

Llanmaes Village Flood Bund Technical Note

December 2020

Prepared by

Checked by

Approved by



Urszula Nedza
Engineer

J. Sebastiampillai
Principal Engineer

Charles Bull
Associate

Revision	Revision date	Details	Authorized	Name	Position
01	17/12/2020	For Review & Comment	JS	Jude Sebastiampillai	Principal Engineer

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1. Introduction

The site is located to the north of Llanmaes village, in the Vale of Glamorgan, South Wales. The landscape is predominantly agricultural. This Technical Note has been prepared to assess the stability of four flood bunds shown in Figure 1 below:

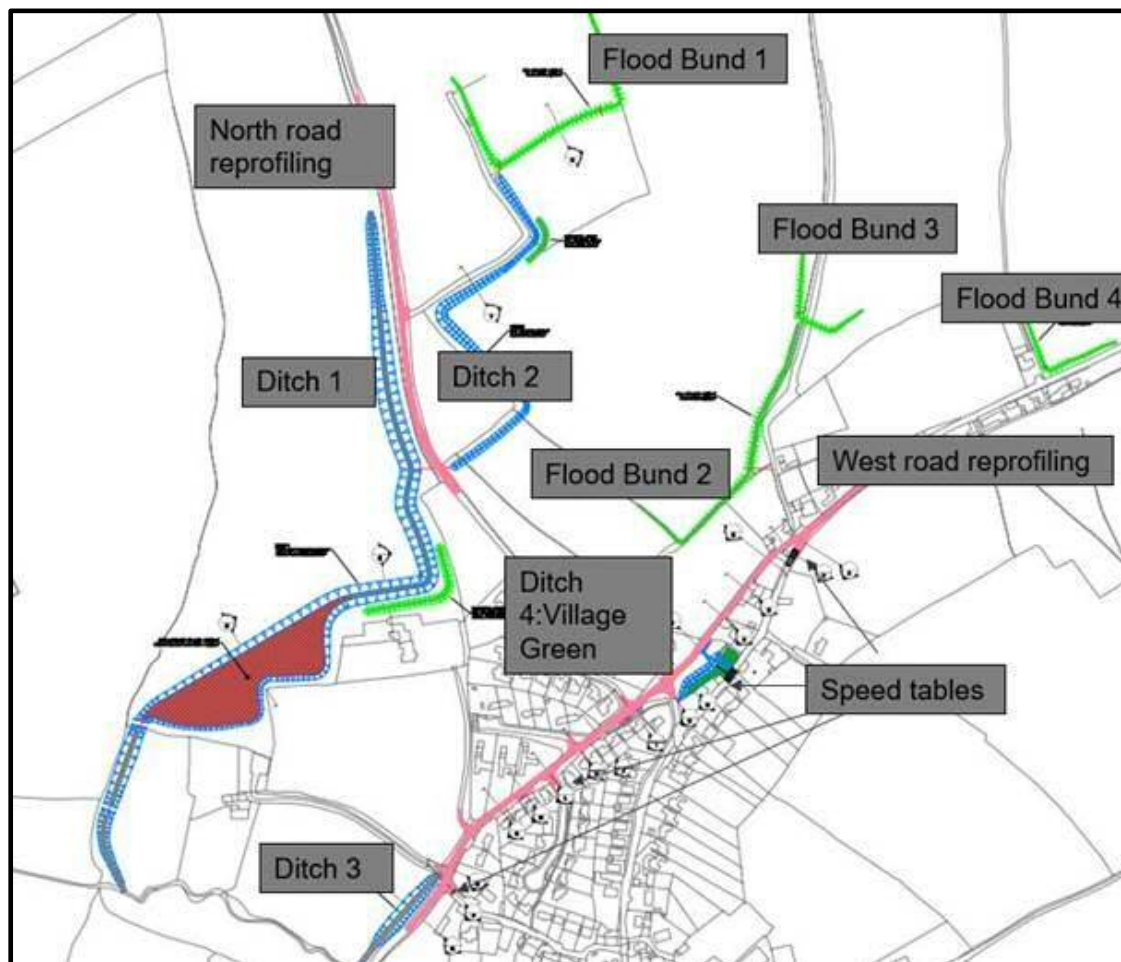


Figure 1. Site Location

The flood bunds are to be constructed with 1V:3H slopes on both sides using the material excavated from the ditch construction. The height of the bund is dependent of the excavated fill volume, therefore this technical note summarises the maximum and minimum height of the bund. The maximum height of the flood water is 1.33m above bund toe level therefore a minimum bund height of 1.5m has been used in the initial analyses.

2. Geology

The geological information of the site has been obtained from the BGS Geological Map⁽¹⁾. Reference has also been made to the PSSR⁽²⁾, prepared for Saint Athan Airport, which is located 2km to the south east of Llanmaes. The solid geology underlying the site comprises Jurassic Porthkerry Member - Blue Lias Formation. It consists of interbedded limestone and calcareous mudstone or siltstone. No superficial deposits are shown on the BGS map directly underneath the flood bunds.

There are localised Head deposits within 600m of the site which were predominantly mapped along Llanmaes Brook.

3. Ground Investigation

A ground investigation was undertaken between 8th and 10th September 2020 to facilitate the design of the flood bunds and ditches within the site. This investigation comprised 24no trial pits. A plan showing the trial pit locations and exploratory hole logs are included in Appendix A.

The following laboratory testing has been undertaken by Professional Soils Laboratory (PSL) on selected representative samples obtained during the investigation:

- 3No Classification testing
- 3No PSD
- 3No Compaction
- 15No CBR
- 3No MCV

A copy of the laboratory testing results is included in Appendix B.

4. Ground Summary

The trial pits undertaken close to the proposed bunds have been assessed to estimate the underlying stratigraphy below each bund location. All trial pits have been referred to in order to obtain the embankment fill properties, on the basis that the fill material used to construct the bunds may be sourced from any of the ditches on site.

The ground conditions encountered within the trial pits are summarised in the table below:

Table 1: Ground Summary

Strata	Description	Depth From, m	Depth To, m
Topsoil	Dark brown clayey topsoil	0	0.25
Weathered Blue Lias (Subsoil)	Brown slightly gravelly slightly sandy clay	0.15	1.55
Porthkerry Member (Blue Lias)	Limestone with clay	0.55	1.85

5. Ground Water and Flood Level

The maximum flood levels used in the slope stability analyses are presented in Table 2. For the rapid draw down analysis, the groundwater level at 1.33m above ground level has been assumed for the initial stage, reducing to ground level at the final stage.

Table 2: Floodwater Levels

	Maximum Volume (m ³) (Rounded up to nearest 50 cubic metres)	Max Level (mAOD)	Max depth (m)
Bund 1	4850	62.92	1.13
Bund 2	2700	59.04	1.04
Bund 3	1000	60.56	1.33
Bund 4	150	62.35	0.48

6. Design Ground Model and Parameters

The design ground model, derived from the ground summary and the design parameters, estimated based on the laboratory tests results, are summarised below.

The effective friction angle has been derived based on the formula outlined in BS8002:2015 using the plasticity index values. A friction angle (ϕ') of 22.5° has been calculated for Weathered Blue Lias. In the absence of direct laboratory testing, a cohesion (c') of 2kPa has been assumed. It is understood that the material excavated during the ditch construction is to be used for the bund construction. Therefore, the same effective friction angle and cohesion values have been assumed for the embankment fill material.

The characteristic unit weight of 17kN/m^3 has been calculated for the Weathered Blue Lias based on the average laboratory test results. The characteristic unit weight of 18kN/m^3 has been assumed for the compacted site won embankment fill.

The parameters for Porthkerry Member (Blue Lias) have been obtained from St. Athan Northern Access Road GIR ⁽³⁾.

The design ground model and characteristic parameters adopted in the analysis are summarised in Table 3.

Table 3: Ground Model and Characteristic Soil Parameters

Strata	Thickness of strata, m	Bulk Unit Weight, γ , (kN/m^3)	Cohesion, c' (kN/m^2)	Friction Angle, ϕ' , ($^\circ$)
Embankment Fill (Site Won)	1.5	18	2	22.5
Weathered Blue Lias (Subsoil)	1.55	17	2	22.5
Porthkerry Member (Blue Lias)	>1.0	15	0	35

7. Slope Stability Analysis

The slope stability analysis of the flood bunds has been carried out in accordance with the requirements of Eurocode 7⁽⁴⁾ using Design Approach 1 combination 1 (DA1-C1) and combination 2 (DA1-C2). The slope stability analysis for floodwater rapid-drawdown effect has also been carried out. The analyses have been carried out using RocScience Slide2018 and the results are presented in Table 4.

Table 4: Summary of Slope Stability Analysis

Bund	Maximum Floodwater Level (m AOD)	Flood depth (m)	Back Slope (flood side of slope)		Front Slope	
			ODF DA1-1	ODF DA1-2	ODF DA1-1	ODF DA1-2
Bund 1 (1.5m high)	62.92	1.13	1.863	1.924	1.424	1.296
Bund 2 (1.5m high)	59.04	1.04	1.813	1.831	1.437	1.294
Bund 3 (1.5m high)	60.54	1.33	1.950	2.132	1.372	1.214
Bund 3 (2.2m high)	60.54	1.33	1.607	1.531	1.307	1.139
Bund 4 (1.5m high)	62.34	0.48	1.642	1.545	1.564	1.447
Bund 3 (1.5m high)	Rapid-draw down		1.241	1.061	N/A	N/A
Bund 3 (2.2m high)	Rapid draw down		1.193	1.008	N/A	N/A

The output from the slope stability analysis is presented in Appendix C.

8. Conclusions and Recommendations

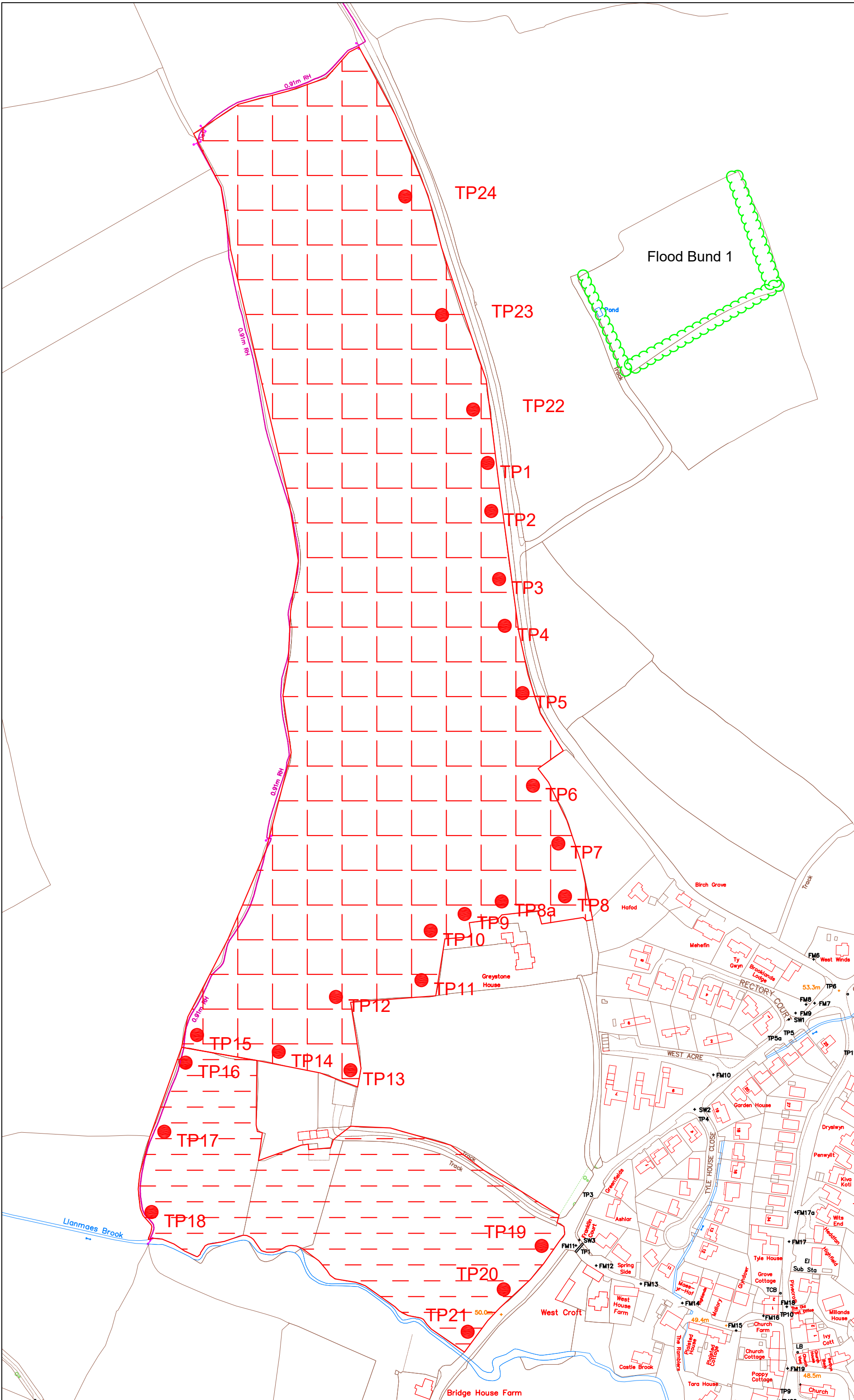
The slope stability analysis indicates that all four bunds with a minimum height of 1.5m meet the stability requirements set out in Eurocode 7. Further analyses have also been undertaken to assess the maximum possible bund height. The results show that the maximum height of the bund to be restricted to 2.2m while the maximum flood level remains at 1.33m above the bund toe.

It is recommended that topsoil be removed from the surface and stockpiled prior to excavation of source material for bund construction. This excavated topsoil material shall then be placed on the bund surface to a minimum thickness of 300mm. The laboratory testing indicated that the Weathered Blue Lias is a high plasticity clay, which is susceptible to surface cracks. Therefore, it is recommended that the topsoil be placed immediately after bund construction to minimise the potential for surface drying of the clay fill. To achieve the required soil parameters used in the design, the fill material shall be treated as Class 2 material and shall be compacted in accordance with the MCHW Series 600 Earthworks Specification ⁽⁵⁾.

