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Lock 12, Aylesbury Canal

Review of Potential Causes of Failure

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1 Introduction

1.1 Terms of Reference

The southern wall of Lock 12 along the Aylesbury Arm of the Grand Union Canal collapsed on the 28 March 2013 resulting in the closure of this section of the canal.

Under the terms and conditions of the Canal and River Trust (CRT) Professional Services Contract 2011 to 2014, Hyder Consulting (UK) Ltd were appointed to undertake a remedial design to replace the failed southern lock wall and provide additional stabilisation measures to the northern lock wall as part of the scope of work.

Temporary stabilisation measures were also assessed and designed to limit further movement of the failed wall and ensure stability of the remainder of the structure.

A Continuous Flight Auger (CFA) contiguous bored piled wall was designed to replace the failed section of wall, and a soil nail solution developed to provide long term additional support to the northern wall of Lock 12.

1.2 Site Location

The site is located approximately 1.3km north of the village of Buckland and approximately 5.2km east of Aylesbury. Both Buckland Road and College Road North cross the canal, with Lock 12 located between these two roads. The area surrounding the lock is predominantly flat farmland with the site at approximately 85m AOD.

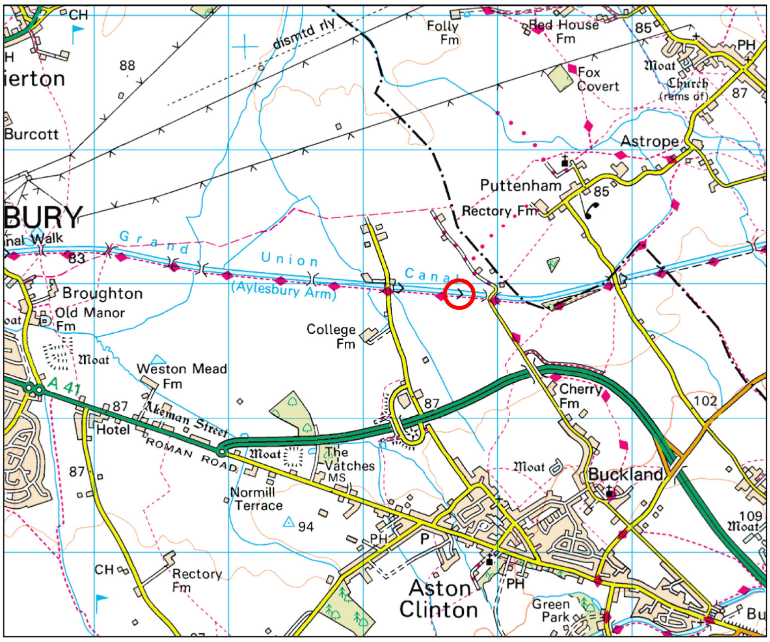


Figure 1 – Site Location Plan

The local topography includes a small embankment, approximately 1m in height, built up to accommodate the lock. A ditch, running parallel to the canal, was identified at the toe of the lock embankment on the southern side with a dairy site located adjacent to the lock to the south.

A new development incorporating a bund of 4.6m in height with a slope angle of approximately 18° is located immediately adjacent to the southern boundary of the CRT owned earthworks to the lock structure, which was constructed shortly before the failure occurred.

1.3 Report Objectives

As part of the scope of work associated with back analysis of the failure to inform the remedial works design, a review of the potential causes of the failure was to be undertaken.

This report provides a summary of the data obtained during the investigations and back analysis to identify the possible causes of failure of the southern wall of Lock 12.

2 Review of Available Information

2.1 Geology

With reference to the published Geological Map for the site location, 1:50,000 Sheet 238, the solid geology has been identified as the Gault Clay of Lower Cretaceous Age.

From the British Geological Survey Document Engineering Geology of British Soils and Rocks – Gault Clay, Technical Report WN/94/31, a number of serious geotechnical problems are generically associated with this deposit, including

- Landslips, or slope instability, with very low slope angles of between 1:3.5 and 1:5 recommended for the design of permanent earthworks
- The Gault Clay is in the high expansive potential category, highly susceptible to shrinkage and swelling due to moisture content changes

2.2 Background Site Investigation Data

A site investigation report was made available associated with the Arla North Development immediately to the south of the Grand Union Canal and opposite Lock 12, reference Project Blueprint, Arla North, Aylesbury. This report was produced by Jordan Prichard Gorman and issued in March 2011 (Document: RM/GI/AN/4290v1).

This confirmed the presence of the Gault Clay as the solid geology beneath the site, overlain by a mantle of between 1.8m and 2.5m thick of Head or Glacial Till Deposits, described typically as a firm to stiff grey brown silty clay with varying proportions of gravel, although identified as soft in local areas.

The underlying Gault Clay was described as a very stiff grey fissured silty Clay.

Maximum groundwater levels were monitored at between 1.1 and 1.3m below existing ground level.

2.3 CRT Investigation

A site investigation was undertaken to the instructions of CRT to provide geotechnical data on the ground and groundwater conditions immediately adjacent to Lock 12, to inform the back analysis and remedial design.

Six window sampled boreholes were undertaken together with associated laboratory testing, the results of which are reported in a Factual Report for CRT, Reference 0001-UA004512-30-UP32-01 dated June 2013.

The ground conditions identified from this investigation can be summarised as

- Made Ground described as a very soft gravelly clay/very loose clayey gravelly sand to a depth of nominally 1m
- Re-worked Gault Clay/Made Ground, typically soft to firm brown/grey Clay, but stiff in locations, proven to a maximum depth of 4.0m. This is almost certainly the backfill material to the open excavation within which the lock and the retaining walls were constructed. Reference should be made to Appendix A for a typical cross section of the form of temporary works employed at the date of construction, and cross sections through various lock arrangements
- Firm becoming very stiff fissured grey Clay, in-situ Gault Clay

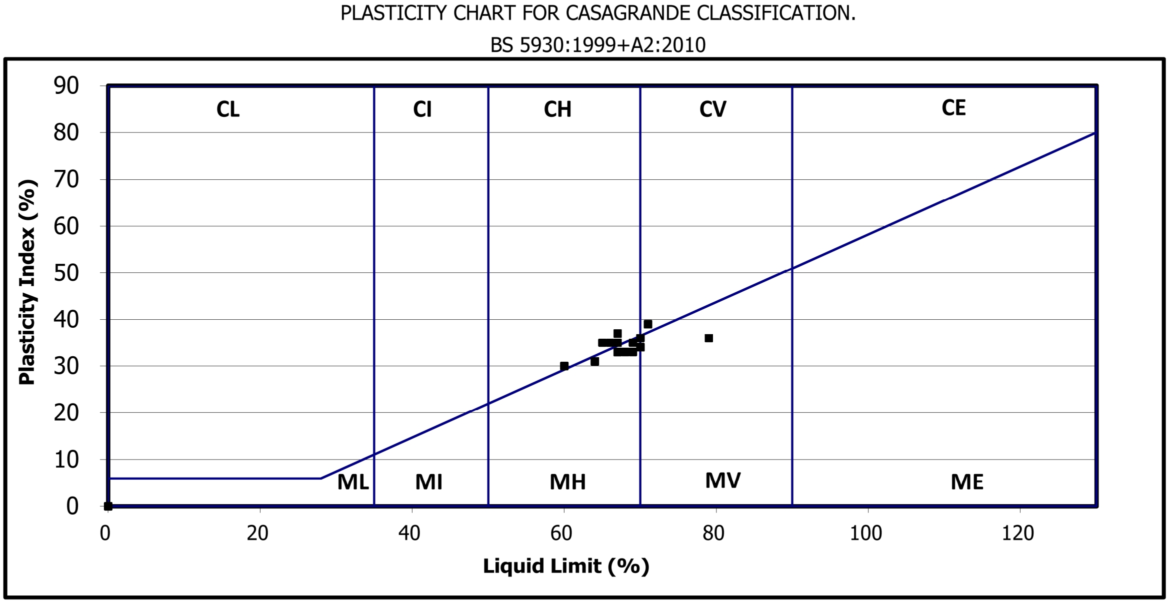


Figure 2 – Plasticity Chart for Gault Clay

The plasticity chart reproduced from the factual site investigation data confirms the High to Very High plasticity of Gault Clay, confirming the materials potential for shrinkage/swelling and also the potential for very low peak and residual drained shear strengths when assessing the stability of earthworks and earth retaining structures.

Ground water was monitored at a minimum depth of 3m bgl in Borehole WS05, constructed in the embankment behind the lock structure. Over the period of monitoring available, it is considered unlikely that the water level in the instrument has reached equilibrium with the surrounding soils.

2.4 Data on the Condition of the Lock Structure

The most recent Principal Inspection (PI) was undertaken in 2007 and this gave the lock a D2 rating. This Grading defines the asset as Poor, which implies a stable condition, but structural cracking and subsidence was evident. There are limited consequences of failure to 3rd Parties implied by this Grading.

The executive summary from this inspection is reproduced below:-

- Lock 12 is a narrow lock on the Grand Union Canal Aylesbury Arm approximately 2 kilometres North of Aston Clinton
- The lock head gate has a significant leak at the cill and its balance beam handrail needs securely fixing.
- There is a vertical crack in the south lock wall and the north west quadrant has significant cracking and is subsiding. Some brickwork repairs are required in the medium term.
- No major defects were observed on the south wall.
- The South (towpath side) chamber wall is inscribed “1911” and is well pointed except at the bedding of all the copings (where some vegetation is establishing) and within the tail gate recess, where brick faces are damaged. Almost all of the copings are badly spalled at the edge.
- There is a vertical crack in centre of the South wall, extending the full depth of the chamber. This is approx. 3mm wide. There is no discernible lateral displacement. The crack was not reported in the previous PI.
- The vertical crack was reported in a PM Notification Summary in 2004, when leaks down the embankments on both sides of the canal were observed as soon as the lock is filled. The Notification also reports, on 06.10.2006, “large offside leak and towpath leak” requiring urgent attention.
- From measurements taken post-failure, the lock walls, from top of wall to invert, are approximately 4.1m high.

Figure 3 – Lock 12 Post-Failure

In the early afternoon of Thursday 28th March 2013, the South East Waterway engineering team were advised by local bankstaff that the south wall of Lock 12 had failed. A photograph taken immediately after the failure is reproduced in Figure 3 above

2.5 Weather Conditions

Collation of information on the weather conditions, specifically rainfall, was undertaken for the preceding 12 months prior to failure, as shown in Figure 4 below.

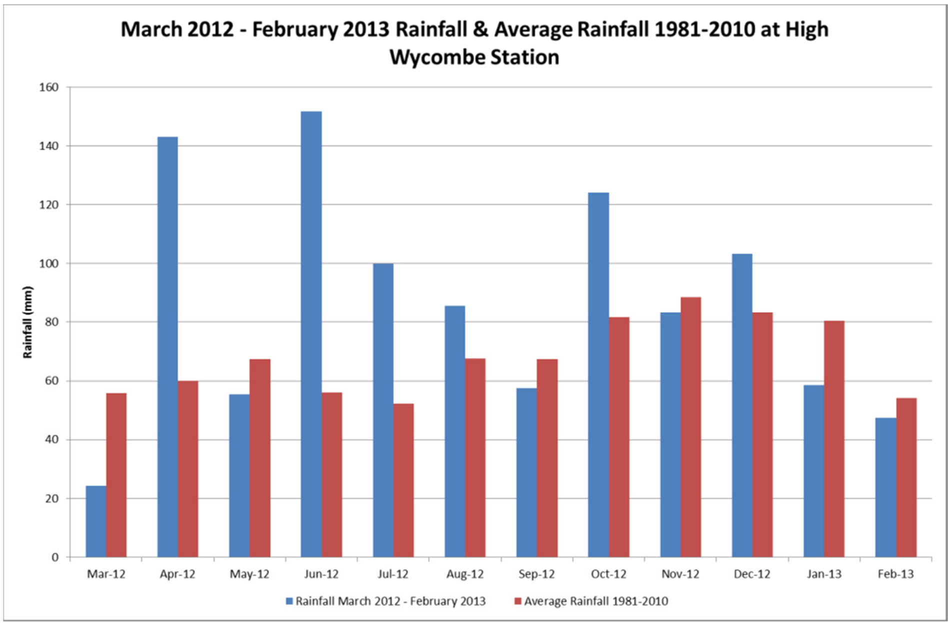


Figure 4 – Average Rainfall vs Rainfall Spring 2012 to Spring 2013

Information was obtained from the Met Office, which includes average monthly rainfall levels from 1981– 2010, taken from a Meteorological Station located at High Wycombe, approximately 20 km from the site. This is the closest station containing historical data available on the website (Met Office, 2013). This has been compared to rainfall in the 12 months preceding the failure of the south wall of Lock 12 within Figure 4.

The data clearly indicates rainfall had been much greater than average, particularly over the period Spring to Autumn 2012, with several months receiving over twice the average rainfall.

3 Analysis of Potential Causes of Failure

3.1 Key Observations

From the background data, a number of observations can be made as follows

- It is potentially significant that the new earth bund to the Arla North development, immediately adjacent to the southern boundary of the CRT land, was constructed shortly before the south wall failed.
- The Gault Clay is a difficult engineering material, highly prone to landslips on relatively shallow slopes, particularly where Glacial or Periglacial effects are known to be present, and highly sensitive to volume change as a result of water content variations. These characteristics can have a significant impact on the performance of earth retaining structures within this geology
- During the last PI, The south wall was described as having a 3mm wide crack running the full depth of the wall, which had not been identified previous to 2004, with significant leaks reported in 2006. The overall lock structure had a condition grade as D (Poor). There is no information available on remedial works undertaken to repair the leaks reported.
- The date mark reported on the south wall of 1911 significantly post-dates construction of the canal. It is unclear as to whether the south wall was repaired or reconstructed at this date, but it may be an indication that there have been previous problems with the south wall to the canal.
- Almost double the average rainfall over the previous summer and autumn has been recorded. This can have a detrimental impact both by increasing water pressures in the retained soils behind the lock walls but can also increase loads by causing swelling of the highly expansive Gault Clay material.

Analyses were run as part of the process of understanding the potential mechanisms of failure, taking note of the data above, for development of the remedial work design, which are described in the following section.

3.2 Impact of the Arla North Development

3.2.1 Introduction

Initially, a slope stability back analysis was undertaken, looking at the potential for global failure of the lock structure. This was undertaken to investigate the potential impact of the new earthworks as part of the Arla North development on the overall stability of the lock/embankment system, but also to inform the remedial work design.

Following this, a PDisp analysis, using Elastic Theory, was undertaken to investigate the increase in stress and resultant strain as a result of the new earthworks construction associated with Arla North on the back of the existing wall.

3.2.2 Global Stability

An analyses was undertaken examining the long term stability of the new earth embankment constructed as part of the new Arla North development, which is located adjacent to the southern boundary of CRT's land. This was to establish if there was a potential for global instability associated with this new embankment to impact the lock structure.

If this was the case, then the new earthworks would be relying on the passive restraint provided by the lock embankment and structure, and significant additional loadings would be expected to be imposed on the CRT structure as a change from conditions predating the new development.

To provide an initial conservative approach, it was assumed that the near surface Gault Clay, Material 6 (blue shading,) shown on the longitudinal sections in Appendix B, contained relict shear surfaces with low residual strengths aligned in an unfavourable orientation, hence a very low angle of internal friction (phi) of 17 degrees was selected . Representative long term shear strengths were assigned to the other strata present based on published data and the classification testing undertaken.

For the long term condition in the analysis described as 'Pre-Failure' within Appendix B, the most critical shear surface was identified as daylighting in the ditch adjacent to the toe of the new embankment. The Factor of Safety of marginally less than 1.2 appears representative, and reflects the BGS recommendations of adopting shallow slope angles in earthworks within Gault Clay soils as summarised in Section 2.1.

As part of the temporary works assessment, 1m of material was removed from the CRT embankment south of the failed wall and the analysis was re-run, with a very similar geometry of the critical shear surface and Factor of Safety against failure obtained. This indicates that the most critical potential failure mechanism is independent of the CRT earthworks and structure at this location.

Although a very simplistic analyses was run, the analysis suggests that the stability of the new earth bund is independent of the earthworks and retaining walls to Lock 12 and is unlikely to have imposed any significant increase in loading on the back of the failed lock wall.

This is supported by

i. No evidence of failure or movement within the new embankment to the Arla North development as a result of the lock wall failure

ii. Given the generally flat nature of the landscape, it is unlikely that continuous shear surfaces exist representing former landslips or glacially sheared material to the extent assumed in the analysis

iii. The local stability of the lock walls will not be determined by these residual shear surfaces. Excavation for construction and the subsequent back filling behind the lock walls will have destroyed any such features immediately behind the walls.

3.2.3 Elastic Analysis

Analysis of the increase in loading and imposition of strain on the back of the wall generated by the construction of the earth bund to the Arla North development was undertaken specifically to identify whether any measurable change to the loading conditions behind the wall can be identified, which could impact the stability of the south wall to Lock 12

The software used for was the Oasys PDisp software, which is a geotechnical software package used to predict stress distribution and settlement/horizontal strain as a result of imposed loadings, from, for example, foundations and earthworks. The analysis is based on Elastic Theory.

The input and output data is provided within Appendix C of this report.

The simplistic ground model as identified within the slope stability model in Appendix B was constructed in the PDisp software, with soil stiffness parameters (Elastic Moduli) assigned on the basis of the soil descriptions from the site investigations and with reference to CIRIA C103 as a conservative approach to the analysis.

A vertical line was drawn on the model to represent the location of the back of the south retaining wall and the increase in stress and strain analyses at this location as a result of the loading conditions created by the new earthworks was calculated.

Two calculations were performed

- Boussinesq Analysis to investigate the change in stress at the back of the wall
- Mindlin analysis to determine the scale of horizontal strain imposed on the back of the wall

The results of the Boussinesq analysis highlighted identified an increase in the Principal Stress (likely to be predominantly horizontal) at the top of the wall of the order of 1 kPa increasing to 4.5 kPa at the base of the wall, as a result of the loadings from the new earthwork to the Arla North Development

The Mindlin Analysis identified a maximum strain (deformation) within the ground at the back of the wall of 0.2mm as a result of the ground movements generated by the new earthworks.

It should be noted that in the absence of direct stiffness data, which was obtained by correlation with soil descriptions, moderately conservative stiffness parameters were assumed. In addition, Elastic analysis is known to over–predict the distribution of stresses related to imposed loadings on the ground.

The increase in stress and strain imposed by the loadings is of a very low order. The increase in stress identified is of a similar order to placing 100mm of soil behind the wall or an increase in water pressures of 200mm behind the wall.

3.3 Wall Stability Analysis

As part of the back-analysis to understand the mechanism of failure and to verify the selection of parameters, a local stability analysis for the southern lock wall was undertaken, based on Earth Pressure Theory.

Details of the soil parameters adopted are included in the output data within Appendix D, selected on the basis of laboratory testing data and published data on the Gault Clay. The parameters adopted were un-factored for the purposes of understanding the failure mechanism. Note lower bound density parameters were adopted for the wall backfill to represent the level of compaction likely to be achieved at the time of construction of the canal.

