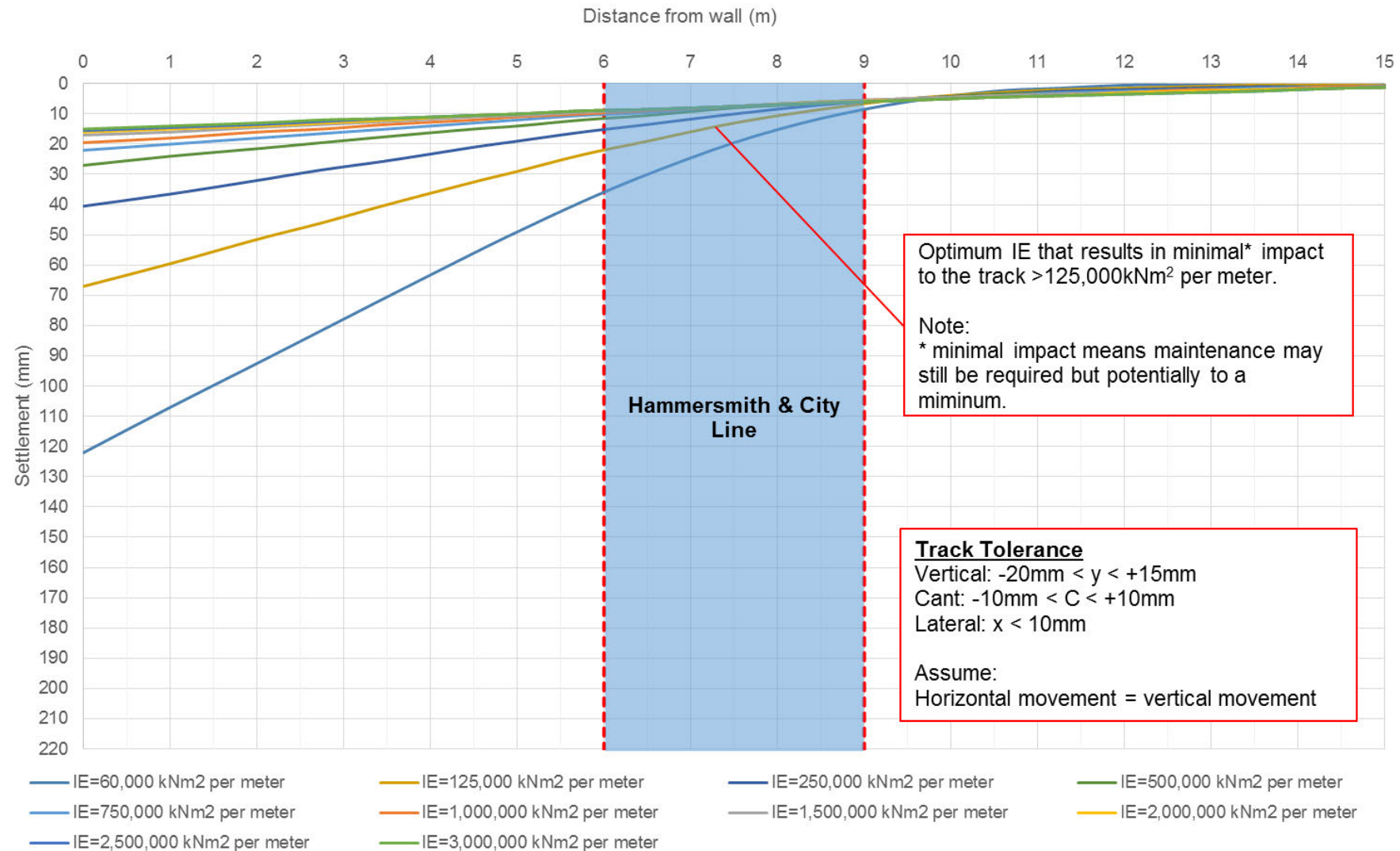
Section A - Predicted ground movement behind retaining wall - 4.5m track offset



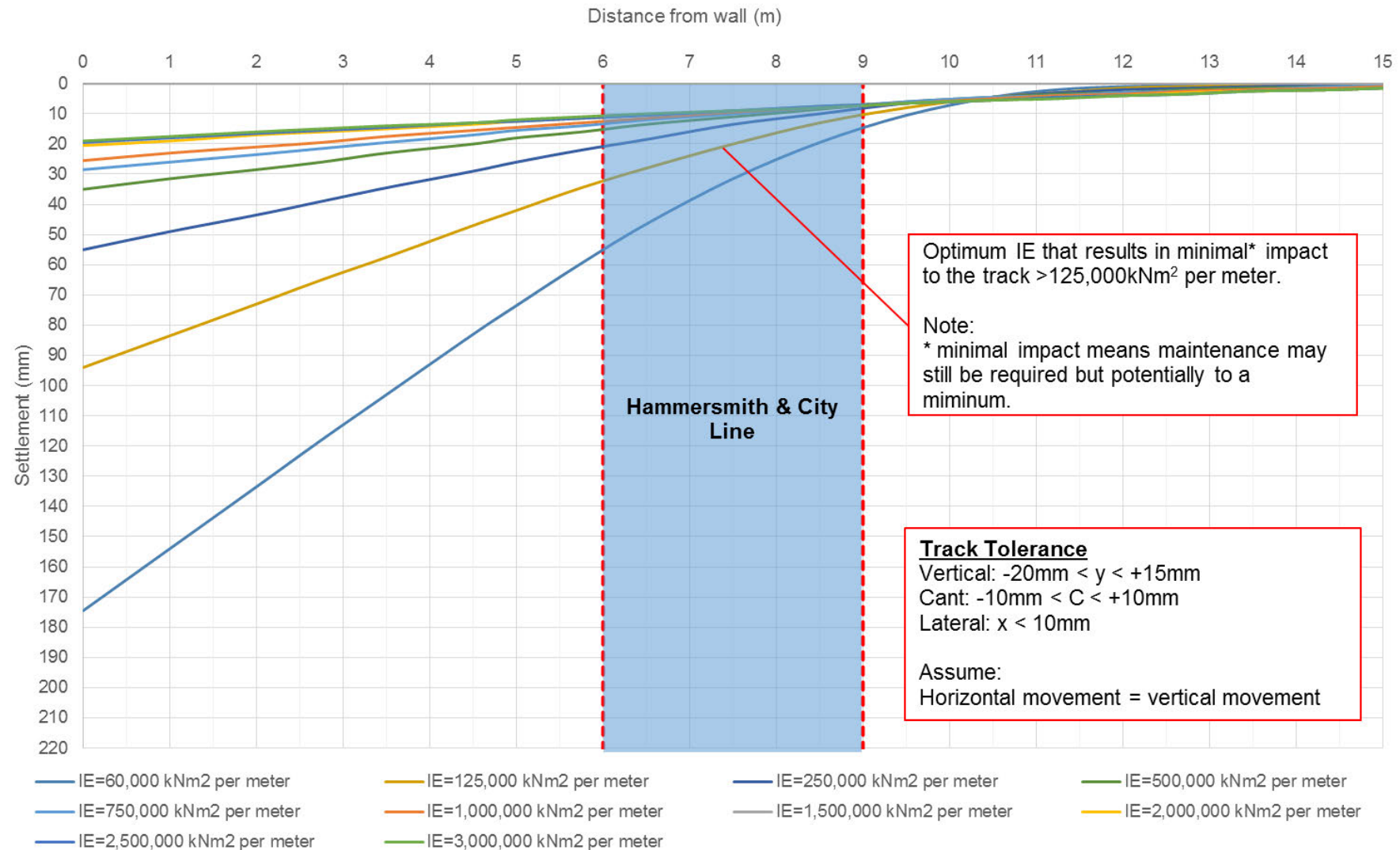
Section B - Predicted ground movement behind retaining wall - 4.5m track offset



Section A - Predicted ground movement behind retaining wall - 6.0m track offset



Section B - Predicted ground movement behind retaining wall - 6.0m track offset



Appendix E – WALLAP Output

Section B_Offset30m_IE 1200000_SLS

TRANSPORT FOR LONDON

Program: WALLAP Version 6.06 Revision A51.B69.R55

Licensed from GEOSOLVE

Data filename/Run ID: PortobelloRoad_SectionB_SP_3m_IEnsens_SLS_v4

Portobello Road Enabling Feasibility

Section 1 - Option 1 (Sheet pile wall)

Sheet No.

Job No.

Made by : I.M

Date:20-12-2019

Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	120.50	3 EFC - drained	3 EFC - drained
2	114.50	5 WLC - drained	5 WLC - drained
3	107.50	7 LC - drained	7 LC - drained

SOIL PROPERTIES

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy)	Ko (dKo/dy)	NC/OC (Nu)	Ka (Kac)	Kp (Kpc)	kN/m2 (dc/dy)
1 Not defined							
2 Ash	11.00	0	0.430	NC	0.229	6.522	
		(5000)		(0.300)	(0.000)	(0.000)	
3 EFC - dra.. (120.50)	19.00	9000	0.577	NC	0.417	2.728	5.000d
		(1200)		(0.200)	(1.520)	(4.501)	
4 EFC - undr.. (120.50)	19.00	12000	1.000	NC	1.000	1.000	30.00u
		(1600)		(0.490)	(2.389)	(2.390)	(4.000)
5 WLC - drained	19.00	25000	1.000	OC	0.417	2.728	5.000d
				(0.200)	(1.520)	(4.501)	
6 WLC - undrained	19.00	33300	1.000	OC	1.000	1.000	80.00u
				(0.490)	(2.389)	(2.390)	
7 LC - drai.. (107.50)	19.00	25000	1.000	OC	0.353	3.416	4.000d
		(6000)		(0.200)	(1.388)	(5.182)	
8 LC - undr.. (107.50)	19.00	33300	1.000	OC	1.000	1.000	80.00u
		(8000)		(0.490)	(2.389)	(2.390)	(8.000)

Additional soil parameters associated with Ka and Kp

		--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction	Wall adhesion	Back-fill	Soil friction	Wall adhesion	Back-fill
		angle	coeff.	angle	angle	coeff.	angle
No. Description							
1 Not defined							
2 Ash		35.00	0.619	0.00	35.00	0.619	0.00
3 EFC - drained		21.00	0.653	0.00	21.00	0.653	0.00
4 EFC - undrained		0.00	0.500	0.00	0.00	0.500	0.00
5 WLC - drained		21.00	0.653	0.00	21.00	0.653	0.00
6 WLC - undrained		0.00	0.500	0.00	0.00	0.500	0.00
7 LC - drained		25.00	0.645	0.00	25.00	0.645	0.00
8 LC - undrained		0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

Initial water table elevation Left side Right side
117.50 117.50

Automatic water pressure balancing at toe of wall : Yes

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
1	1	117.50	117.50	0.0	1	115.00	115.00

0.0 MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 100.00
 Maximum finite element length = 1.20 m
 Youngs modulus of wall E = 3.0000E+07 kN/m2
 Moment of inertia of wall I = 4.1667E-03 m4/m run
 E.I = 125000 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge Far edge		Equiv. soil type	Partial factor/ Category
1	120.50	3.00(L)	50.00	3.00	30.00	=	N/A	1.00 Var
2	120.50	0.10(L)	50.00	3.00	0.00	=	N/A	1.00 -
3	120.50	3.00(L)	50.00	10.00	0.00	=	N/A	1.00 -
4	120.50	0.10(L)	10.00	3.00	0.00	=	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	Apply surcharge no.1 at elevation 120.50
2	Apply surcharge no.2 at elevation 120.50
3	Apply surcharge no.3 at elevation 120.50
4	Apply surcharge no.4 at elevation 120.50
5	Change EI of wall to 125000 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

Stability analysis:

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

Parameters for undrained strata:

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

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m

Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m

Distance to rigid boundary on Right side = 30.00 m

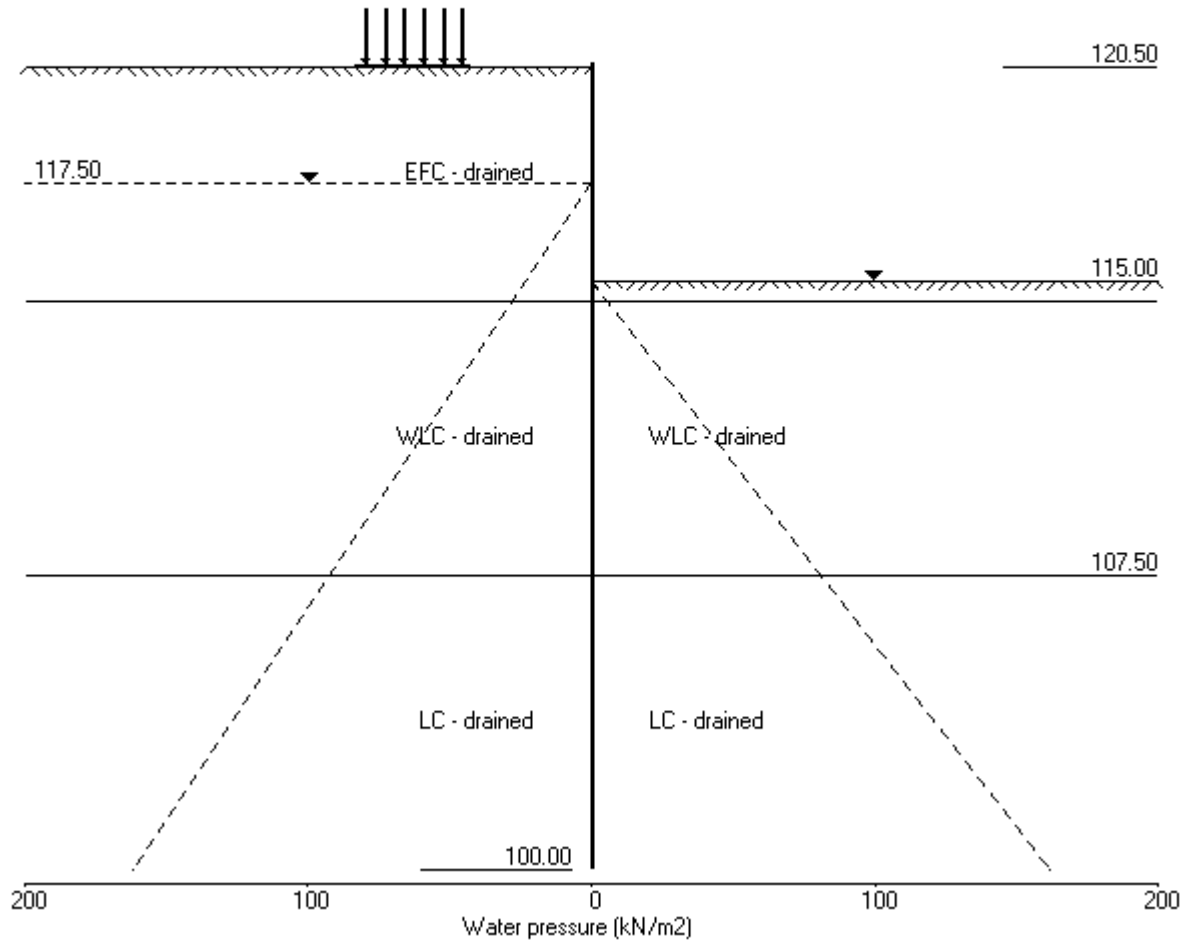
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 120.50	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 120.50	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 120.50	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 120.50	Yes	Yes	Yes
5	Change EI of wall to 125000kN.m2/m run	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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 150 St. Alphonsus Road, London SW4 7BW, UK www.geosolve.co.uk

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_3m_IEsens_SLS_v4	
Portobello Road Enabling Feasibility	Date:20-12-2019
Section 1 - Option 1 (Sheet pile wall)	Checked :

Units: kN,m

Stage No. 7 Excavate to elevation 115.00 on RIGHT side

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

				FoS for toe elev. = 100.00		Toe elev. for FoS = 1.000		
				-----		-----		
Stage	--- G.L. ---	Strut		Factor	Moment	Toe	Wall	Direction
No.	Act. Pass.	Elev.		of	equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
7	120.50 115.00	Cant.		1.337	101.46	105.62	9.38	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall
Right side 30.00 from wall

Limit State: Serviceability Limit State

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

*** Wall displacements reset to zero at stage 5

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	120.50	0.00	0.392	3.77E-02	0.0	0.0	
2	119.65	0.00	0.359	3.77E-02	0.0	0.2	
3	118.80	6.43	0.327	3.77E-02	2.7	1.1	
4	118.15	12.15	0.303	3.77E-02	8.8	4.7	
5	117.50	17.90	0.278	3.76E-02	18.5	13.5	
6	116.88	26.74	0.255	3.75E-02	32.5	29.2	
7	116.25	35.47	0.231	3.72E-02	51.9	55.4	
8	115.63	44.10	0.208	3.68E-02	76.8	95.4	
9	115.00	52.62	0.185	3.62E-02	107.0	152.6	
		30.12	0.185	3.62E-02	107.0	152.6	
10	114.50	20.27	0.167	3.55E-02	119.6	209.5	
11	113.65	3.43	0.138	3.37E-02	129.7	316.5	
12	112.80	-13.52	0.110	3.11E-02	125.4	426.0	
13	111.60	-37.63	0.076	2.64E-02	94.7	560.8	
14	110.40	-61.91	0.047	2.06E-02	35.0	641.2	
15	109.20	-76.06	0.026	1.45E-02	-47.8	650.5	
16	108.35	-59.57	0.016	1.03E-02	-105.4	580.8	
17	107.50	-17.19	0.008	6.73E-03	-138.0	475.4	
18	106.55	10.53	0.004	3.65E-03	-141.2	336.4	
19	105.60	29.68	0.001	1.59E-03	-122.1	206.8	
20	104.40	39.64	0.000	2.19E-04	-80.5	81.2	
21	103.20	33.13	0.000	-2.25E-04	-36.9	12.8	
22	102.00	18.47	0.001	-2.44E-04	-5.9	-8.0	
23	101.00	1.81	0.001	-1.90E-04	4.2	-4.9	
24	100.00	-10.28	0.001	-1.70E-04	0.0	-0.0	

(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.50	0.00	0.00	0.00	22.50	0.00	0.00a	1020
2	119.65	0.00	16.38	0.00	67.18	0.00	0.00a	1136
3	118.80	0.00	33.69	6.43	114.40	6.43	6.43a	1251
4	118.15	0.00	47.42	12.15	151.86	12.15	12.15a	1340
5	117.50	0.00	61.23	17.90	189.52	17.90	17.90a	1428
6	116.88	5.77	68.59	20.97	209.59	20.97	26.74a	1513
7	116.25	11.54	75.70	23.93	229.00	23.93	35.47a	1598
8	115.63	17.31	82.56	26.79	247.70	26.79	44.10a	1683
9	115.00	23.08	89.18	29.55	265.76	29.55	52.62a	1768
10	114.50	27.69	94.34	31.70	279.83	31.70	59.39a	1836
		27.69	94.34	31.70	279.83	31.70	59.39a	2833
11	113.65	35.54	102.88	35.25	303.13	35.25	70.79a	2833
12	112.80	43.38	111.22	38.73	325.87	38.73	82.11a	2833
13	111.60	54.46	122.77	43.54	357.37	43.54	98.00a	2833
14	110.40	65.54	134.17	48.29	388.48	48.29	113.82a	2833
15	109.20	76.62	145.51	53.01	419.41	63.34	139.96	2833
16	108.35	84.46	153.53	56.35	441.28	100.63	185.09	2833
17	107.50	92.31	161.55	59.69	463.14	128.48	220.79	2833
		92.31	161.55	51.40	572.61	128.48	220.79	2833
18	106.55	101.08	170.51	54.56	603.23	148.55	249.63	3479
19	105.60	109.85	179.48	57.72	633.88	165.87	275.71	7428
20	104.40	120.92	190.84	61.72	672.66	182.58	303.50	8898
21	103.20	132.00	202.21	65.73	711.52	191.08	323.08	10367
22	102.00	143.08	211.15	68.88	742.05	195.51	338.59	17696
23	101.00	152.31	223.12	73.10	782.96	197.00	349.31	19526
24	100.00	161.54	232.65	76.46	815.52	200.78	362.32	21357