9. References

1. British Geological Survey (BGS) Maps Portal (<http://www.bgs.ac.uk/data/maps/home.html>)
2. AECOM, St. Athan Northern Access Road – Preliminary Sources Study Report, 60509148/PSSR, October 2016
3. AECOM, St. Athan Northern Access Road – Ground Investigation Report, 60509148/GIR, February 2017
4. British Standards Institution. BS-EN-1997 Eurocode 7: Geotechnical Design - Part 1: General rules.
5. Manual of Contract Documents for Highway Works, Volume 1 Specification For Highway Works.

Appendix A – Trial Pits Location Plan, Exploratory Hole Logs



VALE of GLAMORGAN VISIBLE SERVICES AND HOUSING			
BRO MORGANNWG HIGHWAYS AND ENGINEERING			
The Vale of Glamorgan Council			
Project: Llanmaes Flood Risk Management Scheme			
Drawing Title: Trial Pit Locations			
Scale:	1:1000	Project No.:	15/15
Drawn:	JLW	Issue:	01
Checked:	JLW	Revised:	
Date:	15/03/2015	By:	

Llanmaes FRM

Report on Trial Pitting Undertaken to Support Design

Introduction

Aecom who have been appointed as the designers of the Llanmaes Flood Risk Management Scheme have requested that a number of trial pits be excavated on land to the west of Llanmaes Village. These trial pits are to determine the depth and type of materials to aid in the design of the scheme.

The trial pitting was undertaken on two parcels of land after notice was served on the landowners by The Vale of Glamorgan Council. This followed site meetings between VoG, Aecom and the land owners.

The trial pitting was undertaken over three days from 8th September 2020 to 10th September 2020.

3 extra trial pits were requested by Aecom in the field to the north west, these were undertaken on the 10th.

The weather was inclement on the 8th and 9th with heavy drizzle falling during the entire trial pitting exercise. The weather on the 10th was dry and warm.

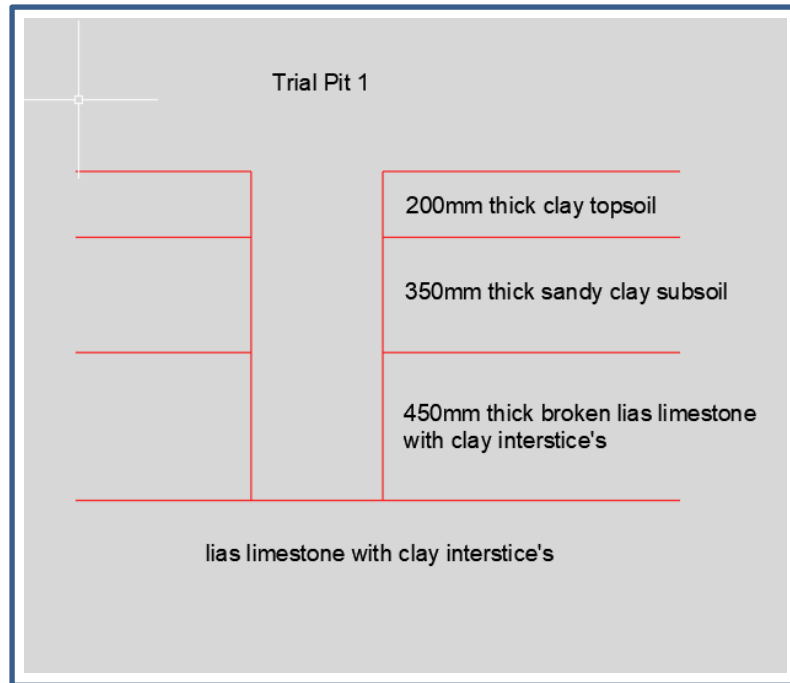
The trial pitting was undertaken by The Vale of Glamorgan Environment team utilising the councils JCB. Aecom and Glamorgan Gwent Archaeological Trust both had a watching brief.

Samples were taken from a number of the trial pits of the excavated material. These samples are to be analysed using Aecom's preferred laboratory.

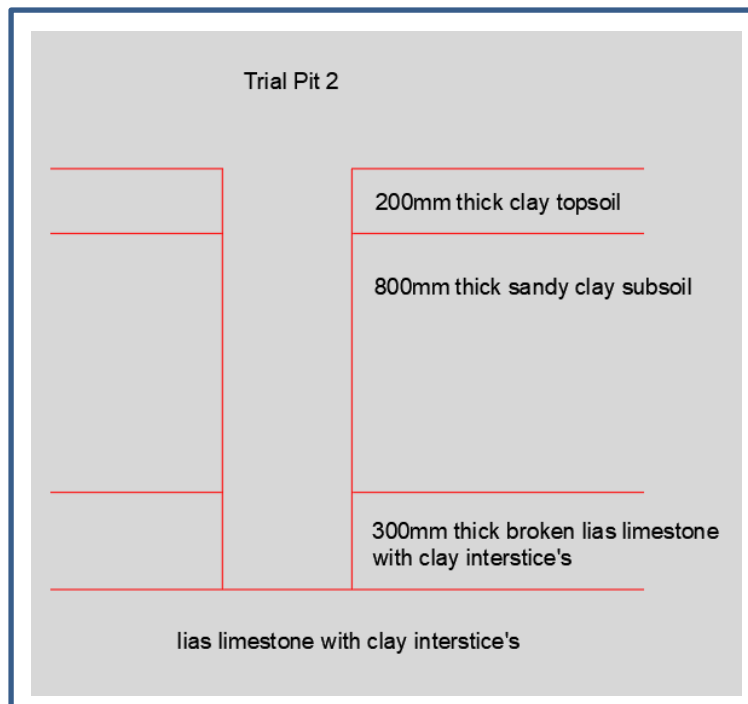
This report and the trial pit logs has been prepared by Huw Morgans Principal Engineer Environment Team Vale of Glamorgan.

A summary of the trial pitting follows.