Three trial pits were dug down the back of the south wall by CRT (Trial Holes 1 to 3). Simple sketches are included within Appendix D.

Different geometries of the wall were identified at each trial hole, and two different cases of wall geometry and water pressures were analysed as follows

- Analysis 1a – Wall geometry shown by Trial Pit 3, with a top of wall thickness of 0.6m, with two step-outs down the wall to a base thickness of 1.95m. Water pressure behind the wall has been assumed at 2.9m above the base of the lock, representing a case where the lock is equalised with the lower level of the canal for a significant period of time. This represents the greatest wall thickness and most onerous water pressures

- Analysis 1b – Wall geometry shown by Trial Pit 1, with a top of wall width of 0.6m, and foundation width of 1.5m, with a step out at 3.2m from the top of the wall. Water pressure was ignored as it is assumed in this analysis that the lock is full and there is equalisation with the top canal level, hence there is no differential head between the canal and groundwater behind the wall. This represents the intermediate wall thickness indicated and the least onerous water pressures

The base slab to the lock was assumed to act as a prop to the wall, and a force within this 'prop' was increased to provide a Factor of Sliding above 1.0, on the basis that the base is intact and was able to support loads associated with sliding of the wall.

For both analysis, the Factor of Safety against overturning for the water pressures selected is of the order of 1.0, which indicates that the wall is in a condition of marginal stability, and well below minimum Safety Factors that would be adopted for a design based on un-factored Parameters.

Because of the operation of the lock and constantly varying water levels and hence changing differential pressures between the front and rear of the wall, and the different geometries of the wall along its length, which includes buttressing at intervals along the wall, it is difficult to predict the exact composite behaviour of the wall.

On the assumption that the soil parameters selected for the assessment are appropriate, the analysis does however suggest that the lock wall is potentially vulnerable to changes in loading conditions behind the wall, particularly ground water pressures, where a measurable increase in pore pressures in the backfill behind the wall would reduce the calculated Factor of Safety below unity.

It is of note that Trial Pit 4 identified a far more robust gravity structure to the north wall, with a 1 in 3 batter described to the rear of this wall.

4 Potential Cause of Failure of the South Lock Wall

4.1 Introduction

As part of the back analysis to determine the mode of failure of the south wall to Lock 12 and select parameters for design, together with records of inspection and data gathered during the investigation work, the following conclusions can be made

4.2 Geological Influences

From the analyses undertaken, it is unlikely that the presence of residual shear surfaces frequently associated with former or active landslips within the Gault Clay has impacted on the Lock structure.

Potentially of more significance is the fact that the Gault Clay is highly susceptible to shrinkage/swelling effects as a result of water content changes, likely to be mainly seasonally related, but reported leakages in the past may have contributed to wetting up and drying of the Gault Clay derived backfill material immediately behind the wall.

Although there was no evidence of instability in 2006, the description of the defects and overall condition rating suggests deterioration of the south wall in particular, which could be related to ground movements and pressures exerted by cyclic soil volume changes over time. This may have weakened the structural integrity of the south wall, and reduced the walls ability to resist earth pressures behind the wall. The leakages reported in 2006 may also have weakened the wall further by internal erosion of the masonry structure.

The north wall, due to its more massive construction, is unlikely to be as susceptible to these seasonal related movements.

4.3 Impact of the Arla North Embankment

The stability of the new earth embankment to the Arla North development does not appear to be dependent on the presence of the CRT lock and shallow embankments to the lock, with critical shear surfaces daylighting outside the existing CRT earthworks. There is currently no evidence of any instability associated with the Arla North earthworks following failure of the south lock wall.

On the basis of a simple elastic analysis, there is however a nominal increase in loading indicated on the back of the wall associated with construction of the Arla North earthwork. This loading in itself is unlikely to have a destabilising impact on the wall, but in combination with other impacts may have had a minor disturbing influence on the wall.

4.4 Back Analysis of the Wall Failure

The back analysis undertaken for two water pressure and wall geometry conditions suggests that the wall stability in overturning is highly susceptible to changes in loading on the back of the wall, particularly soil pore water pressures which will vary according to the prevailing weather conditions.

4.5 Climatic Impacts

The prevailing summer of 2012 was the second wettest since records began in 1910. This is likely to have resulted in much higher than average water pressures in the clays soils behind the wall at the end of Summer 2012.

Although rainfall in the winter of 2012 was at or slightly below average, the lack of evaporation of rainfall and surface run-off in the winter months, particularly given the prevailing cold weather during this period, will have increased water pressures still further.

Typically, water pressures in the ground reach a maximum in March/April and they would have been much higher than normal in the Spring of 2013, which coincides with the timing of the wall failure.

An article in Ground Engineering in October 2013 indicating a UK wide problem with earthwork stability over the period June 2012 to June 2013 is included in Appendix E, for information

4.6 Conclusions

The back analysis undertaken of the local stability of the south lock wall has identified a potential vulnerability to changes in loadings associated with an increase in pore pressures in the overturning mode of failure.

The failure of the south wall to Lock 12 followed shortly after construction of the new embankment to the Arla North development. The global stability analysis suggested no link between the stability of the wall and the new earthworks.

However, the simple elastic analysis undertaken has identified a nominal increase in loading (between 1 and 5kPa from top to base) on the back of the wall as a result of the new earthwork construction, but with negligible strain (<0.2mm). Although the use of an elastic analysis approach may have slightly over-predicted the magnitude of this increase, this level of increase in loading is unlikely to have initiated the collapse in isolation, but may in combination with other factors have had a slight detrimental impact on the wall stability.

It is considered that the deterioration of the south lock wall, possibly in part due to progressive damage caused by the shrinkage and swelling of the Gault Clay materials, and the exceptionally high porewater pressures likely to be in operation in the soils behind the retaining wall in Spring 2013, due to the very wet proceeding Summer and Autumn 2012, has been the primary cause of the overturning and structural failure of the wall.

There may have been a nominal contribution to this failure associated with imposed loadings from the new earthworks to the Arla North development, but it is considered that the timing of the failure during the period where there is likely to have been one of the highest seasonal porewater pressures in the ground since records began is no coincidence, although it should be noted that this failure also occurred shortly after construction of the new embankment for Arla North.

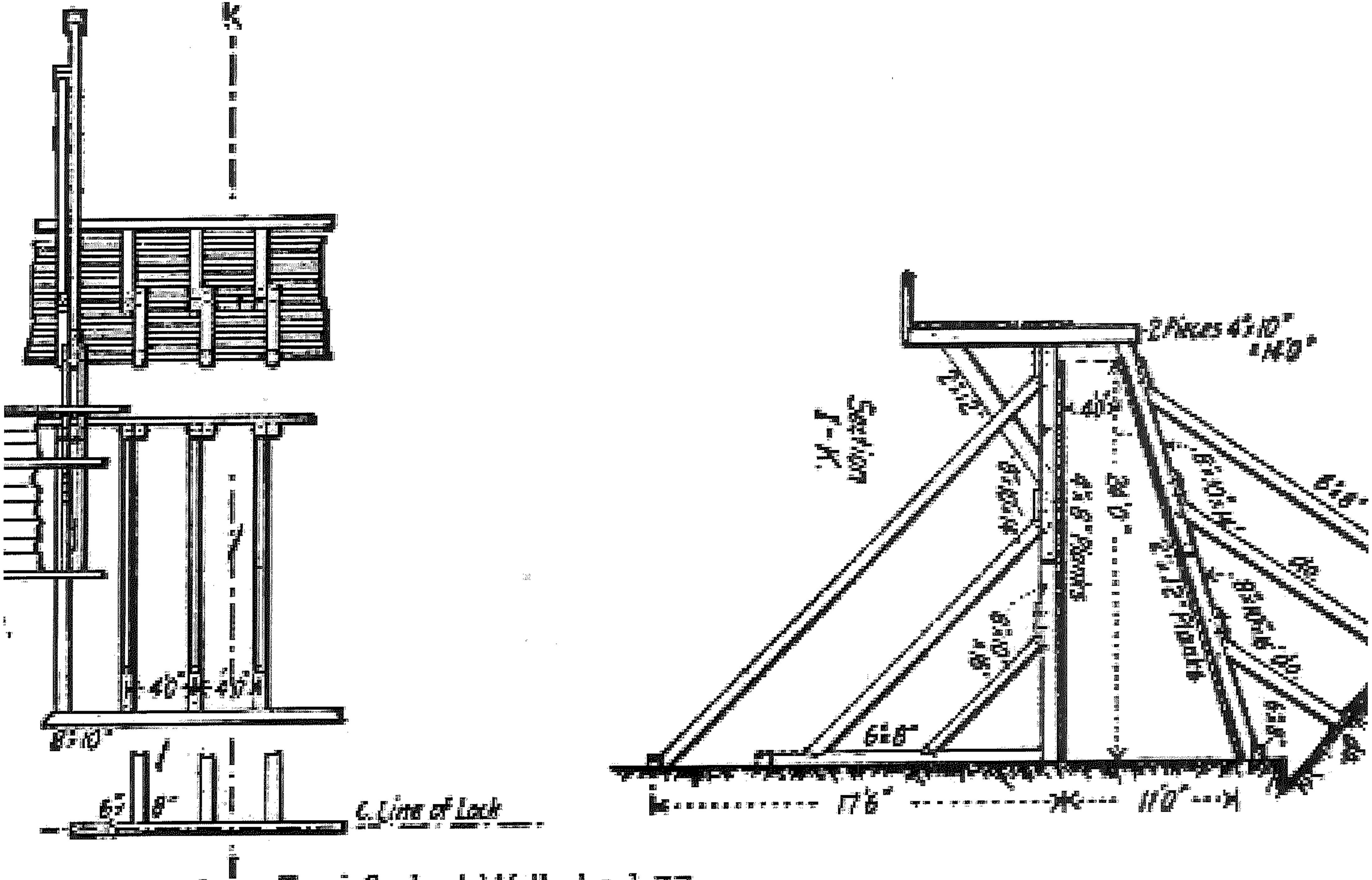
Given the date stamp on the south wall of 1911 and the varying wall cross sections identified along the wall, it is possible that there have historically been problems with the condition or instability of this wall.

The north wall, from the evidence obtained from the trail pitting, is of a far more massive construction than the south wall, and is therefore potentially less vulnerable to structural damage caused by seasonal volume changes in the soils behind the wall, and is capable of resisting significantly higher earth pressures than the failed north wall.

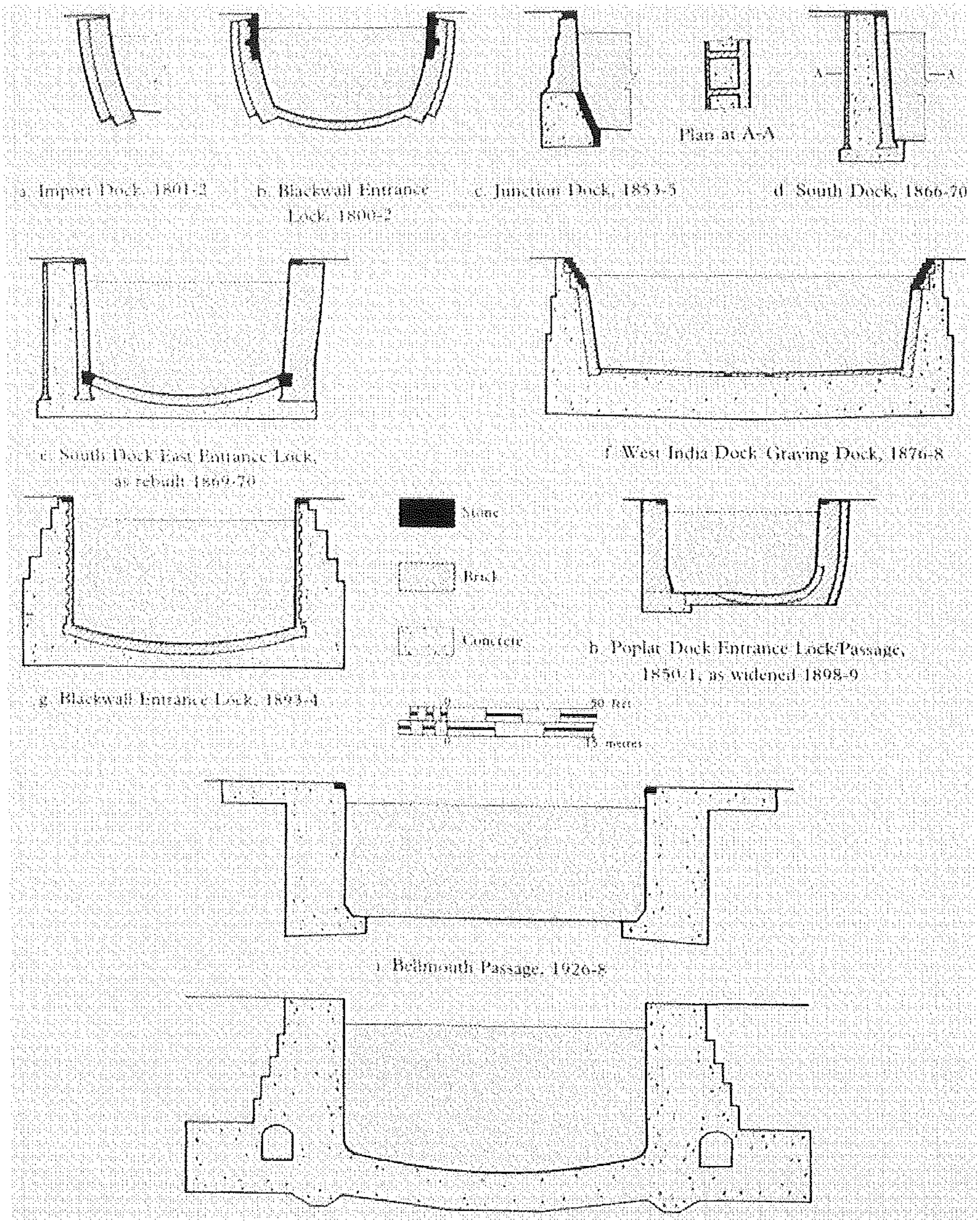
Appendices

Appendix A

Typical Arrangements of Temporary Works and General Arrangements of Lock Structures



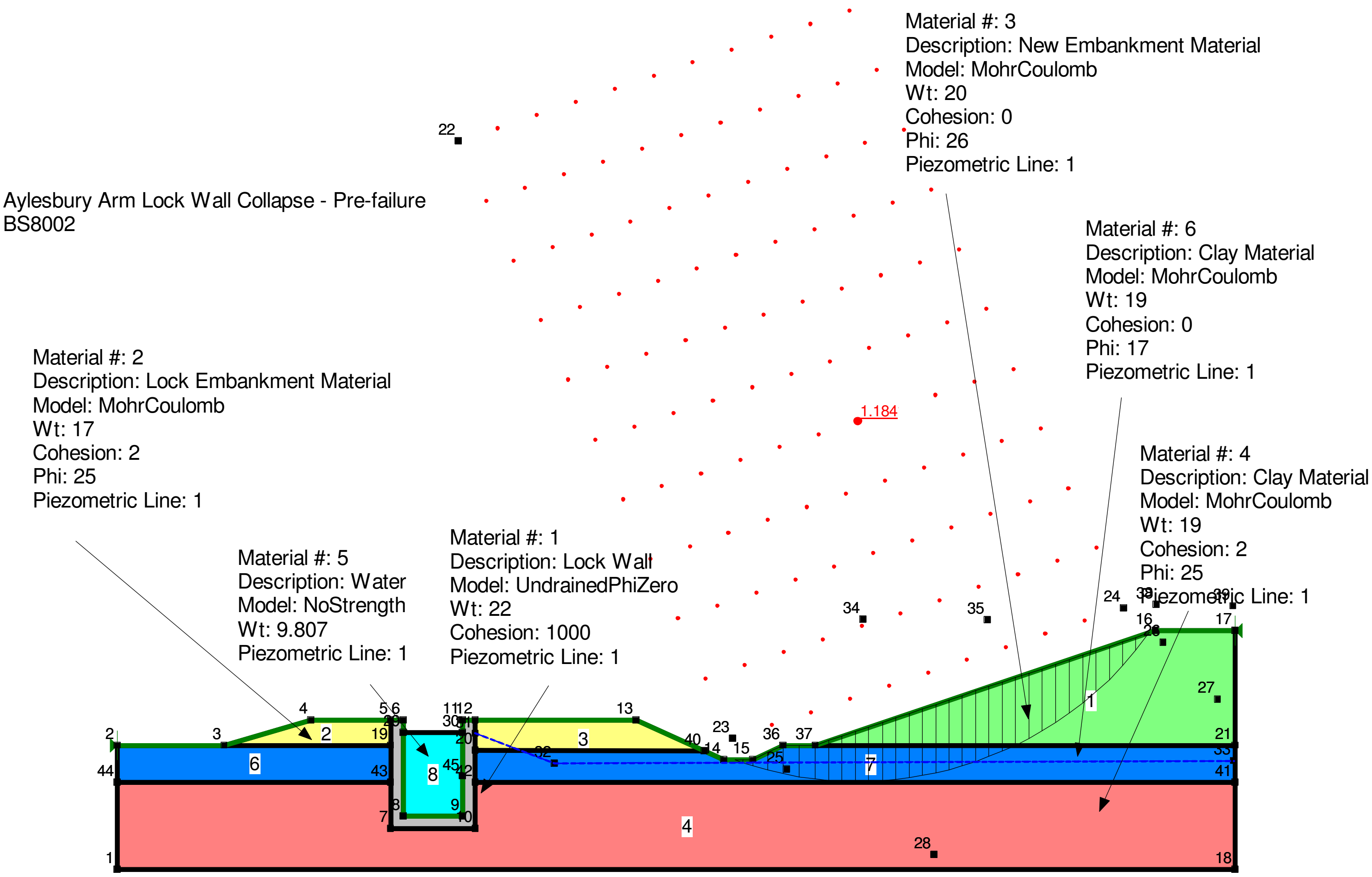
Form for Lock Wall. Lock 37.