Node no.	Y coord	RIGHT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	119.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	118.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	118.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	116.88	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	116.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	115.63	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	22.50	22.50	22.50p	2709
10	114.50	5.38	4.12	0.00	33.73	33.73	39.11p	2813
		5.38	4.12	0.00	33.73	33.73	39.11p	4342
11	113.65	14.54	11.12	0.00	52.82	52.82	67.36p	4342
12	112.80	23.69	18.13	0.00	71.94	71.94	95.63p	4342
13	111.60	36.62	28.05	4.08	99.01	99.01	135.62p	4342
14	110.40	49.54	38.02	8.23	126.20	126.20	175.74p	4342
15	109.20	62.46	48.05	12.41	153.55	153.55	216.01p	4342
16	108.35	71.62	55.19	15.39	173.04	173.04	244.66p	4342
17	107.50	80.77	62.38	18.38	192.64	157.21	237.98	4342
		80.77	62.38	16.44	233.81	157.21	237.98	4342
18	106.55	91.00	70.45	19.28	261.41	148.10	239.10	5332
19	105.60	101.23	78.59	22.15	289.20	144.80	246.03	7428

(continued)

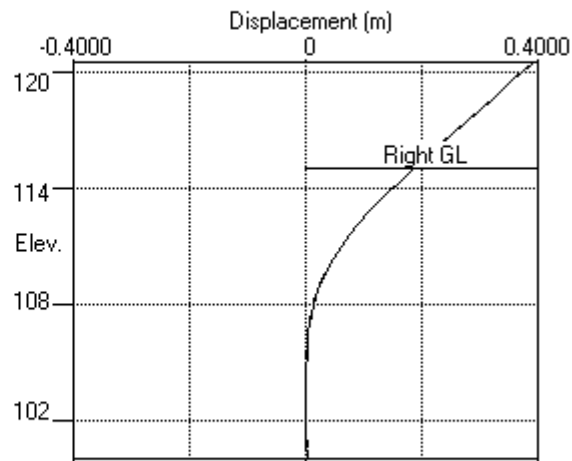
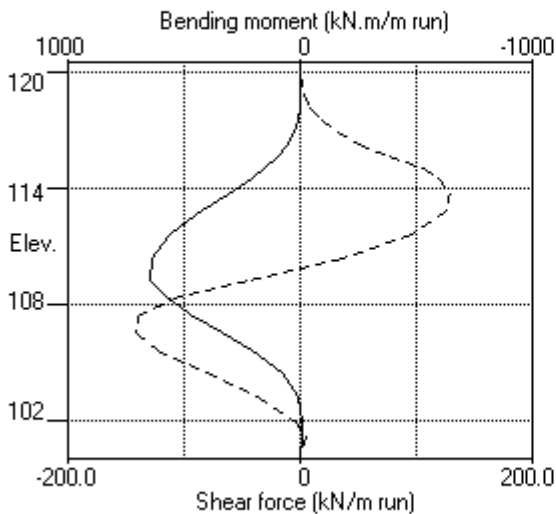
Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	----- RIGHT side -----					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	104.40	114.15	88.94	25.80	324.58	149.71	263.87	8898
21	103.20	127.08	99.39	29.49	360.27	162.87	289.95	10367
22	102.00	140.00	109.93	33.20	396.28	180.12	320.12	17696
23	101.00	150.77	118.78	36.32	426.52	196.73	347.50	19526
24	100.00	161.54	127.70	39.46	456.96	211.06	372.60	21357

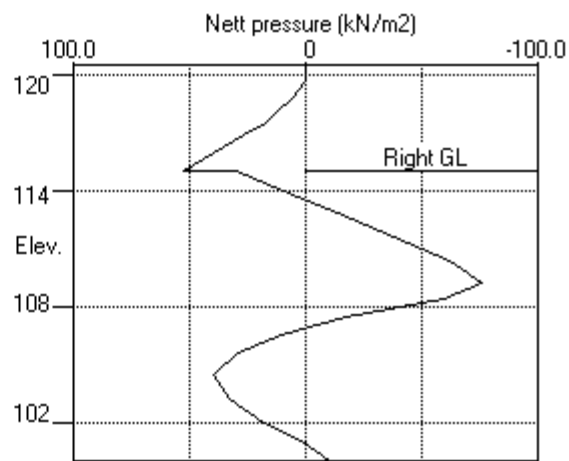
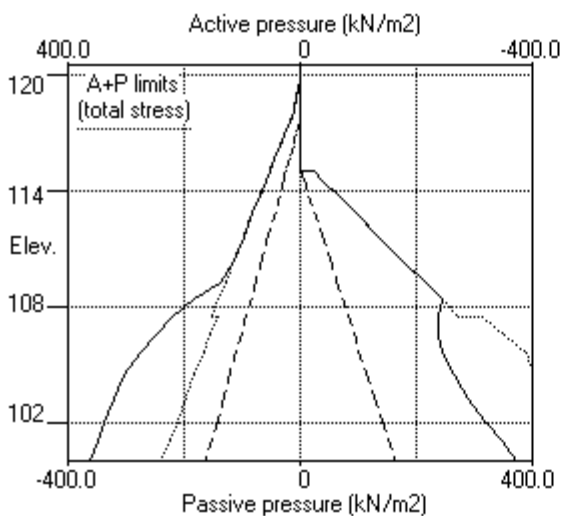
Note: 113.82a Soil pressure at active limit
 244.66p Soil pressure at passive limit

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_3m_IEsens_SLS_v4	
Portobello Road Enabling Feasibility	Date:20-12-2019
Section 1 - Option 1 (Sheet pile wall)	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	--- G.L. ---		Strut Elev.	FoS for toe elev. = 100.00		Toe elev. for FoS = 1.000		Direction of failure
No.	Act.	Pass.		Factor	Moment	Toe elev.	Wall Penetr- -ation	
1	120.50	120.50	Cant.	Conditions not suitable for FoS calc.				
2	120.50	120.50	Cant.	Conditions not suitable for FoS calc.				
3	120.50	120.50	Cant.	Conditions not suitable for FoS calc.				
4	120.50	120.50	Cant.	Conditions not suitable for FoS calc.				
5	120.50	120.50		No analysis at this stage				
6	120.50	120.50	Cant.	Conditions not suitable for FoS calc.				
7	120.50	115.00	Cant.	1.337	101.46	105.62	9.38	L to R

TRANSPORT FOR LONDON

Program: WALLAP Version 6.06 Revision A51.B69.R55

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Data filename/Run ID: PortobelloRoad_SectionB_SP_3m_IEsens_SLS_v4

Portobello Road Enabling Feasibility

Section 1 - Option 1 (Sheet pile wall)

Sheet No.

Job No.

Made by : I.M

Date:20-12-2019

Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall

Right side 30.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut 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/m	kN.m/m	kN/m	kN/m	kN/m	kN/m
1	120.50	0.392	0.000	0	-0	0	-0	0	0	0	0
2	119.65	0.359	0.000	0	-0	0	-0	0	-1	0	-2
3	118.80	0.327	0.000	1	-2	2	-3	3	-3	4	-4
4	118.15	0.303	0.000	5	-5	6	-6	9	-5	12	-7
5	117.50	0.278	0.000	13	-8	18	-11	19	-7	25	-10
6	116.88	0.255	0.000	29	-13	39	-18	32	-8	44	-11
7	116.25	0.231	0.000	55	-18	75	-24	52	-7	70	-10
8	115.63	0.208	0.000	95	-22	129	-29	77	-5	104	-7
9	115.00	0.185	0.000	153	-24	206	-32	107	-2	144	-2
10	114.50	0.167	0.000	210	-24	283	-32	120	0	161	0
11	113.65	0.138	0.000	317	-22	427	-30	130	0	175	0
12	112.80	0.110	0.000	426	-19	575	-26	125	0	169	0
13	111.60	0.076	0.000	561	-14	757	-19	95	0	128	0
14	110.40	0.047	0.000	641	-10	866	-14	35	-0	47	-0
15	109.20	0.026	0.000	651	-6	878	-9	3	-48	4	-65
16	108.35	0.016	0.000	581	-4	784	-5	3	-105	5	-142
17	107.50	0.008	0.000	475	-1	642	-1	4	-138	5	-186
18	106.55	0.004	0.000	336	0	454	0	4	-141	5	-191
19	105.60	0.001	0.000	207	0	279	0	3	-122	4	-165
20	104.40	0.001	0.000	81	0	110	0	1	-81	1	-109
21	103.20	0.001	0.000	13	0	17	0	0	-37	0	-50
22	102.00	0.001	0.000	5	-8	7	-11	0	-6	0	-8
23	101.00	0.001	0.000	3	-5	4	-7	4	-2	6	-3
24	100.00	0.001	-0.000	0	-0	0	-0	0	-0	0	-0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	Calculated		Factored		Calculated		Factored	
	max.	elev.	min.	elev.	max.	elev.	min.	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	1	110.40	-5	116.25	2	-7	3	114.50
2	1	110.40	-5	116.25	2	-7	3	114.50
3	1	110.40	-5	116.25	2	-7	3	114.50
4	1	110.40	-5	116.25	2	-7	3	114.50
5	No calculation at this stage							
6	8	104.40	-24	114.50	10	-32	4	111.60
7	651	109.20	-8	102.00	878	-11	130	113.65

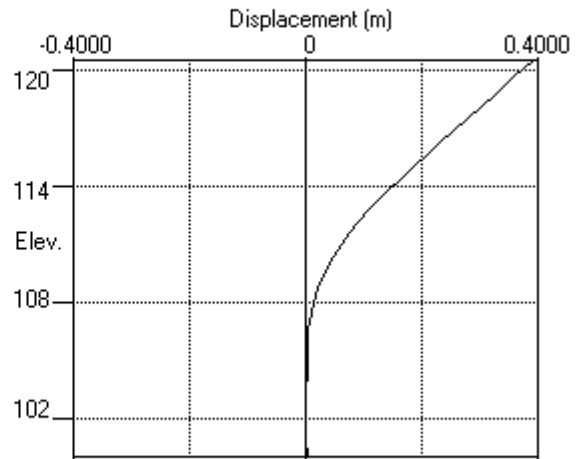
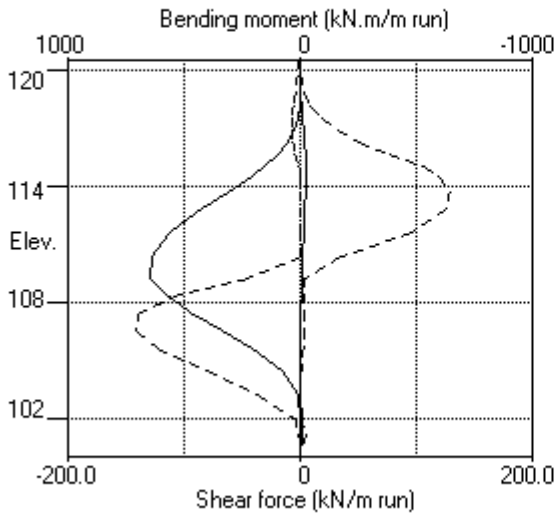
Summary of results (continued)

Maximum and minimum displacement at each stage

Stage -----		Displacement -----				Stage description
no.	maximum	elev.	minimum	elev.	-----	
	m		m			
1	0.001	116.88	0.000	120.50	Apply surcharge no.1 at elev. 120.50	
2	0.001	116.88	0.000	120.50	Apply surcharge no.2 at elev. 120.50	
3	0.001	116.88	0.000	120.50	Apply surcharge no.3 at elev. 120.50	
4	0.001	116.88	0.000	120.50	Apply surcharge no.4 at elev. 120.50	
5	Wall displacements reset to zero					Change EI of wall to 125000kN.m2/m run
6	0.004	112.80	-0.000	100.00	Apply water pressure profile no.1	
7	0.392	120.50	0.000	120.50	Excav. to elev. 115.00 on RIGHT side	

Units: kN,m

Bending moment, shear force, displacement envelopes



Section B_Offset30m_IE 1200000_DA1C 2

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	----- Left side	Soil types ----- Right side
1	120.50	3 EFC - drained	3 EFC - drained
2	114.50	5 WLC - drained	5 WLC - drained
3	107.50	7 LC - drained	7 LC - drained

SOIL PROPERTIES (Unfactored SLS soil strengths)

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy)	Ko (dKo/dy)	NC/OC (Nu)	Ka (Kac)	Kp (Kpc)	kN/m2 (dc/dy)
1 Not defined							
2 Ash	11.00	0 (5000)	0.430	NC (0.300)	0.229 (0.000)	6.522 (0.000)	
3 EFC - dra.. (120.50)	19.00	9000 (1200)	0.577	NC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
4 EFC - und.. (120.50)	19.00	12000 (1600)	1.000	NC (0.490)	1.000 (2.389)	1.000 (2.390)	30.00u (4.000)
5 WLC - drained	19.00	25000	1.000	OC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
6 WLC - undrained	19.00	33300	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u
7 LC - drai.. (107.50)	19.00	25000 (6000)	1.000	OC (0.200)	0.353 (1.388)	3.416 (5.182)	4.000d
8 LC - undr.. (107.50)	19.00	33300 (8000)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u (8.000)

Additional soil parameters associated with Ka and Kp

		--- 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	Not defined						
2	Ash	35.00	0.619	0.00	35.00	0.619	0.00
3	EFC - drained	21.00	0.653	0.00	21.00	0.653	0.00
4	EFC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
5	WLC - drained	21.00	0.653	0.00	21.00	0.653	0.00
6	WLC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
7	LC - drained	25.00	0.645	0.00	25.00	0.645	0.00
8	LC - undrained	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	117.50	117.50

Automatic water pressure balancing at toe of wall : Yes

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	117.50	117.50	0.0	1	115.00	115.00

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 100.00
 Maximum finite element length = 1.20 m
 Youngs modulus of wall E = 1.5000E+07 kN/m2
 Moment of inertia of wall I = 0.072705 m4/m run
 E.I = 1.0906E+06 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge Far edge		Equiv. soil type	Partial factor/ Category
1	120.50	3.00(L)	50.00	3.00	30.00	=	N/A	1.30 Var
2	120.50	0.10(L)	50.00	3.00	0.00	=	N/A	1.00 -
3	120.50	3.00(L)	50.00	10.00	0.00	=	N/A	1.00 -
4	120.50	0.10(L)	10.00	3.00	0.00	=	N/A	1.30 Var
5	120.50	7.50(L)	50.00	3.00	30.00	=	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	Apply surcharge no.1 at elevation 120.50
2	Apply surcharge no.2 at elevation 120.50
3	Apply surcharge no.3 at elevation 120.50
4	Apply surcharge no.4 at elevation 120.50
5	Apply surcharge no.5 at elevation 120.50
6	Change EI of wall to 1.0906E+06 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
7	Apply water pressure profile no.1 (Worst Cred.)
8	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Variable Unfavourable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:

Minimum equivalent fluid density = 5.00 kN/m3

Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients

Open Tension Crack analysis? - No

Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m

Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m

Distance to rigid boundary on Right side = 30.00 m

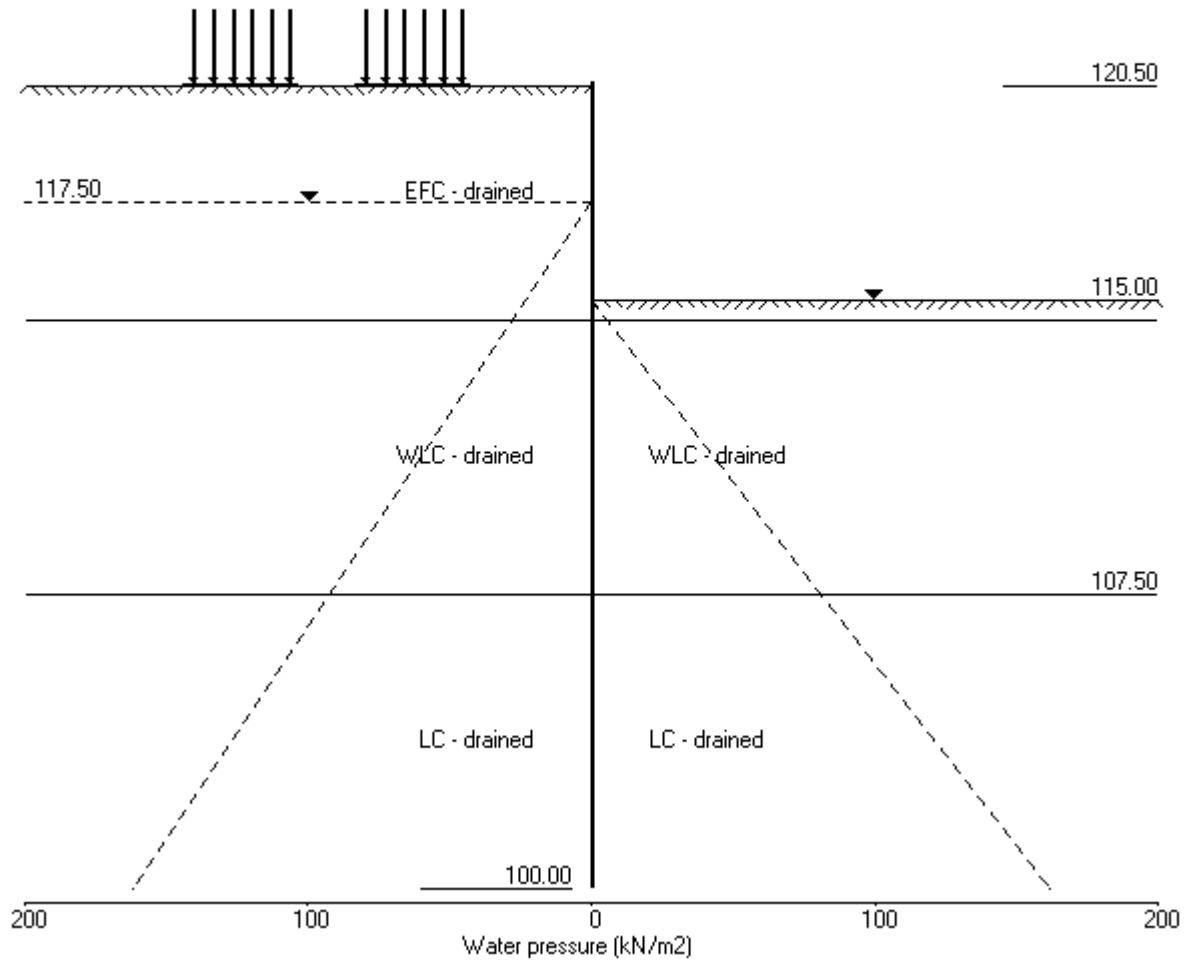
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 120.50	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 120.50	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 120.50	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 120.50	Yes	Yes	Yes
5	Apply surcharge no.5 at elev. 120.50	Yes	Yes	Yes
6	Change EI of wall to 1.0906E+06kN.m2/m	Yes	Yes	Yes
7	Apply water pressure profile no.1	Yes	Yes	Yes
8	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Units: kN,m

Stage No.8 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
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Data filename/Run ID: PortobelloRoad_SectionB_3m_Contig1200mm	ULS2_v2
Portobello Road Enabling Feasibility	Date:17-03-2020
Section 1 - Option 1 (Sheet pile wall)	Checked :

Units: kN,m

Stage No. 8 Excavate to elevation 115.00 on RIGHT side

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

			Overall				Direction of failure
			FoS for toe elev. = 100.00	Moment of equilib. at elev.	Toe elev. for FoS = 1.000	Wall Penetr -ation	
Stage No.	--- G.L. Act.	--- Pass.	Strut Elev.	Factor Safety		Toe elev.	
8	120.50	115.00	Cant.	1.046	101.42	100.99	14.01
							L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m
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 30.00 from wall
Right side 30.00 from wall