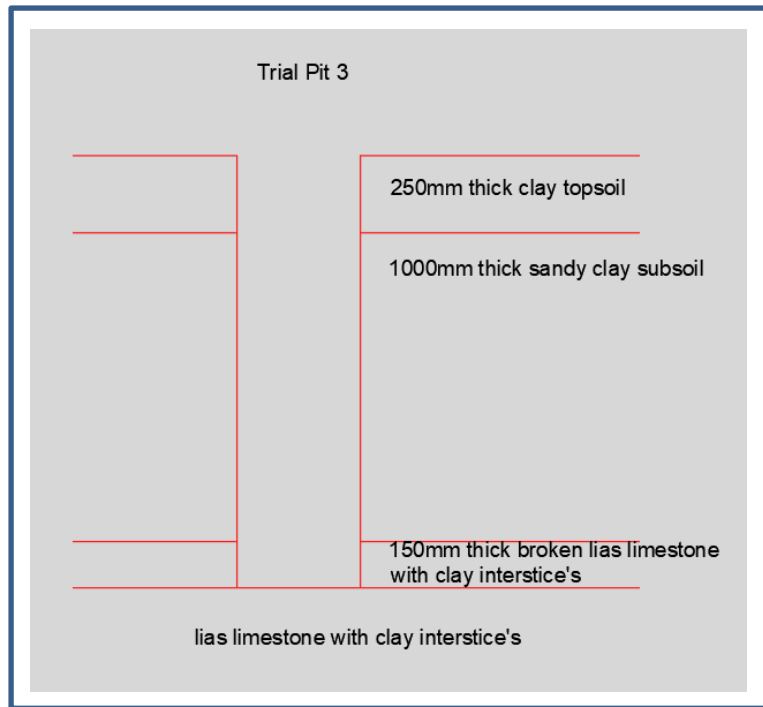
Trial Pit 1



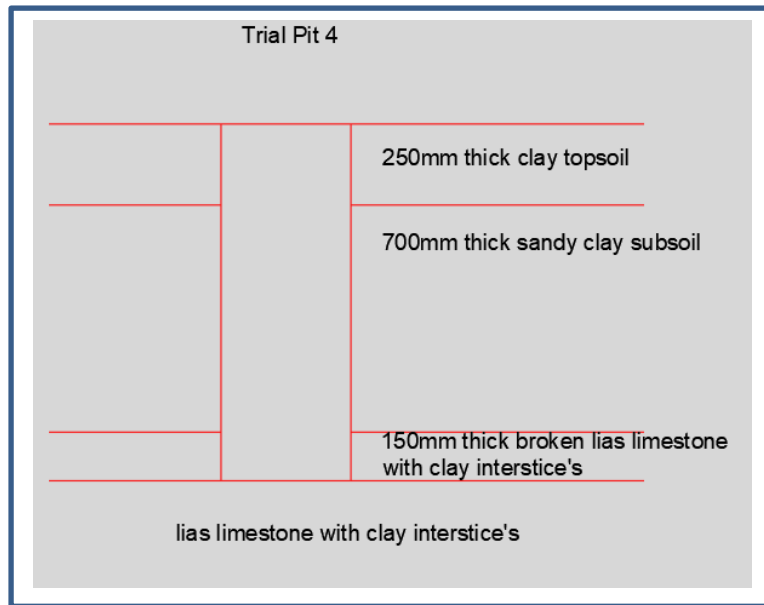
Trial Pit 2



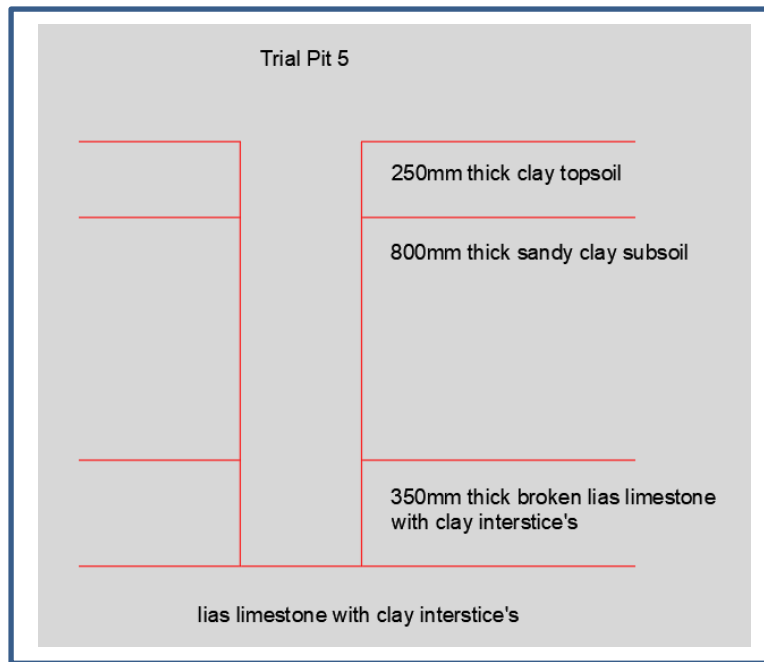
Trial Pit 3



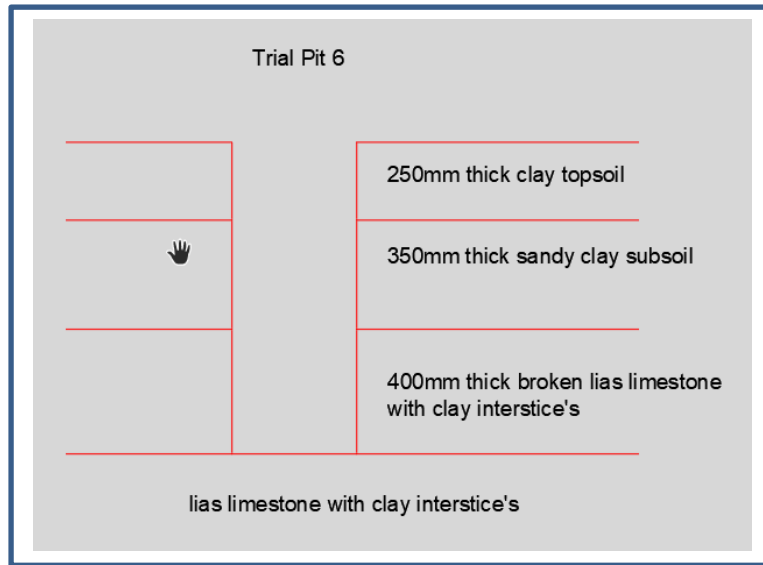
Trial Pit 4



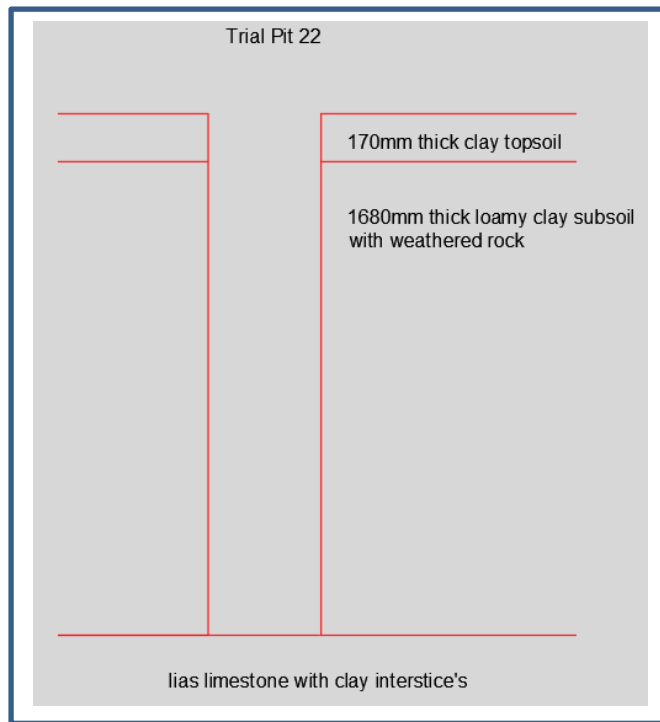
Trial Pit 5



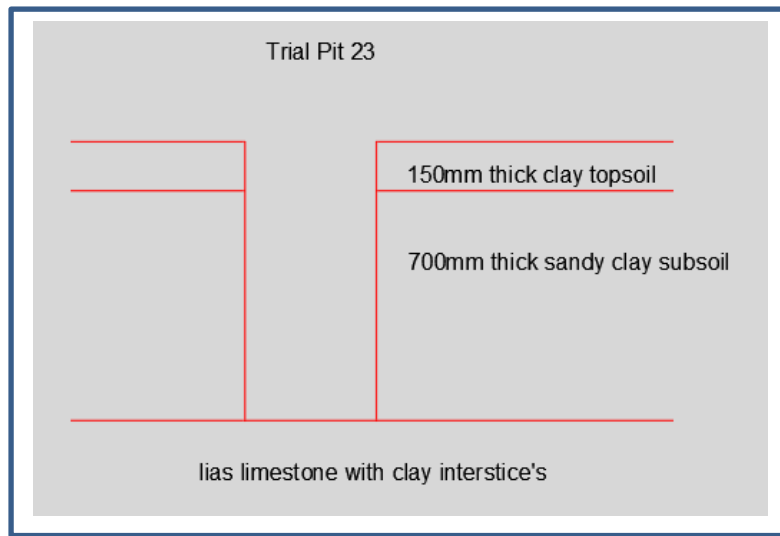
Trial Pit 6



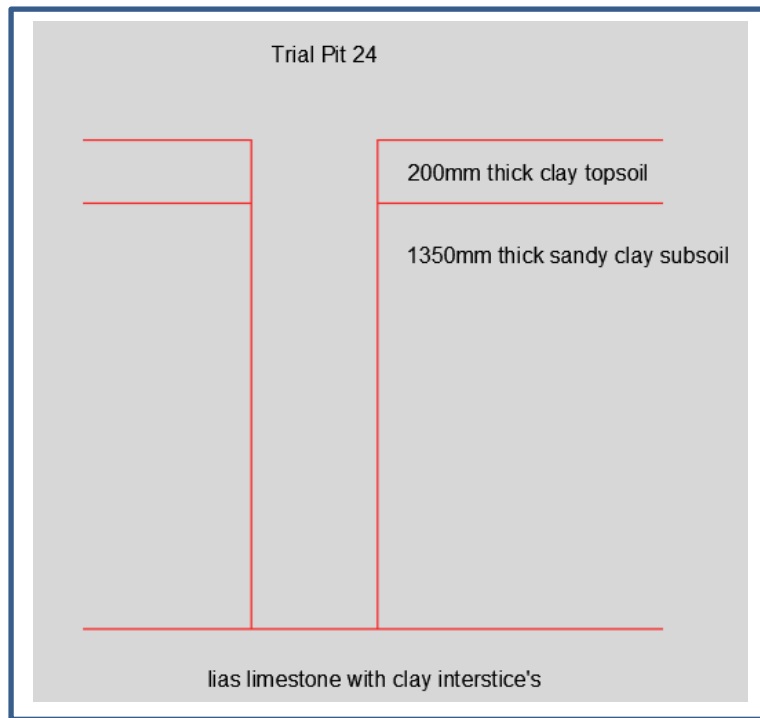
Trial Pit 22



Trial Pit 23



Trial Pit 24



Appendix B – Laboratory Test Data



LABORATORY REPORT



4043

Contract Number: PSL20/5543

Report Date: 04 November 2020

Client's Reference:

Client Name: Aecom
12 Regan Way
Chetwynd Business Park
Chilwell
Nottingham
NG9 6RZ

For the attention of: Josuha Lewis

Contract Title: Llanmaes

Date Received: 13/10/2020

Date Commenced: 13/10/2020

Date Completed: 4/11/2020

Notes: Opinions and Interpretations are outside the UKAS Accreditation

A copy of the Laboratory Schedule of accredited tests as issued by UKAS is attached to this report. This certificate is issued in accordance with the accreditation requirements of the United Kingdom Accreditation Service. The results reported herein relate only to the material supplied to the laboratory. This certificate shall not be reproduced other than in full, without the prior written approval of the laboratory.

Checked and Approved Signatories:



(Laboratory Manager)

A Watkins
(Director)

R Berriman
(Quality Manager)

H Daniels
(Senior Technician)

S Eyre
(Senior Technician)

L Knight
(Senior Technician)

5 – 7 Hexthorpe Road, Hexthorpe,
Doncaster DN4 0AR
tel: +44 (0)844 815 6641
fax: +44 (0)844 815 6642
e-mail: rgunson@prosoils.co.uk
awatkins@prosoils.co.uk

Page 1 of

SUMMARY OF LABORATORY SOIL DESCRIPTIONS

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Description of Sample
TP1-6					Brown slightly gravelly slightly sandy CLAY.
TP16-18					Brown gravelly slightly sandy CLAY.
TP19-21					Brown slightly gravelly slightly sandy CLAY.



4043



Llanmaes

Contract No:
PSL20/5543
Client Ref:

SUMMARY OF SOIL CLASSIFICATION TESTS

(BS1377 : PART 2 : 1990)

Hole Number	Sample Number	Sample Type	Top Depth m	Base Depth m	Moisture Content % <small>Clause 3.2</small>	Linear Shrinkage % <small>Clause 6.5</small>	Particle Density Mg/m ³ <small>Clause 8.2</small>	Liquid Limit % <small>Clause 4.3/4</small>	Plastic Limit % <small>Clause 5.3</small>	Plasticity Index % <small>Clause 5.4</small>	Passing .425mm %	Remarks
TP1-6					39			68	30	38	93	High plasticity CH.
TP16-18					29			66	29	37	84	High plasticity CH.
TP19-21					28			65	28	37	95	High plasticity CH.

SYMBOLS : NP : Non Plastic

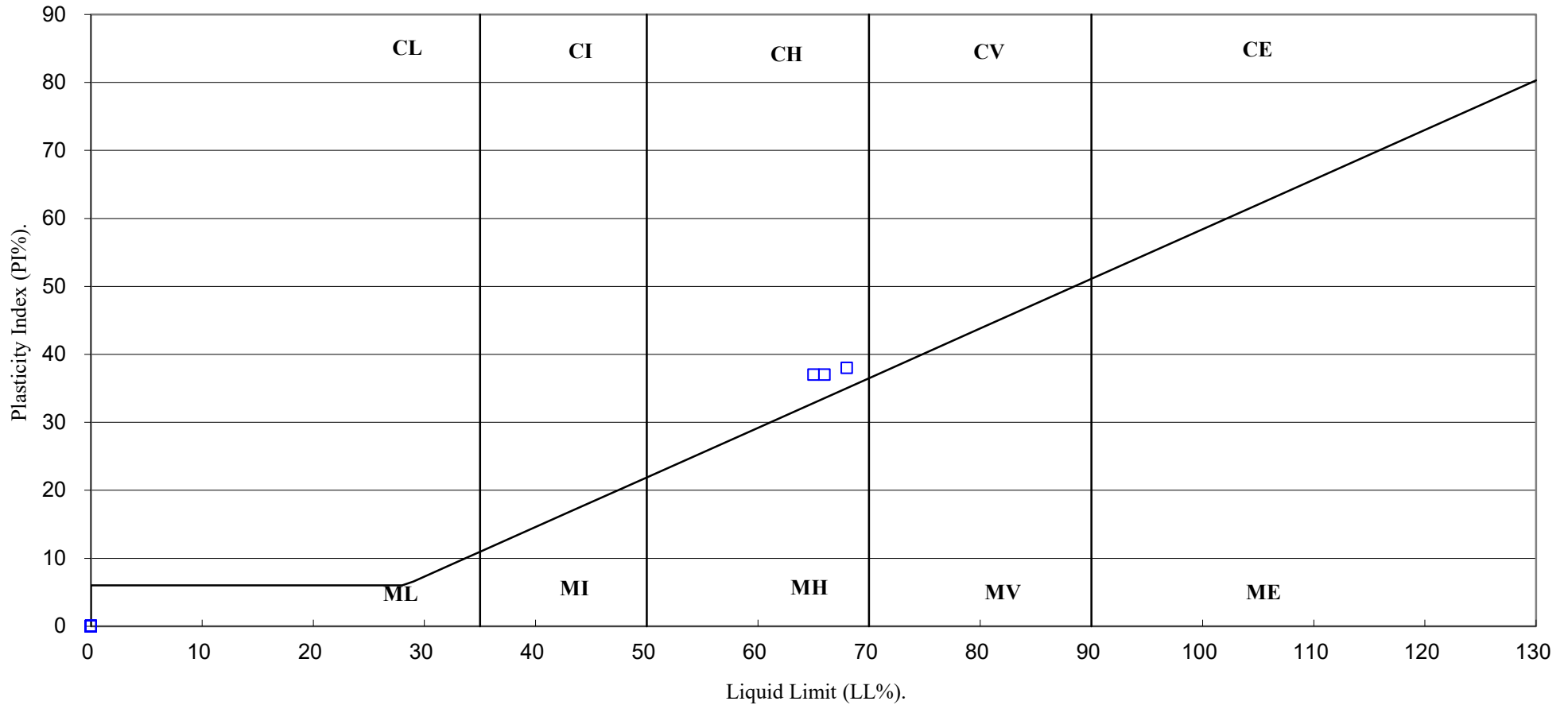
* : Liquid Limit and Plastic Limit Wet Sieved.



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PLASTICITY CHART FOR CASAGRANDE CLASSIFICATION.



4043

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PSL20/5543

Client Ref:

PARTICLE SIZE DISTRIBUTION TEST

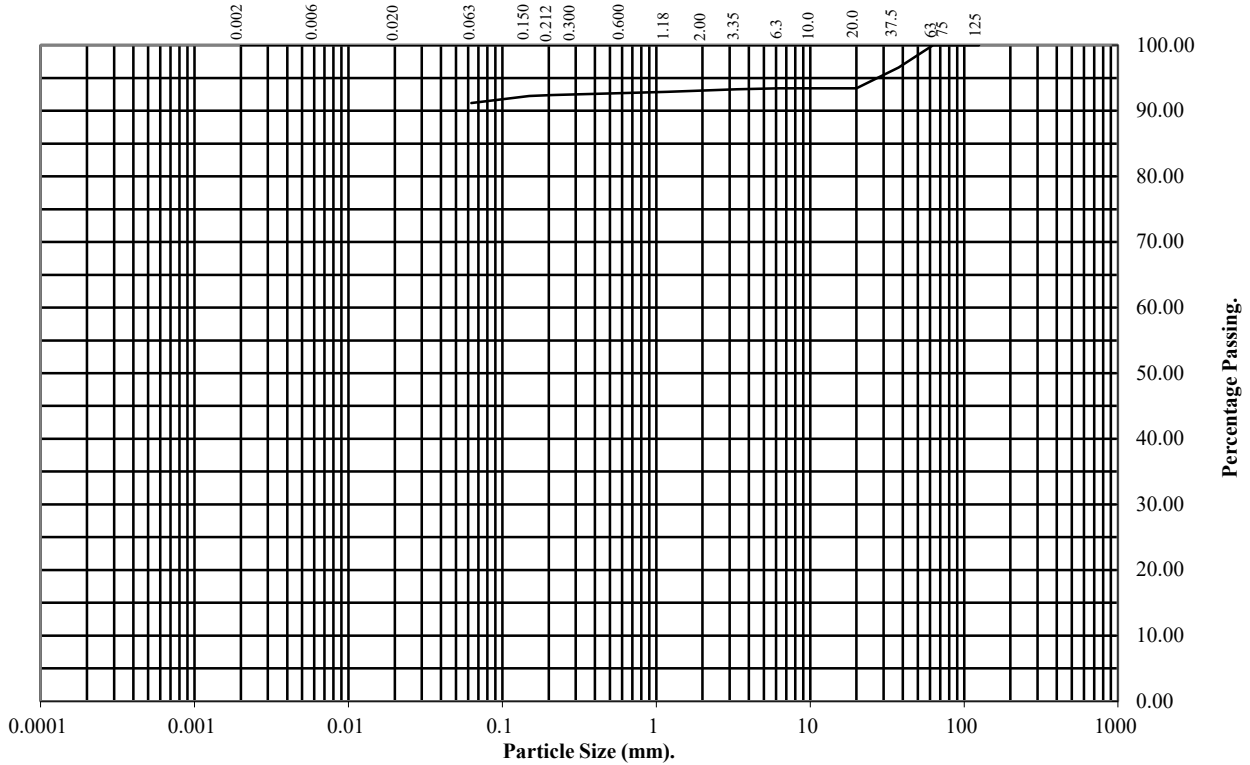
BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number: **TP1-6** **Top Depth (m):**

Sample Number: **Base Depth(m):**

Sample Type:



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	97
20	93
10	93
6.3	93
3.35	93
2	93
1.18	93
0.6	93
0.3	93
0.212	92
0.15	92
0.063	91

Soil Fraction	Total Percentage
Cobbles	0
Gravel	7
Sand	2
Silt/Clay	91

Remarks:
See Summary of Soil Descriptions



Llanmaes

Contract No:
PSL20/5543
Client Ref:

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.4 : 1990

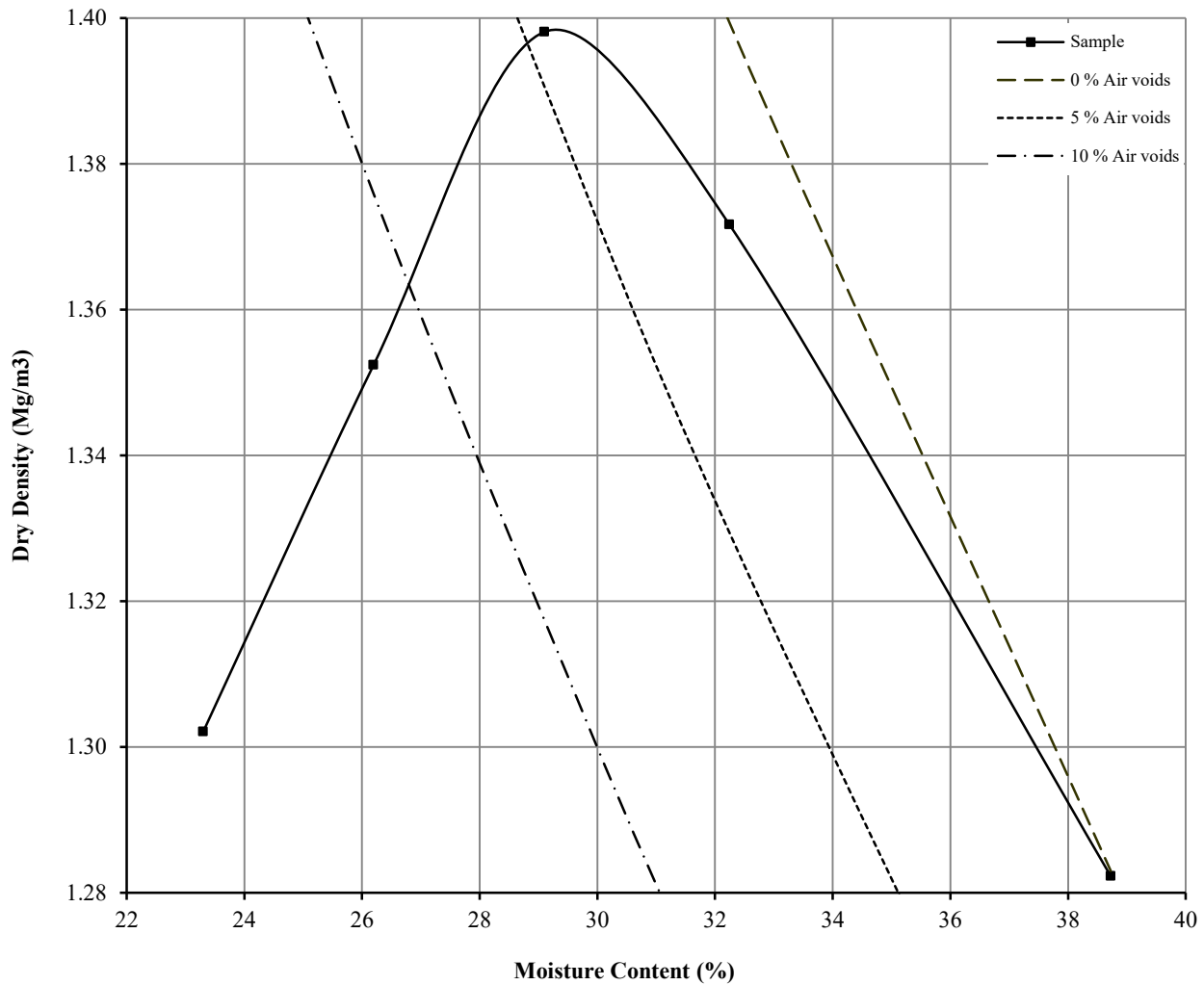
Hole Number: TP1-6

Top Depth (m) :

Sample Number:

Base Depth (m) :

Sample Type:



Initial Moisture Content:	39	Method of Compaction:	2.5kg	Separate Samples
Particle Density (Mg/m ³):	2.55	Assumed	Material Retained on 37.5 mm Test Sieve (%):	3
Maximum Dry Density (Mg/m ³):	1.40		Material Retained on 20.0 mm Test Sieve (%):	4
Optimum Moisture Content (%):	29			
Remarks				
See summary of soil descriptions.				



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Client Ref

CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

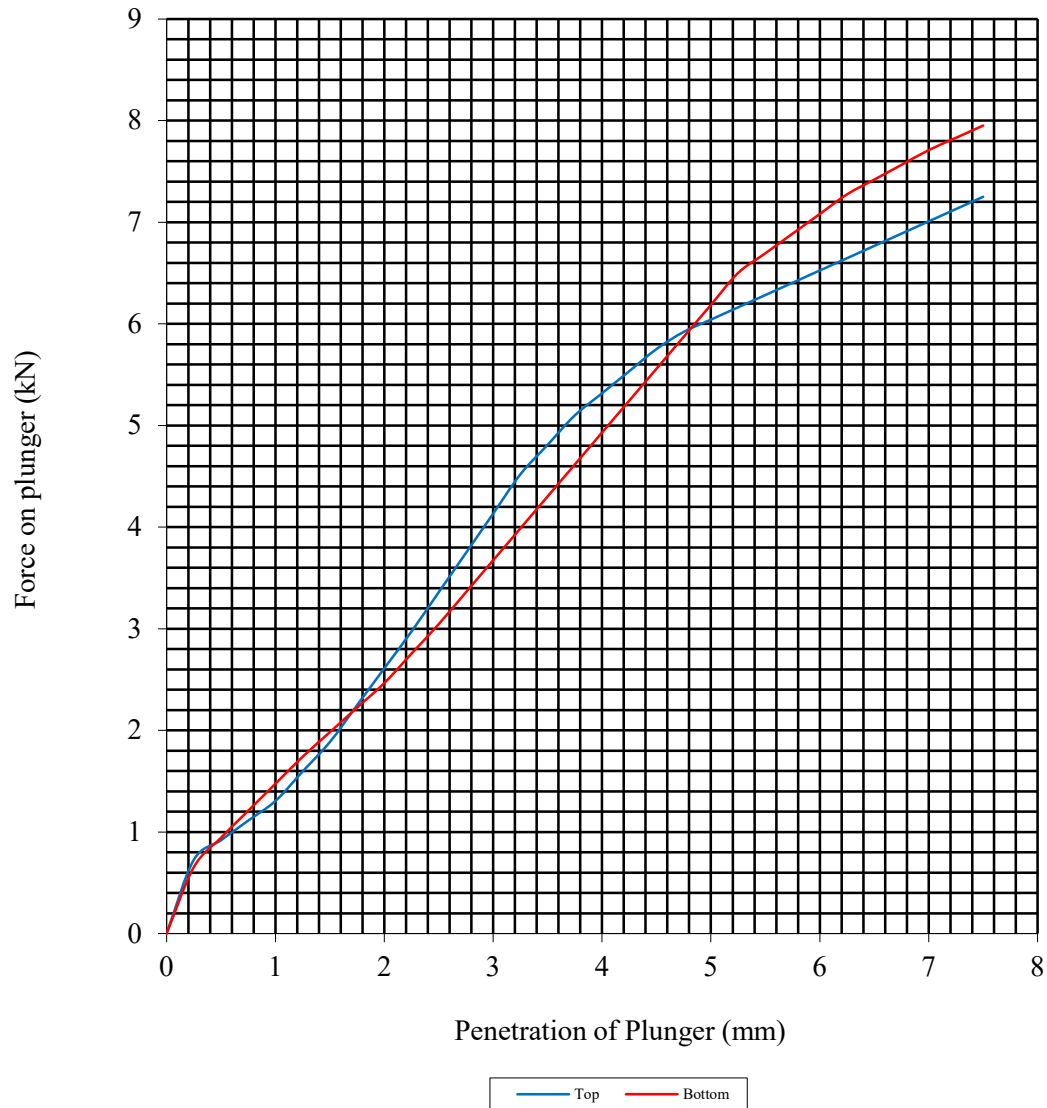
Hole Number: TP1-6

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	23	Surcharge Kg:	4.20	Sample Top	23	Sample Top	30.2
Bulk Density Mg/m ³ :	1.60	Soaking Time hrs	0	Sample Bottom	23	Sample Bottom	30.9
Dry Density Mg/m ³ :	1.30	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	7						
Compaction Conditions		2.5kg					



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

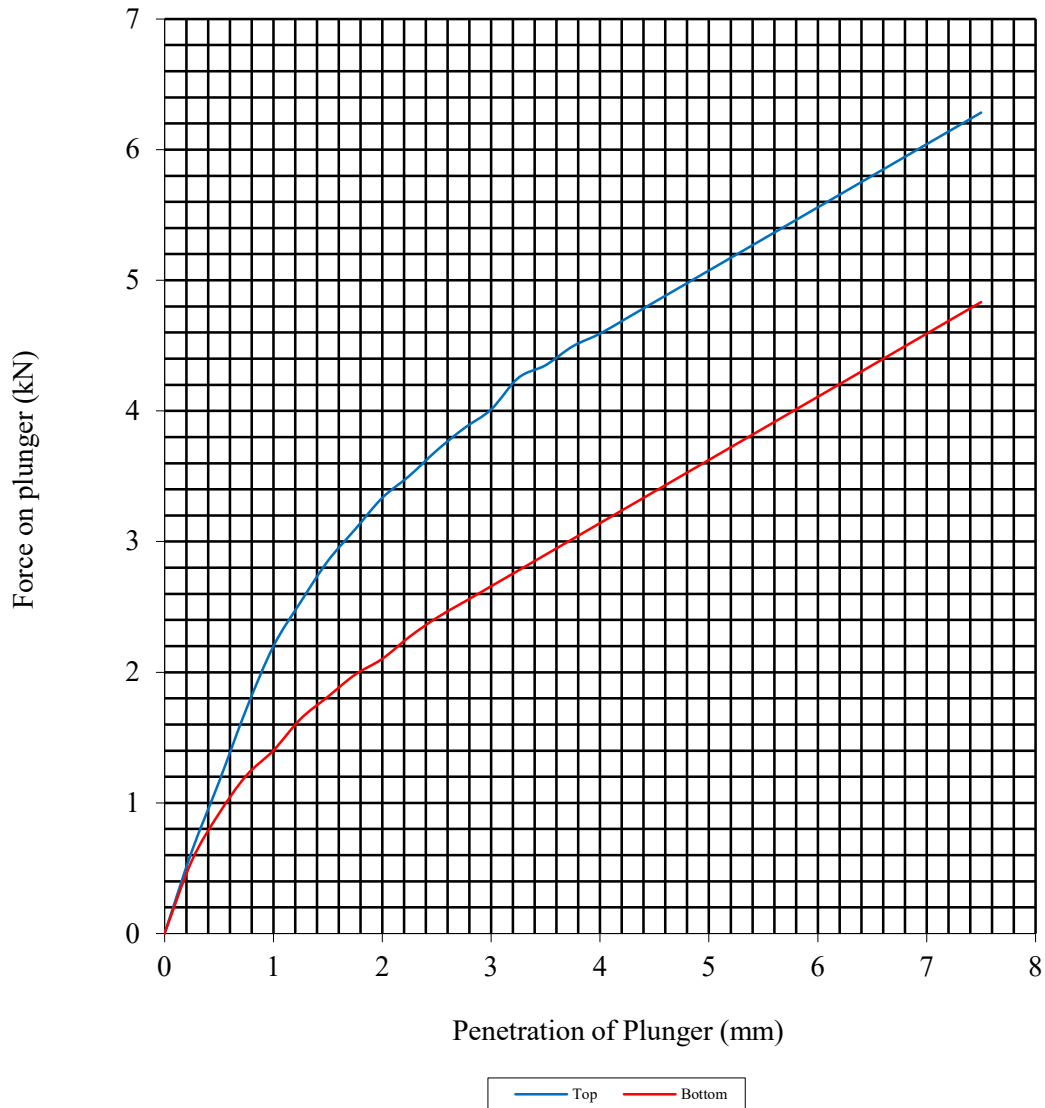
Hole Number: TP1-6

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	26	Surcharge Kg:	4.20	Sample Top	26	Sample Top	28.0
Bulk Density Mg/m ³ :	1.71	Soaking Time hrs	0	Sample Bottom	26	Sample Bottom	18.3
Dry Density Mg/m ³ :	1.35	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	7						
Compaction Conditions	2.5kg						



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

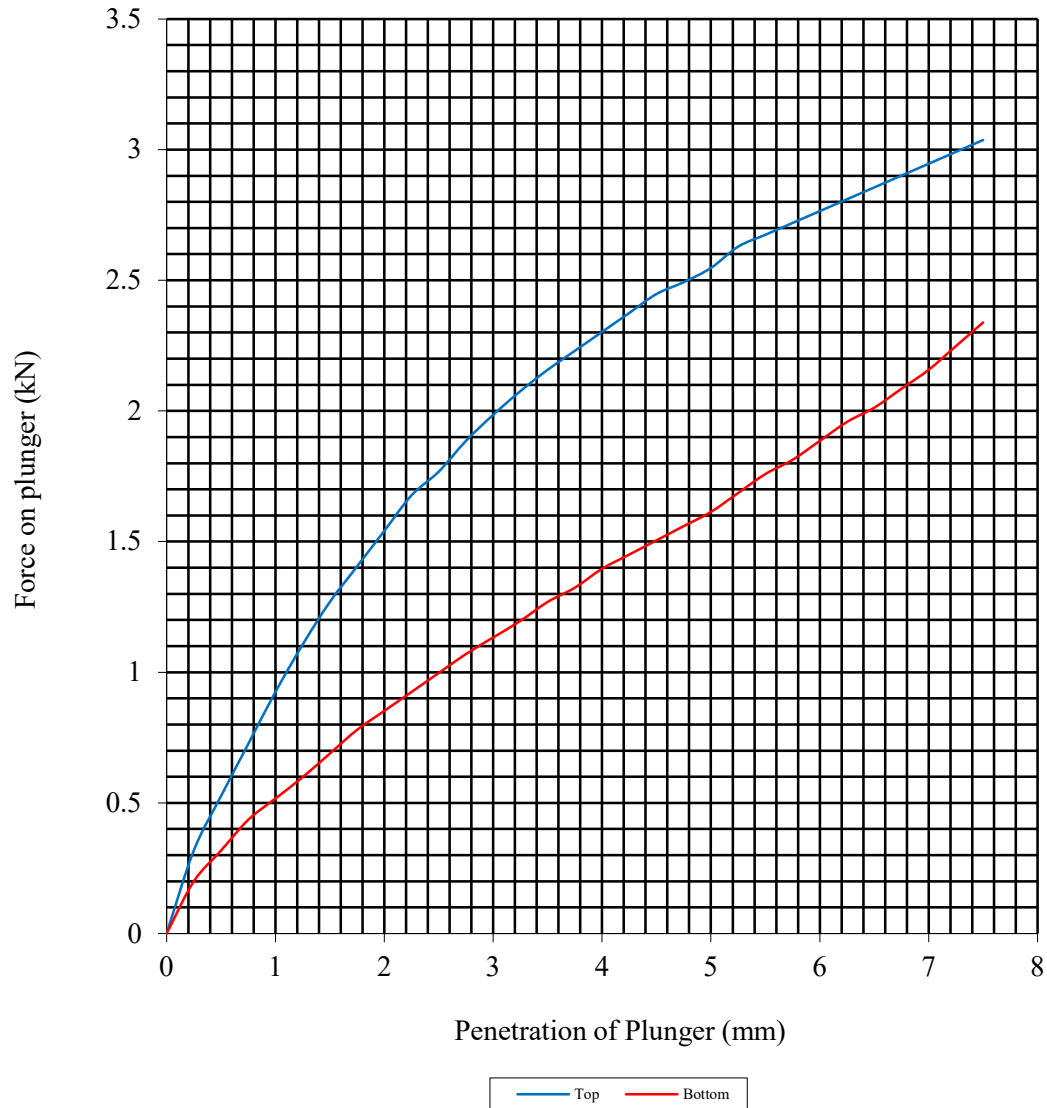
Hole Number: TP1-6

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	29	Surcharge Kg:	4.20	Sample Top	29	Sample Top	13.4
Bulk Density Mg/m ³ :	1.78	Soaking Time hrs	0	Sample Bottom	29	Sample Bottom	8.1
Dry Density Mg/m ³ :	1.38	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	7						
Compaction Conditions	2.5kg						