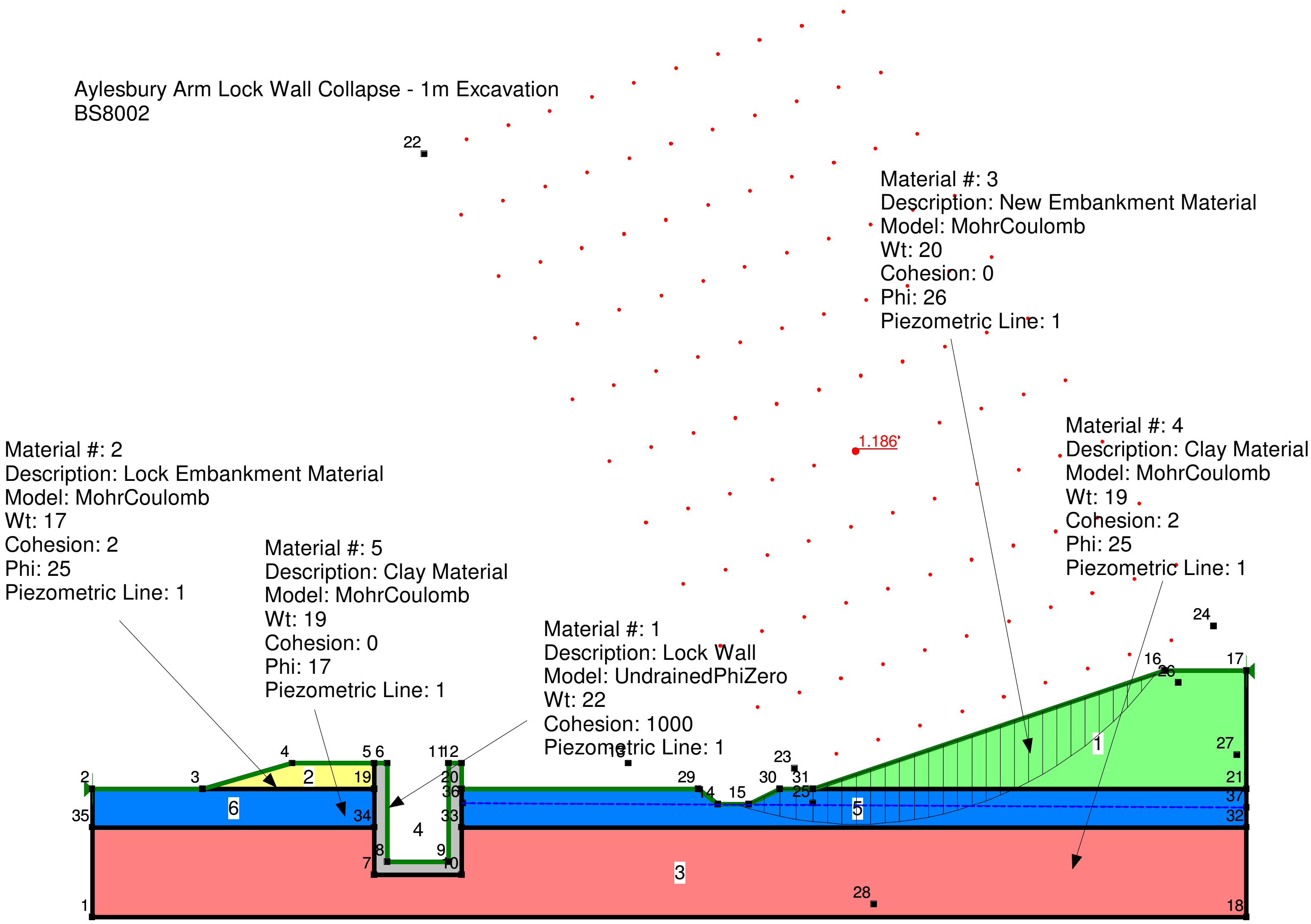
http://www.british-history.ac.uk/

Appendix B

Global Stability Analysis – Arla North Development



Aylesbury Arm Lock Wall Collapse - Pre-failure
BS8002
1.184
Material #: 3
Description: New Embankment Material
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 26
Piezometric Line: 1
Material #: 6
Description: Clay Material
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 17
Piezometric Line: 1
Material #: 2
Description: Lock Embankment Material
Model: MohrCoulomb
Wt: 17
Cohesion: 2
Phi: 25
Piezometric Line: 1
Material #: 4
Description: Clay Material
Model: MohrCoulomb
Wt: 19
Cohesion: 2
Phi: 25
Piezometric Line: 1
Material #: 5
Description: Water
Model: NoStrength
Wt: 9.807
Piezometric Line: 1
Material #: 1
Description: Lock Wall
Model: UndrainedPhiZero
Wt: 22
Cohesion: 1000
Piezometric Line: 1

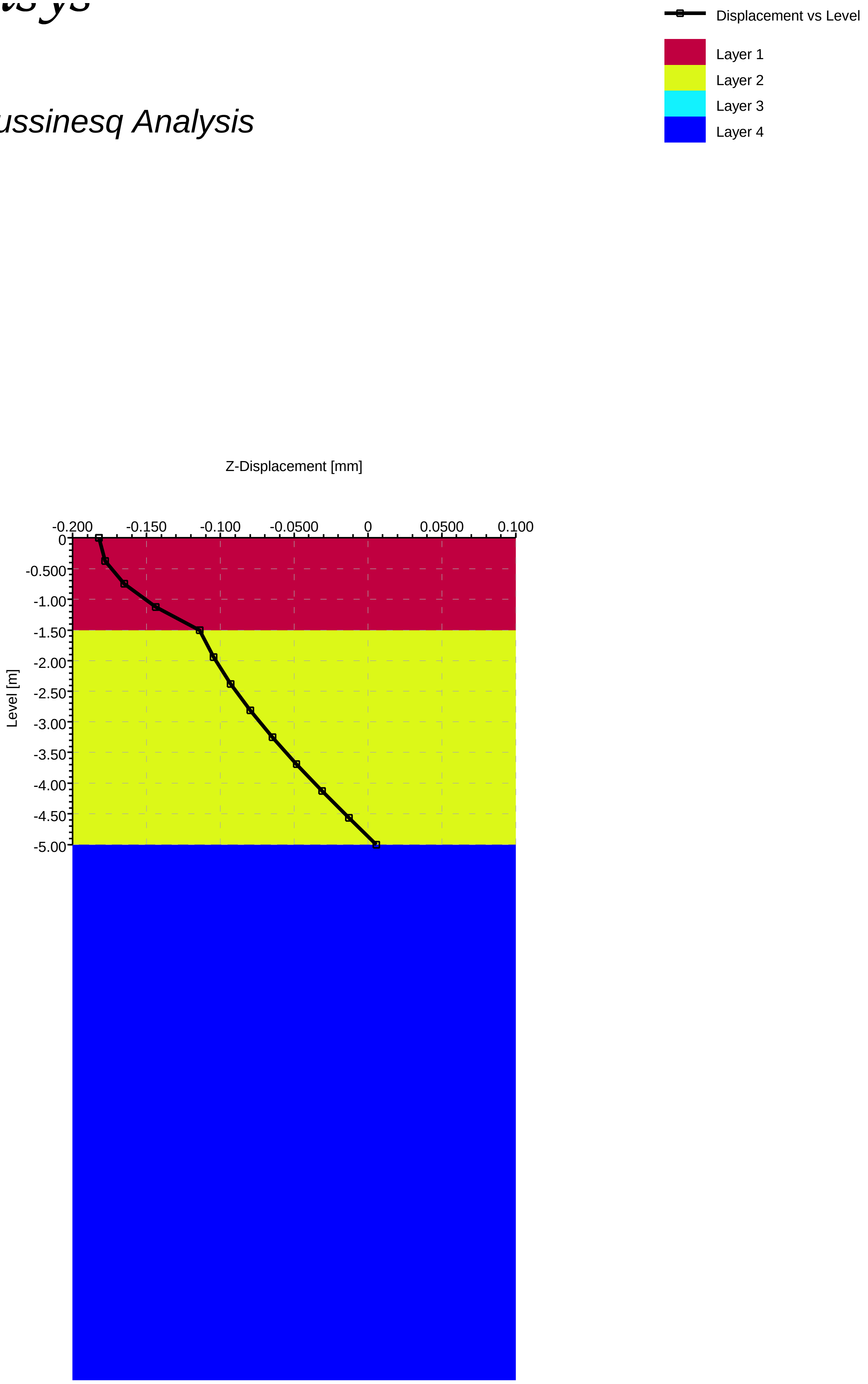

Aylesbury Arm Lock Wall Collapse - 1m Excavation
BS8002
Material #: 3
Description: New Embankment Material
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 26
Piezometric Line: 1
1.186
Material #: 4
Description: Clay Material
Model: MohrCoulomb
Wt: 19
Cohesion: 2
Phi: 25
Piezometric Line: 1
Material #: 2
Description: Lock Embankment Material
Model: MohrCoulomb
Wt: 17
Cohesion: 2
Phi: 25
Piezometric Line: 1
Material #: 5
Description: Clay Material
Model: MohrCoulomb
Wt: 19
Cohesion: 0
Phi: 17
Piezometric Line: 1
Material #: 1
Description: Lock Wall
Model: UndrainedPhiZero
Wt: 22
Cohesion: 1000
Piezometric Line: 1

Appendix C

Elastic Analysis – Arla North Development

Displacement vs Level graph for x [m] = 9.400 and y [m] = 25.000

Boussinesq Analysis



Notes

Boussinesq

Analysis Options

Analysis: Boussinesq
Global Poisson's ratio: 0.20
Maximum allowable ratio between values of E: 1.5
Horizontal rigid boundary level: -5.00 [m OD]
Displacements at area centroids calculated.

Soil ProfilesSoil Profile 1

Layer	Level at top	Number of intermediate displacement levels	Youngs Modulus Top	Youngs Modulus Btm	Poissons ratio	Non-linear curve
	[mOD]		[kN/m²]	[kN/m²]		
1	0.0	3	8000.0	8000.0	0.50000	None
2	-1.5000	7	15000.	15000.	0.20000	None
3	-5.0000	10	30000.	100000.	0.20000	None
4	-20.000	20	100000.	100000.	0.20000	None

Soil ProfilesSoil Profile 2

Layer	Level at top	Number of intermediate displacement levels	Youngs Modulus Top	Youngs Modulus Btm	Poissons ratio	Non-linear curve
	[mOD]		[kN/m²]	[kN/m²]		

Soil Zones

Zone	Name	X coordinates min [m]	X coordinates max [m]	Y coordinates min [m]	Y coordinates max [m]	Profile
1	1	-5.0000	40.000	0.0	50.000	Soil Profile 1

Load Data

Load ref.	Name	Orientation	Centre of load (Global) X [m]	Y [m]	Z(level) [m]	Angle of local x w.r.t. global X [Degrees]	Shape	Dimension Width x/ Radius [m]	Depth y [m]	Load value Normal z [kN/m²]	Tangential x [kN/m²]	Tangential y [kN/m²]	Number of rectangles
1	1	Horizontal	24.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	6.7153	0.0	0.0	N/A
2	2	Horizontal	26.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	20.146	0.0	0.0	N/A
3	3	Horizontal	28.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	33.577	0.0	0.0	N/A
4	4	Horizontal	30.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	47.007	0.0	0.0	N/A
5	5	Horizontal	32.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	60.438	0.0	0.0	N/A
6	6	Horizontal	34.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	73.869	0.0	0.0	N/A
7	7	Horizontal	36.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.299	0.0	0.0	N/A
8	8	Horizontal	38.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.300	0.0	0.0	N/A
9	9	Horizontal	40.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.300	0.0	0.0	N/A

Displacement Data

Ref.	Type	Name	Direction of Extrusion	First point X [m]	First point Y [m]	First point Z(level) [m]	Second point X [m]	Second point Y [m]	Second point Z(level) [m]	No. of intrvls across extrusion/line	Extrusion Depth [m]	No. of intrvls along extrusion	Calculate	Show Detailed results
1	Line	Line 1	N/A	9.40000	.00000	.00000	9.40000	50.00000	.00000	10	N/A	N/A	Yes	Yes
2	Grid	Grid 1	Global Y	-8.20133	-1.99090	.00000	43.79988	N/A	.00000	10	54.319	10	Yes	No
3	Line	Line 2	N/A	9.80000	24.00000	.00000	9.80000	24.00000	-5.00000	15	N/A	N/A	Yes	Yes

Warnings

1 Not all displacement points lie within soil zones. Results calculated for points outside soil zones will assume a soil zone with properties of the first soil profile.

RESULTS FOR GRIDS

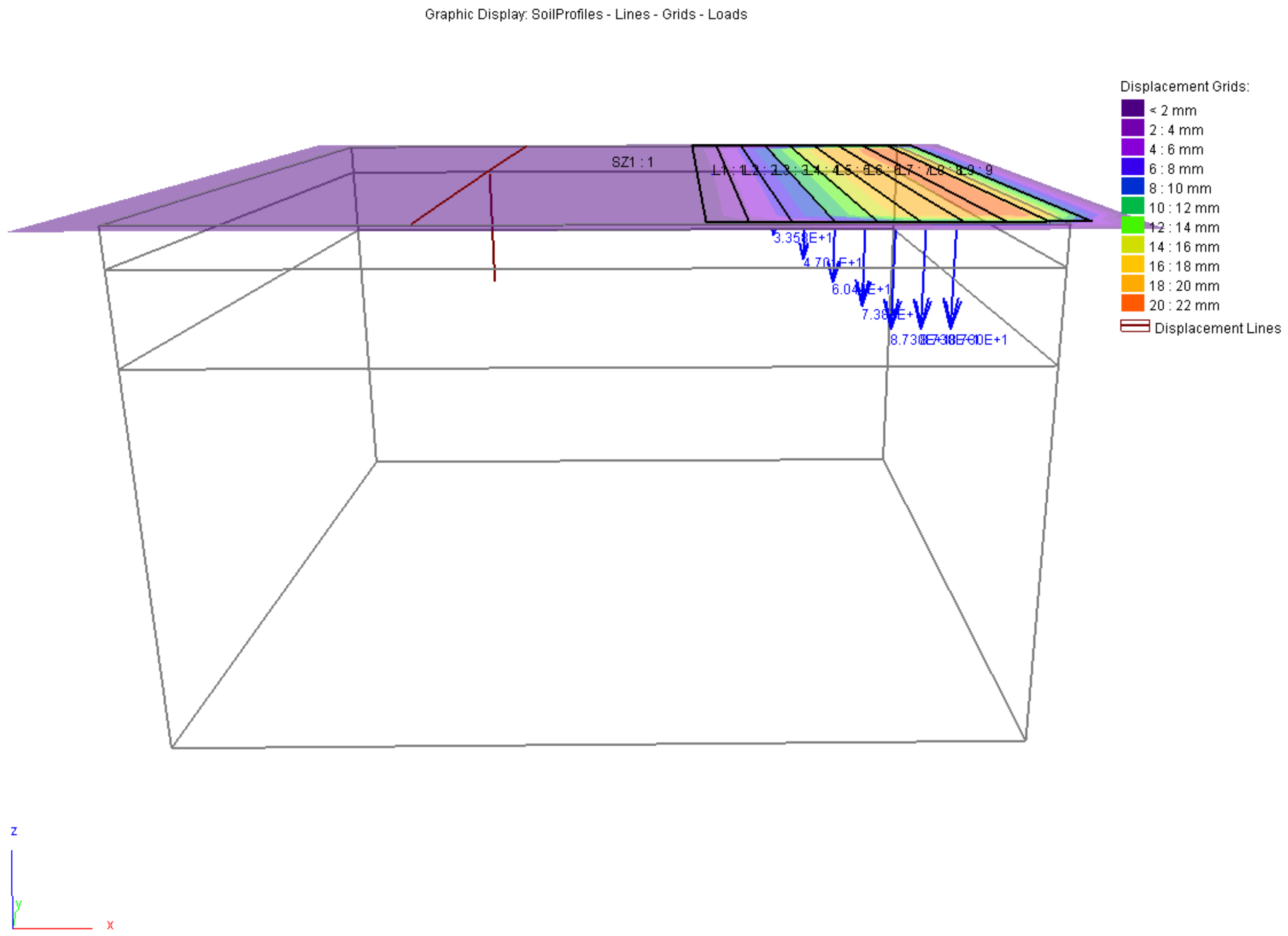
Analysis: Boussinesq
Global Poisson's ratio: 0.20
Horizontal rigid boundary level: -5.00 [m OD]

The maximum displacement difference between
Boussinesq method = 21.758mm and Mindlin method = 17.385mm
occurs at point X = 36.000m Y = 25.000mLevel = 0.0mOD and is: 4.3726mm

Name	Location X [m]	Location Y [m]	Z[Level] [mOD]	Z [mm]	Calc Level [mOD]	Stresses Vert Stress [kN/m²]	Sum Princ [kN/m²]	Vert Strain [%]	
	24.00000	25.00000	.00000	1.3839	-0.18750	6.7253	17.920	0.014100	
	26.00000	25.00000	.00000	4.6000	-0.18750	20.147	48.605	0.073963	
	28.00000	25.00000	.00000	8.0748	-0.18750	33.577	79.981	0.12968	
	30.00000	25.00000	.00000	11.612	-0.18750	47.007	111.43	0.18493	
	32.00000	25.00000	.00000	15.175	-0.18750	60.438	142.78	0.24081	
	34.00000	25.00000	.00000	18.695	-0.18750	73.867	173.78	0.29886	
	36.00000	25.00000	.00000	21.758	-0.18750	87.279	203.24	0.36623	
	38.00000	25.00000	.00000	21.831	-0.18750	87.295	203.34	0.36587	
	40.00000	25.00000	.00000	19.220	-0.18750	87.183	195.67	0.41175	
Line 1	9.40000	.00000	.00000	-0.11473	-0.18750	7.6050E-6	0.11362	-709.97E-6	
	9.40000	5.00000	.00000	-0.13806	-0.18750	11.107E-6	0.13844	-865.02E-6	
	9.40000	10.00000	.00000	-0.15756	-0.18750	11.408E-6	0.15879	-992.22E-6	
	9.40000	15.00000	.00000	-0.17151	-0.18750	12.909E-6	0.17301	-0.0010811	
	9.40000	20.00000	.00000	-0.17967	-0.18750	13.109E-6	0.18118	-0.0011322	
	9.40000	25.00000	.00000	-0.18234	-0.18750	12.608E-6	0.18383	-0.0011487	
	9.40000	30.00000	.00000	-0.17967	-0.18750	13.109E-6	0.18118	-0.0011322	
	9.40000	35.00000	.00000	-0.17151	-0.18750	12.909E-6	0.17301	-0.0010811	
	9.40000	40.00000	.00000	-0.15756	-0.18750	11.408E-6	0.15879	-992.22E-6	
	9.40000	45.00000	.00000	-0.13806	-0.18750	11.107E-6	0.13844	-865.02E-6	
	9.40000	50.00000	.00000	-0.11473	-0.18750	7.6050E-6	0.11362	-709.97E-6	
Grid 1	-8.20133	-1.99090	.00000	-0.032566	-0.18750	1.1007E-6	0.029708	-185.65E-6	!
	-8.20133	3.44099	.00000	-0.036743	-0.18750	1.5010E-6	0.033602	-209.98E-6	!
	-8.20133	8.87289	.00000	-0.040406	-0.18750	0.0	0.037017	-231.34E-6	!
	-8.20133	14.30479	.00000	-0.043241	-0.18750	1.8012E-6	0.039665	-247.87E-6	!
	-8.20133	19.73669	.00000	-0.045014	-0.18750	0.0	0.041318	-258.24E-6	!
	-8.20133	25.16859	.00000	-0.045594	-0.18750	1.8012E-6	0.041858	-261.58E-6	!
	-8.20133	30.60048	.00000	-0.044938	-0.18750	0.0	0.041248	-257.80E-6	!
	-8.20133	36.03238	.00000	-0.043094	-0.18750	1.7011E-6	0.039526	-247.00E-6	!
	-8.20133	41.46428	.00000	-0.040200	-0.18750	1.6011E-6	0.036827	-230.14E-6	!
	-8.20133	46.89618	.00000	-0.036495	-0.18750	1.9013E-6	0.033367	-208.51E-6	!
	-8.20133	52.32808	.00000	-0.032298	-0.18750	0.0	0.029453	-184.08E-6	!
	-3.00121	-1.99090	.00000	-0.044008	-0.18750	0.0	0.040575	-253.59E-6	!
	-3.00121	3.44099	.00000	-0.050692	-0.18750	2.3015E-6	0.046923	-293.23E-6	
	-3.00121	8.87289	.00000	-0.056590	-0.18750	1.9013E-6	0.052515	-328.18E-6	
	-3.00121	14.30479	.00000	-0.061139	-0.18750	3.5023E-6	0.056835	-355.15E-6	
	-3.00121	19.73669	.00000	-0.063968	-0.18750	2.5017E-6	0.059513	-371.91E-6	
	-3.00121	25.16859	.00000	-0.064888	-0.18750	2.0013E-6	0.060377	-377.32E-6	
	-3.00121	30.60048	.00000	-0.063847	-0.18750	2.2015E-6	0.059391	-371.15E-6	
	-3.00121	36.03238	.00000	-0.060904	-0.18750	1.5010E-6	0.056609	-353.78E-6	
	-3.00121	41.46428	.00000	-0.056258	-0.18750	0.0	0.052201	-326.24E-6	
	-3.00121	46.89618	.00000	-0.050293	-0.18750	2.3015E-6	0.046538	-290.82E-6	
	-3.00121	52.32808	.00000	-0.043582	-0.18750	0.0	0.040167	-251.06E-6	!
	2.19891	-1.99090	.00000	-0.061485	-0.18750	0.0	0.057655	-360.33E-6	!
	2.19891	3.44099	.00000	-0.072739	-0.18750	3.1021E-6	0.068649	-429.00E-6	
	2.19891	8.87289	.00000	-0.082680	-0.18750	3.0020E-6	0.078337	-489.55E-6	
	2.19891	14.30479	.00000	-0.090250	-0.18750	4.2028E-6	0.085685	-535.45E-6	
	2.19891	19.73669	.00000	-0.094881	-0.18750	3.1021E-6	0.090149	-563.37E-6	
	2.19891	25.16859	.00000	-0.096372	-0.18750	4.0027E-6	0.091584	-572.32E-6	
	2.19891	30.60048	.00000	-0.094684	-0.18750	3.9026E-6	0.089961	-562.18E-6	
	2.19891	36.03238	.00000	-0.089862	-0.18750	4.1027E-6	0.085313	-533.13E-6	
	2.19891	41.46428	.00000	-0.082123	-0.18750	2.4016E-6	0.077800	-486.21E-6	
	2.19891	46.89618	.00000	-0.072066	-0.18750	1.6010E-6	0.067985	-424.87E-6	
	2.19891	52.32808	.00000	-0.060774	-0.18750	0.0	0.056958	-355.98E-6	!
	7.39903	-1.99090	.00000	-0.089647	-0.18750	4.6031E-6	0.086590	-541.10E-6	!
	7.39903	3.44099	.00000	-0.10991	-0.18750	7.1047E-6	0.10746	-671.49E-6	
	7.39903	8.87289	.00000	-0.12765	-0.18750	9.5063E-6	0.12558	-784.71E-6	
	7.39903	14.30479	.00000	-0.14073	-0.18750	9.4062E-6	0.13873	-866.87E-6	
	7.39903	19.73669	.00000	-0.14847	-0.18750	8.2054E-6	0.14639	-914.76E-6	
	7.39903	25.16859	.00000	-0.15092	-0.18750	10.607E-6	0.14879	-929.76E-6	
	7.39903	30.60048	.00000	-0.14815	-0.18750	8.2054E-6	0.14607	-912.78E-6	
	7.39903	36.03238	.00000	-0.14007	-0.18750	9.9066E-6	0.13807	-862.74E-6	