Limit State: ULS DA1 Combination 2

*** Wall displacements reset to zero at stage 6

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	120.50	0.00	0.227	1.61E-02	0.0	-0.0	
2	119.65	1.43	0.213	1.61E-02	0.6	0.6	
3	118.80	10.14	0.199	1.61E-02	5.5	2.8	
4	118.15	17.15	0.189	1.61E-02	14.4	9.0	
5	117.50	24.26	0.178	1.61E-02	27.9	22.6	
6	116.88	33.98	0.168	1.61E-02	46.1	45.4	
7	116.25	43.57	0.158	1.61E-02	70.3	81.5	
8	115.63	53.01	0.148	1.60E-02	100.5	134.5	
9	115.00	62.32	0.138	1.59E-02	136.5	208.3	
		46.50	0.138	1.59E-02	136.5	208.3	
10	114.50	39.36	0.130	1.58E-02	158.0	282.1	
11	113.65	27.05	0.117	1.55E-02	186.2	429.1	
12	112.80	14.56	0.104	1.51E-02	203.9	595.6	
13	111.60	-3.33	0.086	1.43E-02	210.6	846.2	
14	110.40	-21.49	0.070	1.32E-02	195.7	1092.0	
15	109.20	-39.89	0.054	1.19E-02	158.9	1306.6	
16	108.35	-53.06	0.045	1.08E-02	119.4	1425.6	
17	107.50	-66.35	0.036	9.73E-03	68.6	1506.2	
		-98.85	0.036	9.73E-03	68.6	1506.2	
18	106.55	-107.40	0.027	8.41E-03	-29.3	1524.7	
19	105.60	-111.20	0.020	7.12E-03	-133.2	1446.3	
20	104.40	-79.78	0.012	5.65E-03	-247.7	1223.6	
21	103.20	-34.68	0.006	4.50E-03	-316.4	868.4	
22	102.00	14.74	0.001	3.77E-03	-328.4	463.3	
23	101.00	155.67	-0.002	3.50E-03	-243.2	142.1	
24	100.00	330.69	-0.006	3.43E-03	-0.0	0.0	

(continued)

Stage No.8 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.50	0.00	0.00	0.00	15.82	0.00	0.00a	844
2	119.65	0.00	16.46	1.43	52.27	1.43	1.43a	940
3	118.80	0.00	34.22	10.14	91.59	10.14	10.14a	1035
4	118.15	0.00	48.53	17.15	123.29	17.15	17.15a	1109
5	117.50	0.00	63.03	24.26	155.40	24.26	24.26a	1182
6	116.88	5.77	71.09	28.21	173.23	28.21	33.98a	1252
7	116.25	11.54	78.88	32.03	190.49	32.03	43.57a	1322
8	115.63	17.31	86.38	35.71	207.10	35.71	53.01a	1393
9	115.00	23.08	93.59	39.24	223.07	39.24	62.32a	1463
10	114.50	27.69	99.18	41.98	235.44	41.98	69.67a	1519
		27.69	99.18	41.98	235.44	41.98	69.67a	2345
11	113.65	35.54	108.36	46.48	255.76	46.48	82.02a	2345
12	112.80	43.38	117.21	50.82	275.38	50.82	94.21a	2345
13	111.60	54.46	129.31	56.75	302.16	56.75	111.21a	2345
14	110.40	65.54	141.07	62.52	328.20	62.52	128.05a	2345
15	109.20	76.62	152.60	68.17	353.73	68.17	144.78a	2345
16	108.35	84.46	160.67	72.13	371.61	72.13	156.59a	2345
17	107.50	92.31	168.69	76.06	389.37	76.06	168.37a	2345
		92.31	168.69	67.02	460.09	68.62	160.93	2345
18	106.55	101.08	177.61	70.82	483.66	82.89	183.97	2879
19	105.60	109.85	186.49	74.61	507.15	102.06	211.90	3414
20	104.40	120.92	197.69	79.38	536.75	130.60	251.52	4089
21	103.20	132.00	208.87	84.15	566.31	161.83	293.83	4764
22	102.00	143.08	220.05	88.92	595.88	195.00	338.08	5440
23	101.00	152.31	229.38	92.89	620.53	274.71	427.02	24984
24	100.00	161.54	238.71	96.87	645.21	380.23	541.77	27327

Node no.	Y coord	RIGHT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	119.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	118.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	118.15	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	116.88	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	116.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	115.63	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	15.82	15.82	15.82p	1918
10	114.50	5.38	4.12	0.00	24.93	24.93	30.32p	1992
		5.38	4.12	0.00	24.93	24.93	30.32p	3073
11	113.65	14.54	11.12	0.00	40.43	40.43	54.97p	3073
12	112.80	23.69	18.13	2.25	55.95	55.95	79.65p	3073
13	111.60	36.62	28.05	7.11	77.93	77.93	114.54p	3073
14	110.40	49.54	38.02	12.00	100.00	100.00	149.54p	3073
15	109.20	62.46	48.05	16.91	122.21	122.21	184.67p	3073
16	108.35	71.62	55.19	20.42	138.03	138.03	209.65p	3073
17	107.50	80.77	62.38	23.94	153.94	153.94	234.71p	3073
		80.77	62.38	21.68	179.01	179.01	259.78p	3073
18	106.55	91.00	70.45	25.12	200.37	200.37	291.37p	3774
19	105.60	101.23	78.59	28.59	221.87	221.87	323.10p	4475

(continued)

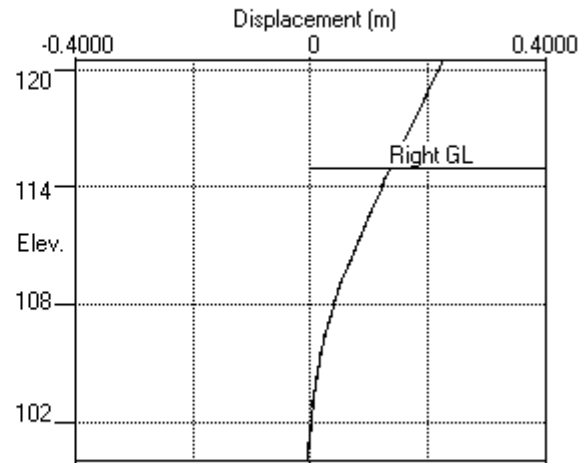
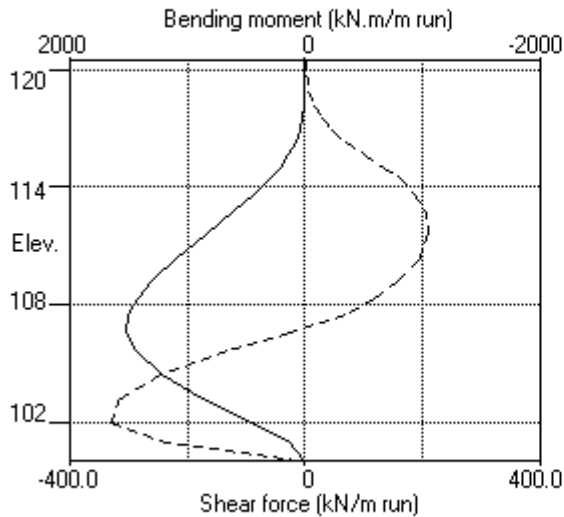
Stage No.8 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	----- RIGHT side -----					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
20	104.40	114.15	88.94	33.01	249.25	217.15	331.31	5360
21	103.20	127.08	99.39	37.46	276.88	201.43	328.51	6245
22	102.00	140.00	109.93	41.96	304.74	183.34	323.34	7130
23	101.00	150.77	118.78	45.73	328.14	120.58	271.35	24984
24	100.00	161.54	127.70	49.53	351.70	49.53	211.07a	27327

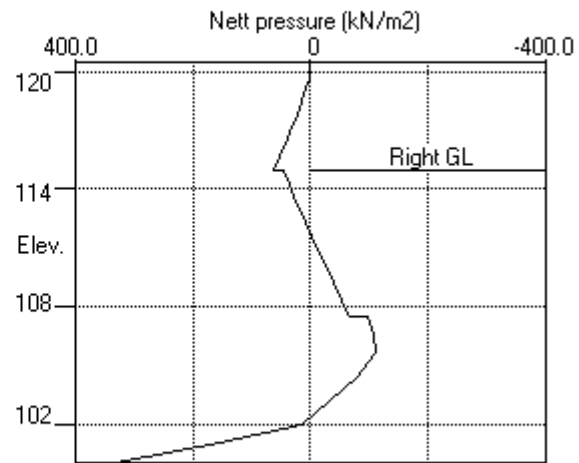
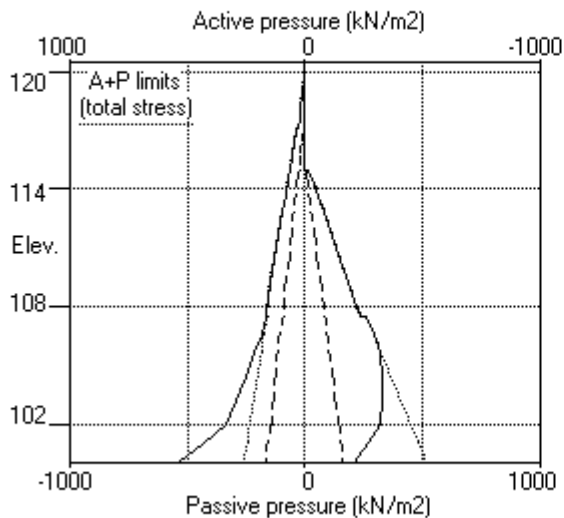
Note: 211.07a Soil pressure at active limit
 323.10p Soil pressure at passive limit

Units: kN,m

Stage No.8 Excav. to elev. 115.00 on RIGHT side



Stage No.8 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_3m_Contig1200mm	ULS2_v2
Portobello Road Enabling Feasibility	Date:17-03-2020
Section 1 - Option 1 (Sheet pile wall)	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. = 100.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of equilib.	elev.	Penetr	of
				Safety at elev.		-ation	failure
1	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
2	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
3	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
4	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
5	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
6	120.50	120.50		No analysis at this stage			
7	120.50	120.50	Cant.	Conditions not suitable for FoS calc.			
8	120.50	115.00	Cant.	1.046 101.42	100.99	14.01	L to R

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m
 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 30.00 from wall
 Right side 30.00 from wall

Limit State: ULS DAL Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum m	minimum m	maximum kN.m/m	minimum kN.m/m	maximum kN/m	minimum kN/m
1	120.50	0.227	0.000	0.0	-0.0	0.0	0.0
2	119.65	0.213	0.000	0.6	-1.0	0.6	-3.9
3	118.80	0.199	0.000	2.8	-6.5	5.5	-9.1
4	118.15	0.189	0.000	9.0	-13.6	14.4	-12.9
5	117.50	0.178	0.000	22.6	-23.0	27.9	-16.1
6	116.88	0.168	0.000	45.4	-33.7	46.1	-17.5
7	116.25	0.158	0.000	81.5	-44.3	70.3	-16.3
8	115.63	0.148	0.000	134.5	-53.5	100.5	-13.0
9	115.00	0.138	0.000	208.3	-60.1	136.5	-7.9
10	114.50	0.130	0.000	282.1	-62.8	158.0	-3.0
11	113.65	0.117	0.000	429.1	-64.2	186.2	-0.3
12	112.80	0.104	0.000	595.6	-63.6	203.9	0.0
13	111.60	0.086	0.000	846.2	-59.8	210.6	0.0
14	110.40	0.070	0.000	1092.0	-53.3	195.7	0.0
15	109.20	0.054	0.000	1306.6	-44.5	158.9	0.0
16	108.35	0.045	0.000	1425.6	-36.9	119.4	0.0
17	107.50	0.036	0.000	1506.2	-28.4	68.6	0.0
18	106.55	0.027	0.000	1524.7	-17.7	11.0	-29.3
19	105.60	0.020	0.000	1446.3	-7.8	9.6	-133.2
20	104.40	0.012	0.000	1223.6	0.0	6.3	-247.7
21	103.20	0.006	0.000	868.4	0.0	2.3	-316.4
22	102.00	0.001	0.000	463.3	0.0	0.0	-328.4
23	101.00	0.000	-0.002	142.1	0.0	0.0	-243.2
24	100.00	0.000	-0.006	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	maximum kN.m/m	elev.	minimum kN.m/m	elev.	maximum kN/m	elev.	minimum kN/m	elev.
1	2.9	105.60	-8.6	115.63	4.1	114.50	-3.1	118.15
2	2.9	105.60	-8.6	115.63	4.1	114.50	-3.1	118.15
3	2.9	105.60	-8.6	115.63	4.1	114.50	-3.1	118.15
4	2.9	105.60	-8.6	115.63	4.1	114.50	-3.1	118.15
5	1.7	104.40	-11.9	115.63	5.1	114.50	-4.0	118.15
6	No calculation at this stage							
7	6.5	103.20	-64.2	113.65	11.0	106.55	-17.5	116.88
8	1524.7	106.55	-0.0	120.50	210.6	111.60	-328.4	102.00

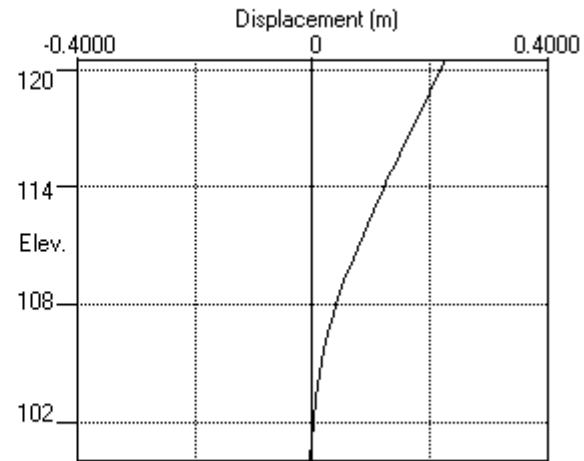
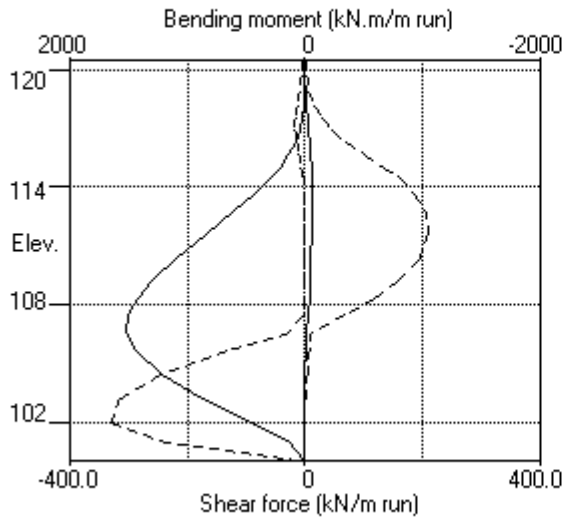
Summary of results (continued)

Maximum and minimum displacement at each stage

Stage -----		Displacement -----		Stage description	
no.	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.001	120.50	0.000	120.50	Apply surcharge no.1 at elev. 120.50
2	0.001	120.50	0.000	120.50	Apply surcharge no.2 at elev. 120.50
3	0.001	120.50	0.000	120.50	Apply surcharge no.3 at elev. 120.50
4	0.001	120.50	0.000	120.50	Apply surcharge no.4 at elev. 120.50
5	0.002	120.50	0.000	120.50	Apply surcharge no.5 at elev. 120.50
6	Wall displacements reset to zero			Change EI of wall to 1.0906E+06kN.m2/m run	
7	0.004	114.50	-0.000	100.00	Apply water pressure profile no.1
8	0.227	120.50	-0.006	100.00	Excav. to elev. 115.00 on RIGHT side

Units: kN,m

Bending moment, shear force, displacement envelopes



Section B_Offset45m_IE500000_SLS

TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_4_5m_IEsens_SLS_v4	
Portobello Road Enabling Feasibility	Date: 20-12-2019
Section 1 - Option 1 (Sheet pile wall)	Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Left side	Soil types	Right side
1	120.00	3 EFC - drained		3 EFC - drained
2	114.50	5 WLC - drained		5 WLC - drained
3	107.50	7 LC - drained		7 LC - drained

SOIL PROPERTIES

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh, kN/m2 (dEh/dy)	Ko (dKo/dy)	NC/OC (Nu)	Ka (Kac)	Kp (Kpc)	kN/m2 (dc/dy)
1 Not defined							
2 Ash	11.00	0 (5000)	0.430	NC (0.300)	0.229 (0.000)	6.522 (0.000)	
3 EFC - drained	19.00	9000	0.577	NC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
4 EFC - undrained	19.00	12000	1.000	NC (0.490)	1.000 (2.389)	1.000 (2.390)	30.00u
5 WLC - drained	19.00	25000	1.000	OC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
6 WLC - undrained	19.00	33300	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u
7 LC - drai... (107.50)	19.00	25000 (6000)	1.000	OC (0.200)	0.353 (1.388)	3.416 (5.182)	4.000d
8 LC - undr... (107.50)	19.00	33300 (8000)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u (8.000)

Additional soil parameters associated with Ka and Kp

----- Soil type -----	--- parameters for Ka ---	--- parameters for Kp ---
No. Description	Soil friction angle	Soil friction angle
1 Not defined		
2 Ash	35.00	35.00
3 EFC - drained	21.00	21.00
4 EFC - undrained	0.00	0.00
5 WLC - drained	21.00	21.00
6 WLC - undrained	0.00	0.00
7 LC - drained	25.00	25.00
8 LC - undrained	0.00	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	117.50	117.50

Automatic water pressure balancing at toe of wall : Yes

Water press.	Left side	Right side
profile no.	Point no.	Point no.
Elev. m	Elev. m	Elev. m
Piezo elev. m	Piezo elev. m	Piezo elev. m
Water press. kN/m2	Water press. kN/m2	Water press. kN/m2
1	1	1
117.50	117.50	115.00
117.50	117.50	115.00
0.0	0.0	0.0

MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 101.00
 Maximum finite element length = 1.00 m
 Youngs modulus of wall E = 3.0000E+07 kN/m2
 Moment of inertia of wall I = 0.033333 m4/m run
 E.I = 1000000 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Distance from Elev.	Length parallel to wall	Width perpend. to wall	Surcharge		Equiv. soil type	Partial factor/ Category
				Near edge	Far edge		
1	120.00	4.50(L)	50.00	3.00	30.00	=	N/A 1.00 Var
2	120.00	0.10(L)	50.00	1.50	5.50	=	N/A 1.00 -
3	120.00	1.50(L)	50.00	10.00	0.00	5.50	N/A 1.00 -
4	120.00	0.10(L)	10.00	1.50	5.00	=	N/A 1.00 Var

Note: L = Left side, R = Right side
 A trapezoidal surcharge is defined by two values:
 N = at edge near to wall, F = at edge far from wall
 Limit State Categories P/U = Permanent Unfavourable
 P/F = Permanent Favourable
 Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 120.00
2	Apply surcharge no.2 at elevation 120.00
3	Apply surcharge no.3 at elevation 120.00
4	Apply surcharge no.4 at elevation 120.00
5	Change EI of wall to 1000000 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

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

Bending moment and displacement calculation:
 Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m
 Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m
 Distance to rigid boundary on Right side = 30.00 m