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

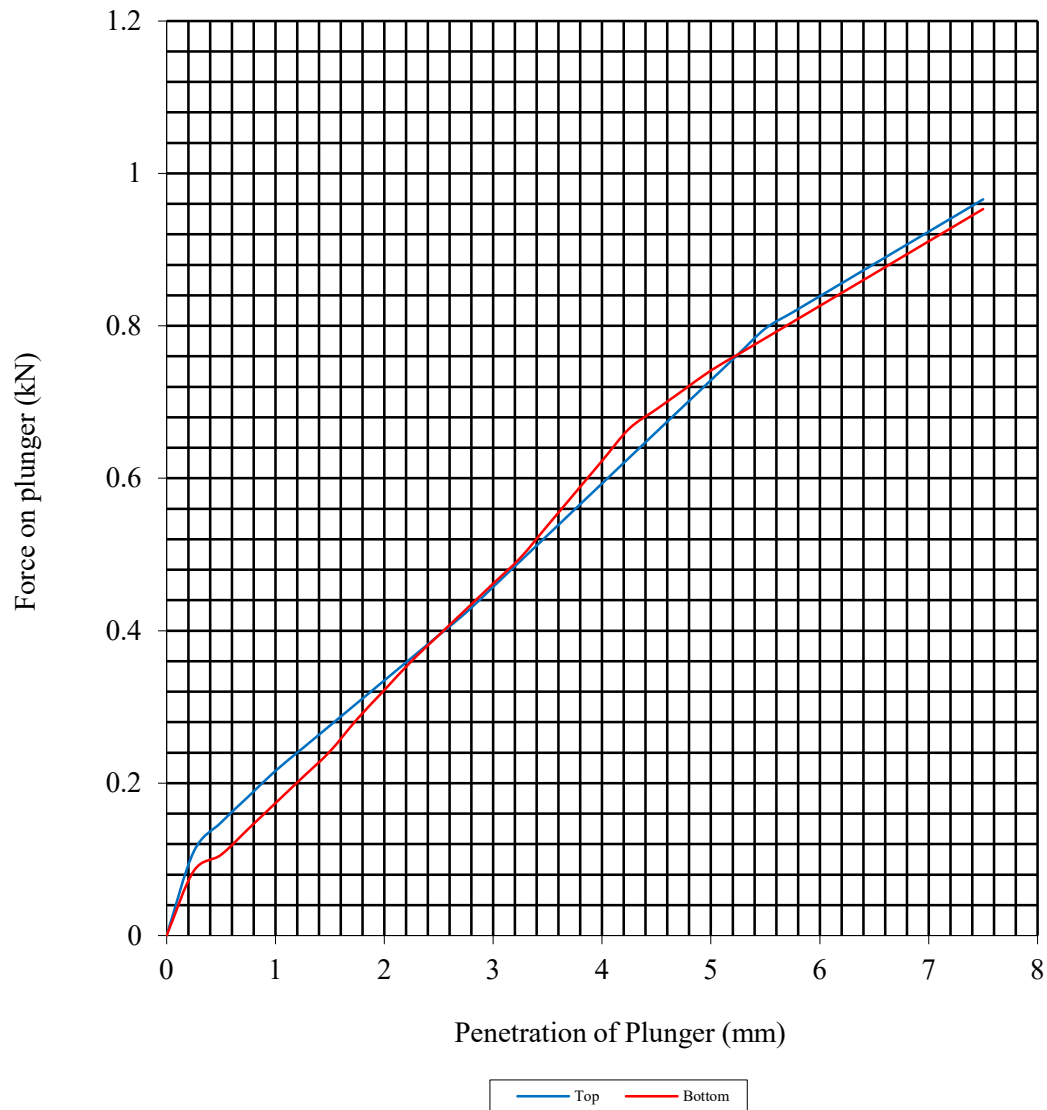
Hole Number: TP1-6

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	32	Surcharge Kg:	4.20	Sample Top	32	Sample Top	3.6
Bulk Density Mg/m ³ :	1.81	Soaking Time hrs	0	Sample Bottom	32	Sample Bottom	3.7
Dry Density Mg/m ³ :	1.37	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:		7					
Compaction Conditions		2.5kg					



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

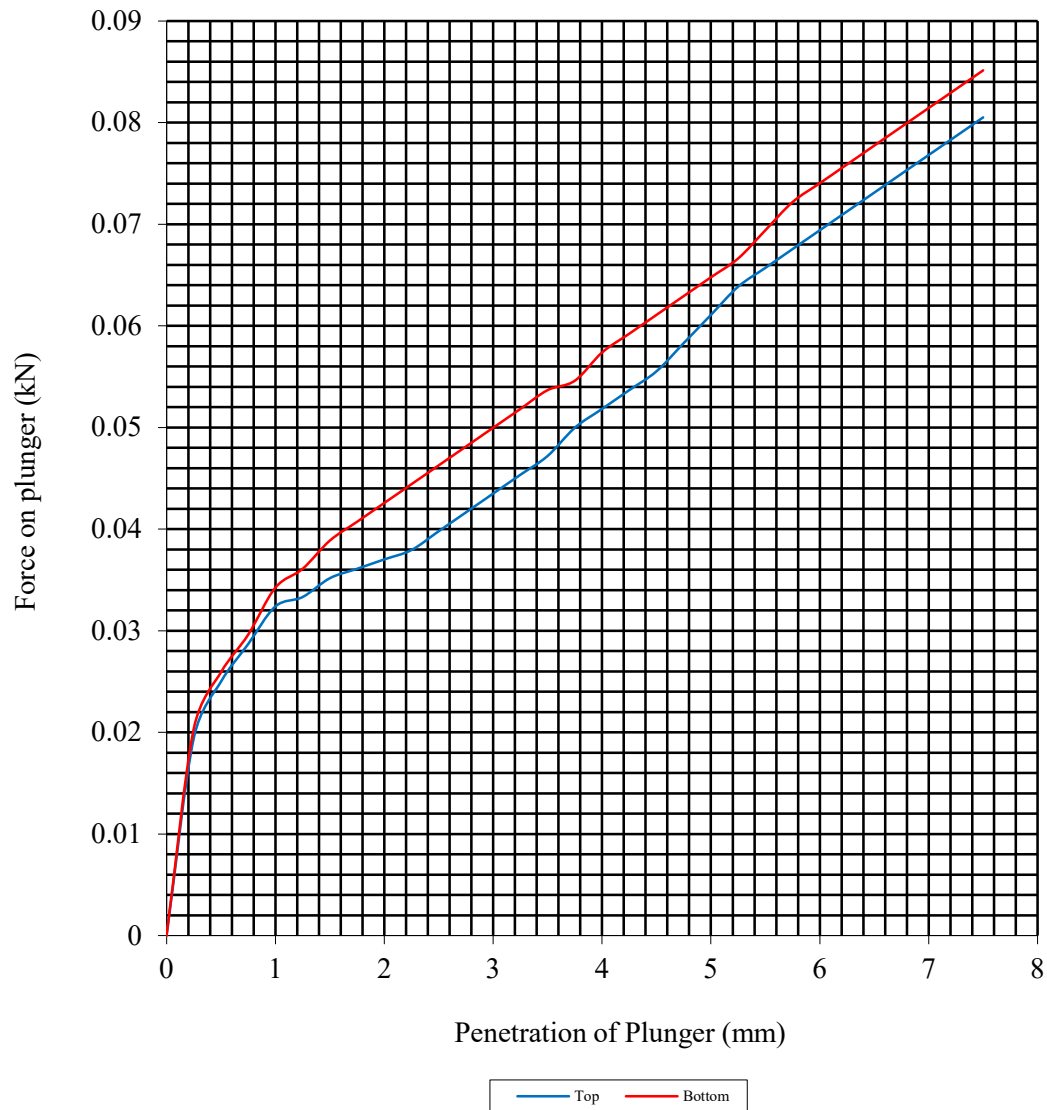
Hole Number: TP1-6

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	39	Surcharge Kg:	4.20	Sample Top	39	Sample Top	0.3
Bulk Density Mg/m ³ :	1.78	Soaking Time hrs	0	Sample Bottom	39	Sample Bottom	0.4
Dry Density Mg/m ³ :	1.28	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	7						
Compaction Conditions		2.5kg					



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MOISTURE CONDITION VALUE

BS1377 : Part 4 : 1990 Clause 5.4

Hole Number: TP1-6

Top Depth (m):

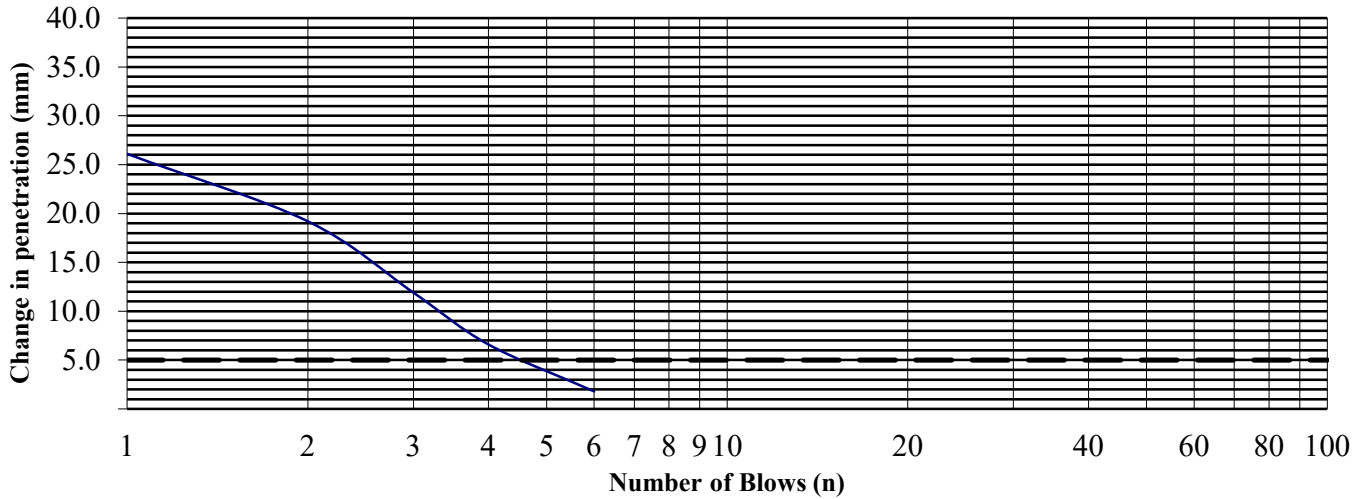
Sample Number:

Base Depth (m):

Sample Type:

Material Retained on the 20mm BS Test Sieve (%):	7
Interpretation based on steepest straight line intercept with 5mm change in penetration.	

MCV Determination



Blows (N)	Penetration (mm)	n to 4n (mm)
1	110.7	26.1
2	97.8	19.2
3	90.0	11.9
4	84.6	6.6
6	79.7	1.8
8	78.6	
12	78.1	
16	78.0	
24	77.9	
32		
48		
64		
96		
128		
192		
256		

Test Results.