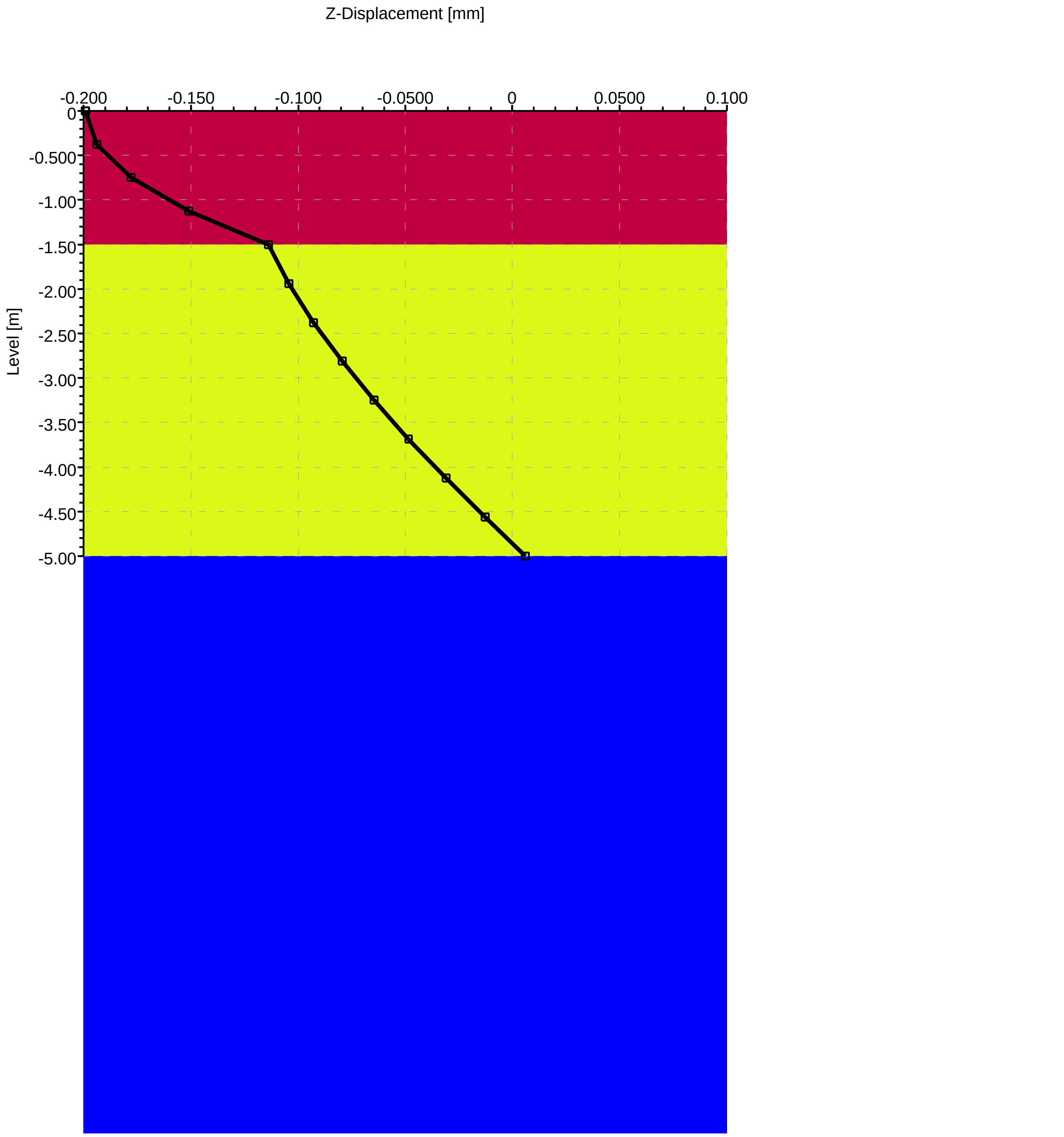
Name	Location				Stresses			
	X	Y	Z[Level]	Z	Calc Level	Vert Stress	Sum Princ	Vert Strain
	[m]	[m]	[mOD]	[mm]	[mOD]	[kN/m²]	[kN/m²]	[%]
	7.39903	41.46428	.00000	-0.12667	-0.18750	7.6050E-6	0.12458	-778.51E-6
	7.39903	46.89618	.00000	-0.10870	-0.18750	6.8045E-6	0.10622	-663.72E-6
	7.39903	52.32808	.00000	-0.088376	-0.18750	6.3042E-6	0.085285	-532.91E-6 !
	12.59915	-1.99090	.00000	-0.13791	-0.18750	12.408E-6	0.14167	-885.23E-6 !
	12.59915	3.44099	.00000	-0.17762	-0.18750	21.414E-6	0.18795	-0.0011743
	12.59915	8.87289	.00000	-0.21140	-0.18750	24.116E-6	0.22593	-0.0014116
	12.59915	14.30479	.00000	-0.23479	-0.18750	26.918E-6	0.25083	-0.0015672
	12.59915	19.73669	.00000	-0.24783	-0.18750	29.620E-6	0.26421	-0.0016508
	12.59915	25.16859	.00000	-0.25181	-0.18750	28.819E-6	0.26823	-0.0016759
	12.59915	30.60048	.00000	-0.24729	-0.18750	28.719E-6	0.26367	-0.0016474
	12.59915	36.03238	.00000	-0.23365	-0.18750	27.118E-6	0.24965	-0.0015598
	12.59915	41.46428	.00000	-0.20959	-0.18750	25.417E-6	0.22395	-0.0013992
	12.59915	46.89618	.00000	-0.17525	-0.18750	18.612E-6	0.18521	-0.0011572
	12.59915	52.32808	.00000	-0.13544	-0.18750	12.909E-6	0.13881	-867.31E-6 !
	17.79927	-1.99090	.00000	-0.22107	-0.18750	54.136E-6	0.27140	-0.0016953 !
	17.79927	3.44099	.00000	-0.29744	-0.18750	121.88E-6	0.41579	-0.0025964
	17.79927	8.87289	.00000	-0.36376	-0.18750	148.50E-6	0.51182	-0.0031961
	17.79927	14.30479	.00000	-0.40599	-0.18750	156.10E-6	0.56144	-0.0035061
	17.79927	19.73669	.00000	-0.42753	-0.18750	158.71E-6	0.58459	-0.0036507
	17.79927	25.16859	.00000	-0.43382	-0.18750	161.61E-6	0.59112	-0.0036915
	17.79927	30.60048	.00000	-0.42668	-0.18750	157.70E-6	0.58370	-0.0036452
	17.79927	36.03238	.00000	-0.40404	-0.18750	156.20E-6	0.55928	-0.0034926
	17.79927	41.46428	.00000	-0.36032	-0.18750	150.10E-6	0.50747	-0.0031689
	17.79927	46.89618	.00000	-0.29277	-0.18750	119.58E-6	0.40781	-0.0025466
	17.79927	52.32808	.00000	-0.21630	-0.18750	51.934E-6	0.26267	-0.0016407 !
	22.99939	-1.99090	.00000	-0.25579	-0.18750	981.33E-6	0.76575	-0.0047676 !
	22.99939	3.44099	.00000	0.63435	-0.18750	3.3463	9.1417	0.0056072
	22.99939	8.87289	.00000	0.54133	-0.18750	3.3466	9.4555	0.0036513
	22.99939	14.30479	.00000	0.46898	-0.18750	3.3466	9.5536	0.0030380
	22.99939	19.73669	.00000	0.43557	-0.18750	3.3466	9.5914	0.0028018
	22.99939	25.16859	.00000	0.42634	-0.18750	3.3466	9.6013	0.0027400
	22.99939	30.60048	.00000	0.43684	-0.18750	3.3466	9.5901	0.0028105
	22.99939	36.03238	.00000	0.47213	-0.18750	3.3466	9.5499	0.0030615
	22.99939	41.46428	.00000	0.54749	-0.18750	3.3465	9.4455	0.0037136
	22.99939	46.89618	.00000	0.63348	-0.18750	3.3462	9.1002	0.0058656
	22.99939	52.32808	.00000	-0.26885	-0.18750	687.58E-6	0.69468	-0.0043289 !
	28.19951	-1.99090	.00000	0.059532	-0.18750	0.0061311	2.2107	-0.013702 !
	28.19951	3.44099	.00000	8.4959	-0.18750	33.600	79.767	0.13145
	28.19951	8.87289	.00000	8.4643	-0.18750	33.601	80.616	0.12616
	28.19951	14.30479	.00000	8.3562	-0.18750	33.601	80.785	0.12511
	28.19951	19.73669	.00000	8.3102	-0.18750	33.601	80.839	0.12477
	28.19951	25.16859	.00000	8.2980	-0.18750	33.601	80.853	0.12469
	28.19951	30.60048	.00000	8.3119	-0.18750	33.601	80.837	0.12478
	28.19951	36.03238	.00000	8.3607	-0.18750	33.601	80.779	0.12515
	28.19951	41.46428	.00000	8.4737	-0.18750	33.601	80.596	0.12629
	28.19951	46.89618	.00000	8.4543	-0.18750	33.599	79.612	0.13241
	28.19951	52.32808	.00000	-0.067014	-0.18750	0.0038484	1.8510	-0.011497 !
	33.39964	-1.99090	.00000	0.51439	-0.18750	0.012004	3.7499	-0.023212 !
	33.39964	3.44099	.00000	18.082	-0.18750	73.637	168.66	0.32660
	33.39964	8.87289	.00000	18.162	-0.18750	73.640	170.06	0.31787
	33.39964	14.30479	.00000	18.030	-0.18750	73.640	170.28	0.31647
	33.39964	19.73669	.00000	17.977	-0.18750	73.640	170.35	0.31607
	33.39964	25.16859	.00000	17.963	-0.18750	73.640	170.36	0.31597
	33.39964	30.60048	.00000	17.979	-0.18750	73.640	170.35	0.31608
	33.39964	36.03238	.00000	18.036	-0.18750	73.640	170.28	0.31652
	33.39964	41.46428	.00000	18.173	-0.18750	73.640	170.03	0.31805
	33.39964	46.89618	.00000	17.989	-0.18750	73.637	168.37	0.32835
	33.39964	52.32808	.00000	0.25262	-0.18750	0.0074580	3.0636	-0.019008 !
	38.59975	-1.99090	.00000	0.65365	-0.18750	0.013829	3.8750	-0.023959 !
	38.59975	3.44099	.00000	21.573	-0.18750	87.288	200.84	0.38138
	38.59975	8.87289	.00000	21.687	-0.18750	87.291	202.22	0.37281
	38.59975	14.30479	.00000	21.563	-0.18750	87.291	202.43	0.37149
	38.59975	19.73669	.00000	21.511	-0.18750	87.291	202.50	0.37111
	38.59975	25.16859	.00000	21.498	-0.18750	87.291	202.51	0.37101
	38.59975	30.60048	.00000	21.513	-0.18750	87.291	202.49	0.37112
	38.59975	36.03238	.00000	21.568	-0.18750	87.291	202.43	0.37153
	38.59975	41.46428	.00000	21.698	-0.18750	87.291	202.20	0.37297
	38.59975	46.89618	.00000	21.470	-0.18750	87.287	200.55	0.38320
	38.59975	52.32808	.00000	0.35516	-0.18750	0.0083906	3.1094	-0.019276 !
	43.79988	-1.99090	.00000	-0.30705	-0.18750	978.65E-6	1.0736	-0.0066915 !
	43.79988	3.44099	.00000	0.021599	-0.18750	0.0050298	2.7386	-0.017022 !
	43.79988	8.87289	.00000	-0.093336	-0.18750	0.0054196	3.2237	-0.020047 !
	43.79988	14.30479	.00000	-0.18487	-0.18750	0.0054563	3.3572	-0.020880 !
	43.79988	19.73669	.00000	-0.22505	-0.18750	0.0054643	3.4039	-0.021172 !
	43.79988	25.16859	.00000	-0.23586	-0.18750	0.0054659	3.4156	-0.021245 !
	43.79988	30.60048	.00000	-0.22355	-0.18750	0.0054626	3.4023	-0.021162 !
	43.79988	36.03238	.00000	-0.18100	-0.18750	0.0054567	3.3524	-0.020850 !
	43.79988	41.46428	.00000	-0.085367	-0.18750	0.0054138	3.2093	-0.019957 !
	43.79988	46.89618	.00000	0.019856	-0.18750	0.0049425	2.6761	-0.016633 !
	43.79988	52.32808	.00000	-0.31993	-0.18750	806.64E-6	0.98608	-0.0061478 !
Line 2	9.80000	24.00000	.00000	-0.18948	-0.18750	15.310E-6	0.19205	-0.0012000
	9.80000	24.00000	-0.33333	-0.18593	-0.52778	336.12E-6	0.54024	-0.0033702
	9.80000	24.00000	-0.66667	-0.17529	-0.87500	0.0015253	0.89449	-0.0055620
	9.80000	24.00000	-1.00000	-0.15760	-1.1250	0.0032334	1.1485	-0.0071176
	9.80000	24.00000	-1.33333	-0.13302	-1.4167	0.0064320	1.4434	-0.0089008
	9.80000	24.00000	-1.66667	-0.11474	-1.9048	0.015495	1.9324	-0.0024526
	9.80000	24.00000	-2.00000	-0.10682	-2.2143	0.024176	2.2389	-0.0027917
	9.80000	24.00000	-2.33333	-0.097682	-2.5556	0.036840	2.5728	-0.0031357
	9.80000	24.00000	-2.66667	-0.087412	-2.9000	0.053291	2.9053	-0.0034473
	9.80000	24.00000	-3.00000	-0.076089	-3.2000	0.070904	3.1905	-0.0036868
	9.80000	24.00000	-3.33333	-0.063884	-3.5417	0.094958	3.5101	-0.0039205
	9.80000	24.00000	-3.66667	-0.050905	-3.8889	0.12402	3.8287	-0.0041127
	9.80000	24.00000	-4.00000	-0.037268	-4.1667	0.15078	4.0787	-0.0042321
	9.80000	24.00000	-4.33333	-0.023161	-4.5000	0.18713	4.3727	-0.0043333
	9.80000	24.00000	-4.66667	-0.0087171	-4.8333	0.22822	4.6599	-0.0043874
	9.80000	24.00000	-5.00000	-0.084312	-5.5316	0.32991	5.2377	-0.0020102

! Point lies outside soil zones. Results calculated for this point assume a soil zone with properties of the first soil profile.


Graphic Display: SoilProfiles - Lines - Grids - Loads
Displacement Grids:
< 2 mm
2 : 4 mm
4 : 6 mm
6 : 8 mm
8 : 10 mm
10 : 12 mm
12 : 14 mm
14 : 16 mm
16 : 18 mm
18 : 20 mm
20 : 22 mm
Displacement Lines
SZ1 : 1
z
y
x

Displacement vs Level graph for x [m] = 9.400 and y [m] = 25.000

Mindlin Analysis



Oasys

Notes
Boussinesq

Analysis Options
Analysis: Mindlin - Horizontal dispacements are calculated
Soil above horizontal load on horizontal plane dampens displacements below load : Yes
Soil above vertical load on horizontal plane dampens displacements below load : No
Maximum allowable ratio between values of E: 1.5
Horizontal rigid boundary level: -5.00 [m OD]
Displacements at area centroids calculated.