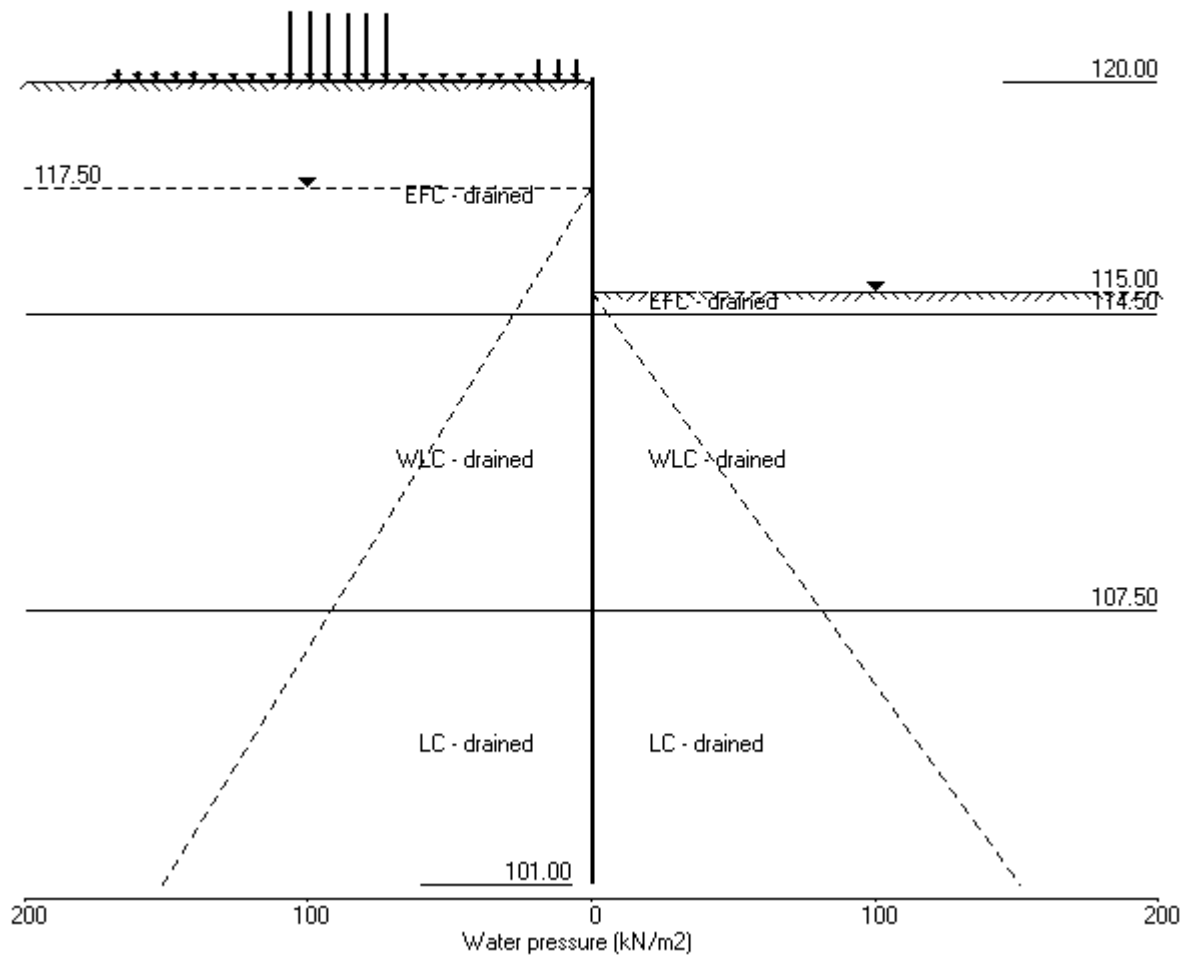
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 120.00	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 120.00	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 120.00	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 120.00	Yes	Yes	Yes
5	Change EI of wall to 1000000kN.m2/m ru	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_4_5m_IEsens_SLS_v4	Date:20-12-2019
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

Units: kN,m

Stage No. 7 Excavate to elevation 115.00 on RIGHT side

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

				FoS for toe elev. = 101.00		Toe elev. for FoS = 1.000		
				-----		-----		
Stage	--- G.L. ---	Strut		Factor	Moment	Toe	Wall	Direction
No.	Act. Pass.	Elev.		of	equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
7	120.00 115.00	Cant.		1.328	102.36	106.21	8.79	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m
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 30.00 from wall
Right side 30.00 from wall

Limit State: Serviceability Limit State

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

*** Wall displacements reset to zero at stage 5

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	120.00	0.00	0.069	5.69E-03	0.0	0.0	
2	119.00	3.89	0.063	5.69E-03	1.9	1.4	
3	118.25	9.63	0.059	5.69E-03	7.0	4.5	
4	117.50	15.39	0.054	5.68E-03	16.4	12.9	
5	116.75	25.34	0.050	5.67E-03	31.7	30.5	
6	116.00	35.40	0.046	5.63E-03	54.5	62.3	
7	115.00	48.87	0.040	5.54E-03	96.6	136.6	
		26.37	0.040	5.54E-03	96.6	136.6	
8	114.50	16.53	0.037	5.47E-03	107.3	187.7	
9	113.75	1.75	0.033	5.31E-03	114.2	271.4	
10	113.00	-13.09	0.030	5.09E-03	109.9	356.0	
11	112.00	-32.98	0.025	4.71E-03	86.9	455.7	
12	111.00	-37.55	0.020	4.24E-03	51.6	532.5	
13	110.00	-41.98	0.016	3.71E-03	11.8	562.7	
14	109.00	-36.96	0.013	3.17E-03	-27.6	558.5	
15	108.25	-24.54	0.010	2.78E-03	-50.7	527.3	
16	107.50	-13.98	0.009	2.41E-03	-65.1	482.3	
17	106.75	-11.94	0.007	2.08E-03	-74.8	429.4	
18	106.00	-8.39	0.005	1.78E-03	-82.5	369.9	
19	105.00	-2.11	0.004	1.46E-03	-87.7	283.0	
20	104.00	5.39	0.002	1.23E-03	-86.1	193.9	
21	103.00	13.98	0.001	1.08E-03	-76.4	110.3	
22	102.00	28.99	0.000	1.01E-03	-54.9	40.7	
23	101.00	80.84	-0.001	9.90E-04	0.0	-0.0	

(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.00	0.00	0.00	0.00	22.50	0.00	0.00a	948
2	119.00	0.00	27.58	3.89	97.73	3.89	3.89a	948
3	118.25	0.00	41.37	9.63	135.34	9.63	9.63a	948
4	117.50	0.00	55.21	15.39	173.08	15.39	15.39a	948
5	116.75	6.89	62.55	18.45	193.13	18.45	25.34a	948
6	116.00	13.77	70.17	21.63	213.91	21.63	35.40a	948
7	115.00	22.95	80.48	25.92	242.01	25.92	48.87a	948
8	114.50	27.54	85.62	28.06	256.03	28.06	55.60a	948
		27.54	85.62	28.06	256.03	28.06	55.60a	2634
9	113.75	34.43	93.26	31.25	276.89	31.25	65.67a	2634
10	113.00	41.31	100.82	34.39	297.50	34.39	75.71a	2634
11	112.00	50.49	110.76	38.53	324.61	38.53	89.02a	2634
12	111.00	59.67	120.56	42.61	351.33	58.07	117.74	2634
13	110.00	68.85	130.25	46.65	377.78	77.82	146.68	2634
14	109.00	78.03	139.87	50.66	404.02	96.05	174.08	2634
15	108.25	84.92	147.05	53.65	423.60	108.73	193.65	2634
16	107.50	91.80	154.21	56.63	443.13	120.61	212.42	2634
		91.80	154.21	48.81	547.55	120.61	212.42	2634
17	106.75	98.69	161.36	51.33	571.96	128.75	227.43	3108
18	106.00	105.57	168.50	53.85	596.35	137.55	243.13	3582
19	105.00	114.75	178.01	57.20	628.84	150.00	264.75	4214
20	104.00	123.93	187.52	60.55	661.33	163.02	286.96	4846
21	103.00	133.11	197.03	63.91	693.83	176.57	309.68	5478
22	102.00	142.30	206.55	67.26	726.35	193.37	335.67	30428
23	101.00	151.48	216.08	70.62	758.90	229.15	380.63	33576

Node no.	Y coord	RIGHT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	119.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	118.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	116.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	116.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	22.50	22.50	22.50p	1269
8	114.50	5.41	4.09	0.00	33.66	33.66	39.07p	1269
		5.41	4.09	0.00	33.66	33.66	39.07p	3526
9	113.75	13.52	10.23	0.00	50.40	50.40	63.93p	3526
10	113.00	21.64	16.37	0.00	67.16	67.16	88.80p	3526
11	112.00	32.46	24.58	2.64	89.55	89.55	122.01p	3526
12	111.00	43.28	32.81	6.07	112.01	112.01	155.29p	3526
13	110.00	54.10	41.08	9.51	134.56	134.56	188.66p	3526
14	109.00	64.92	49.39	12.97	157.22	146.13	211.04	3526
15	108.25	73.03	55.65	15.58	174.29	145.15	218.18	3526
16	107.50	81.15	61.94	18.20	191.45	145.25	226.39	3526
		81.15	61.94	16.28	232.32	145.25	226.39	3526
17	106.75	89.26	68.26	18.51	253.90	150.11	239.37	4161
18	106.00	97.38	74.60	20.75	275.59	154.14	251.51	4796
19	105.00	108.20	83.12	23.75	304.68	158.67	266.87	5642
20	104.00	119.02	91.69	26.77	333.96	162.56	281.57	6488

(continued)

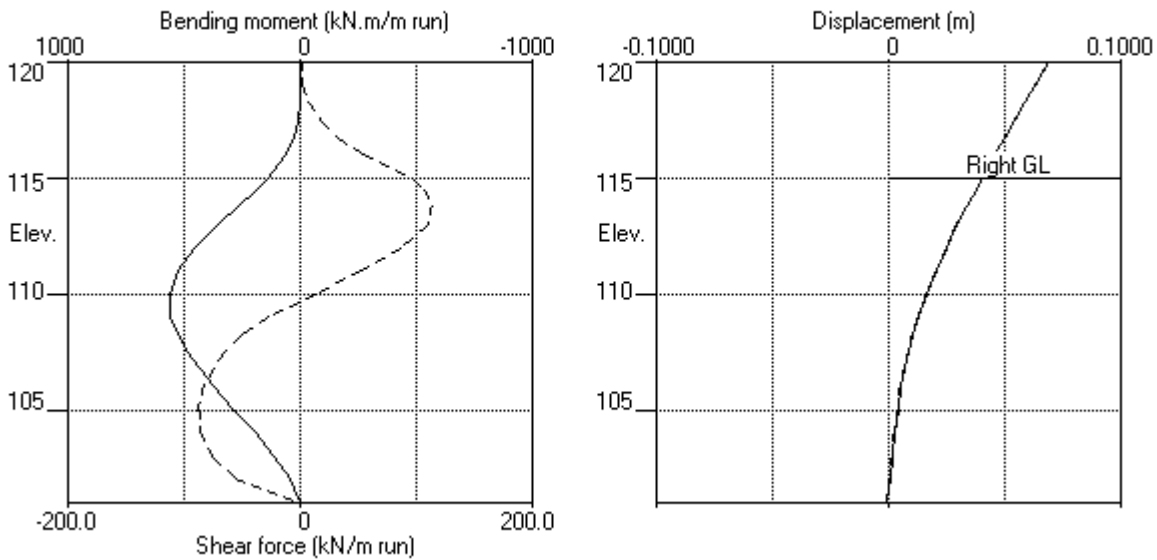
Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	----- RIGHT side -----					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
21	103.00	129.84	100.32	29.81	363.45	165.86	295.70	7335
22	102.00	140.66	109.01	32.88	393.13	166.02	306.68	30428
23	101.00	151.48	117.76	35.96	423.00	148.31	299.78	33576

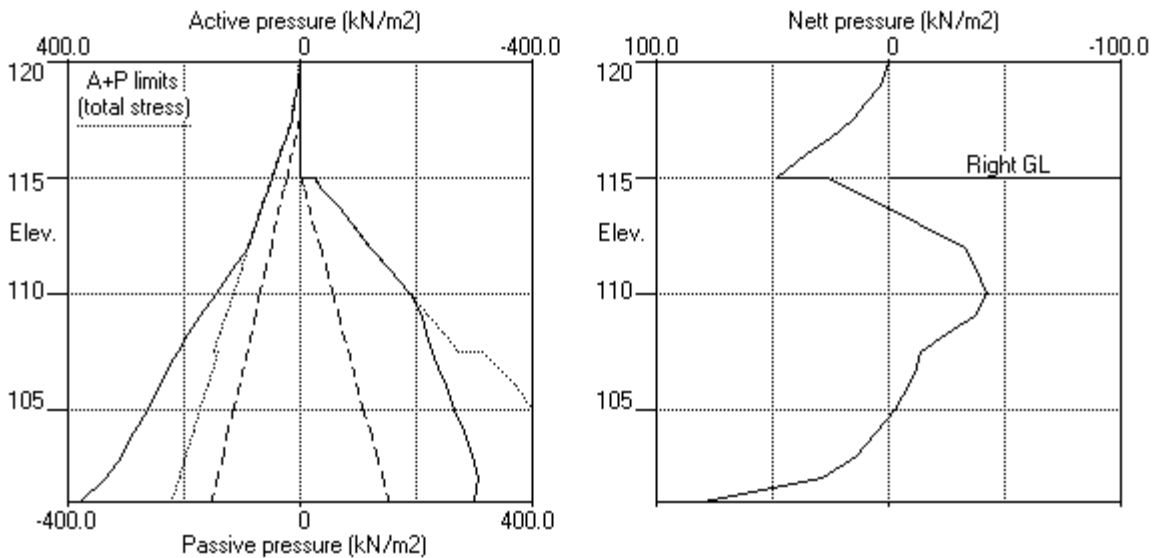
Note: 89.02a Soil pressure at active limit
 188.66p Soil pressure at passive limit

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_4_5m_IEsens_SLS_v4	
Portobello Road Enabling Feasibility	Date:20-12-2019
Section 1 - Option 1 (Sheet pile wall)	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	--- G.L. ---		Strut Elev.	FoS for toe elev. = 101.00		Toe elev. for FoS = 1.000		Direction of failure
No.	Act.	Pass.		Factor	Moment	Toe elev.	Wall Penetr	
				Safety	at elev.	-ation		
1	120.00	120.00	Cant.	Conditions not suitable for FoS calc.				
2	120.00	120.00	Cant.	Conditions not suitable for FoS calc.				
3	120.00	120.00	Cant.	Conditions not suitable for FoS calc.				
4	120.00	120.00	Cant.	Conditions not suitable for FoS calc.				
5	120.00	120.00		No analysis at this stage				
6	120.00	120.00	Cant.	Conditions not suitable for FoS calc.				
7	120.00	115.00	Cant.	1.328	102.36	106.21	8.79	L to R

Checked :

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	103.00	-4	115.00	0	-5	1	114.50	-1	117.50	2	-2
2	11	112.00	-1	117.50	15	-1	5	114.50	-2	109.00	7	-2
3	11	112.00	-1	117.50	15	-1	6	114.50	-2	109.00	8	-2
4	24	112.00	-0	118.25	33	-0	9	114.50	-3	108.25	12	-4
5	No calculation at this stage											
6	8	104.00	-29	115.00	11	-39	6	114.50	-10	116.75	8	-13
7	563	110.00	-0	101.00	760	-0	114	113.75	-88	105.00	154	-118

Summary of results (continued)

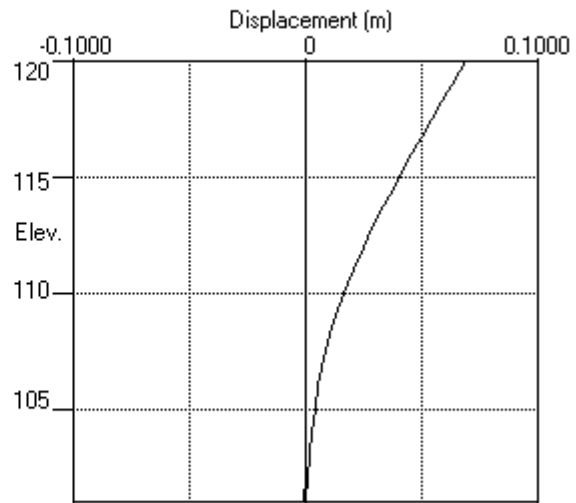
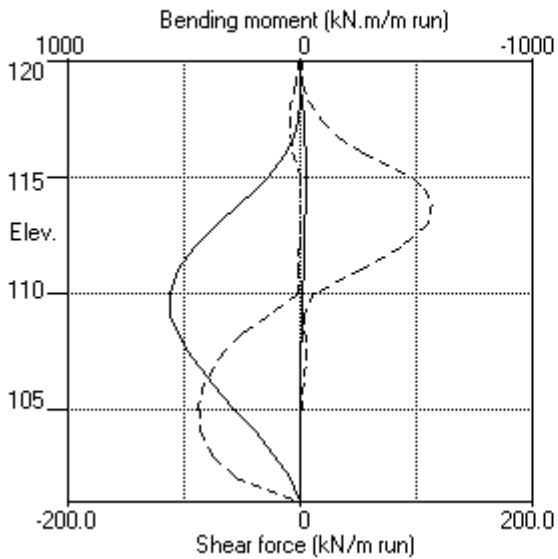
Maximum and minimum displacement at each stage

Stage no.	-----	Displacement	-----	Stage description
	maximum	elev.	minimum	elev.
	m		m	
1	0.001	120.00	0.000	120.00
2	0.002	120.00	0.000	120.00
3	0.002	120.00	0.000	120.00
4	0.003	120.00	0.000	120.00
5	Wall displacements reset to zero			Change EI of wall to 1000000kN.m2/m run
6	0.004	120.00	-0.000	101.00
7	0.069	120.00	-0.001	101.00

Excav. to elev. 115.00 on RIGHT side

Units: kN,m

Bending moment, shear force, displacement envelopes



Section B_Offset45m_IE500000_DA1C2

TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_45m_Contig900mm_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	120.00	3 EFC - drained	3 EFC - drained
2	114.50	5 WLC - drained	5 WLC - drained
3	107.50	7 LC - drained	7 LC - drained

SOIL PROPERTIES (Unfactored SLS soil strengths)

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy)	Ko (dKo/dy)	NC/OC (Nu)	Ka (Kac)	Kp (Kpc)	kN/m2 (dc/dy)
1 Not defined							
2 Ash	11.00	0 (5000)	0.430	NC (0.300)	0.229 (0.000)	6.522 (0.000)	
3 EFC - drained	19.00	9000	0.577	NC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
4 EFC - undrained	19.00	12000	1.000	NC (0.490)	1.000 (2.389)	1.000 (2.390)	30.00u
5 WLC - drained	19.00	25000	1.000	OC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
6 WLC - undrained	19.00	33300	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u
7 LC - drai.. (107.50)	19.00	25000 (6000)	1.000	OC (0.200)	0.353 (1.388)	3.416 (5.182)	4.000d
8 LC - undr.. (107.50)	19.00	33300 (8000)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u (8.000)

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 Not defined						
2 Ash	35.00	0.619	0.00	35.00	0.619	0.00
3 EFC - drained	21.00	0.653	0.00	21.00	0.653	0.00
4 EFC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
5 WLC - drained	21.00	0.653	0.00	21.00	0.653	0.00
6 WLC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
7 LC - drained	25.00	0.645	0.00	25.00	0.645	0.00
8 LC - undrained	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	117.50	117.50

Automatic water pressure balancing at toe of wall : Yes

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	117.50	117.50	0.0	1	115.00	115.00	0.0 MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 101.00
 Maximum finite element length = 1.00 m
 Youngs modulus of wall E = 1.5000E+07 kN/m2
 Moment of inertia of wall I = 0.032206 m4/m run
 E.I = 483090 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Distance from Elev.	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 -----		Equiv. soil type	Partial factor/ Category
				Near edge	Far edge		
1	120.00	4.50(L)	50.00	3.00	30.00	=	N/A 1.30 Var
2	120.00	0.10(L)	50.00	1.50	5.50	=	N/A 1.00 -
3	120.00	1.50(L)	50.00	10.00	0.00	5.50	N/A 1.00 -
4	120.00	0.10(L)	10.00	1.50	5.00	=	N/A 1.30 Var

Note: L = Left side, R = Right side
 A trapezoidal surcharge is defined by two values:
 N = at edge near to wall, F = at edge far from wall
 Limit State Categories P/U = Permanent Unfavourable
 P/F = Permanent Favourable
 Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 120.00
2	Apply surcharge no.2 at elevation 120.00
3	Apply surcharge no.3 at elevation 120.00
4	Apply surcharge no.4 at elevation 120.00
5	Change EI of wall to 483090 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
6	Apply water pressure profile no.1 (Worst Cred.)
7	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

Stability analysis:

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

Parameters for undrained strata:

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

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m
 Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m
 Distance to rigid boundary on Right side = 30.00 m