Moisture Content (%)	39
MCV	6.6



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Contract No:
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PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number:

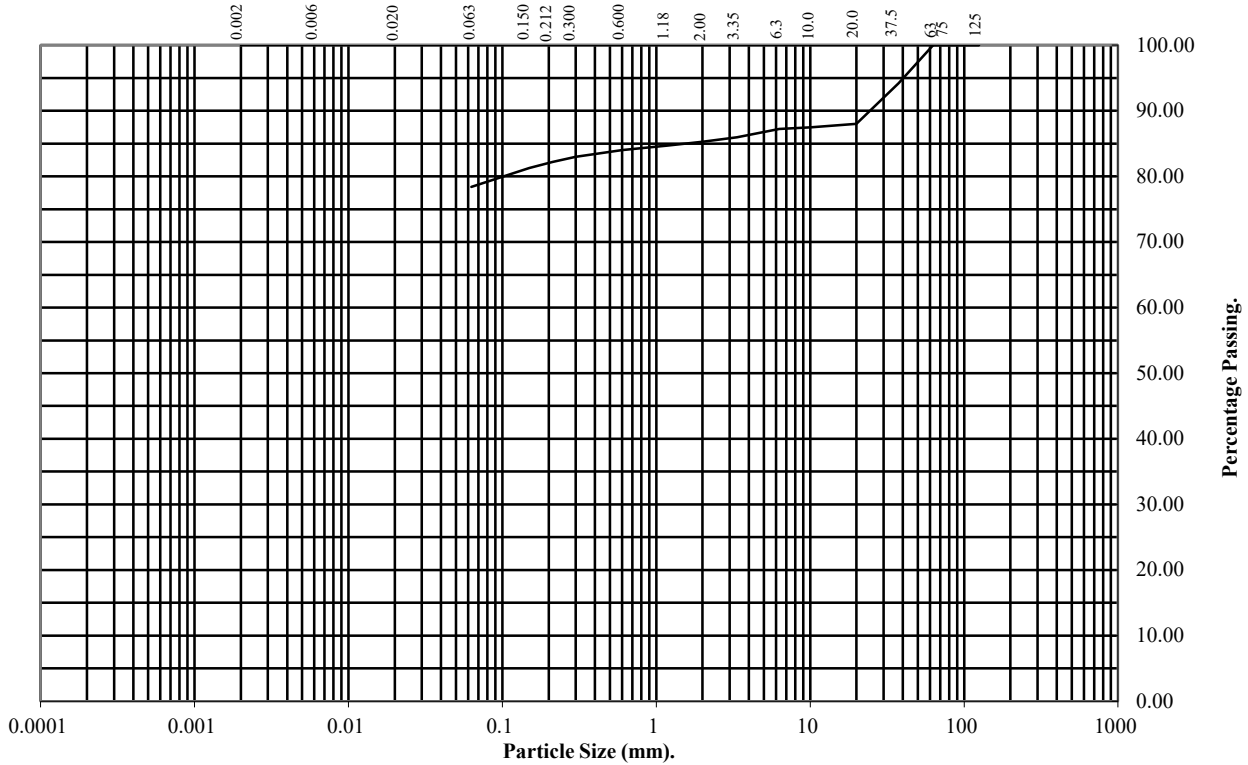
TP16-18

Top Depth (m):

Sample Number:

Base Depth(m):

Sample Type:



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	94
20	88
10	87
6.3	87
3.35	86
2	85
1.18	85
0.6	84
0.3	83
0.212	82
0.15	81
0.063	78

Soil Fraction	Total Percentage
Cobbles	0
Gravel	15
Sand	7
Silt/Clay	78

Remarks:

See Summary of Soil Descriptions



Llanmaes

Contract No:
PSL20/5543
Client Ref:

DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.4 : 1990

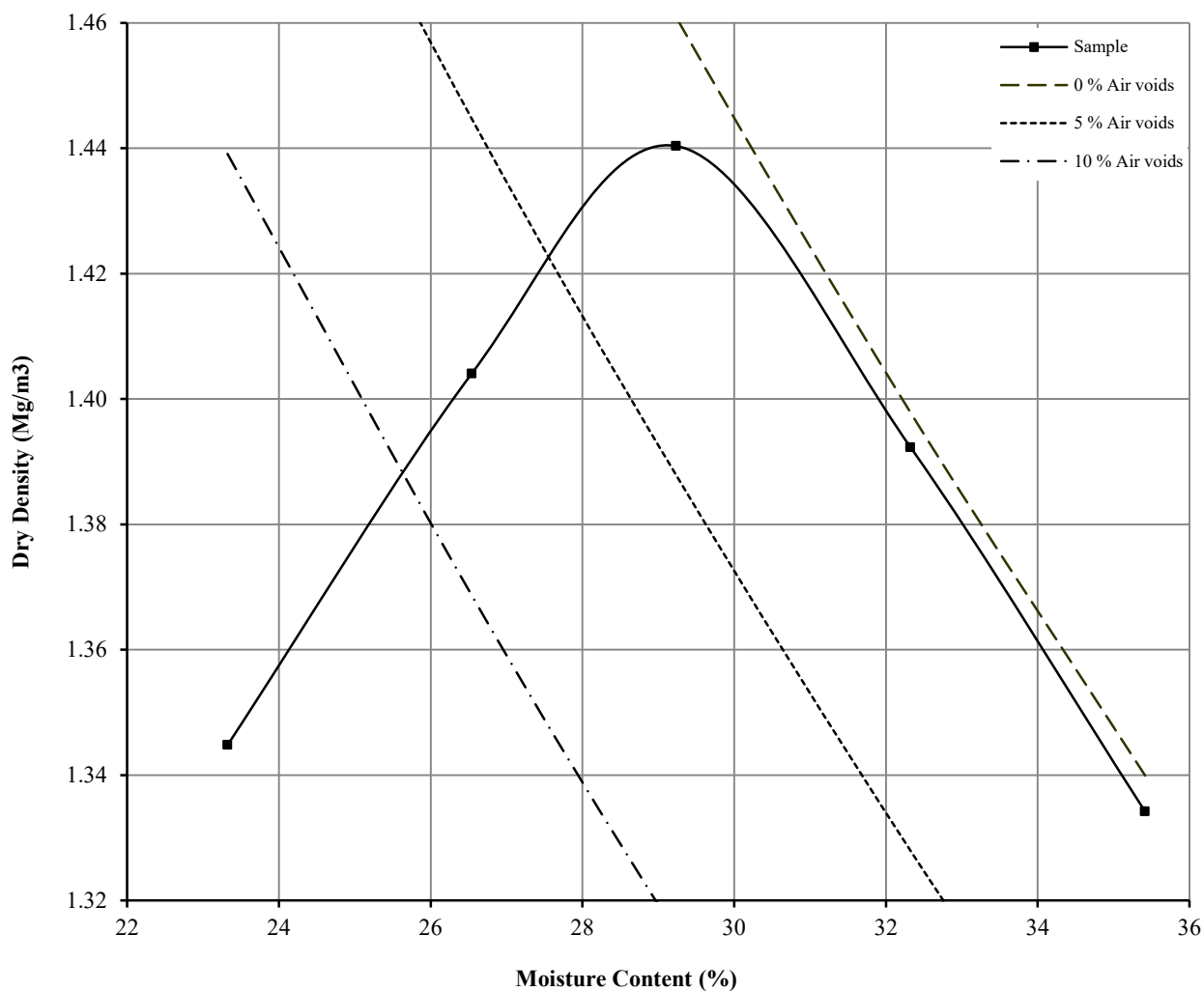
Hole Number: TP16-18

Top Depth (m) :

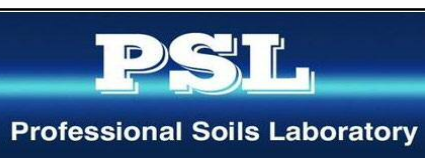
Sample Number:

Base Depth (m) :

Sample Type:



Initial Moisture Content:	29	Method of Compaction:	2.5kg	Separate Samples
Particle Density (Mg/m ³):	2.55	Assumed	Material Retained on 37.5 mm Test Sieve (%):	6
Maximum Dry Density (Mg/m ³):	1.44		Material Retained on 20.0 mm Test Sieve (%):	6
Optimum Moisture Content (%):	29			
Remarks				
See summary of soil descriptions.				



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

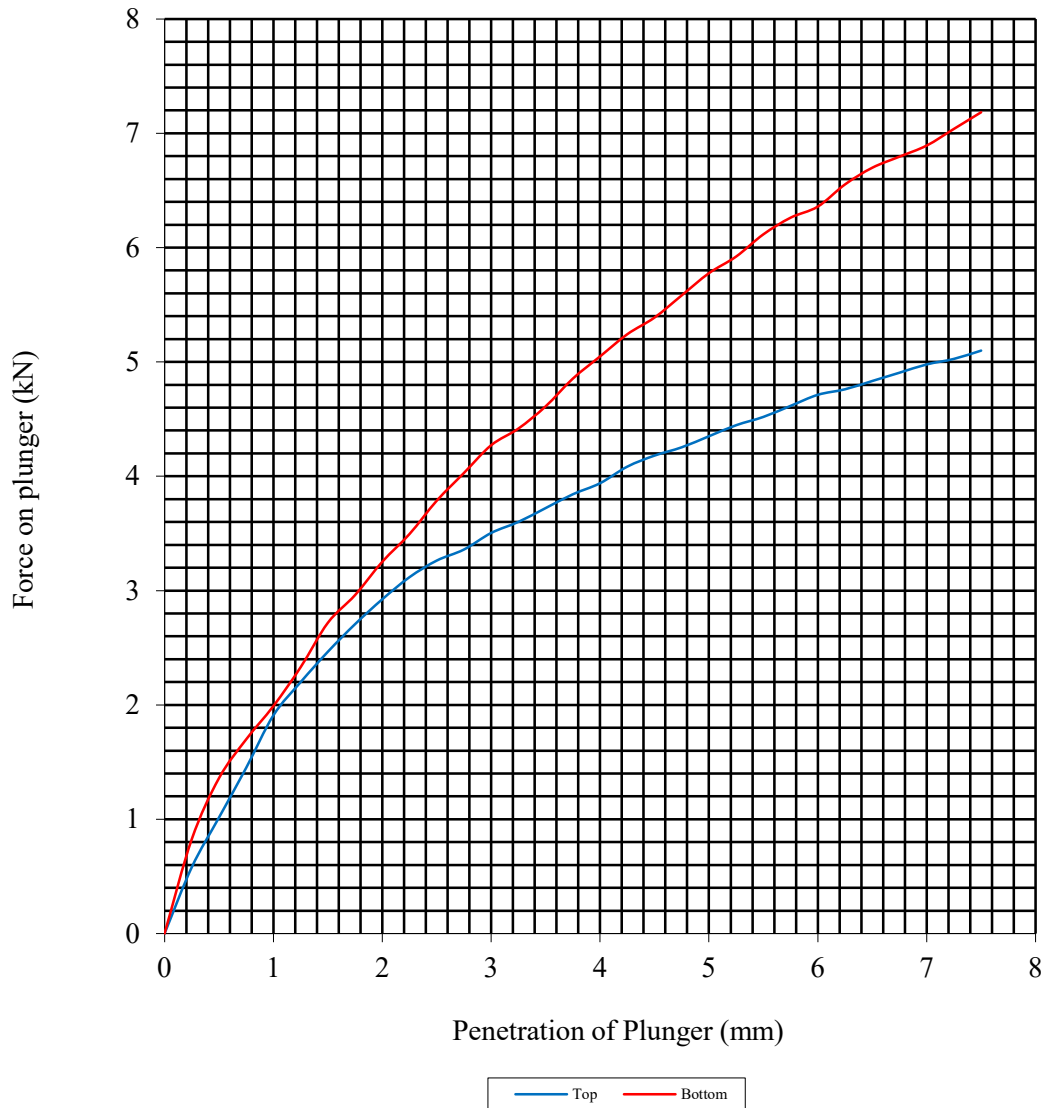
Hole Number: TP16-18

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	23	Surcharge Kg:	4.20	Sample Top	23	Sample Top	24.7
Bulk Density Mg/m ³ :	1.66	Soaking Time hrs	0	Sample Bottom	24	Sample Bottom	28.9
Dry Density Mg/m ³ :	1.34	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	12						
Compaction Conditions	2.5kg						



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Contract No:
PSL20/5543
Client Ref:

CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

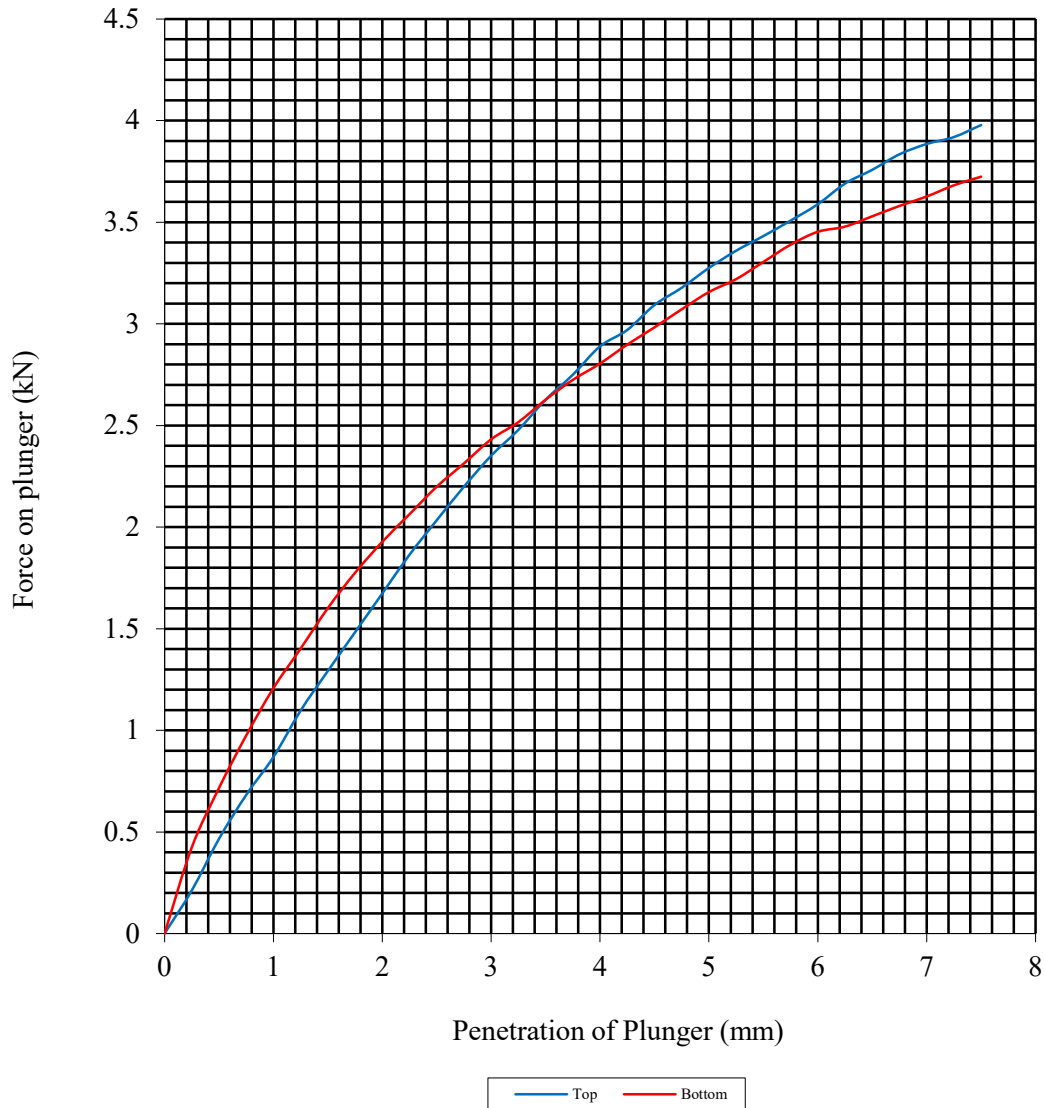
Hole Number: TP16-18

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	26	Surcharge Kg:	4.20	Sample Top	26	Sample Top	16.4
Bulk Density Mg/m ³ :	1.77	Soaking Time hrs	0	Sample Bottom	26	Sample Bottom	16.7
Dry Density Mg/m ³ :	1.40	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			12				
Compaction Conditions		2.5kg					