Soil ProfilesSoil Profile 1

Layer	Level at top	Number of intermediate displacement levels	Youngs Modulus Top	Youngs Modulus Btm	Poissons ratio	Non-linear curve
	[mOD]		[kN/m²]	[kN/m²]		
1	0.0	3	8000.0	8000.0	0.50000	None
2	-1.5000	7	15000.	15000.	0.20000	None
3	-5.0000	10	30000.	100000.	0.20000	None
4	-20.000	20	100000.	100000.	0.20000	None

Soil ProfilesSoil Profile 2

Layer	Level at top	Number of intermediate displacement levels	Youngs Modulus Top	Youngs Modulus Btm	Poissons ratio	Non-linear curve
	[mOD]		[kN/m²]	[kN/m²]		

Soil Zones

Zone	Name	X coordinates min	X coordinates max	Y coordinates min	Y coordinates max	Profile
		[m]	[m]	[m]	[m]	
1	1	-5.0000	40.000	0.0	50.000	Soil Profile 1

Load Data

Load ref.	Name	Orientation	Loaded plane: Centre of load (Global) X	Y	Z(level)	Angle of local x w.r.t. global X	Shape	Dimension Width x/ Radius	Depth y	Loads: Load value Normal z	Tangential x	Tangential y	Number of rectangles
			[m]	[m]	[m]	[Degrees]		[m]	[m]	[kN/m²]	[kN/m²]	[kN/m²]	
1	1	Horizontal	24.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	6.7153	0.0	0.0	N/A
2	2	Horizontal	26.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	20.146	0.0	0.0	N/A
3	3	Horizontal	28.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	33.577	0.0	0.0	N/A
4	4	Horizontal	30.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	47.007	0.0	0.0	N/A
5	5	Horizontal	32.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	60.438	0.0	0.0	N/A
6	6	Horizontal	34.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	73.869	0.0	0.0	N/A
7	7	Horizontal	36.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.299	0.0	0.0	N/A
8	8	Horizontal	38.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.300	0.0	0.0	N/A
9	9	Horizontal	40.000	25.000	0.0	0.0	Rectangular	2.0000	50.000	87.300	0.0	0.0	N/A

Displacement Data

Ref.	Type	Name	Direction of Extrusion	Line/Line for extrusion: First point X	Y	Z(level)	Second point X	Y	Z(level)	No. of intrvls across extrusion/line	Extrusion Depth	No. of intrvls along extrusion	Calculate	Show Detailed results
				[m]	[m]	[m]	[m]	[m]	[m]		[m]			
1	Line	Line 1	N/A	9.40000	.00000	.00000	9.40000	50.00000	.00000	10	N/A	N/A	Yes	Yes
2	Grid	Grid 1	Global Y	-8.20133	-1.99090	.00000	43.79988	N/A	.00000	10	54.319	10	Yes	No
3	Line	Line 2	N/A	9.80000	24.00000	.00000	9.80000	24.00000	-5.00000	15	N/A	N/A	Yes	Yes

RESULTS FOR GRIDS

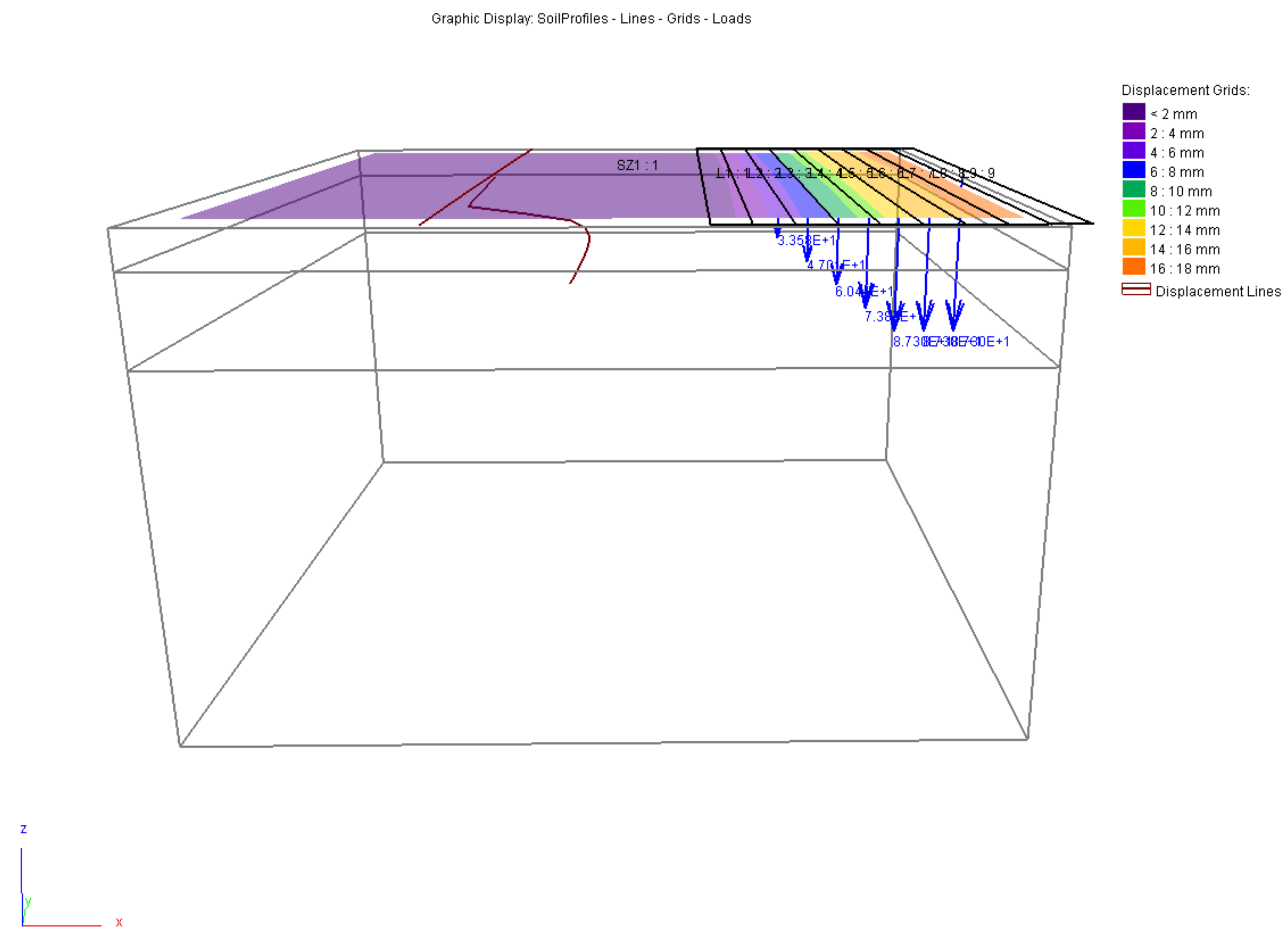
Analysis: Mindlin
Maximum allowable ratio between values of E: 1.5
Horizontal rigid boundary level: -5.00 [m OD]

Name	Location X	Location Y	Location Z[Level]	Displacement X	Displacement Y	Displacement Z
	[m]	[m]	[mOD]	[mm]	[mm]	[mm]
	24.00000	25.00000	.00000	0.0	0.0	0.86051
	26.00000	25.00000	.00000	0.0	0.0	3.4443
	28.00000	25.00000	.00000	1.9073E-6	0.0	6.2416
	30.00000	25.00000	.00000	0.0	0.0	9.0952
	32.00000	25.00000	.00000	-1.9073E-6	0.0	11.984
	34.00000	25.00000	.00000	-1.9073E-6	0.0	14.860
	36.00000	25.00000	.00000	-1.9073E-6	0.0	17.385
	38.00000	25.00000	.00000	-1.9073E-6	0.0	17.475
	40.00000	25.00000	.00000	-1.9073E-6	0.0	15.344
Line 1	9.40000	.00000	.00000	0.0	1.9073E-6	-0.12506
	9.40000	5.00000	.00000	0.0	0.0	-0.15069
	9.40000	10.00000	.00000	-1.9073E-6	0.0	-0.17215
	9.40000	15.00000	.00000	3.8147E-6	0.0	-0.18740
	9.40000	20.00000	.00000	3.8147E-6	0.0	-0.19623
	9.40000	25.00000	.00000	3.8147E-6	0.0	-0.19922
	9.40000	30.00000	.00000	3.8147E-6	0.0	-0.19626
	9.40000	35.00000	.00000	3.8147E-6	0.0	-0.18743
	9.40000	40.00000	.00000	-1.9073E-6	0.0	-0.17212
	9.40000	45.00000	.00000	0.0	0.0	-0.15072
	9.40000	50.00000	.00000	0.0	-1.9073E-6	-0.12520
Grid 1	-8.20133	-1.99090	.00000	-1.#IND	-1.#IND	-0.035386 !
	-8.20133	3.44099	.00000	-1.#IND	-1.#IND	-0.040079 !
	-8.20133	8.87289	.00000	-1.#IND	-1.#IND	-0.043745 !
	-8.20133	14.30479	.00000	-1.#IND	-1.#IND	-0.046926 !
	-8.20133	19.73669	.00000	-1.#IND	-1.#IND	-0.048800 !
	-8.20133	25.16859	.00000	-1.#IND	-1.#IND	-0.049488 !
	-8.20133	30.60048	.00000	-1.#IND	-1.#IND	-0.048703 !
	-8.20133	36.03238	.00000	-1.#IND	-1.#IND	-0.046850 !
	-8.20133	41.46428	.00000	-1.#IND	-1.#IND	-0.043563 !
	-8.20133	46.89618	.00000	-1.#IND	-1.#IND	-0.039703 !
	-8.20133	52.32808	.00000	-1.#IND	-1.#IND	-0.035163 !
	-3.00121	-1.99090	.00000	-1.#IND	-1.#IND	-0.047923 !
	-3.00121	3.44099	.00000	0.0	0.0	-0.054888
	-3.00121	8.87289	.00000	0.0	0.0	-0.061421
	-3.00121	14.30479	.00000	0.0	0.0	-0.066250
	-3.00121	19.73669	.00000	0.0	0.0	-0.069404
	-3.00121	25.16859	.00000	1.9073E-6	0.0	-0.070346
	-3.00121	30.60048	.00000	0.0	0.0	-0.069231
	-3.00121	36.03238	.00000	0.0	0.0	-0.066007
	-3.00121	41.46428	.00000	1.9073E-6	0.0	-0.060980
	-3.00121	46.89618	.00000	0.0	0.0	-0.054683
	-3.00121	52.32808	.00000	-1.#IND	-1.#IND	-0.047142 !
	2.19891	-1.99090	.00000	-1.#IND	-1.#IND	-0.066617 !
	2.19891	3.44099	.00000	0.0	0.0	-0.079064
	2.19891	8.87289	.00000	0.0	0.0	-0.089911
	2.19891	14.30479	.00000	0.0	0.0	-0.098078
	2.19891	19.73669	.00000	0.0	0.0	-0.10321
	2.19891	25.16859	.00000	0.0	0.0	-0.10467
	2.19891	30.60048	.00000	3.8147E-6	0.0	-0.10295
	2.19891	36.03238	.00000	0.0	0.0	-0.097658
	2.19891	41.46428	.00000	0.0	0.0	-0.089308
	2.19891	46.89618	.00000	0.0	0.0	-0.078155
	2.19891	52.32808	.00000	-1.#IND	-1.#IND	-0.066236 !
	7.39903	-1.99090	.00000	-1.#IND	-1.#IND	-0.097620 !
	7.39903	3.44099	.00000	0.0	1.9073E-6	-0.11971
	7.39903	8.87289	.00000	0.0	0.0	-0.13923
	7.39903	14.30479	.00000	0.0	0.0	-0.15336
	7.39903	19.73669	.00000	0.0	0.0	-0.16185
	7.39903	25.16859	.00000	3.8147E-6	0.0	-0.16451
	7.39903	30.60048	.00000	0.0	0.0	-0.16150
	7.39903	36.03238	.00000	5.7220E-6	0.0	-0.15267
	7.39903	41.46428	.00000	5.7220E-6	0.0	-0.13804
	7.39903	46.89618	.00000	0.0	-1.9073E-6	-0.11848
	7.39903	52.32808	.00000	-1.#IND	-1.#IND	-0.095994 !
	12.59915	-1.99090	.00000	-1.#IND	-1.#IND	-0.15084 !
	12.59915	3.44099	.00000	0.0	1.9073E-6	-0.19488
	12.59915	8.87289	.00000	0.0	0.0	-0.23234
	12.59915	14.30479	.00000	3.8147E-6	0.0	-0.25790
	12.59915	19.73669	.00000	0.0	0.0	-0.27209
	12.59915	25.16859	.00000	0.0	0.0	-0.27650
	12.59915	30.60048	.00000	1.9073E-6	0.0	-0.27158
	12.59915	36.03238	.00000	5.7220E-6	0.0	-0.25667
	12.59915	41.46428	.00000	3.8147E-6	-1.9073E-6	-0.23022

Name	Location			Displacement			
	X	Y	Z[Level]	X	Y	Z	
	[m]	[m]	[mOD]	[mm]	[mm]	[mm]	
	12.59915	46.89618	.00000	0.0	-3.8147E-6	-0.19219	
	12.59915	52.32808	.00000	-1.#IND	-1.#IND	-0.14818	!
	17.79927	-1.99090	.00000	-1.#IND	-1.#IND	-0.24611	!
	17.79927	3.44099	.00000	3.8147E-6	1.9073E-6	-0.33586	
	17.79927	8.87289	.00000	7.6294E-6	3.8147E-6	-0.41111	
	17.79927	14.30479	.00000	3.8147E-6	0.0	-0.45781	
	17.79927	19.73669	.00000	3.8147E-6	0.0	-0.48156	
	17.79927	25.16859	.00000	0.0	0.0	-0.48837	
	17.79927	30.60048	.00000	0.0	0.0	-0.48062	
	17.79927	36.03238	.00000	11.444E-6	0.0	-0.45565	
	17.79927	41.46428	.00000	0.0	0.0	-0.40718	
	17.79927	46.89618	.00000	-1.9073E-6	1.9073E-6	-0.33038	
	17.79927	52.32808	.00000	-1.#IND	-1.#IND	-0.24055	!
	22.99939	-1.99090	.00000	-1.#IND	-1.#IND	-0.32403	!
	22.99939	3.44099	.00000	0.0	-1.9073E-6	0.34988	
	22.99939	8.87289	.00000	0.0	0.0	0.22836	
	22.99939	14.30479	.00000	0.0	1.9073E-6	0.14683	
	22.99939	19.73669	.00000	0.0	0.0	0.11006	
	22.99939	25.16859	.00000	7.6294E-6	0.0	0.099739	
	22.99939	30.60048	.00000	5.7220E-6	0.0	0.11141	
	22.99939	36.03238	.00000	1.9073E-6	0.0	0.15046	
	22.99939	41.46428	.00000	1.9073E-6	-1.9073E-6	0.23542	
	22.99939	46.89618	.00000	1.9073E-6	0.0	0.35254	
	22.99939	52.32808	.00000	-1.#IND	-1.#IND	-0.33125	!
	28.19951	-1.99090	.00000	-1.#IND	-1.#IND	-0.12683	!
	28.19951	3.44099	.00000	0.0	0.0	6.7154	
	28.19951	8.87289	.00000	9.5367E-6	3.8147E-6	6.6085	
	28.19951	14.30479	.00000	-5.7220E-6	-1.9073E-6	6.4848	
	28.19951	19.73669	.00000	1.9073E-6	0.0	6.4337	
	28.19951	25.16859	.00000	1.9073E-6	0.0	6.4203	
	28.19951	30.60048	.00000	1.9073E-6	0.0	6.4355	
	28.19951	36.03238	.00000	1.9073E-6	0.0	6.4899	
	28.19951	41.46428	.00000	9.5367E-6	-5.7220E-6	6.6198	
	28.19951	46.89618	.00000	0.0	-7.6294E-6	6.6867	
	28.19951	52.32808	.00000	-1.#IND	-1.#IND	-0.22658	!
	33.39964	-1.99090	.00000	-1.#IND	-1.#IND	0.20358	!
	33.39964	3.44099	.00000	-5.7220E-6	13.351E-6	14.525	
	33.39964	8.87289	.00000	-3.8147E-6	1.9073E-6	14.482	
	33.39964	14.30479	.00000	-1.9073E-6	3.8147E-6	14.330	
	33.39964	19.73669	.00000	-3.8147E-6	0.0	14.270	
	33.39964	25.16859	.00000	-1.9073E-6	0.0	14.255	
	33.39964	30.60048	.00000	-3.8147E-6	0.0	14.272	
	33.39964	36.03238	.00000	1.9073E-6	-1.9073E-6	14.336	
	33.39964	41.46428	.00000	3.8147E-6	0.0	14.496	
	33.39964	46.89618	.00000	1.9073E-6	-1.9073E-6	14.456	
	33.39964	52.32808	.00000	-1.#IND	-1.#IND	-0.0077288	!
	38.59975	-1.99090	.00000	-1.#IND	-1.#IND	0.33692	!
	38.59975	3.44099	.00000	-9.5367E-6	11.444E-6	17.430	
	38.59975	8.87289	.00000	-1.9073E-6	0.0	17.423	
	38.59975	14.30479	.00000	0.0	1.9073E-6	17.279	
	38.59975	19.73669	.00000	-1.9073E-6	0.0	17.222	
	38.59975	25.16859	.00000	0.0	0.0	17.208	
	38.59975	30.60048	.00000	-3.8147E-6	0.0	17.224	
	38.59975	36.03238	.00000	-3.8147E-6	-1.9073E-6	17.285	
	38.59975	41.46428	.00000	-3.8147E-6	-7.6294E-6	17.436	
	38.59975	46.89618	.00000	-1.9073E-6	-7.6294E-6	17.351	
	38.59975	52.32808	.00000	-1.#IND	-1.#IND	0.093597	!
	43.79988	-1.99090	.00000	-1.#IND	-1.#IND	-0.40376	!
	43.79988	3.44099	.00000	-1.#IND	-1.#IND	-0.21604	!
	43.79988	8.87289	.00000	-1.#IND	-1.#IND	-0.37513	!
	43.79988	14.30479	.00000	-1.#IND	-1.#IND	-0.47891	!
	43.79988	19.73669	.00000	-1.#IND	-1.#IND	-0.52358	!
	43.79988	25.16859	.00000	-1.#IND	-1.#IND	-0.53543	!
	43.79988	30.60048	.00000	-1.#IND	-1.#IND	-0.52194	!
	43.79988	36.03238	.00000	-1.#IND	-1.#IND	-0.47478	!
	43.79988	41.46428	.00000	-1.#IND	-1.#IND	-0.36572	!
	43.79988	46.89618	.00000	-1.#IND	-1.#IND	-0.21231	!
	43.79988	52.32808	.00000	-1.#IND	-1.#IND	-0.40919	!
Line 2	9.80000	24.00000	.00000	3.8147E-6	0.0	-0.20709	
	9.80000	24.00000	-0.33333	-0.60419	-0.011826	-0.20266	
	9.80000	24.00000	-0.66667	-1.2074	-0.023640	-0.18934	
	9.80000	24.00000	-1.00000	-1.8086	-0.035437	-0.16733	
	9.80000	24.00000	-1.33333	-2.4069	-0.047201	-0.13651	
	9.80000	24.00000	-1.66667	2.2555	0.075747	-0.11442	
	9.80000	24.00000	-2.00000	6.0287	0.17500	-0.10650	
	9.80000	24.00000	-2.33333	7.1894	0.20702	-0.097364	
	9.80000	24.00000	-2.66667	7.5138	0.21748	-0.087127	
	9.80000	24.00000	-3.00000	7.4992	0.21917	-0.075771	
	9.80000	24.00000	-3.33333	7.3264	0.21678	-0.063622	
	9.80000	24.00000	-3.66667	7.0731	0.21225	-0.050622	
	9.80000	24.00000	-4.00000	6.7766	0.20654	-0.037010	
	9.80000	24.00000	-4.33333	6.4569	0.20017	-0.022873	
	9.80000	24.00000	-4.66667	6.1251	0.19343	-0.0085038	
	9.80000	24.00000	-5.00000	5.7880	0.18642	0.0	

! Point lies outside soil zones. Results calculated for this point assume a soil zone with properties of the first soil profile.