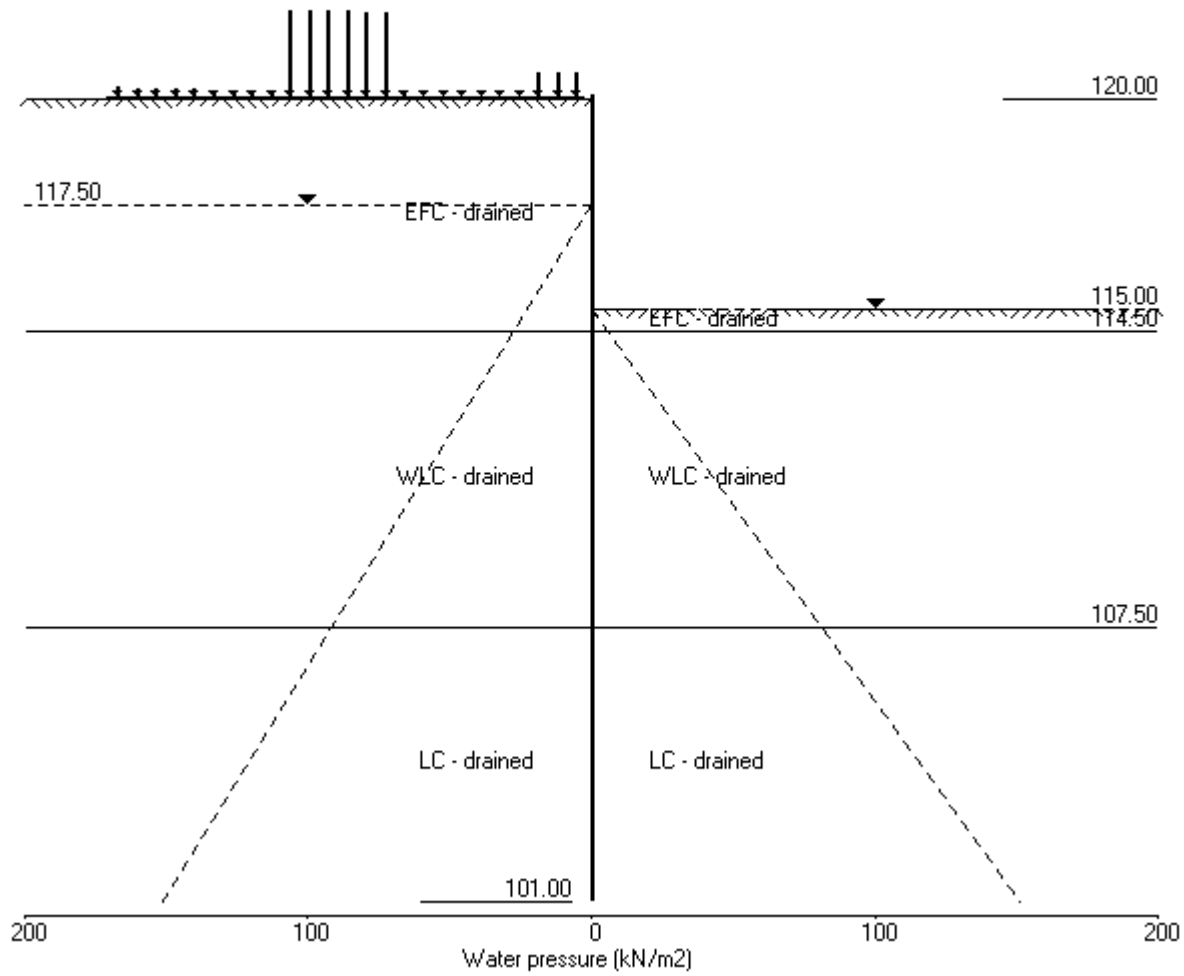
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 120.00	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 120.00	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 120.00	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 120.00	Yes	Yes	Yes
5	Change EI of wall to 483090kN.m2/m run	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_45m_Contig900mm_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

Units: kN,m

Stage No. 7 Excavate to elevation 115.00 on RIGHT side

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

			Overall				Direction of failure
			FoS for toe elev. = 101.00	Moment of equilib. at elev.	Toe elev. for FoS = 1.000	Wall Penetr-ation	
Stage No.	--- G.L. Act.	--- Pass.	Strut Elev.	Factor Safety		Toe elev.	
7	120.00	115.00	Cant.	1.052	102.35	102.01	12.99

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall

Right side 30.00 from wall

Limit State: ULS DAI Combination 2

*** Wall displacements reset to zero at stage 5

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	120.00	0.00	0.292	2.37E-02	0.0	-0.0	
2	119.00	7.49	0.268	2.37E-02	3.7	2.1	
3	118.25	14.23	0.250	2.37E-02	11.9	7.6	
4	117.50	21.03	0.232	2.37E-02	25.1	21.1	
5	116.75	31.57	0.215	2.36E-02	44.8	46.8	
6	116.00	42.26	0.197	2.35E-02	72.5	90.3	
7	115.00	56.59	0.173	2.32E-02	121.9	186.2	
		40.78	0.173	2.32E-02	121.9	186.2	
8	114.50	33.46	0.162	2.30E-02	140.5	252.0	
9	113.75	22.44	0.145	2.26E-02	161.5	365.6	
10	113.00	11.35	0.128	2.19E-02	174.1	491.8	
11	112.00	-3.57	0.107	2.08E-02	178.0	668.8	
12	111.00	-18.63	0.086	1.92E-02	166.9	842.3	
13	110.00	-33.83	0.068	1.74E-02	140.7	997.1	
14	109.00	-49.17	0.052	1.52E-02	99.2	1118.0	
15	108.25	-60.76	0.041	1.34E-02	58.0	1177.4	
16	107.50	-72.43	0.031	1.16E-02	8.0	1202.6	
		-103.74	0.031	1.16E-02	8.0	1202.6	
17	106.75	-105.07	0.023	9.81E-03	-70.3	1178.4	
18	106.00	-98.39	0.017	8.04E-03	-146.6	1102.1	
19	105.00	-57.92	0.010	5.97E-03	-224.7	906.1	
20	104.00	-18.19	0.005	4.36E-03	-262.8	652.2	
21	103.00	19.24	0.001	3.30E-03	-262.3	380.1	
22	102.00	125.68	-0.002	2.77E-03	-189.8	127.2	
23	101.00	253.91	-0.005	2.64E-03	0.0	-0.0	

(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.00	0.00	0.00	0.00	15.82	0.00	0.00a	914
2	119.00	0.00	28.81	7.49	79.62	7.49	7.49a	914
3	118.25	0.00	42.58	14.23	110.11	14.23	14.23a	914
4	117.50	0.00	56.44	21.03	140.79	21.03	21.03a	914
5	116.75	6.89	63.89	24.68	157.30	24.68	31.57a	914
6	116.00	13.77	71.66	28.49	174.51	28.49	42.26a	914
7	115.00	22.95	82.17	33.64	197.78	33.64	56.59a	914
8	114.50	27.54	87.40	36.21	209.36	36.21	63.75a	914
		27.54	87.40	36.21	209.36	36.21	63.75a	2538
9	113.75	34.43	95.16	40.01	226.54	40.01	74.44a	2538
10	113.00	41.31	102.79	43.75	243.44	43.75	85.06a	2538
11	112.00	50.49	112.78	48.65	265.57	48.65	99.14a	2538
12	111.00	59.67	122.60	53.46	287.30	53.46	113.13a	2538
13	110.00	68.85	132.27	58.20	308.73	58.20	127.06a	2538
14	109.00	78.03	141.85	62.90	329.94	62.90	140.93a	2538
15	108.25	84.92	148.99	66.40	345.75	66.40	151.32a	2538
16	107.50	91.80	156.11	69.89	361.51	69.89	161.69a	2538
		91.80	156.11	61.65	426.82	63.46	155.26	2538
17	106.75	98.69	163.21	64.68	445.59	80.06	178.75	2995
18	106.00	105.57	170.29	67.70	464.32	99.24	204.82	3452
19	105.00	114.75	179.73	71.72	489.28	126.32	241.08	4061
20	104.00	123.93	189.17	75.75	514.24	153.13	277.07	4670
21	103.00	133.11	198.62	79.78	539.20	179.00	312.12	5280
22	102.00	142.30	208.07	83.81	564.19	241.90	384.20	20898
23	101.00	151.48	217.53	87.84	589.21	315.87	467.34	23059

Node no.	Y coord	RIGHT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	119.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	118.25	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	116.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	116.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	15.82	15.82	15.82p	1221
8	114.50	5.41	4.09	0.00	24.88	24.88	30.29p	1221
		5.41	4.09	0.00	24.88	24.88	30.29p	3391
9	113.75	13.52	10.23	0.00	38.47	38.47	51.99p	3391
10	113.00	21.64	16.37	1.39	52.07	52.07	73.71p	3391
11	112.00	32.46	24.58	5.41	70.25	70.25	102.71p	3391
12	111.00	43.28	32.81	9.45	88.48	88.48	131.76p	3391
13	110.00	54.10	41.08	13.50	106.79	106.79	160.89p	3391
14	109.00	64.92	49.39	17.57	125.19	125.19	190.11p	3391
15	108.25	73.03	55.65	20.64	139.05	139.05	212.08p	3391
16	107.50	81.15	61.94	23.72	152.98	152.98	234.12p	3391
		81.15	61.94	21.49	177.85	177.85	259.00p	3391
17	106.75	89.26	68.26	24.19	194.56	194.56	283.82p	4002
18	106.00	97.38	74.60	26.89	211.34	205.83	303.20	4612
19	105.00	108.20	83.12	30.52	233.85	190.80	299.00	5426
20	104.00	119.02	91.69	34.18	256.51	176.24	295.26	6240

(continued)

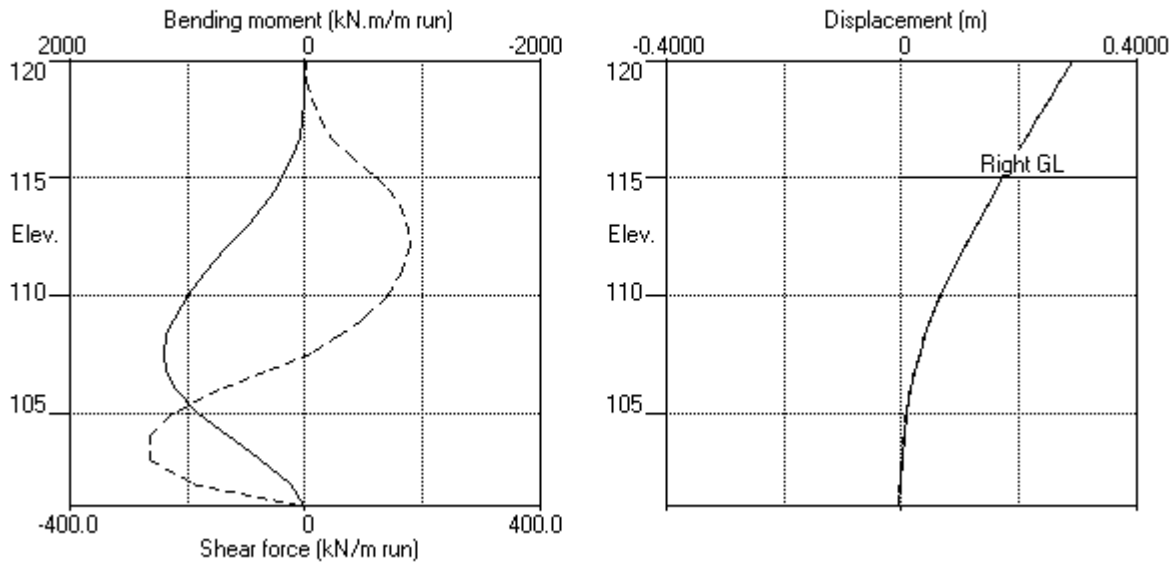
Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	----- RIGHT side -----					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
21	103.00	129.84	100.32	37.86	279.33	163.04	292.88	7054
22	102.00	140.66	109.01	41.57	302.30	117.87	258.52	20898
23	101.00	151.48	117.76	45.29	325.42	61.96	213.43	23059

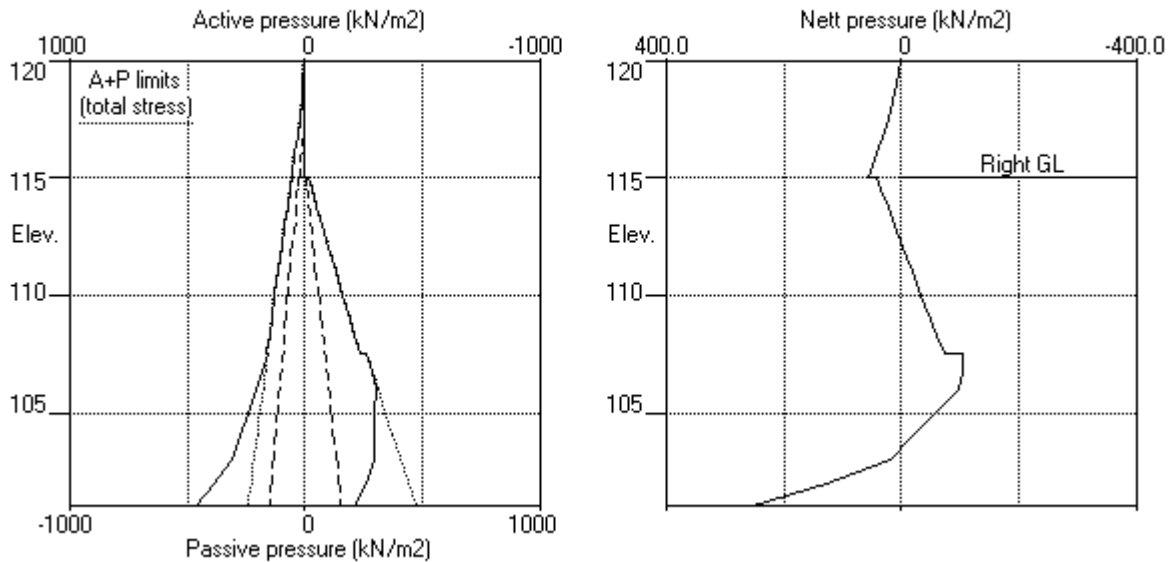
Note: 161.69a Soil pressure at active limit
 283.82p Soil pressure at passive limit

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_45m_Contig900mm_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

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. = 101.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of equilib.	elev.	Penetr	of
				Safety at elev.		-ation	failure
1	120.00	120.00	Cant.	Conditions not suitable for FoS calc.			
2	120.00	120.00	Cant.	Conditions not suitable for FoS calc.			
3	120.00	120.00	Cant.	Conditions not suitable for FoS calc.			
4	120.00	120.00	Cant.	Conditions not suitable for FoS calc.			
5	120.00	120.00		No analysis at this stage			
6	120.00	120.00	Cant.	Conditions not suitable for FoS calc.			
7	120.00	115.00	Cant.	1.052 102.35	102.01	12.99	L to R

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m
 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 30.00 from wall
 Right side 30.00 from wall

Limit State: ULS DAL Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum m	minimum m	maximum kN.m/m	minimum kN.m/m	maximum kN/m	minimum kN/m
1	120.00	0.292	0.000	0.0	-0.0	0.0	0.0
2	119.00	0.268	0.000	2.1	-1.5	3.7	-4.4
3	118.25	0.250	0.000	7.6	-5.8	11.9	-6.8
4	117.50	0.232	0.000	21.1	-11.8	25.1	-9.1
5	116.75	0.215	0.000	46.8	-19.0	44.8	-9.3
6	116.00	0.197	0.000	90.3	-24.8	72.5	-5.9
7	115.00	0.173	0.000	186.2	-27.0	121.9	0.0
8	114.50	0.162	0.000	252.0	-24.4	140.5	0.0
9	113.75	0.145	0.000	365.6	-19.3	161.5	0.0
10	113.00	0.128	0.000	491.8	-15.5	174.1	0.0
11	112.00	0.107	0.000	668.8	-11.9	178.0	-0.9
12	111.00	0.086	0.000	842.3	-9.2	166.9	-2.4
13	110.00	0.068	0.000	997.1	-6.9	140.7	-3.1
14	109.00	0.052	0.000	1118.0	-4.6	99.2	-3.2
15	108.25	0.041	0.000	1177.4	-2.4	58.0	-2.9
16	107.50	0.031	0.000	1202.6	-1.1	8.0	-2.4
17	106.75	0.023	0.000	1178.4	-0.8	4.1	-70.3
18	106.00	0.017	0.000	1102.1	-0.5	3.5	-146.6
19	105.00	0.010	0.000	906.1	-0.1	1.8	-224.7
20	104.00	0.005	0.000	652.2	0.0	0.2	-262.8
21	103.00	0.001	0.000	380.1	0.0	0.0	-262.3
22	102.00	0.000	-0.002	127.2	0.0	0.0	-189.8
23	101.00	0.000	-0.005	0.0	-0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	maximum kN.m/m	elev.	minimum kN.m/m	elev.	maximum kN/m	elev.	minimum kN/m	elev.
1	0.2	103.00	-4.2	115.00	2.0	114.50	-1.6	117.50
2	7.4	112.00	-1.8	116.75	4.9	114.50	-1.4	110.00
3	8.0	112.00	-2.6	116.75	5.6	114.50	-1.5	109.00
4	18.9	112.00	-1.1	118.25	8.8	114.50	-3.2	109.00
5	No calculation at this stage							
6	9.4	104.00	-27.0	115.00	7.9	114.50	-9.3	116.75
7	1202.6	107.50	-0.0	120.00	178.0	112.00	-262.8	104.00

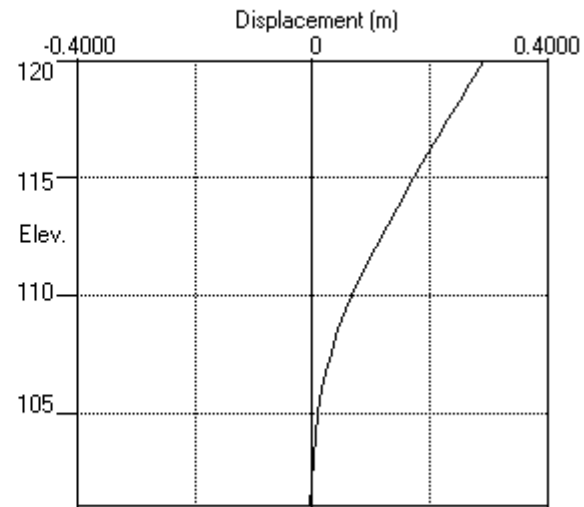
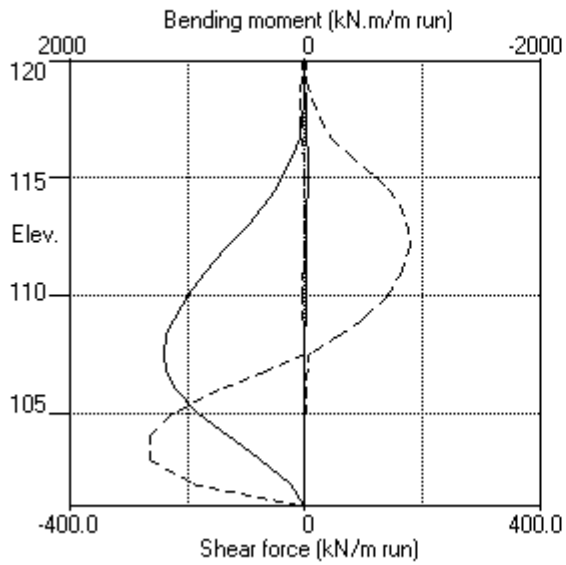
Summary of results (continued)

Maximum and minimum displacement at each stage

Stage -----		Displacement -----				Stage description
no.	maximum	elev.	minimum	elev.	-----	
	m		m			
1	0.001	120.00	0.000	120.00	Apply surcharge no.1 at elev. 120.00	
2	0.002	120.00	0.000	120.00	Apply surcharge no.2 at elev. 120.00	
3	0.002	120.00	0.000	120.00	Apply surcharge no.3 at elev. 120.00	
4	0.003	120.00	0.000	120.00	Apply surcharge no.4 at elev. 120.00	
5	Wall displacements reset to zero					Change EI of wall to 483090kN.m2/m run
6	0.004	115.00	-0.000	101.00	Apply water pressure profile no.1	
7	0.292	120.00	-0.005	101.00	Excav. to elev. 115.00 on RIGHT side	

Units: kN,m

Bending moment, shear force, displacement envelopes



Section B_Offset60m_IE125000_SLS

TRANSPORT FOR LONDON

Program: WALLAP Version 6.06 Revision A51.B69.R55

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Data filename/Run ID: PortobelloRoad_SectionB_SP_6m_IEsens_SLS_v4

Portobello Road Enabling Feasibility

Section 1 - Option 1 (Sheet pile wall)

Sheet No.

Job No.