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Contract No:
PSL20/5543
Client Ref:

CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

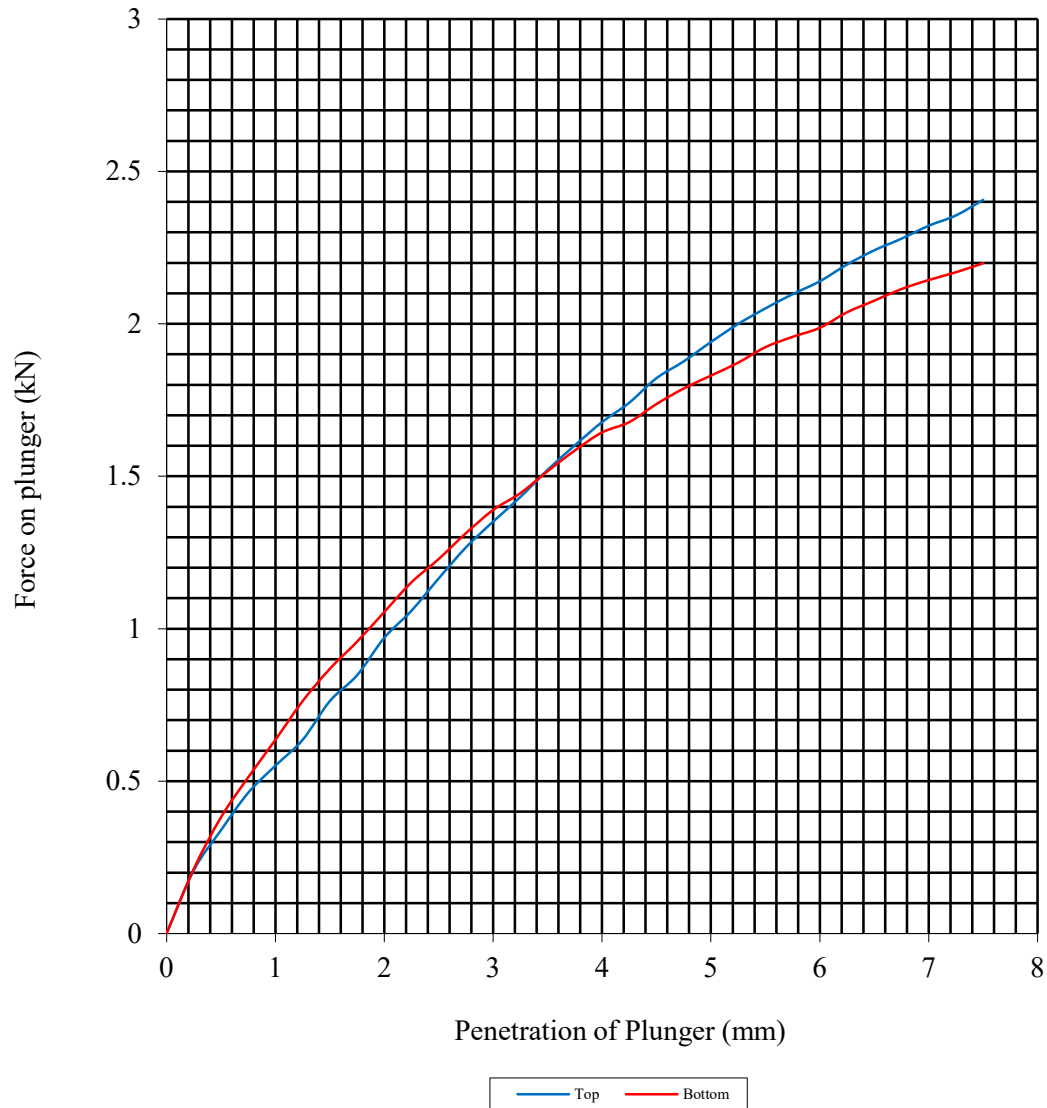
Hole Number: TP16-18

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	29	Surcharge Kg:	4.20	Sample Top	29	Sample Top	9.7
Bulk Density Mg/m ³ :	1.87	Soaking Time hrs	0	Sample Bottom	29	Sample Bottom	9.3
Dry Density Mg/m ³ :	1.44	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			12				
Compaction Conditions		2.5kg					



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

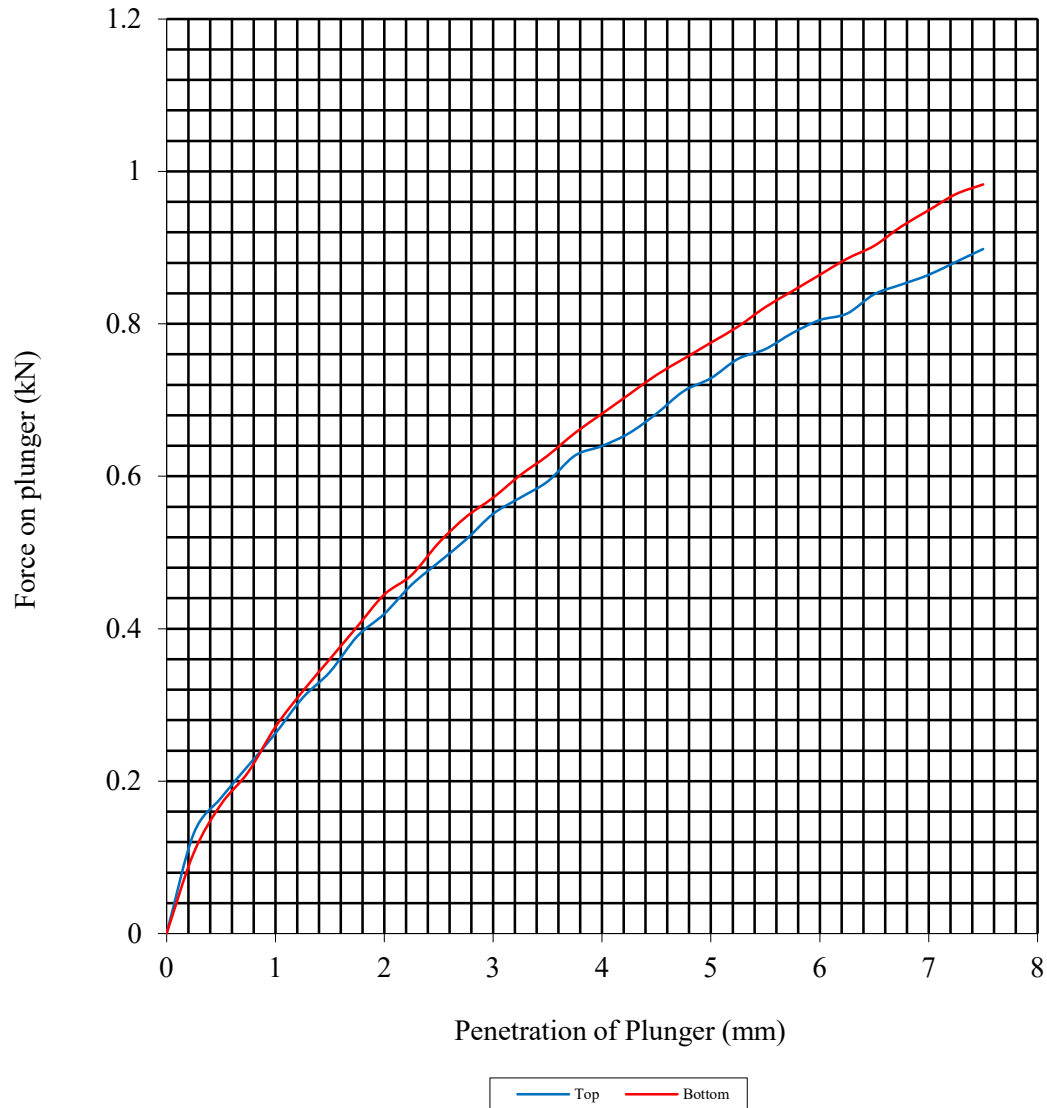
Hole Number: TP16-18

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	32	Surcharge Kg:	4.20	Sample Top	32	Sample Top	3.7
Bulk Density Mg/m ³ :	1.84	Soaking Time hrs	0	Sample Bottom	32	Sample Bottom	3.9
Dry Density Mg/m ³ :	1.39	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			12				
Compaction Conditions		2.5kg					



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BS 1377 : Part 4 : 1990

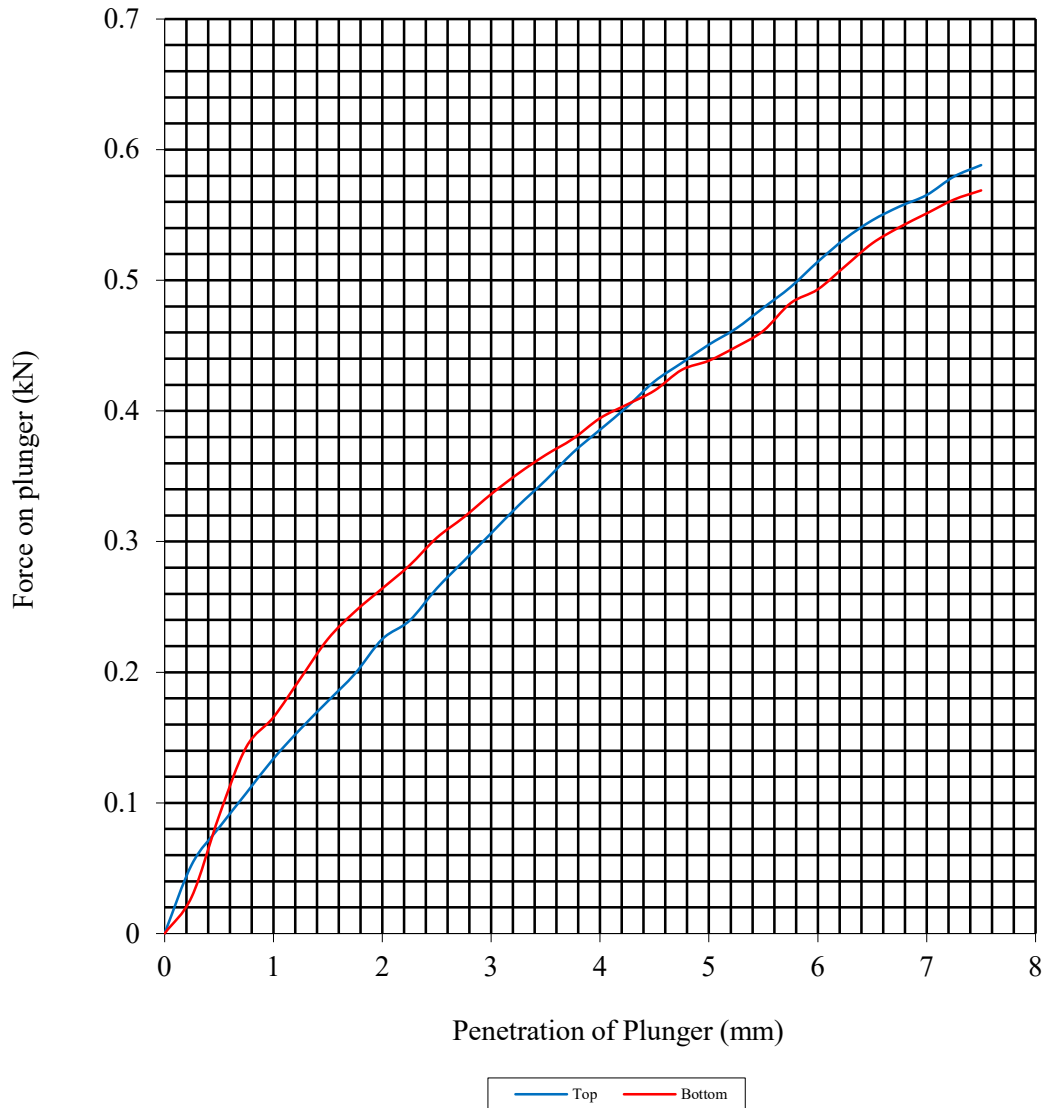
Hole Number: TP16-18

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	35	Surcharge Kg:	4.20	Sample Top	35	Sample Top	2.3
Bulk Density Mg/m ³ :	1.81	Soaking Time hrs	0	Sample Bottom	35	Sample Bottom	2.3
Dry Density Mg/m ³ :	1.33	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			12				
Compaction Conditions		2.5kg					



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MOISTURE CONDITION VALUE

BS1377 : Part 4 : 1990 Clause 5.4

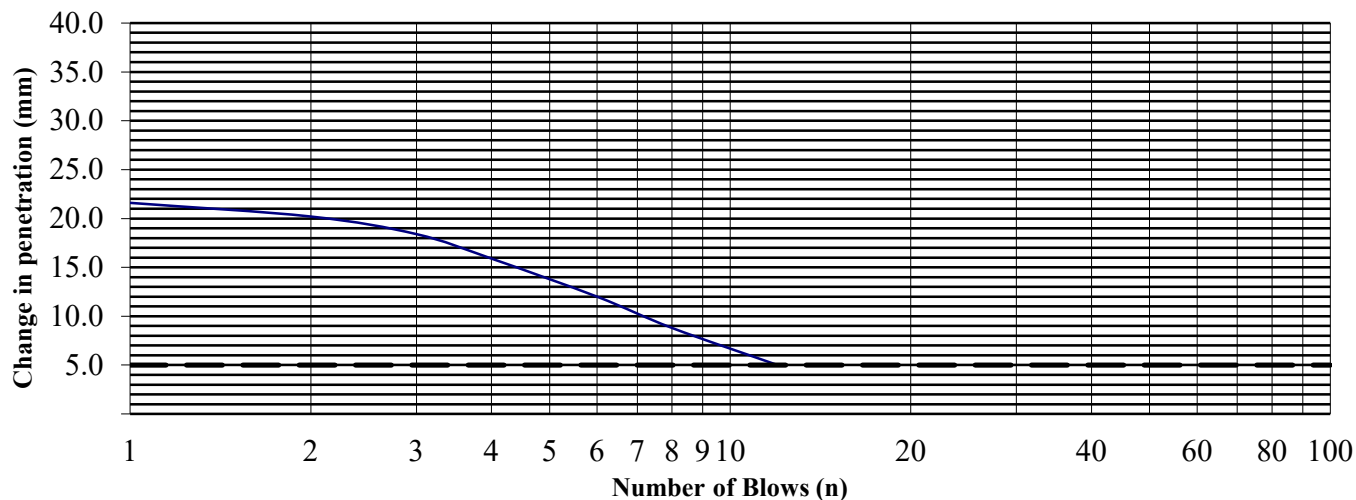
Hole Number: TP16-18 Top Depth (m):

Sample Number: Base Depth (m):

Sample Type:

Material Retained on the 20mm BS Test Sieve (%):	12
Interpretation based on steepest straight line intercept with 5mm change in penetration.	