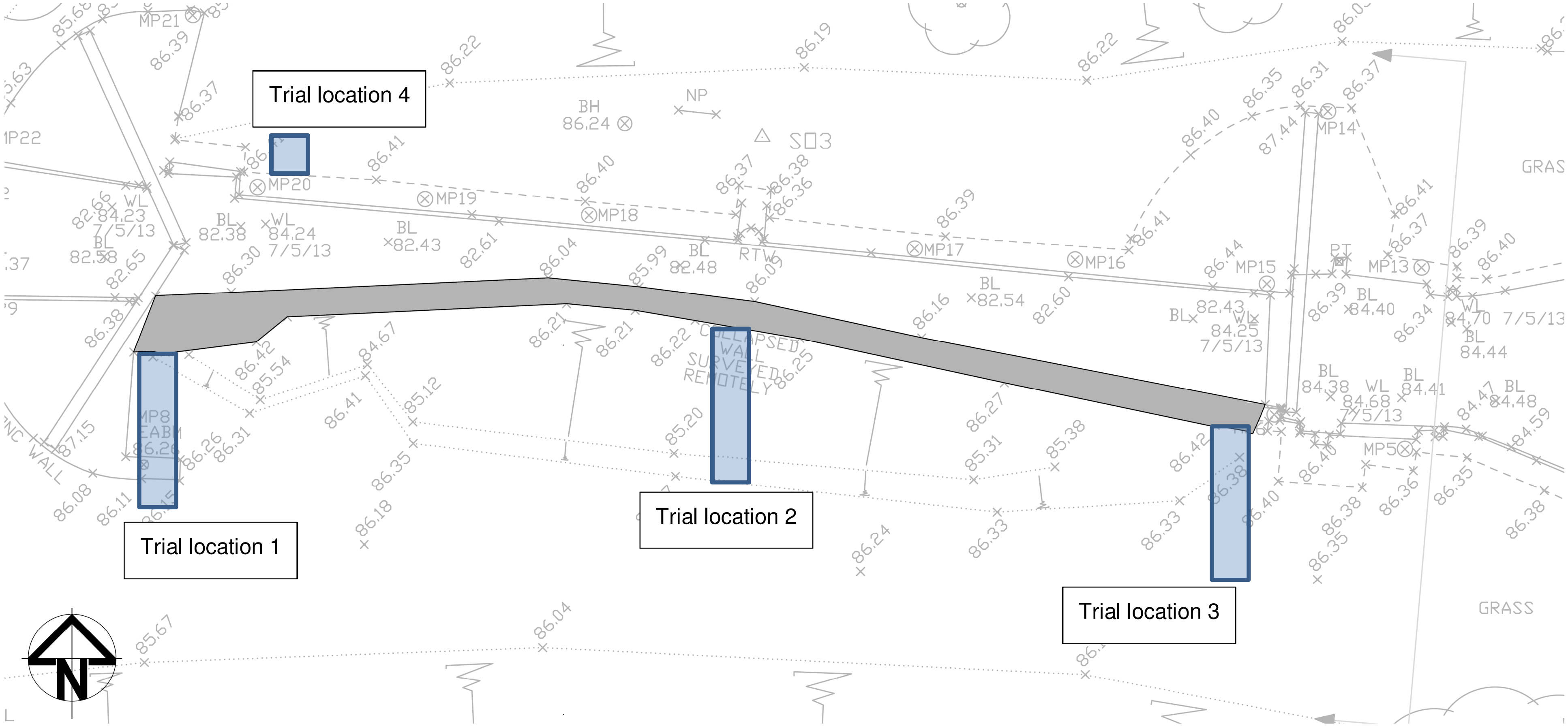
Oasys



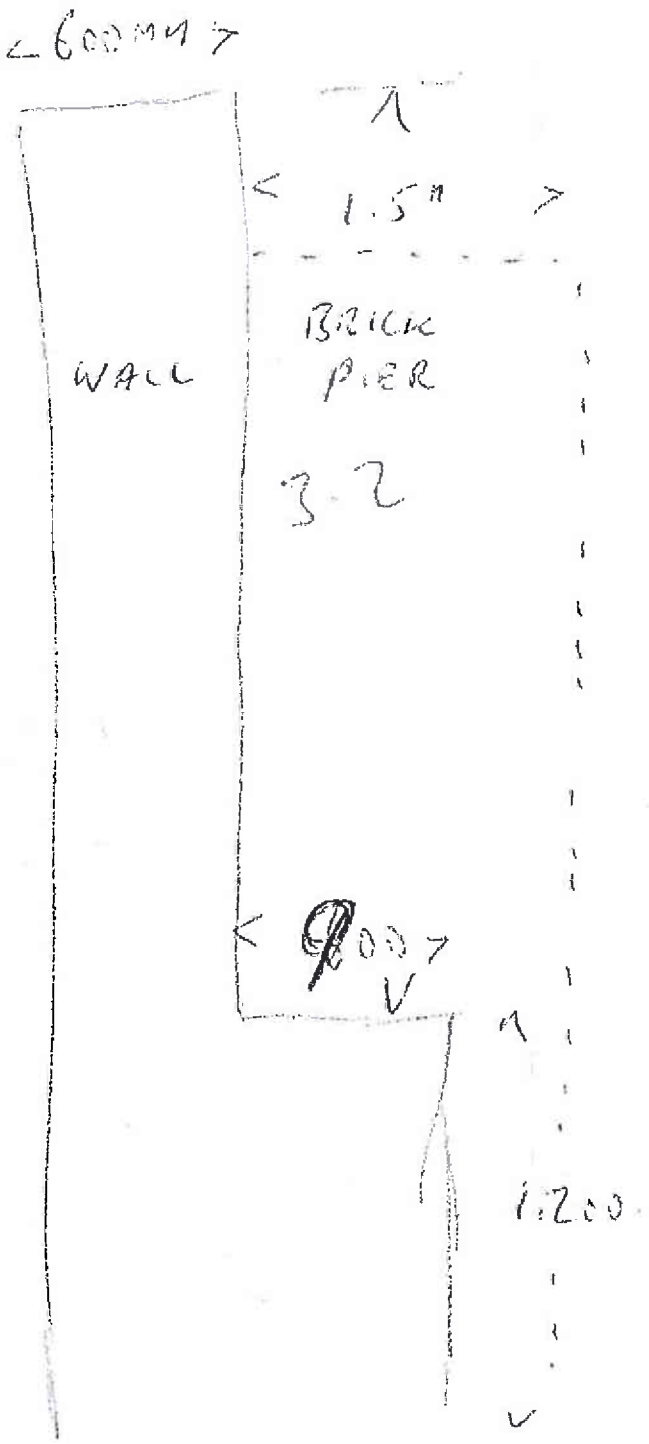
Graphic Display: SoilProfiles - Lines - Grids - Loads
SZ1 : 1
Displacement Grids:
< 2 mm
2 : 4 mm
4 : 6 mm
6 : 8 mm
8 : 10 mm
10 : 12 mm
12 : 14 mm
14 : 16 mm
16 : 18 mm
Displacement Lines
z
y
x

Appendix D

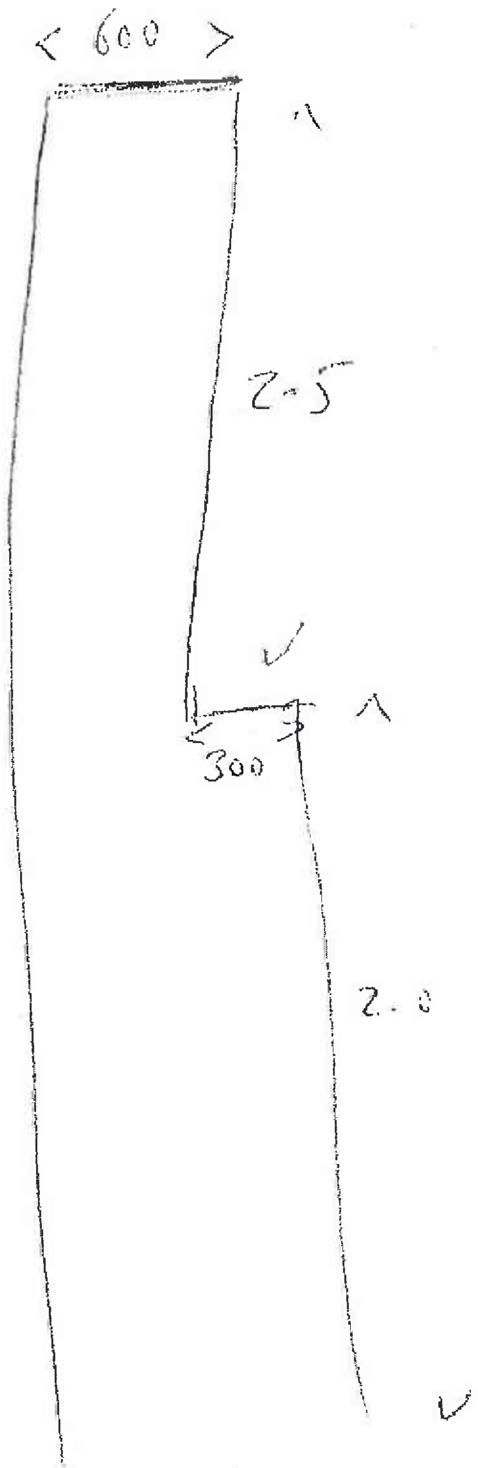
Wall Stability Analysis


Trial location 4
Trial location 1
Trial location 2
Trial location 3
COLLAPSED WALL SURVEYED REMOTELY
GRASS
N

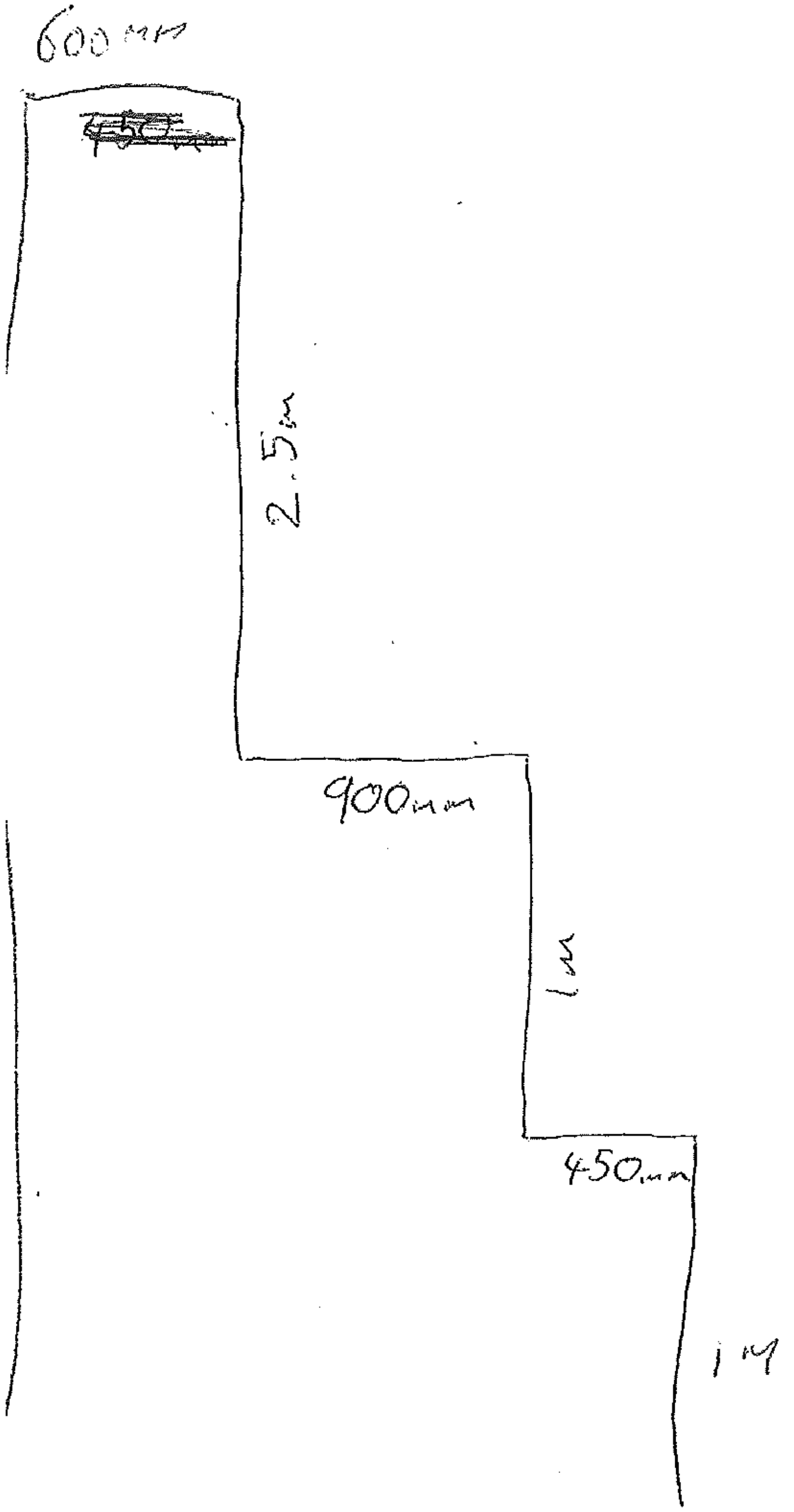
TRIAL HOLE 1



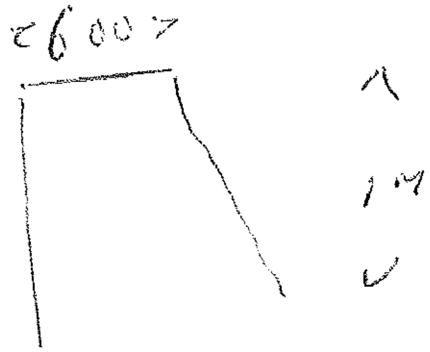
TRIAL HOLE 2.



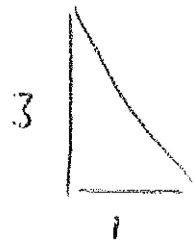
TRIAL HOLE 3.



TRIAL HOLE 4



APPROX 1 IN 3 SLOPE TO REAR.



PROPPED GRAVITY WALL DESIGN (BS8002:1994) v.013.00

\\HC-UKR-BM-FS-10\BM_Projects\UA005938 Aylesbury Arm Lock Wall Collapse\D-Calcs\Back Analysis Oct 2013\[Aylesbury BA 001 rev01.xlsm]Gravity Wall Design

J GATTER 2009

Hyder Consulting

Project:	Aylesbury Canal Lock Wall				
Wall Ref:	Emergency Works of Failed Wall				
Job No:	UA005938	Run No:	1b		
Desc:	*Existing Wall State - propped*	Author:	CF	Date:	20/06/2013
		Checked By:		Date:	
Design Ref:		Approved By:		Date:	
Drawing References:					

NOTES: *Wall dimensions as obtained from Trial Hole 1 as an intermediate case. Top of wall thickness 600mm, base of wall thickness 1.5m. Mimumum water level*

ANALYSIS - INPUT DATA

Hyder Consulting **v.013.00**

USE PARTIAL FACTORS OF SAFETY ? (Y / N)	N
ALLOW FOR VERTICAL SOIL FORCE (Y / N)	N

				Value	Unit	Partial Factors of Safety		Factored		
Soil 1:	*Above water*	γ_{s1}	Unit wt fill	17.0	[kN/m^3]	$S\gamma_{1\ fill}$	1.00	γ_{s1}	*17.0*	[kN/m^3]
	Below water	γ'_{s1}	Submerged wt	*7.2*	[kN/m^3]			$\gamma'_{s1\ (sub)}$	*7.2*	
Soil 2:	*Above water*	γ_{s2}	Unit wt fill	17.0	[kN/m^3]	$S\gamma_{2\ fill}$	1.00	γ_{s2}	*17.0*	[kN/m^3]
	Below water	γ'_{s2}	Submerged wt	*7.2*	[kN/m^3]			$\gamma'_{s2\ (sub)}$	*7.2*	
Soil 3_f:	*Above water*	γ_{s2}	Unit wt fill	19.0	[kN/m^3]	$S\gamma_{3f\ fill}$	1.00	γ_{s3f}	*19.0*	[kN/m^3]
	Below water	γ'_{s2}	Submerged wt	*9.2*	[kN/m^3]			$\gamma'_{s3f\ (sub)}$	*9.2*	
Wall:	WALL	γ_w	Unit wt	22.0	[kN/m^3]	$S\gamma_{masonry}$	1.00			
	PARAPET	γ_p	Unit wt	22.0	[kN/m^3]					
	BASE	γ_b	Unit wt	22.0	[kN/m^3]	$S\gamma_{concrete}$	1.00			
Water:		γ_u	Unit wt water	9.81	[kN/m^3]					
Soil 1:		$\phi_1'_{peak}$	Fill	25.0	[deg]	$S\phi_{fill}$ [M]	1.50	$\phi_1'_{des}$	*25.0*	
		c_1		0.0	[kN/m^3]					
Soil 2:		$\phi_2'_{peak}$	Fill	23.0	[deg]			$\phi_2'_{des}$	*23.0*	[deg]
		c_2		0.0	[kN/m^3]					
Soil 3_f:		$\phi_f'_{peak}$		25.0	[deg]	$S\phi_{formation}$	1.50	$\phi_f'_{des}$	*25.0*	
		c_a'	Formation	2.0	[kN/m^3]					
		c_u		0.0	[kN/m^3]					
Loads:		s_r	UDL	5	[kN/m^2]	$S_{surcharge}$	1.00			
		s_L	Linear Load	5	[kN/m^2]	MUST BE GREATER THAN UDL				
	APPLY LOAD SHED (Y/N)		N	*0.0*	[kN/m^2]					
			s_L offset	0.0	[m from back of wall]					
			s_L width	0.0	[m]	s_L' effective width	*0.02*	[m]		
			Load shed angle	35	[deg]					
	APPLY BASE SHEAR (Y/N)		N	*0.0*	[kN/m run]	**Qs** - Shear component of reultant load (per m run) - Bearing capacity calculation				

Required Factor of Safety against overturning	1.0	Global min.
Required Factor of Safety against sliding	1.0	Global min.
Required Factor of Safety against bearing failure	1.0	Global min