Made by : I.M

Date:20-12-2019

Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	119.50	3 EFC - drained	3 EFC - drained
2	114.50	5 WLC - drained	5 WLC - drained
3	107.50	7 LC - drained	7 LC - drained

SOIL PROPERTIES

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description (Datum elev.)	kN/m3	Eh,kN/m2 (dEh/dy)	Ko (dKo/dy)	NC/OC (Nu)	Ka (Kac)	Kp (Kpc)	kN/m2 (dc/dy)
1 Not defined							
2 Ash	11.00	0 (5000)	0.430	NC (0.300)	0.229 (0.000)	6.522 (0.000)	
3 EFC - drained	19.00	9000	0.577	NC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
4 EFC - undrained	19.00	12000	1.000	NC (0.490)	1.000 (2.389)	1.000 (2.390)	30.00u
5 WLC - drained	19.00	25000	1.000	OC (0.200)	0.417 (1.520)	2.728 (4.501)	5.000d
6 WLC - undrained	19.00	33300	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u
7 LC - drai.. (107.50)	19.00	25000 (6000)	1.000	OC (0.200)	0.353 (1.388)	3.416 (5.182)	4.000d
8 LC - undr.. (107.50)	19.00	33300 (8000)	1.000	OC (0.490)	1.000 (2.389)	1.000 (2.390)	80.00u (8.000)

Additional soil parameters associated with Ka and Kp

		--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction	Wall adhesion	Back-fill	Soil friction	Wall adhesion	Back-fill
		angle	coeff.	angle	angle	coeff.	angle
No. Description							
1 Not defined							
2 Ash		35.00	0.619	0.00	35.00	0.619	0.00
3 EFC - drained		21.00	0.653	0.00	21.00	0.653	0.00
4 EFC - undrained		0.00	0.500	0.00	0.00	0.500	0.00
5 WLC - drained		21.00	0.653	0.00	21.00	0.653	0.00
6 WLC - undrained		0.00	0.500	0.00	0.00	0.500	0.00
7 LC - drained		25.00	0.645	0.00	25.00	0.645	0.00
8 LC - undrained		0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

Initial water table elevation Left side Right side
117.50 117.50

Automatic water pressure balancing at toe of wall : Yes

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
1	1	117.50	117.50	0.0	1	115.00	115.00

0.0 MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 102.00
 Maximum finite element length = 1.00 m
 Youngs modulus of wall E = 3.0000E+07 kN/m2
 Moment of inertia of wall I = 0.083333 m4/m run
 E.I = 2.5000E+06 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Distance from Elev.	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge Far edge		Equiv. soil type	Partial factor/ Category
1	119.50	6.00(L)	50.00	3.00	30.00 =	N/A	1.00 Var
2	119.50	0.10(L)	50.00	3.00	0.00 11.00	N/A	1.00 -
3	119.50	3.00(L)	50.00	10.00	11.00 =	N/A	1.00 -
4	119.50	0.10(L)	10.00	3.00	5.00 =	N/A	1.00 Var

Note: L = Left side, R = Right side
 A trapezoidal surcharge is defined by two values:
 N = at edge near to wall, F = at edge far from wall
 Limit State Categories P/U = Permanent Unfavourable
 P/F = Permanent Favourable
 Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description -----
1	Apply surcharge no.1 at elevation 119.50
2	Apply surcharge no.2 at elevation 119.50
3	Apply surcharge no.3 at elevation 119.50
4	Apply surcharge no.4 at elevation 119.50
5	Change EI of wall to 2.5000E+06 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
6	Apply water pressure profile no.1 (Mod. Conserv.)
7	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

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

Bending moment and displacement calculation:
 Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:
 Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m
 Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m
 Distance to rigid boundary on Right side = 30.00 m

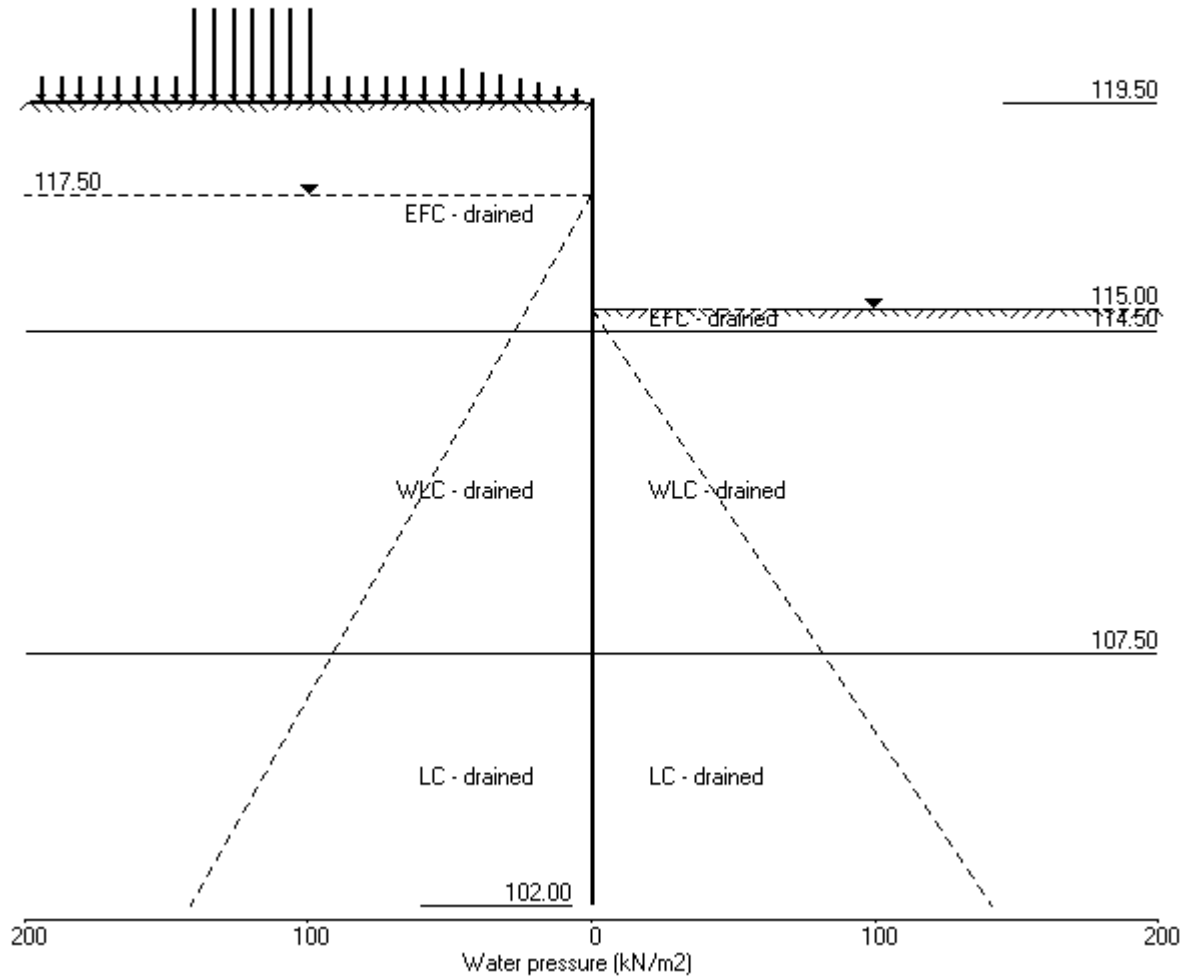
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 119.50	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 119.50	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 119.50	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 119.50	Yes	Yes	Yes
5	Change EI of wall to 2.5000E+06kN.m2/m	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_SP_6m_IEsens_SLS_v4	
Portobello Road Enabling Feasibility	Date:20-12-2019
Section 1 - Option 1 (Sheet pile wall)	Checked :

Units: kN,m

Stage No. 7 Excavate to elevation 115.00 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				FoS for toe elev. = 102.00		Toe elev. for FoS = 1.000		
				-----		-----		
Stage	--- G.L. ---	Strut		Factor	Moment	Toe	Wall	Direction
No.	Act. Pass.	Elev.		of	equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
7	119.50 115.00	Cant.		1.323	103.22	106.99	8.01	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall

Right side 30.00 from wall

Limit State: Serviceability Limit State

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

*** Wall displacements reset to zero at stage 5

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	119.50	0.00	0.039	2.86E-03	0.0	-0.0	
2	118.50	2.92	0.036	2.86E-03	1.5	1.3	
3	117.50	11.71	0.033	2.86E-03	8.8	5.6	
4	116.75	22.11	0.031	2.86E-03	21.5	16.4	
5	116.00	32.42	0.029	2.85E-03	41.9	39.6	
6	115.00	46.08	0.026	2.82E-03	81.2	99.9	
		23.58	0.026	2.82E-03	81.2	99.9	
7	114.50	13.85	0.025	2.80E-03	90.5	143.0	
8	113.75	-0.78	0.023	2.75E-03	95.4	213.3	
9	113.00	-15.47	0.021	2.69E-03	89.3	283.2	
10	112.00	-24.43	0.018	2.57E-03	69.4	369.1	
11	111.00	-32.90	0.015	2.42E-03	40.7	423.6	
12	110.00	-36.17	0.013	2.26E-03	6.2	451.5	
13	109.00	-25.59	0.011	2.09E-03	-24.7	439.4	
14	108.25	-18.32	0.009	1.97E-03	-41.2	413.6	
15	107.50	-11.58	0.008	1.85E-03	-52.4	377.4	
16	106.75	-11.81	0.007	1.75E-03	-61.1	334.8	
17	106.00	-9.97	0.005	1.66E-03	-69.3	285.5	
18	105.00	-4.52	0.004	1.57E-03	-76.6	211.0	
19	104.00	4.49	0.002	1.50E-03	-76.6	131.9	
20	103.00	17.26	0.001	1.47E-03	-65.7	57.3	
21	102.00	114.14	-0.001	1.46E-03	0.0	0.0	

(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side						Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Effective stresses							
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2			
1	119.50	0.00	0.00	0.00	22.50	0.00	0.00a	875	
2	118.50	0.00	25.26	2.92	91.40	2.92	2.92a	875	
3	117.50	0.00	46.37	11.71	148.98	11.71	11.71a	875	
4	116.75	6.84	54.91	15.27	172.28	15.27	22.11a	875	
5	116.00	13.68	63.24	18.74	195.00	18.74	32.42a	875	
6	115.00	22.81	74.12	23.27	224.68	23.27	46.08a	875	
7	114.50	27.37	79.48	25.51	239.30	25.51	52.87a	875	
		27.37	79.48	25.51	239.30	25.51	52.87a	2432	
8	113.75	34.21	87.42	28.81	260.96	28.81	63.02a	2432	
9	113.00	41.05	95.25	32.08	282.32	32.08	73.13a	2432	
10	112.00	50.18	105.52	36.35	310.31	47.09	97.27	2432	
11	111.00	59.30	115.60	40.55	337.80	62.67	121.96	2432	
12	110.00	68.42	125.52	44.68	364.87	77.78	146.20	2432	
13	109.00	77.54	135.31	48.76	391.58	92.42	169.96	2432	
14	108.25	84.39	142.59	51.79	411.43	103.09	187.48	2432	
15	107.50	91.23	149.82	54.80	431.16	113.53	204.76	2432	
		91.23	149.82	47.26	532.55	113.53	204.76	2432	
16	106.75	98.07	157.02	49.80	557.14	120.76	218.83	2870	
17	106.00	104.91	164.19	52.33	581.63	128.94	233.85	3307	
18	105.00	114.04	173.71	55.69	614.17	141.22	255.26	3891	
19	104.00	123.16	183.21	59.03	646.62	155.15	278.31	4474	
20	103.00	132.28	192.70	62.38	679.02	170.84	303.12	5058	
21	102.00	141.40	202.18	65.72	711.40	228.96	370.37	55467	

Node no.	Y coord	RIGHT side						Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2			
1	119.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
2	118.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
3	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
4	116.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
5	116.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
6	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	
7	114.50	0.00	0.00	0.00	22.50	22.50	22.50p	1078	
		5.44	4.06	0.00	33.58	33.58	39.02p	1078	
		5.44	4.06	0.00	33.58	33.58	39.02p	2993	
8	113.75	13.60	10.16	0.00	50.20	50.20	63.80p	2993	
9	113.00	21.75	16.26	0.00	66.84	66.84	88.60p	2993	
10	112.00	32.63	24.40	2.56	89.07	89.07	121.70p	2993	
11	111.00	43.51	32.58	5.97	111.36	111.36	154.86p	2993	
12	110.00	54.39	40.78	9.38	133.73	127.98	182.37	2993	
13	109.00	65.26	49.01	12.82	156.19	130.29	195.55	2993	
14	108.25	73.42	55.22	15.40	173.12	132.38	205.80	2993	
15	107.50	81.58	61.45	17.99	190.11	134.76	216.34	2993	
		81.58	61.45	16.11	230.65	134.76	216.34	2993	
16	106.75	89.74	67.70	18.31	252.02	140.90	230.64	3532	
17	106.00	97.89	73.99	20.53	273.49	145.92	243.82	4071	
18	105.00	108.77	82.41	23.50	302.26	151.00	259.77	4790	
19	104.00	119.65	90.89	26.49	331.22	154.17	273.82	5508	
20	103.00	130.53	99.42	29.49	360.35	155.33	285.86	6226	
21	102.00	141.40	108.00	32.52	389.66	114.83	256.23	55467	

Run ID. PortobelloRoad_SectionB_SP_6m_IEsens_SLS_v4
Portobello Road Enabling Feasibility
Section 1 - Option 1 (Sheet pile wall)

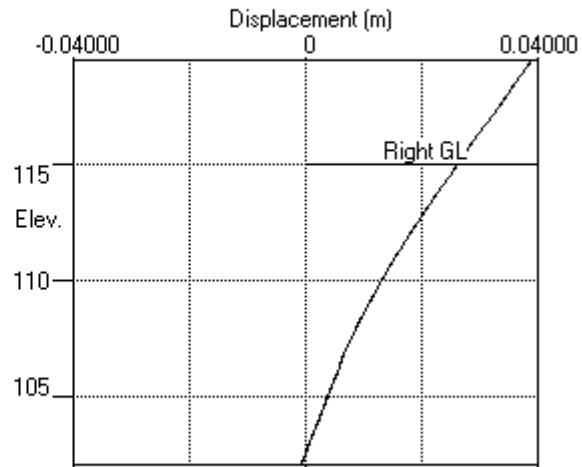
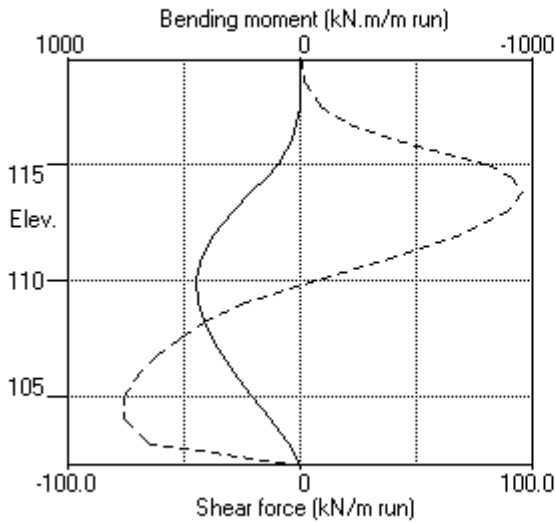
Sheet No.
Date:20-12-2019
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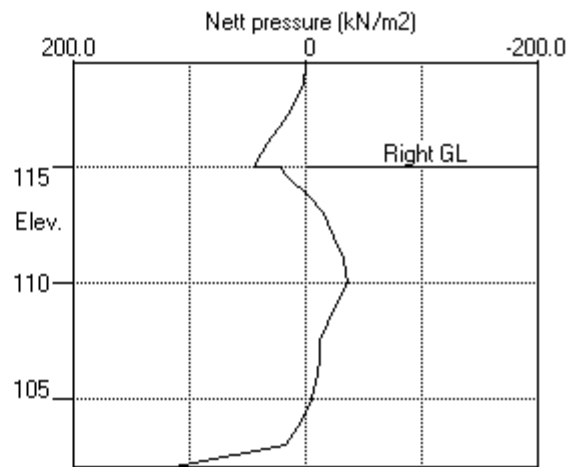
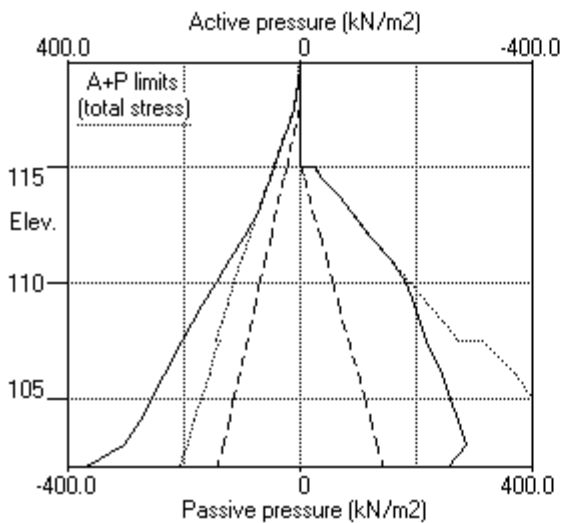
Stage No.7 Excavate to elevation 115.00 on RIGHT side
Note: 73.13a Soil pressure at active limit
 154.86p Soil pressure at passive limit

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



Stage No.7 Excav. to elev. 115.00 on RIGHT side



			FoS for toe elev. = 102.00		Toe elev. for FoS = 1.000			
Stage	--- G.L. ---		Strut	Factor	Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of	equilib.	elev.	Penetr	of
				Safety	at elev.		-ation	failure
1	119.50	119.50	Cant.	Conditions not suitable for FoS calc.				
2	119.50	119.50	Cant.	Conditions not suitable for FoS calc.				
3	119.50	119.50	Cant.	Conditions not suitable for FoS calc.				
4	119.50	119.50	Cant.	Conditions not suitable for FoS calc.				
5	119.50	119.50		No analysis at this stage				
6	119.50	119.50	Cant.	Conditions not suitable for FoS calc.				
7	119.50	115.00	Cant.	1.323	103.22	106.99	8.01	L to R

TRANSPORT FOR LONDON

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Data filename/Run ID: PortobelloRoad_SectionB_SP_6m_IEsens_SLS_v4

Portobello Road Enabling Feasibility

Section 1 - Option 1 (Sheet pile wall)

Sheet No.

Job No.

Made by : I.M

Date:20-12-2019

Checked :

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall

Right side 30.00 from wall

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut 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. m	min. m	max. kN.m/m	min. kN.m/m	max. kN.m/m	min. kN.m/m	max. kN/m	min. kN/m	max. kN/m	min. kN/m
1	119.50	0.039	0.000	0	-0	0	-0	0	0	0	0
2	118.50	0.036	0.000	1	-2	2	-3	1	-5	2	-7
3	117.50	0.033	0.000	6	-10	8	-13	9	-10	12	-13
4	116.75	0.031	0.000	16	-18	22	-24	21	-10	29	-14
5	116.00	0.029	0.000	40	-24	54	-33	42	-7	57	-9
6	115.00	0.026	0.000	100	-27	135	-37	81	-0	110	-0
7	114.50	0.025	0.000	143	-25	193	-33	91	0	122	0
8	113.75	0.023	0.000	213	-20	288	-27	95	-0	129	-0
9	113.00	0.021	0.000	283	-16	382	-22	89	-0	121	-0
10	112.00	0.018	0.000	369	-12	498	-16	69	-0	94	-1
11	111.00	0.015	0.000	424	-9	572	-13	41	-1	55	-1
12	110.00	0.013	0.000	452	-7	610	-10	6	-2	8	-3
13	109.00	0.011	0.000	439	-5	593	-7	2	-25	3	-33
14	108.25	0.009	0.000	414	-3	558	-4	3	-41	4	-56
15	107.50	0.008	0.000	377	-3	510	-4	3	-52	4	-71
16	106.75	0.007	0.000	335	-3	452	-3	3	-61	4	-83
17	106.00	0.005	0.000	286	-2	385	-3	2	-69	3	-94
18	105.00	0.004	0.000	211	-1	285	-2	1	-77	1	-103
19	104.00	0.002	0.000	132	-1	178	-1	1	-77	1	-103
20	103.00	0.001	0.000	57	-0	77	-0	0	-66	0	-89
21	102.00	0.000	-0.001	0	0	0	0	0	-0	0	-0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment						Shear force					
	Calculated				Factored		Calculated				Factored	
	max. elev.		min. elev.		max.	min.	max. elev.		min. elev.		max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	
1	0	102.00	-3	109.00	0	-4	1	105.00	-1	116.75	1	-1
2	8	112.00	-1	116.75	11	-1	4	114.50	-1	108.25	5	-1
3	9	112.00	-3	116.75	12	-4	6	114.50	-1	117.50	8	-2
4	29	111.00	-1	117.50	39	-1	11	114.50	-4	105.00	15	-5
5	No calculation at this stage											
6	5	105.00	-27	115.00	7	-37	8	114.50	-10	116.75	10	-14
7	452	110.00	-0	119.50	610	-0	95	113.75	-77	104.00	129	-103

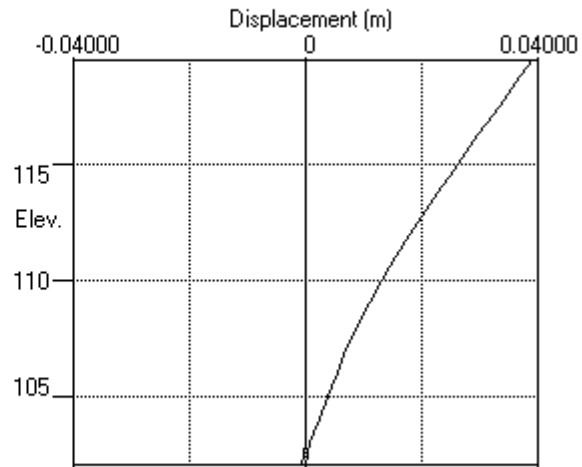
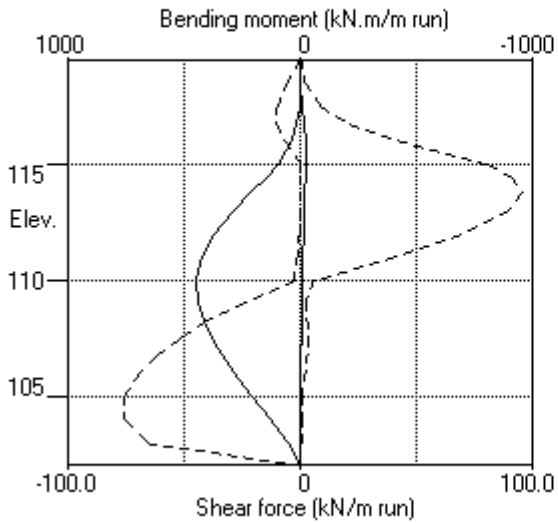
Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	-----	Displacement	-----		Stage description
	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.000	119.50	0.000	119.50	Apply surcharge no.1 at elev. 119.50
2	0.001	119.50	0.000	119.50	Apply surcharge no.2 at elev. 119.50
3	0.002	119.50	0.000	119.50	Apply surcharge no.3 at elev. 119.50
4	0.003	119.50	0.000	119.50	Apply surcharge no.4 at elev. 119.50
5	Wall displacements reset to zero				Change EI of wall to 2.5000E+06kN.m2/m run
6	0.005	119.50	0.000	119.50	Apply water pressure profile no.1
7	0.039	119.50	-0.001	102.00	Excav. to elev. 115.00 on RIGHT side

Units: kN,m

Bending moment, shear force, displacement envelopes



Section B_Offset60m_IE125000_DA1C2

TRANSPORT FOR LONDON

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Data filename/Run ID: PortobelloRoad_SectionB_6m_Sheetpile3600_v1_ULS2

Portobello Road Enabling Feasibility

Section 1 - Option 1 (Sheet pile wall)

Sheet No.

Job No.

Made by : I.M

Date:17-03-2020

Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types	
		Left side	Right side
1	119.50	3 EFC - drained	3 EFC - drained
2	114.50	5 WLC - drained	5 WLC - drained
3	107.50	7 LC - drained	7 LC - drained

SOIL PROPERTIES (Unfactored SLS soil strengths)

-- Soil type --	Bulk density	Young's Modulus	At rest coeff.	Consol state.	Active limit	Passive limit	Cohesion
No. Description	kN/m3	Eh,kN/m2	Ko	NC/OC	Ka	Kp	kN/m2
(Datum elev.)		(dEh/dy)	(dKo/dy)	(Nu)	(Kac)	(Kpc)	(dc/dy)
1 Not defined							
2 Ash	11.00	0	0.430	NC	0.229	6.522	
		(5000)		(0.300)	(0.000)	(0.000)	
3 EFC - drained	19.00	9000	0.577	NC	0.417	2.728	5.000d
				(0.200)	(1.520)	(4.501)	
4 EFC - undrained	19.00	12000	1.000	NC	1.000	1.000	30.00u
				(0.490)	(2.389)	(2.390)	
5 WLC - drained	19.00	25000	1.000	OC	0.417	2.728	5.000d
				(0.200)	(1.520)	(4.501)	
6 WLC - undrained	19.00	33300	1.000	OC	1.000	1.000	80.00u
				(0.490)	(2.389)	(2.390)	
7 LC - drai..	19.00	25000	1.000	OC	0.353	3.416	4.000d
(107.50)		(6000)		(0.200)	(1.388)	(5.182)	
8 LC - undr..	19.00	33300	1.000	OC	1.000	1.000	80.00u
(107.50)		(8000)		(0.490)	(2.389)	(2.390)	(8.000)

Additional soil parameters associated with Ka and Kp

--- parameters for Ka ---				--- parameters for Kp ---			
Soil		Wall	Back-	Soil		Wall	Back-
friction		adhesion	fill	friction		adhesion	fill
angle		coeff.	angle	angle		coeff.	angle
----- Soil type -----							
No.	Description						
1	Not defined						
2	Ash	35.00	0.619	0.00	35.00	0.619	0.00
3	EFC - drained	21.00	0.653	0.00	21.00	0.653	0.00
4	EFC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
5	WLC - drained	21.00	0.653	0.00	21.00	0.653	0.00
6	WLC - undrained	0.00	0.500	0.00	0.00	0.500	0.00
7	LC - drained	25.00	0.645	0.00	25.00	0.645	0.00
8	LC - undrained	0.00	0.500	0.00	0.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

Initial water table elevation Left side Right side
117.50 117.50

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Left side				Right side				
	Point	Elev.	Piezo	Water	Point	Elev.	Piezo	Water	
	no.		elev.	press.	no.		elev.	press.	
		m	m	kN/m2		m	m	kN/m2	
1	1	117.50	117.50	0.0	1	115.00	115.00	0.0	MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = 102.00
 Maximum finite element length = 1.00 m
 Youngs modulus of wall E = 1.4000E+08 kN/m2
 Moment of inertia of wall I = 8.9610E-04 m4/m run
 E.I = 125454 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge Far edge		Equiv. soil type	Partial factor/ Category
1	119.50	6.00(L)	50.00	3.00	30.00	=	N/A	1.30 Var
2	119.50	0.10(L)	50.00	3.00	0.00	11.00	N/A	1.00 -
3	119.50	3.00(L)	50.00	10.00	11.00	=	N/A	1.00 -
4	119.50	0.10(L)	10.00	3.00	5.00	=	N/A	1.30 Var

Note: L = Left side, R = Right side
 A trapezoidal surcharge is defined by two values:
 N = at edge near to wall, F = at edge far from wall
 Limit State Categories P/U = Permanent Unfavourable
 P/F = Permanent Favourable
 Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 119.50
2	Apply surcharge no.2 at elevation 119.50
3	Apply surcharge no.3 at elevation 119.50
4	Apply surcharge no.4 at elevation 119.50
5	Change EI of wall to 125154 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
6	Apply water pressure profile no.1 (Worst Cred.)
7	Excavate to elevation 115.00 on RIGHT side

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

Stability analysis:

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

Parameters for undrained strata:

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

Bending moment and displacement calculation:

Method - Subgrade reaction model using Influence Coefficients
 Open Tension Crack analysis? - No
 Non-linear Modulus Parameter (L) = 0 m

Boundary conditions:

Length of wall (normal to plane of analysis) = 50.00 m

Width of excavation on Left side of wall = 30.00 m
 Width of excavation on Right side of wall = 30.00 m

Distance to rigid boundary on Left side = 30.00 m
 Distance to rigid boundary on Right side = 30.00 m

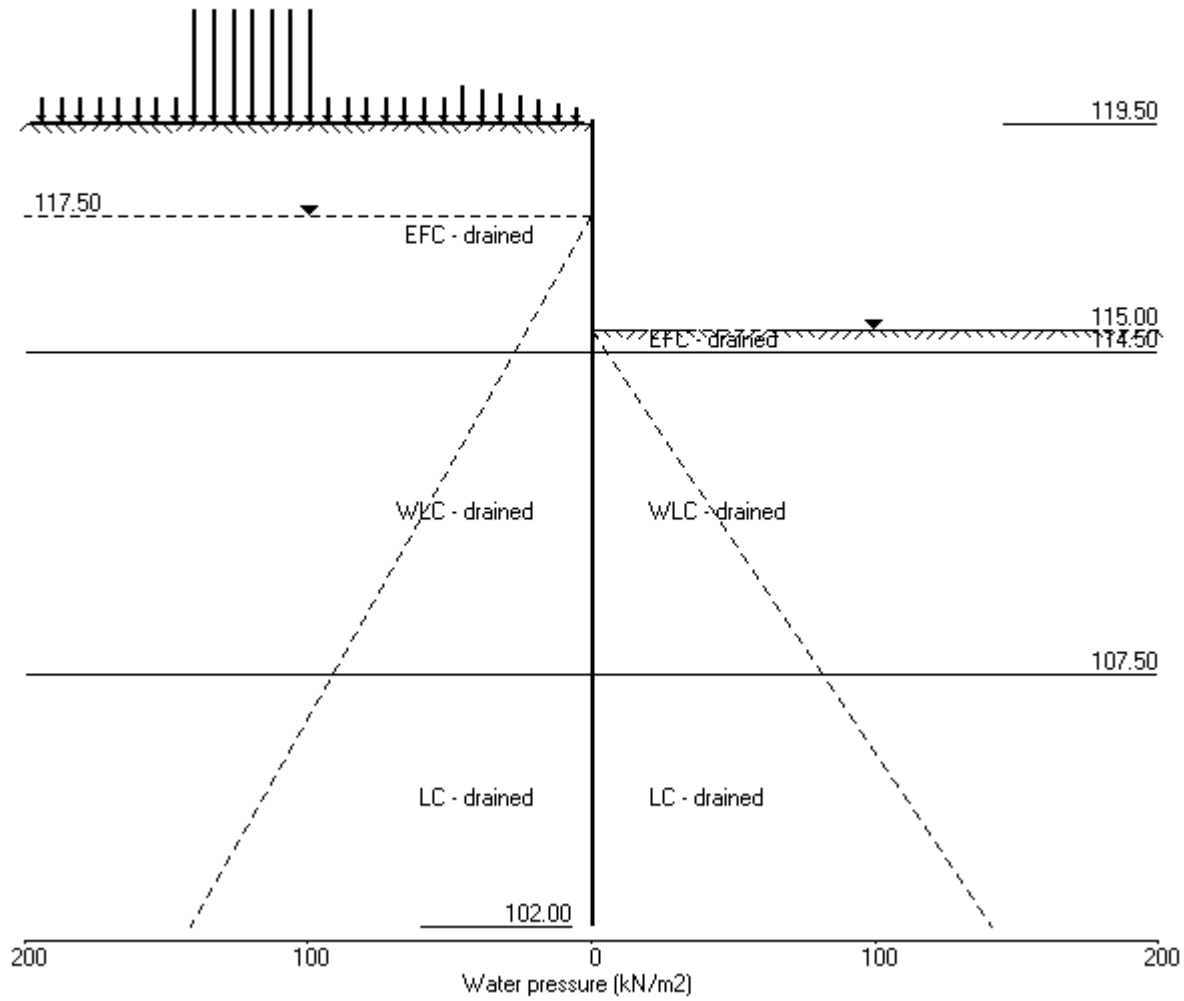
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 119.50	Yes	Yes	Yes
2	Apply surcharge no.2 at elev. 119.50	Yes	Yes	Yes
3	Apply surcharge no.3 at elev. 119.50	Yes	Yes	Yes
4	Apply surcharge no.4 at elev. 119.50	Yes	Yes	Yes
5	Change EI of wall to 125154kN.m2/m run	Yes	Yes	Yes
6	Apply water pressure profile no.1	Yes	Yes	Yes
7	Excav. to elev. 115.00 on RIGHT side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_6m_Sheetpile3600_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

Units: kN,m

Stage No. 7 Excavate to elevation 115.00 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			Overall		Toe elev. for			
			FoS for toe		FoS = 1.000			
			elev. = 102.00					
			-----		-----			
Stage	--- G.L. ---	Strut	Factor	Moment	Toe	Wall	Direction	
No.	Act. Pass.	Elev.	of	of equilib.	elev.	Penetr	of	
			Safety	at elev.		-ation	failure	
7	119.50	115.00	Cant.	1.048	103.21	102.88	12.12	L to R

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m

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 30.00 from wall

Right side 30.00 from wall

Limit State: ULS DA1 Combination 2

*** Wall displacements reset to zero at stage 5

Node	Y	Nett	Wall	Wall	Shear	Bending	Strut	EI of
no.	coord	pressure	disp.	rotation	force	moment	forces	wall
		kN/m2	m	rad.	kN/m	kN.m/m	kN/m	kN.m2/m
1	119.50	0.00	0.639	5.96E-02	0.0	0.0		125154
2	118.50	6.38	0.579	5.96E-02	3.2	1.9		125154
3	117.50	16.76	0.520	5.95E-02	14.8	10.0		125154
4	116.75	27.79	0.475	5.94E-02	31.5	26.8		125154
5	116.00	38.73	0.431	5.91E-02	56.4	59.2		125154
6	115.00	53.21	0.372	5.83E-02	102.4	137.3		125154
		37.39	0.372	5.83E-02	102.4	137.3		
7	114.50	30.17	0.343	5.76E-02	119.3	192.8		125154
8	113.75	19.28	0.300	5.62E-02	137.8	289.6		125154
9	113.00	8.33	0.259	5.42E-02	148.2	397.2		125154
10	112.00	-6.41	0.206	5.05E-02	149.1	546.7		125154
11	111.00	-21.30	0.158	4.56E-02	135.3	689.8		125154
12	110.00	-36.34	0.115	3.97E-02	106.5	811.6		125154
13	109.00	-51.53	0.079	3.29E-02	62.5	897.0		125154
14	108.25	-63.02	0.056	2.74E-02	19.6	928.2		125154
15	107.50	-74.60	0.038	2.18E-02	-32.0	924.0		125154
		-107.21	0.038	2.18E-02	-32.0	924.0		
16	106.75	-119.63	0.023	1.65E-02	-117.1	875.2		125154
17	106.00	-81.85	0.013	1.15E-02	-192.7	760.2		125154
18	105.00	-12.44	0.004	6.45E-03	-239.8	526.4		125154
19	104.00	50.17	-0.001	3.22E-03	-220.9	280.1		125154
20	103.00	112.06	-0.003	1.77E-03	-139.8	84.0		125154
21	102.00	167.57	-0.005	1.43E-03	0.0	-0.0		---

(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

Node no.	Y coord	LEFT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	119.50	0.00	0.00	0.00	15.82	0.00	0.00a	991
2	118.50	0.00	26.56	6.38	74.64	6.38	6.38a	991
3	117.50	0.00	47.73	16.76	121.51	16.76	16.76a	991
4	116.75	6.84	56.28	20.95	140.44	20.95	27.79a	991
5	116.00	13.68	64.63	25.04	158.93	25.04	38.73a	991
6	115.00	22.81	75.57	30.41	183.16	30.41	53.21a	991
7	114.50	27.37	80.97	33.05	195.11	33.05	60.42a	991
		27.37	80.97	33.05	195.11	33.05	60.42a	2754
8	113.75	34.21	88.97	36.98	212.84	36.98	71.19a	2754
9	113.00	41.05	96.86	40.84	230.31	40.84	81.90a	2754
10	112.00	50.18	107.19	45.91	253.18	45.91	96.08a	2754
11	111.00	59.30	117.31	50.87	275.59	50.87	110.17a	2754
12	110.00	68.42	127.25	55.74	297.60	55.74	124.16a	2754
13	109.00	77.54	137.04	60.54	319.29	60.54	138.09a	2754
14	108.25	84.39	144.31	64.11	335.38	64.11	148.49a	2754
15	107.50	91.23	151.52	67.64	351.36	67.64	158.87a	2754
		91.23	151.52	59.70	414.70	59.70	150.92a	2754
16	106.75	98.07	158.70	62.75	433.66	65.14	163.21	3250
17	106.00	104.91	165.83	65.80	452.54	99.43	204.34	3745
18	105.00	114.04	175.31	69.84	477.60	138.68	252.71	4406
19	104.00	123.16	184.76	73.87	502.58	177.41	300.57	12435
20	103.00	132.28	194.20	77.89	527.53	218.23	350.51	14057
21	102.00	141.40	203.62	81.91	552.44	255.86	397.26	15679

Node no.	Y coord	RIGHT side					Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Effective Active limit kN/m2	Effective Passive limit kN/m2	Earth pressure kN/m2		
1	119.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	118.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	117.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	116.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	116.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	15.82	15.82	15.82p	1347
7	114.50	5.44	4.06	0.00	24.81	24.81	30.25p	1347
		5.44	4.06	0.00	24.81	24.81	30.25p	3742
8	113.75	13.60	10.16	0.00	38.31	38.31	51.90p	3742
9	113.00	21.75	16.26	1.33	51.82	51.82	73.57p	3742
10	112.00	32.63	24.40	5.32	69.86	69.86	102.49p	3742
11	111.00	43.51	32.58	9.33	87.95	87.95	131.46p	3742
12	110.00	54.39	40.78	13.35	106.11	106.11	160.50p	3742
13	109.00	65.26	49.01	17.39	124.36	124.36	189.62p	3742
14	108.25	73.42	55.22	20.43	138.10	138.10	211.52p	3742
15	107.50	81.58	61.45	23.48	151.89	151.89	233.47p	3742
		81.58	61.45	21.28	176.56	176.56	258.14p	3742
16	106.75	89.74	67.70	23.95	193.10	193.10	282.84p	4415
17	106.00	97.89	73.99	26.63	209.71	188.29	286.19	5089
18	105.00	108.77	82.41	30.22	231.98	156.38	265.15	5987
19	104.00	119.65	90.89	33.84	254.39	130.75	250.40	12435
20	103.00	130.53	99.42	37.47	276.94	107.92	238.45	14057
21	102.00	141.40	108.00	41.13	299.62	88.29	229.70	15679

Run ID. PortobelloRoad_SectionB_6m_Sheetpile3600_v1_ULS2	Sheet No.
Portobello Road Enabling Feasibility	Date:17-03-2020
Section 1 - Option 1 (Sheet pile wall)	Checked :

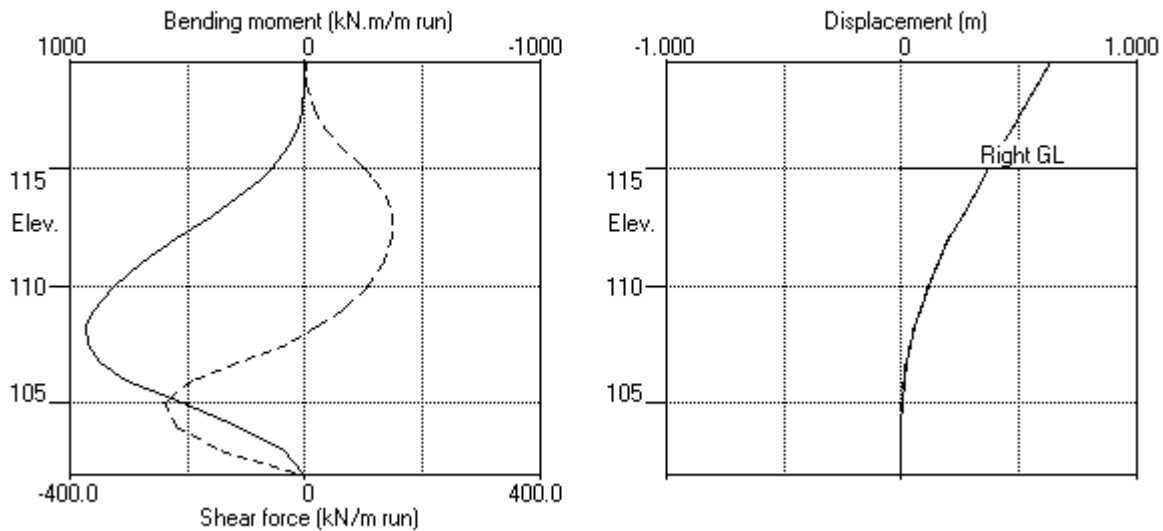
(continued)