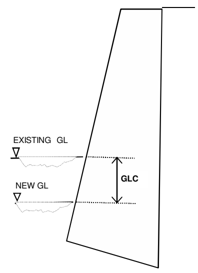
WALL FRICTION RATIOS

$\delta's_1/\phi$ =	*0.66*
$\delta's_2/\phi$ =	*1.00*
$\delta's_{3f}/\phi$ =	*0.66*

DIMENSIONS

			Value	Description	Elevations			Affected by water?
	SOILS	Soil thickness S_1	1.00	Thickness of Soil 1 [m] *(from top of wall)*				
			1.00		*Top elevation*	*4.46*	[m]	No
					Bottom elevation	*3.46*		
Warning! S_2 IS NEGATIVE		Soil thickness S_2	*3.46*	Thickness of Soil 2 [m]	*Top elevation*	*3.46*	[m]	Yes
					Bottom elevation	*0.00*		
		Soil thickness $S_{3\ foundation}$	*0.00*	Thickness of Soil 3_f below gl / overdig [m]	*Top elevation*	*0.00*	[m]	Yes
					Bottom elevation	*0.00*		
	WATER	BEHIND WALL	0.00	Water height behind [m] *(above ground level)*				
			0.00					
		IN FRONT	-1.15	Water height in front [m] (above ground level)				
TOO HIGH			*-1.15*					
IGNORE WATER INFRONT OF WALL (Y / N)		Y	**0.00**	Effective height of water in front of wall *(above ground level)*				

		Value	Description			
DIMENSIONS	P_h	0.00	Parapet height [m]	APPLY PARAPET LOAD (Y/N)	N	
	P_w	0.50	Parapet width [m]			
	z	0.00	Toe depth [m] *(below ground level)*			
	z GLC	*0.00*				
	r	4.46	Retained height [m] *(top of wall to gl)*	FACTORED PROPERTIES		
	r GLC	*4.46*		γ_{des} Wall	*22.0*	[kN/m^3]
	w_1	0.00	Equiv. face width [m]			
		0.00		γ_{des} Base	*22.0*	[kN/m^3]
	w_2	0.60	Top of wall width [m]	Batter θ°	*0.0*	[deg]
	B	1.50	Base width [m]			
	L	1.0	Wall length [m]			
	h	*0.90*	Heel projection [m]			
	t	0.00	Toe projection [m]			
	t GLC	*0.00*		Surcharge (Sr_{des})	*5.0*	[kN/m^2]
	d	1.20	Min base thickness [m]	$\delta_1'_{des}$ fill-wall	16.50	[deg]
	d'	*1.20*	Max base thickness [m]	$\delta_2'_{des}$ fill-wall	23.00	[deg]
	β_{back}	0.0	Back slope angle [deg]	$\delta_f'_{des}$ formation	16.50	[deg]
	β_{front}	0.0	Front slope angle [deg]			
	α	90	Back wall angle [deg]			
	ω	0.0	Base Tilt [deg]	Max base depth	*0.00*	[m bgl]



GROUND LEVEL CHANGE (IN FRONT) (Y/N)		EXISTING GL	-0.60	[m]
			0.00	**LOWERED**
ALLOW FOR OVERDIG ?	N	o_d	*0.0*	Overdig = 0.5m or 10% or r, which ever is less.

PROP	DEPTH pd	**0.00**	[m] - (below EXISTING ground level)
		0.00	[m] - (below proposed NEW ground level)
	FORCE Pf	**60**	[kN/m run]
	effective pd	*0.00*	[m] **PROP Depth (Rotation around PROP)**
	effective Pf	*60*	[kN/m run] **No Passive Resistance utilised**
ANCHOR	HEIGHT ah	**3.46**	[m] - (above EXISTING ground level)
		3.46	[m] - (above proposed NEW ground level)
	FORCE Af	**0**	[kN/m run] Horizontal thrust at ANCHOR level / m run

FoS - SLIDE	1.50
FoS - OVERTURNING	1.00
FoS - BEARING FAILURE (Drained)	0.02
FoS - BEARING FAILURE (Undrained)	0.00

Use Coulomb method or Input own Earth Pressure Coefficients K_a & K_p	COULOMB

	Ka	Kp
Soil 1	0.44	2.60
Soil 2	0.44	2.60
Soil 3f	0.41	2.85

Refer to BS 8002 Annex A for the determination of these values

GRAPHICAL OUTPUT

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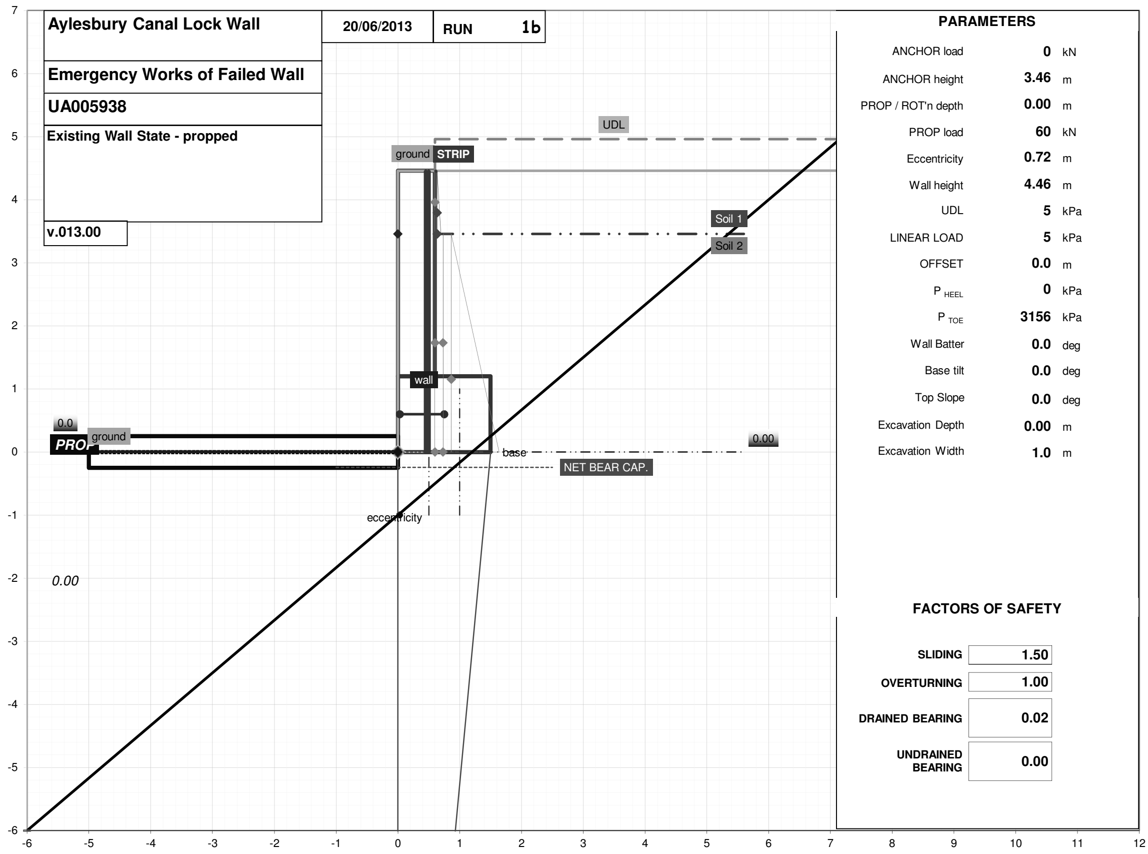

SCALE 0.6

DERRIVED VALUES

Soil 1:	COULOMB	K_{a1} =	0.36		
		$\tan\ \delta_1$ =	0.30	deg	
	COULOMB	K_{p1} =	3.55		δ'/ϕ' = 0.67
					ϕ'_{des} = 25.0
Soil 2:	COULOMB	K_{a2} =	0.38		
		$\tan\ \delta_2$ =	0.42	deg	
	COULOMB	K_{p2} =	3.14		δ'/ϕ' = 1.00
					ϕ'_{des} = 23.0
Soil 3: (Foundation)	COULOMB	K_{af} =	0.36		
		$\tan\ \delta_f'$ =	0.30	deg	
		$\tan\ (\delta_f' + \omega)$ =	0.30	deg	Allowance for base tilt
	COULOMB	K_{pf} =	3.55		δ'/ϕ' = 0.67
					ϕ'_{des} = 25.0

Total height of wall (r + z) =	4.46	m	
Effective retained height of wall (r +pd) =	4.46	m	*Height above PROP*
Effective retained height of wall back =	4.46	m	

		SATURATION				
Effective thickness of Soil 1 awl =	1.00	dry	[m]	*Effective thickness of Soil 1 below PROP =*	0.00	[m]
Effective thickness of Soil 1 bwl =	0.00	dry	[m]			
Effective thickness of Soil 2 awl =	3.46	dry	[m]	*Effective thickness of Soil 2 below PROP =*	0.00	[m]
Effective thickness of Soil 2 bwl =	0.00	dry	[m]			
Effective thickness of Soil 3 awl =	0.00	wet	[m]			
Effective thickness of Soil 3 bwl =	0.00	dry	[m]			

STRIP LOAD HEIGHT	4.45	[magl]				
Soil 1 affected	TRUE		Effective Applied Height	0.99	[m]	*above base of soil*
Soil 2 affected	TRUE		Effective Applied Height	3.46	[m]	*above base of soil*

CALCULATIONS

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Per m run		*Force*			PROP *Lever arm*	PROP *Moment*	*Comment*
HORIZONTAL - (Disturb)		[kN]			[m]	[kN.m]	
				UDL (Surcharge)			
1	Sr_1	**1.8**		*1.80*	**3.96**	**7.14**	
	Sr_2	**6.6**		*6.61*	**1.73**	**11.43**	
				STRIP LOAD			
	S_{L1}	**0.0**		*0.00*	**3.95**	**0.00**	
	S_{L2}	**0.0**		*0.00*	**1.73**	**0.00**	
				SOIL 1 (active)			
S1a	Soil 1 (awl)	**3.1**	tri	*3.07*	**3.79**	**11.64**	
S1b	Soil 1 (bwl)	**0.0**	sq	*0.00*	**3.46**	**0.00**	
S1c	Soil 1 (bwl)	**0.0**	tri	*0.00*	**3.46**	**0.00**	
				WATER (Behind Wall)			
U	water	**0.0**		*0.00*	**0.00**	**0.00**	*Water head above ground level*
				SOIL 2 (active)			
S2a2	Soil 2 (awl)	**38.9**	tri	*38.86*	**1.15**	**44.82**	
S2a1	Soil 2 (awl)	**22.5**	sq	*22.46*	**1.73**	**38.86**	
S2b	Soil 2 (bwl)	**0.0**	sq	*0.00*	**0.00**	**0.00**	
S2c	Soil 2 (bwl)	**0.0**	tri	*0.00*	**0.00**	**0.00**	**M_h = 113.89**
				SOIL 2 (passive)			
1	Sr_3	**0.0**	sq	*0.00*	**0.00**	**0.00**	*Surcharge*
Pp_{min}	119.0						
Pp_{max}	119.0						
U1		**0.0**	sq	*0.00*	**0.00**	**0.00**	*Water pressure within passive zone*
U2		**0.0**	tri	*0.00*	**0.00**	**0.00**	*Water pressure within passive zone*
Fp1		**0.0**	sq	*0.00*	**0.00**	**0.00**	*Passive reaction (below PROP)*
Fp2		**0.0**	tri	*0.00*	**0.00**	**0.00**	*Passive reaction (below PROP)*
				SOIL 3 (passive) INFRONT			
Pp_{min}	0.0						*Max depth of passive soil [m]* 0.00
Pp_{max}	0.0						
Fpf3a	Soil 3 (awl)	**0.0**	tri	*0.00*	**0.00**	**0.00**	**Passive Resistance Ignored - PROPPED**
Fpf3b	Soil 3 (bwl)	**0.0**	sq	*0.00*	**0.00**	**0.00**	
Fpf3c	Soil 3 (bwl)	**0.0**	tri	*0.00*	**0.00**	**0.00**	
U	water	**0.0**	tri	*0.00*	**0.00**	**0.00**	**P_{RES} =** **P_p** *(Passive)* **or P_f** *(Prop Force)* 60.00 kN/m run
P_p Total passive reistance				**0.00**			
				PROP FORCE			
P_f	**PROP**	**-60.0**			**0.00**	**0.00**	
				ANCHOR FORCE			
A_{fh}	**ANCHOR**	**0.0**		*0.00*	**3.46**	**0.00**	
	Rh =	**12.8**	**$Rh_{(net)}$ =**	**72.80**	**M_h =**	**113.89**	

Per m run		*Force*			PROP *Lever arm*	PROP *Moment*	
VERTICAL - (Restore)		[kN]			[m]	[kN.m]	
				LOADS			
Ww_1	wall stem	**0.0**		*0.00*	**0.00**	**0.00**	*Wall (triangle)*
Ww_2	wall stem	**43.0**		*43.03*	**0.30**	**12.91**	*Wall (rectangle)*
Wb_1	wall base	**39.6**		*39.60*	**0.75**	**29.70**	*Base (rectangle)*
Wb_2	wall downstand	**0.0**		*0.00*	**1.00**	**0.00**	*Base (traingle)*
Wp	parapet	**0.0**		*0.00*	**0.25**	**0.00**	*Parapet (rectangle)*
$Ws_{1\ dry}$	Soil 1	**15.3**		*15.30*	**1.05**	**16.07**	*Soil 1 dry weight on top of heal*
$Ws_{1\ wet}$	Soil 1	**0.0**		*0.00*	**1.05**	**0.00**	*Soil 1 wet weight on top of heal*
$Ws_{2\ dry}$	Soil 2	**52.9**		*52.94*	**1.05**	**55.58**	*Soil 2 dry weight on top of heal*
$Ws_{2\ wet}$	Soil 2	**0.0**		*0.00*	**1.05**	**0.00**	*Soil 2 wet weight on top of heal*
Wsr	surcharge	**4.5**		*4.50*	**1.05**	**4.73**	**M_w = 114.26**
				SOIL 1 (active)			
S1a	Soil 1 (awl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
S1b	Soil 1 (bwl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S1c	Soil 1 (bwl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
				SOIL 2 (active)			
S2a2	Soil 2 (awl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
S2a1	Soil 2 (awl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S2b	Soil 2 (bwl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S2c	Soil 2 (bwl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
				ANCHOR FORCE			
A_{fv}	**ANCHOR**	**0.0**		*0.00*	**0.00**	**0.00**	*Vert component of ANCHOR force (about Prop)*
	Rv =	**155.4**	**$Rv_{(net)}$ =**	**155.37**	**M_v =**	**118.98**	**$M_{v(net)}$ = 0.00**

$M_{(net)}$ = **5.10** *(Mv-Mh)*

W = Weight of wall	155.37	**slide**	**1.50**	
Pv = Vertical force	0.00	**overturn**	**1.00**	= Mw / (Mh - Mv)
ca' = Effective cohesion	2.0			
B = Base width	1.50			
Pp = Passive force in front of wall	0.00			

Ph = Horizontal force	72.80
Pp = Prop force	60

STABILITY RESULTS

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Middle 3rd (distances from toe in m)

Lever arm of base resultant (from toe) **M(net)/Rv =** 0.03 m — ***0.50*** **to** ***1.00***

! OUTSIDE MIDDLE THIRD !

Eccentricity of resultant (e) e = 0.72 m

Maximum and minimum bearing pressures (P) *P = (Rv / B)•(1 {+/-} 6***e** */ B)*

P_{max} =	3156 kN/m²	P_{min} =	0 kN/m²	q_{net} Net Bearing Capacity	48.31
	EXCEEDS BEARING CAPACITY		OK	*BEARING FAILURE*	kPa

FoS AGAINST SLIDING $F = \{ (W + P_v) \cdot \tan(\delta+\omega) + (c_a' \cdot B) + P_{RES} \} / P_h$ **1.50** ***OK*** **Minimum FoS:** **1.0**

FoS AGAINST OVERTURNING $F = M_w / (M_h - M_{v(net)})$ **1.00** ***OK*** **Minimum FoS:** **1.0**

FoS AGAINST BEARING FAILURE **Minimum FoS:** **1.0**

P_{MAX} Max Bearing Pressure	3156.10	
q'_{ult} Drained Ultimate Bear. Cap.	48.31	
FOS	0.02	***CHECK !!!***
q_{ult} Undrained Ultimate Bear. Cap.	0.00	
FOS	0.00	***CHECK !!!***

COMMENTS: Reference (BS8002 Earth Retaining Structures dated 1994)

PROPPED GRAVITY WALL DESIGN (BS8002:1994)

v.013.00

\\HC-UKR-BM-FS-10\BM_Projects\UA005938 Aylesbury Arm Lock Wall Collapse\F-Reports\Review of Potential Failure Mechanisms\[Appendix C Aylesbury BA 001 TP3.xlsm]Gravity Wall Design

J GATTER 2009

Hyder Consulting

Project:	Aylesbury Canal Lock Wall		
Wall Ref:	Emergency Works of Failed Wall		
Job No:	UA005938	Run No:	1a
Desc:	*Existing Wall State - propped*	Author:	CF
		Date:	20/06/2013
		Checked By:	
		Date:	
Design Ref:		Approved By:	
		Date:	
Drawing References:			

NOTES: *Section based on Trial Hole 3. Maximum Assumed Water Level*

ANALYSIS - INPUT DATA

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USE PARTIAL FACTORS OF SAFETY ? (Y / N)	N	
ALLOW FOR VERTICAL SOIL FORCE (Y / N)	N	

						Partial Factors of Safety		Factored		
Soil 1:	*Above water*	γ_{s1}	Unit wt fill	17.0	[kN/m³]	$S\gamma_{1\ fill}$	1.00	γ_{s1}	*17.0*	[kN/m³]
	Below water	γ'_{s1}	Submerged wt	*7.2*	[kN/m³]			$\gamma'_{s1\ (sub)}$	*7.2*	
Soil 2:	*Above water*	γ_{s2}	Unit wt fill	17.0	[kN/m³]	$S\gamma_{2\ fill}$	1.00	γ_{s2}	*17.0*	[kN/m³]
	Below water	γ'_{s2}	Submerged wt	*7.2*	[kN/m³]			$\gamma'_{s2\ (sub)}$	*7.2*	
Soil 3f:	*Above water*	γ_{s2}	Unit wt fill	19.0	[kN/m³]	$S\gamma_{3f\ fill}$	1.00	γ_{s3f}	*19.0*	[kN/m³]
	Below water	γ'_{s2}	Submerged wt	*9.2*	[kN/m³]			$\gamma'_{s3f\ (sub)}$	*9.2*	
Wall:	WALL	γ_w	Unit wt	22.0	[kN/m³]	$S\gamma_{masonry}$	1.00			
	PARAPET	γ_p	Unit wt	22.0	[kN/m³]					
	BASE	γ_b	Unit wt	22.0	[kN/m³]	$S\gamma_{concrete}$	1.00			
Water:		γ_u	Unit wt water	9.81	[kN/m³]					
Soil 1:		$\phi_1'_{peak}$	Fill	25.0	[deg]	$S\phi_{fill}$ [M]	1.50	$\phi_1'_{des}$	*25.0*	
		c_1		0.0	[kN/m³]					
Soil 2:		$\phi_2'_{peak}$	Fill	23.0	[deg]			$\phi_2'_{des}$	*23.0*	[deg]
		c_2		0.0	[kN/m³]					
Soil 3f:		$\phi_f'_{peak}$		25.0	[deg]	$S\phi_{formation}$	1.50	$\phi_f'_{des}$	*25.0*	
		c_a'	Formation	2.0	[kN/m³]					
		c_u		0.0	[kN/m³]					
Loads:		s_r	UDL	5	[kN/m²]	$S_{surcharge}$	1.00			
		s_L	Linear Load	5	[kN/m²]	MUST BE GREATER THAN UDL				
	APPLY LOAD SHED (Y/N)	N		*0.0*	[kN/m²]					
			s_L offset	0.0	[m from back of wall]					
			s_L width	0.0	[m]	s_L' effective width	*0.02*	[m]		
			Load shed angle	35	[deg]					
	APPLY BASE SHEAR (Y/N)	N		*0.0*	[kN/m run]	**Qs** - Shear component of reultant load (per m run) - Bearing capacity calculation				