Stage No.7 Excavate to elevation 115.00 on RIGHT side

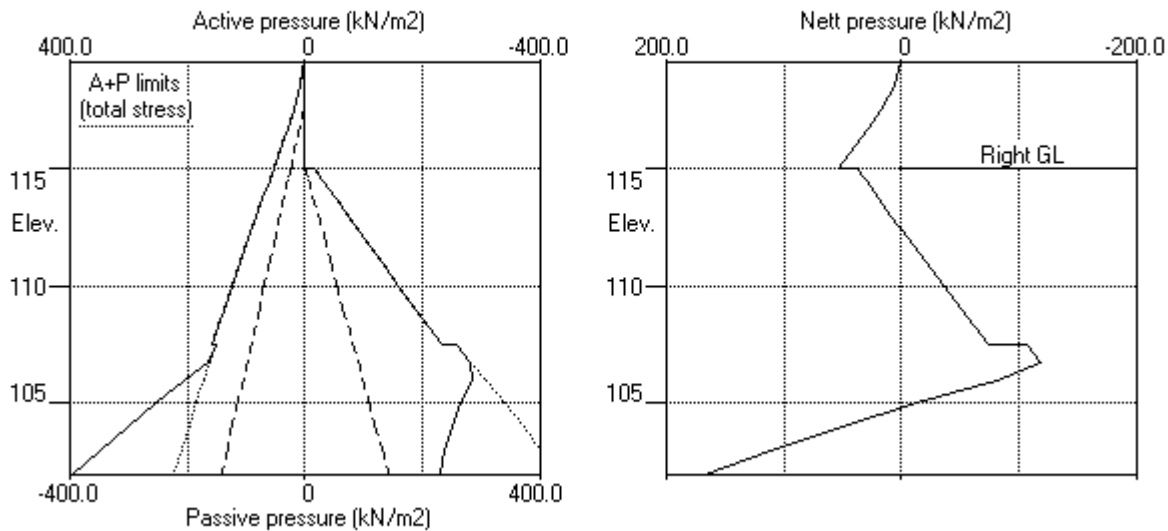
Note: 150.92a Soil pressure at active limit
 282.84p Soil pressure at passive limit

Units: kN,m

Stage No.7 Excav. to elev. 115.00 on RIGHT side



Stage No.7 Excav. to elev. 115.00 on RIGHT side



TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_6m_Sheetpile3600_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

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. = 102.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor Moment	Toe	Wall	Direction
No.	Act.	Pass.	Elev.	of equilib.	elev.	Penetr	of
				Safety at elev.		-ation	failure
1	119.50	119.50	Cant.	Conditions not suitable for FoS calc.			
2	119.50	119.50	Cant.	Conditions not suitable for FoS calc.			
3	119.50	119.50	Cant.	Conditions not suitable for FoS calc.			
4	119.50	119.50	Cant.	Conditions not suitable for FoS calc.			
5	119.50	119.50		No analysis at this stage			
6	119.50	119.50	Cant.	Conditions not suitable for FoS calc.			
7	119.50	115.00	Cant.	1.048 103.21	102.88	12.12	L to R

TRANSPORT FOR LONDON	Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55	Job No.
Licensed from GEOSOLVE	Made by : I.M
Data filename/Run ID: PortobelloRoad_SectionB_6m_Sheetpile3600_v1_ULS2	Date:17-03-2020
Portobello Road Enabling Feasibility	Checked :
Section 1 - Option 1 (Sheet pile wall)	

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 50.00m
 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 30.00 from wall
 Right side 30.00 from wall

Limit State: ULS DAL Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum m	minimum m	maximum kN.m/m	minimum kN.m/m	maximum kN/m	minimum kN/m
1	119.50	0.639	0.000	0.0	-0.0	0.0	0.0
2	118.50	0.579	0.000	1.9	-1.7	3.2	-4.9
3	117.50	0.520	0.000	10.0	-8.7	14.8	-8.8
4	116.75	0.475	0.000	26.8	-15.6	31.5	-8.7
5	116.00	0.431	0.000	59.2	-20.8	56.4	-4.8
6	115.00	0.372	0.000	137.3	-21.3	102.4	0.0
7	114.50	0.343	0.000	192.8	-17.5	119.3	0.0
8	113.75	0.300	0.000	289.6	-10.9	137.8	0.0
9	113.00	0.259	0.000	397.2	-6.5	148.2	0.0
10	112.00	0.206	0.000	546.7	-3.1	149.1	-1.2
11	111.00	0.158	0.000	689.8	-1.6	135.3	-2.2
12	110.00	0.115	0.000	811.6	-1.0	106.5	-2.3
13	109.00	0.079	0.000	897.0	-1.1	62.5	-1.9
14	108.25	0.056	0.000	928.2	-1.2	19.6	-1.4
15	107.50	0.038	0.000	924.0	-1.1	1.8	-32.0
16	106.75	0.023	0.000	875.2	-1.0	2.2	-117.1
17	106.00	0.013	0.000	760.2	-0.7	1.8	-192.7
18	105.00	0.004	0.000	526.4	-0.4	0.6	-239.8
19	104.00	0.001	-0.001	280.1	-0.1	0.2	-220.9
20	103.00	0.000	-0.003	84.0	0.0	0.1	-139.8
21	102.00	0.000	-0.005	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	maximum kN.m/m	elev.	minimum kN.m/m	elev.	maximum kN/m	elev.	minimum kN/m	elev.
1	0.0	103.00	-1.3	115.00	0.8	114.50	-0.6	116.75
2	2.1	112.00	-2.4	116.00	3.0	114.50	-1.1	117.50
3	3.2	112.00	-4.7	116.00	5.1	114.50	-2.2	117.50
4	8.7	113.00	-4.2	116.75	8.1	114.50	-2.3	110.00
5	No calculation at this stage							
6	4.9	105.00	-21.3	115.00	10.6	114.50	-8.8	117.50
7	928.2	108.25	-0.0	102.00	149.1	112.00	-239.8	105.00

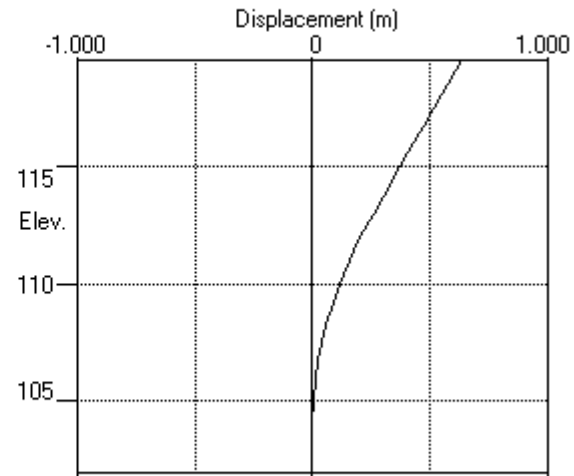
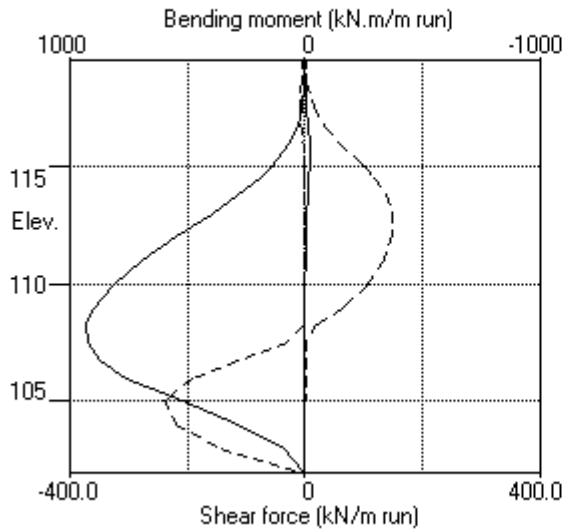
Summary of results (continued)

Maximum and minimum displacement at each stage

Stage -----		Displacement -----		Stage description	
no.	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.000	111.00	0.000	119.50	Apply surcharge no.1 at elev. 119.50
2	0.001	119.50	0.000	119.50	Apply surcharge no.2 at elev. 119.50
3	0.002	119.50	0.000	119.50	Apply surcharge no.3 at elev. 119.50
4	0.003	119.50	0.000	119.50	Apply surcharge no.4 at elev. 119.50
5	Wall displacements reset to zero				Change EI of wall to 125154kN.m2/m run
6	0.004	114.50	-0.000	102.00	Apply water pressure profile no.1
7	0.639	119.50	-0.005	102.00	Excav. to elev. 115.00 on RIGHT side

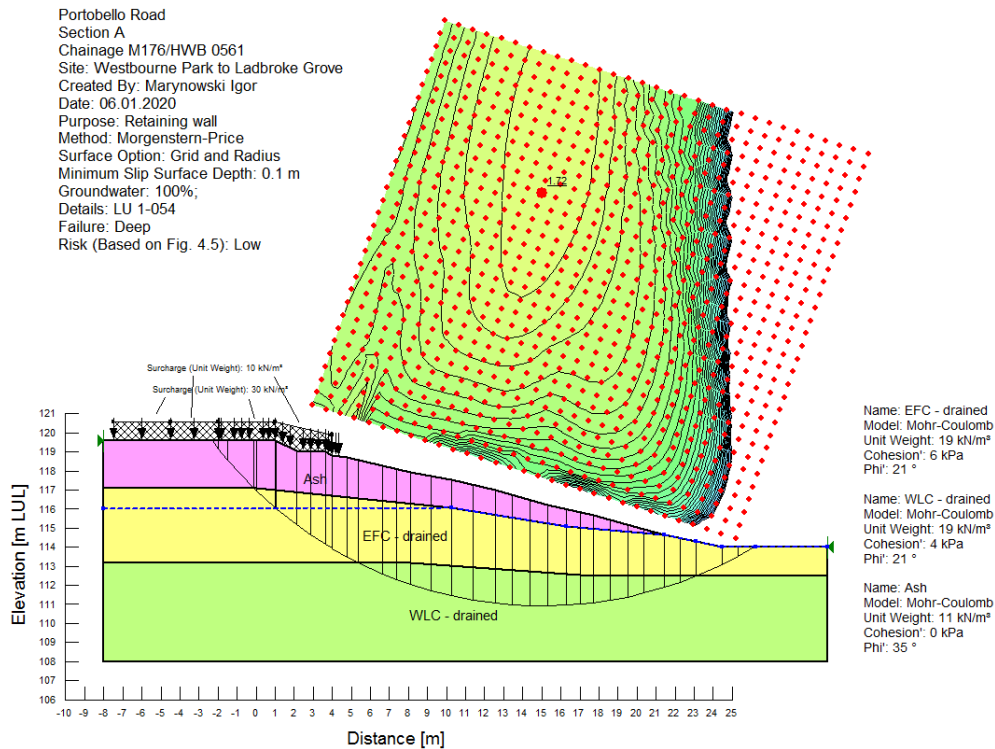
Units: kN,m

Bending moment, shear force, displacement envelopes

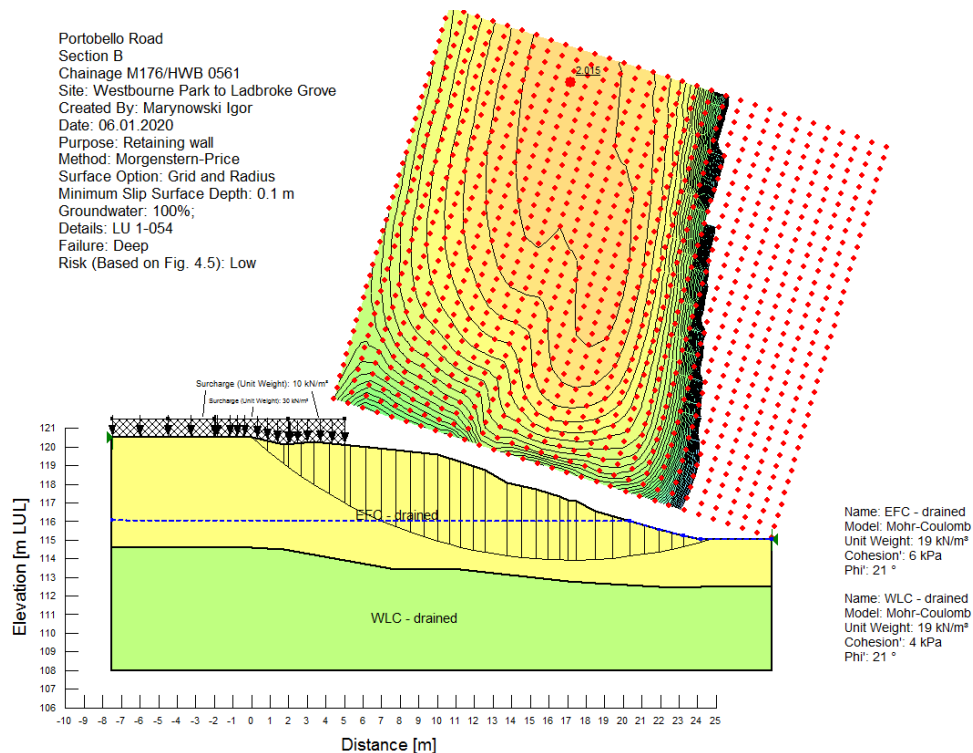


Appendix F – Slope/W Output

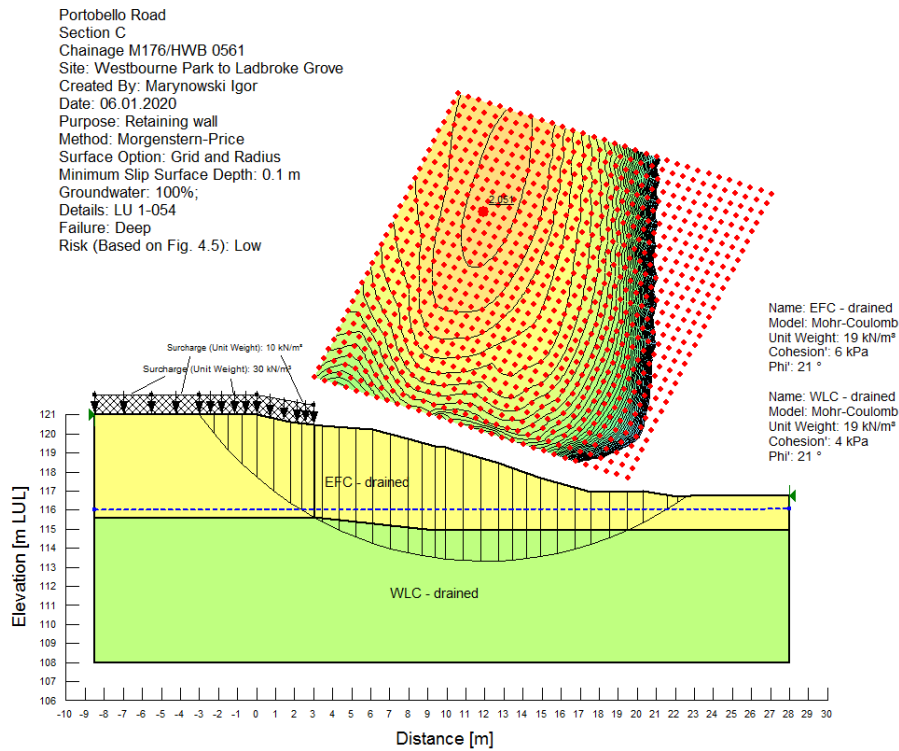
Existing slope stability of Section A



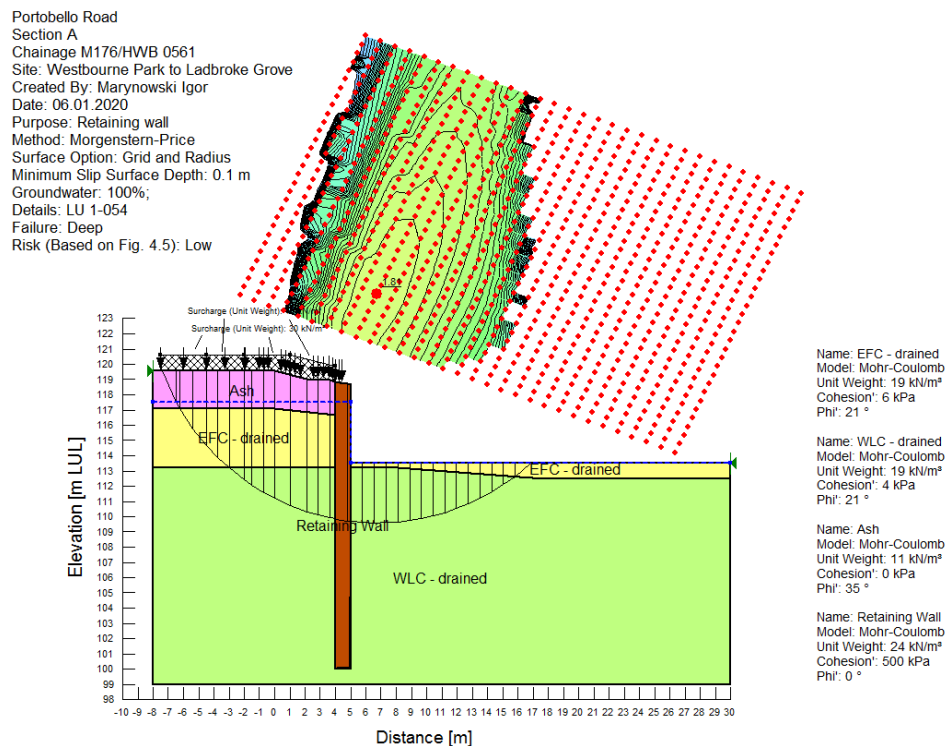
Existing slope stability of Section B.



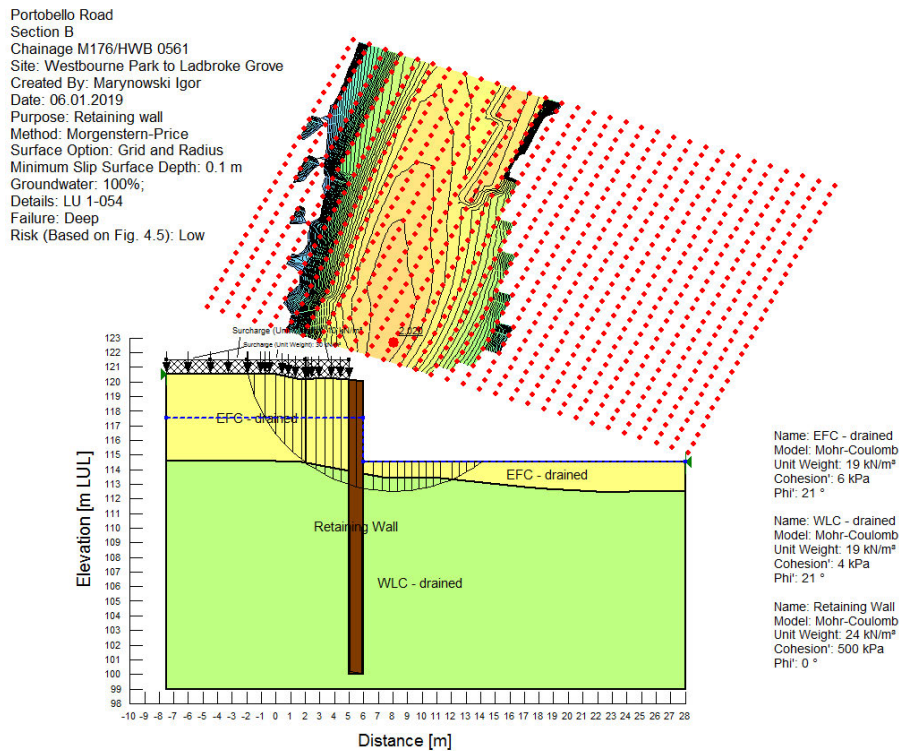
Existing slope stability of Section C



Retaining wall slope stability of Section A.



Retaining wall slope stability of Section B.



Retaining wall slope stability of Section C