Required Factor of Safety against overturning	**1.0**	Global min.
Required Factor of Safety against sliding	**1.0**	Global min.
Required Factor of Safety against bearing failure	**1.0**	Global min

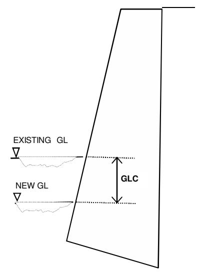
WALL FRICTION RATIOS

$\delta's_1/\phi$ =	*0.66*
$\delta's_2/\phi$ =	*1.00*
$\delta's_{3f}/\phi$ =	*0.66*

DIMENSIONS

			Value	Description	ELEVATIONS			AFFECTED BY WATER?
	SOILS	Soil thickness S_1	1.00	Thickness of Soil 1 [m] *(from top of wall)*				
			1.00		*Top elevation*	*4.46*	[m]	**No**
					Bottom elevation	*3.46*		
Warning! S_2 IS NEGATIVE		Soil thickness S_2	*3.46*	Thickness of Soil 2 [m]	*Top elevation*	*3.46*	[m]	**Yes**
					Bottom elevation	*0.00*		
		Soil thickness $S_{3\ foundation}$	*0.00*	Thickness of Soil 3f below gl / overdig [m]	*Top elevation*	*0.00*	[m]	**Yes**
					Bottom elevation	*0.00*		
	WATER	BEHIND WALL	2.90	Water height behind [m] *(above ground level)*				
			2.90					
		IN FRONT	-1.15	Water height in front [m] (above ground level)				
TOO HIGH			*-1.15*					
IGNORE WATER INFRONT OF WALL (Y / N)	Y		**0.00**	Effective height of water in front of wall *(above ground level)*				

DIMENSIONS	P_h	0.00	Parapet height [m]	APPLY PARAPET LOAD (Y/N)	N	
	P_w	0.50	Parapet width [m]			
	z	0.00	Toe depth [m] *(below ground level)*			
	z GLC	*0.00*				
	r	4.46	Retained height [m] *(top of wall to gl)*	**FACTORED PROPERTIES**		
	r GLC	*4.46*		γ_{des} Wall	*22.0*	[kN/m³]
	w_1	0.00	Equiv. face width [m]			
		0.00		γ_{des} Base	*22.0*	[kN/m³]
	w_2	0.60	Top of wall width [m]	Batter θ°	*0.0*	[deg]
	B	1.95	Base width [m]			
	L	1.0	Wall length [m]			
	h	*1.35*	Heel projection [m]			
	t	0.00	Toe projection [m]			
	t GLC	*0.00*		Surcharge (Sr_{des})	*5.0*	[kN/m²]
	d	1.00	Min base thickness [m]	$\delta_1'_{des}$ fill-wall	16.50	[deg]
	d'	*1.00*	Max base thickness [m]	$\delta_2'_{des}$ fill-wall	23.00	[deg]
	β_{back}	0.0	Back slope angle [deg]	$\delta_f'_{des}$ formation	16.50	[deg]
	β_{front}	0.0	Front slope angle [deg]			
	α	90	Back wall angle [deg]			
	ω	0.0	Base Tilt [deg]	Max base depth	*0.00*	[m bgl]
GROUND LEVEL CHANGE (IN FRONT) (Y/N)	EXISTING GL	-0.60	[m]			
		0.00	**LOWERED**			
ALLOW FOR OVERDIG ? N	o_d	*0.0*	Overdig = 0.5m or 10% or r, which ever is less.			



		Value	Description
PROP	DEPTH pd	**0.00**	[m] - (below EXISTING ground level)
		0.00	[m] - (below proposed NEW ground level)
	FORCE Pf	**50**	[kN/m run]
	effective pd	*0.00*	[m] **PROP Depth (Rotation around PROP)**
	effective Pf	*50*	[kN/m run] **No Passive Resistance utilised**
ANCHOR	HEIGHT ah	**3.46**	[m] - (above EXISTING ground level)
		3.46	[m] - (above proposed NEW ground level)
	FORCE Af	**0**	[kN/m run] Horizontal thrust at ANCHOR level / m run

FoS - SLIDE	1.03
FoS - OVERTURNING	0.99
FoS - BEARING FAILURE (Drained)	0.02
FoS - BEARING FAILURE (Undrained)	0.00

Use Coulomb method or Input own Earth Pressure Coefficients K_a & K_p	COULOMB

	Ka	Kp
Soil 1	0.44	2.60
Soil 2	0.44	2.60
Soil 3f	0.41	2.85

Refer to BS 8002 Annex A for the determination of these values

GRAPHICAL OUTPUT

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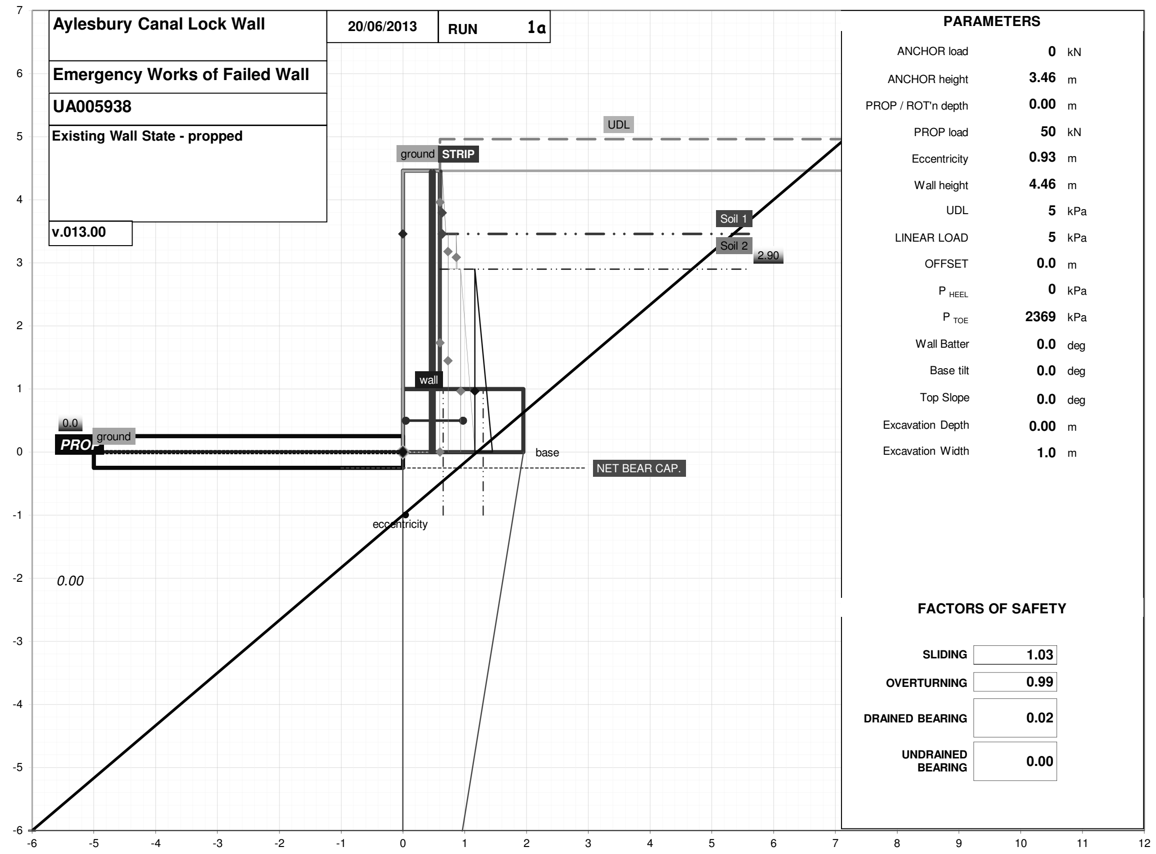

SCALE 0.6

DERRIVED VALUES

Soil 1:	COULOMB	K_{a1} =	0.36		
		$\tan\ \delta_1$ =	0.30	deg	
	COULOMB	K_{p1} =	3.55		δ'/ϕ' = 0.67
					ϕ'_{des} = 25.0
Soil 2:	COULOMB	K_{a2} =	0.38		
		$\tan\ \delta_2$ =	0.42	deg	
	COULOMB	K_{p2} =	3.14		δ'/ϕ' = 1.00
					ϕ'_{des} = 23.0
Soil 3: (Foundation)	COULOMB	K_{af} =	0.36		
		$\tan\ \delta_f'$ =	0.30	deg	
		$\tan\ (\delta_f' + \omega)$ =	0.30	deg	Allowance for base tilt
	COULOMB	K_{pf} =	3.55		δ'/ϕ' = 0.67
					ϕ'_{des} = 25.0

Total height of wall (r + z) =	4.46	m	
Effective retained height of wall (r +pd) =	4.46	m	*Height above PROP*
Effective retained height of wall back =	4.46	m	

		SATURATION				
Effective thickness of Soil 1 awl =	1.00	**dry**	[m]	*Effective thickness of Soil 1 below PROP =*	0.00	[m]
Effective thickness of Soil 1 bwl =	0.00	**dry**	[m]			
Effective thickness of Soil 2 awl =	0.56	**dry**	[m]	*Effective thickness of Soil 2 below PROP =*	0.00	[m]
Effective thickness of Soil 2 bwl =	2.90	**wet**	[m]			
Effective thickness of Soil 3 awl =	0.00	**wet**	[m]			
Effective thickness of Soil 3 bwl =	0.00	**dry**	[m]			

STRIP LOAD HEIGHT	4.45	[magl]				
Soil 1 affected	TRUE		Effective Applied Height	0.99	[m]	*above base of soil*
Soil 2 affected	TRUE		Effective Applied Height	3.46	[m]	*above base of soil*

CALCULATIONS

v.013.00

Per m run		*Force*			*PROP Lever arm*	*PROP Moment*	*Comment*
HORIZONTAL - (Disturb)		[kN]			[m]	[kN.m]	
			UDL (Surcharge)				
1	Sr_1	**1.8**		*1.80*	**3.96**	**7.14**	
	Sr_2	**6.6**		*6.61*	**1.73**	**11.43**	
			STRIP LOAD				
	S_{L1}	**0.0**		*0.00*	**3.95**	**0.00**	
	S_{L2}	**0.0**		*0.00*	**1.73**	**0.00**	
			SOIL 1 (active)				
S1a	Soil 1 (awl)	**3.1**	tri	*3.07*	**3.79**	**11.64**	
S1b	Soil 1 (bwl)	**0.0**	sq	*0.00*	**3.46**	**0.00**	
S1c	Soil 1 (bwl)	**0.0**	tri	*0.00*	**3.46**	**0.00**	
			WATER (Behind Wall)				
U	water	**41.3**		*41.25*	**0.97**	**39.88**	*Water head above ground level*
			SOIL 2 (active)				
S2a2	Soil 2 (awl)	**1.0**	tri	*1.02*	**3.09**	**3.14**	
S2a1	Soil 2 (awl)	**3.6**	sq	*3.64*	**3.18**	**11.56**	
S2b	Soil 2 (bwl)	**29.4**	sq	*29.37*	**1.45**	**42.59**	
S2c	Soil 2 (bwl)	**11.5**	tri	*11.55*	**0.97**	**11.16**	**M_h = 138.53**
			SOIL 2 (passive)				
1	Sr_3	**0.0**	sq	*0.00*	**0.00**	**0.00**	*Surcharge*
Pp_{min}	74.4						
Pp_{max}	74.4						
U1		**0.0**	sq	*0.00*	**0.00**	**0.00**	*Water pressure within passive zone*
U2		**0.0**	tri	*0.00*	**0.00**	**0.00**	*Water pressure within passive zone*
Fp1		**0.0**	sq	*0.00*	**0.00**	**0.00**	*Passive reaction (below PROP)*
Fp2		**0.0**	tri	*0.00*	**0.00**	**0.00**	*Passive reaction (below PROP)*
			SOIL 3 (passive) INFRONT				
Pp_{min}	0.0						*Max depth of passive soil [m]* 0.00
Pp_{max}	0.0						
Fpf3a	Soil 3 (awl)	**0.0**	tri	*0.00*	**0.00**	**0.00**	**Passive Resistance Ignored - PROPPED**
Fpf3b	Soil 3 (bwl)	**0.0**	sq	*0.00*	**0.00**	**0.00**	
Fpf3c	Soil 3 (bwl)	**0.0**	tri	*0.00*	**0.00**	**0.00**	
U	water	**0.0**	tri	*0.00*	**0.00**	**0.00**	P_{RES} = P_p *(Passive)* or P_f *(Prop Force)* 50.00 kN/m run
P_p Total passive reistance			**0.00**				
			PROP FORCE				
P_f	**PROP**	**-50.0**			**0.00**	**0.00**	
			ANCHOR FORCE				
A_{fh}	**ANCHOR**	**0.0**		*0.00*	**3.46**	**0.00**	
	Rh =	**48.3**	**$Rh_{(net)}$ =**	**98.30**	**M_h =**	**138.53**	

Per m run		*Force*			*PROP Lever arm*	*PROP Moment*	
VERTICAL - (Restore)		[kN]			[m]	[kN.m]	
			LOADS				
Ww_1	wall stem	**0.0**		*0.00*	**0.00**	**0.00**	*Wall (triangle)*
Ww_2	wall stem	**45.7**		*45.67*	**0.30**	**13.70**	*Wall (rectangle)*
Wb_1	wall base	**42.9**		*42.90*	**0.98**	**41.83**	*Base (rectangle)*
Wb_2	wall downstand	**0.0**		*0.00*	**1.30**	**0.00**	*Base (traingle)*
Wp	parapet	**0.0**		*0.00*	**0.25**	**0.00**	*Parapet (rectangle)*
$Ws_{1\,dry}$	Soil 1	**23.0**		*22.95*	**1.28**	**29.26**	*Soil 1 dry weight on top of heal*
$Ws_{1\,wet}$	Soil 1	**0.0**		*0.00*	**1.28**	**0.00**	*Soil 1 wet weight on top of heal*
$Ws_{2\,dry}$	Soil 2	**12.9**		*12.85*	**1.28**	**16.39**	*Soil 2 dry weight on top of heal*
$Ws_{2\,wet}$	Soil 2	**28.1**		*28.15*	**1.28**	**35.89**	*Soil 2 wet weight on top of heal*
Wsr	surcharge	**6.8**		*6.75*	**1.28**	**8.61**	**M_w = 137.07**
			SOIL 1 (active)				
S1a	Soil 1 (awl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
S1b	Soil 1 (bwl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S1c	Soil 1 (bwl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
			SOIL 2 (active)				
S2a2	Soil 2 (awl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
S2a1	Soil 2 (awl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S2b	Soil 2 (bwl)	**0.0**	sq	*0.00*	**0.60**	**0.00**	
S2c	Soil 2 (bwl)	**0.0**	tri	*0.00*	**0.60**	**0.00**	
			ANCHOR FORCE				
A_{fv}	**ANCHOR**	**0.0**		*0.00*	**0.00**	**0.00**	*Vert component of ANCHOR force (about Prop)*
	Rv =	**159.3**	**$Rv_{(net)}$ =**	**159.27**	**M_v =**	**145.67**	**$M_{v(net)}$ = 0.00**

$M_{(net)}$ = 7.14 *(Mv-Mh)*

W = Weight of wall	159.27	**slide**	**1.03**	
Pv = Vertical force	0.00	**overturn**	**0.99**	= Mw / (Mh - Mv)
ca' = Effective cohesion	2.0			
B = Base width	1.95			
Pp = Passive force in front of wall	0.00			

Ph = Horizontal force	98.30
Pp = Prop force	50

STABILITY RESULTS

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Middle 3rd (distances from toe in m)

Lever arm of base resultant (from toe) **M(net)/Rv =** **0.04** m *0.65* to *1.30*

! OUTSIDE MIDDLE THIRD !

Eccentricity of resultant (e) e = **0.93** m

Maximum and minimum bearing pressures (P) *P = (Rv / B)•(1 {+/-} 6* **e** */ B)*

P_{max} = **2369** kN/m^2 **P_{min} =** **0** kN/m^2 **q_{net} Net Bearing Capacity** **50.75** **kPa**

EXCEEDS BEARING CAPACITY **OK** *BEARING FAILURE*

FoS AGAINST SLIDING	$F = \{ (W + P_v) \cdot tan(\delta+\omega) + (c_a' \cdot B) + P_{RES} \} / P_h$	**1.03**	***OK***	**Minimum FoS:**	**1.0**
FoS AGAINST OVERTURNING	$F = M_w / (M_h - M_{v(net)})$	**0.99**	***CHECK !!!***	**Minimum FoS:**	**1.0**
FoS AGAINST BEARING FAILURE	**P_{MAX}** Max Bearing Pressure	**2369.00**			
	q'_{ult} Drained Ultimate Bear. Cap.	**50.75**		**Minimum FoS:**	**1.0**
	FOS	**0.02**	***CHECK !!!***		
	q_{ult} Undrained Ultimate Bear. Cap.	**0.00**			
	FOS	**0.00**	***CHECK !!!***		

COMMENTS: Reference (BS8002 Earth Retaining Structures dated 1994)

Appendix E

Ground Engineering Article October 2013

Weather impact on landslides highlighted

Wet weather in 2012 resulted in a dramatic increase in the number of landslides occurring outside the normal "season" according to new research by the British Geological Society (BGS).

The higher incident rate has resulted in the BGS using Twitter, as well as traditional media and public contact, to improve response time and coverage of landslide monitoring, which has enabled a landslide forecast to be incorporated into the Daily Hazard Assessment reports issued by the Natural Hazards Partnership (NHP).

The BGS research presented at the British Science Festival in Newcastle this week also shows that the increased landslide rate that occurred in 2012 is continuing into this year.

According to the research, there was a five-fold increase in the number of landslides recorded by the BGS Landslide Response Team in the period between June 2012 and June 2013. "In addition, there has been an unprecedented increase in the number of landslides outside of the generally accepted 'Landslide Season' of October to March, especially during the summer months," said the report.

The report links the increase to the "exceptional amount of rainfall over the last 12 months, especially last summer which was the second wettest in the UK (and the wettest English summer) since records began in 1910".