MCV Determination



Blows (N)	Penetration (mm)	n to 4n (mm)
1	112.4	21.6
2	101.7	20.2
3	95.5	18.4
4	90.8	15.9
6	85.1	12.0
8	81.5	8.8
12	77.1	5.0
16	74.9	
24	73.1	
32	72.7	
48	72.1	
64		
96		
128		
192		
256		

Test Results.

Moisture Content (%)	29
MCV	10.5



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PARTICLE SIZE DISTRIBUTION TEST

BS1377 : Part 2 : 1990

Wet Sieve, Clause 9.2

Hole Number:

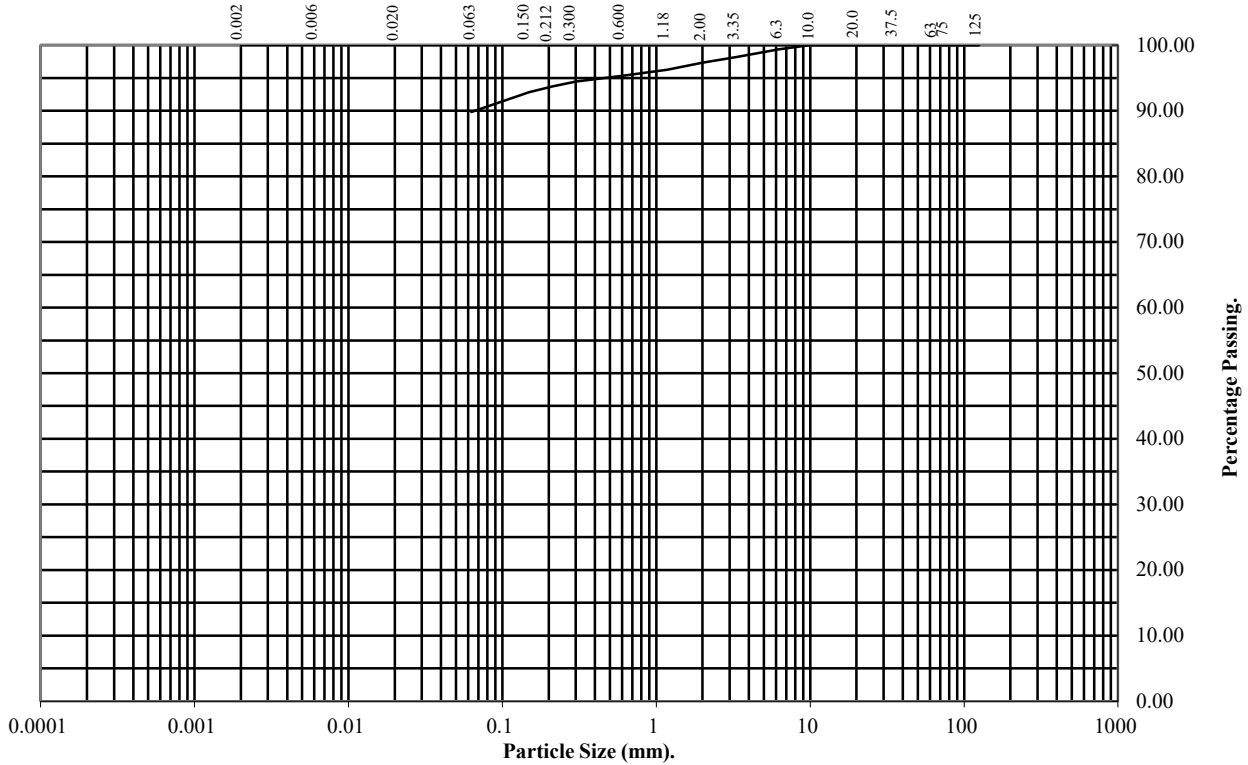
TP19-21

Top Depth (m):

Sample Number:

Base Depth(m):

Sample Type:



BS Test Sieve (mm)	Percentage Passing
125	100
75	100
63	100
37.5	100
20	100
10	100
6.3	99
3.35	98
2	97
1.18	96
0.6	95
0.3	94
0.212	94
0.15	93
0.063	90

Soil Fraction	Total Percentage
Cobbles	0
Gravel	3
Sand	7
Silt/Clay	90

Remarks:
See Summary of Soil Descriptions



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DRY DENSITY / MOISTURE CONTENT RELATIONSHIP

BS 1377 : Part 4 : Clause 3.3 : 1990

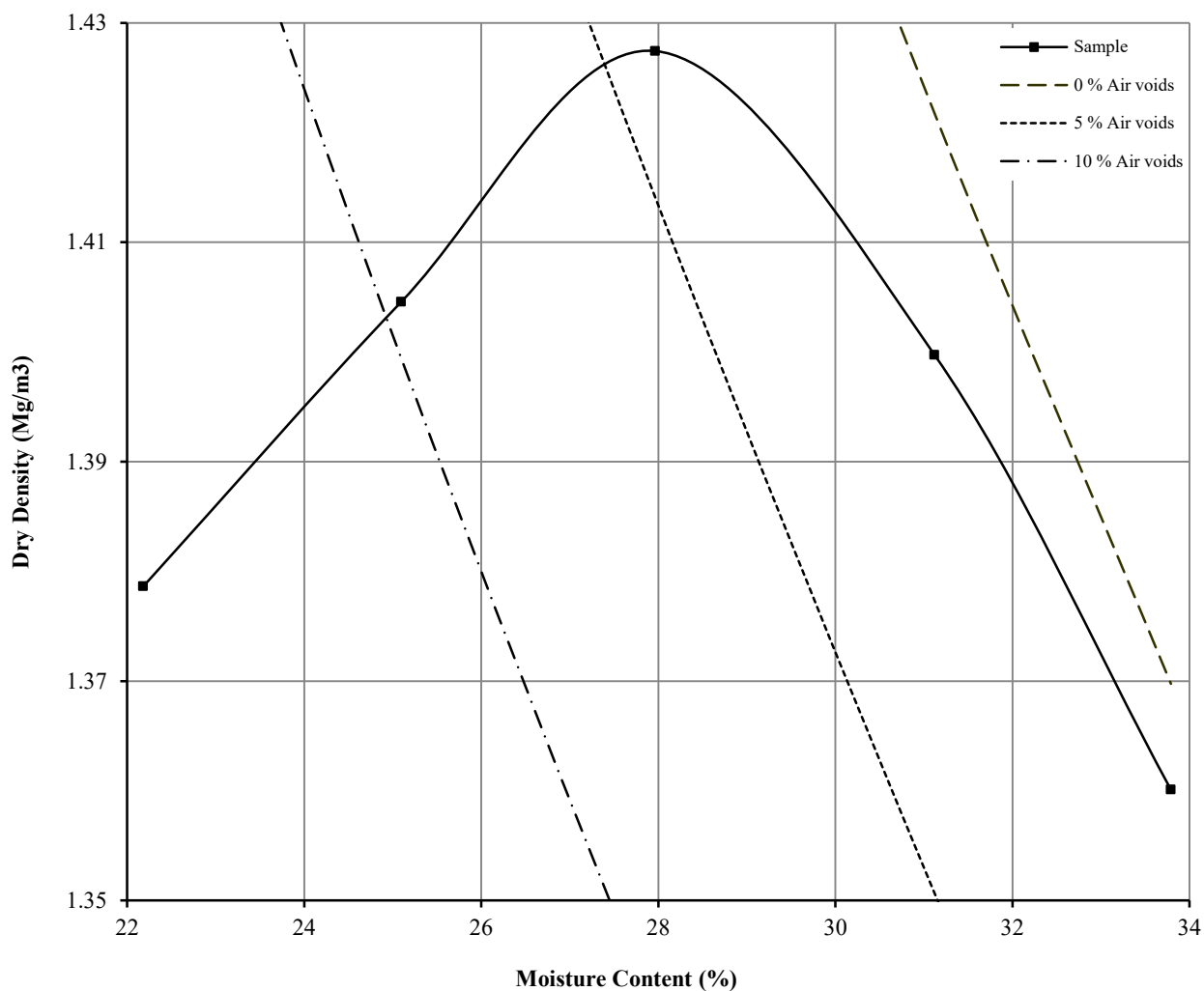
Hole Number: TP19-21

Top Depth (m) :

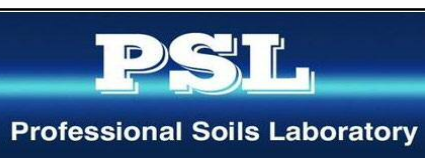
Sample Number:

Base Depth (m) :

Sample Type:



Initial Moisture Content:	28	Method of Compaction:	2.5kg	Separate Samples
Particle Density (Mg/m ³):	2.55	Assumed	Material Retained on 37.5 mm Test Sieve (%):	0
Maximum Dry Density (Mg/m ³):	1.43		Material Retained on 20.0 mm Test Sieve (%):	0
Optimum Moisture Content (%):	28			
Remarks				
See summary of soil descriptions.				



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BS 1377 : Part 4 : 1990

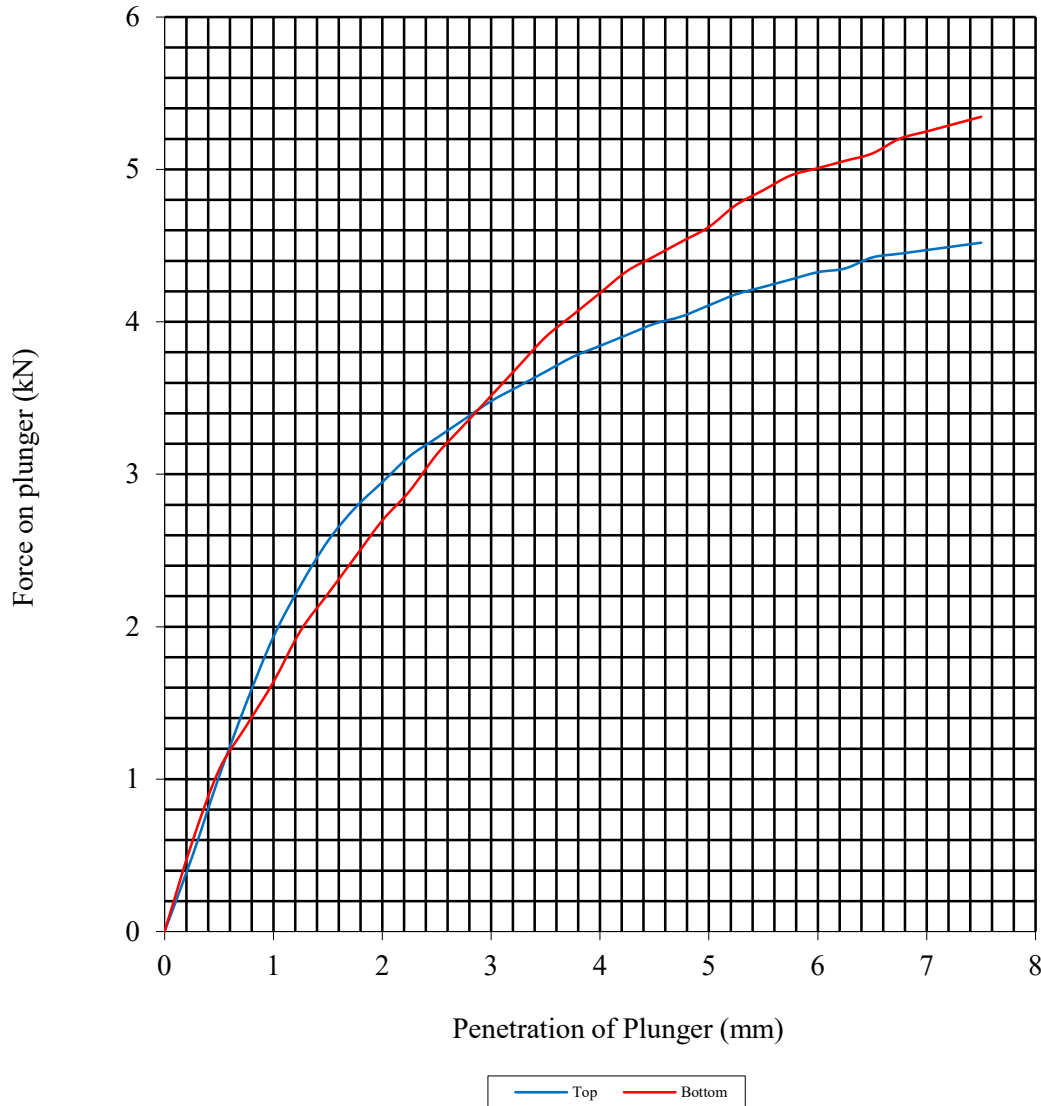
Hole Number: TP19-21

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	22	Surcharge Kg:	4.20	Sample Top	22	Sample Top	24.5
Bulk Density Mg/m ³ :	1.68	Soaking Time hrs	0	Sample Bottom	22	Sample Bottom	23.7
Dry Density Mg/m ³ :	1.38	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	0						
Compaction Conditions	2.5kg						



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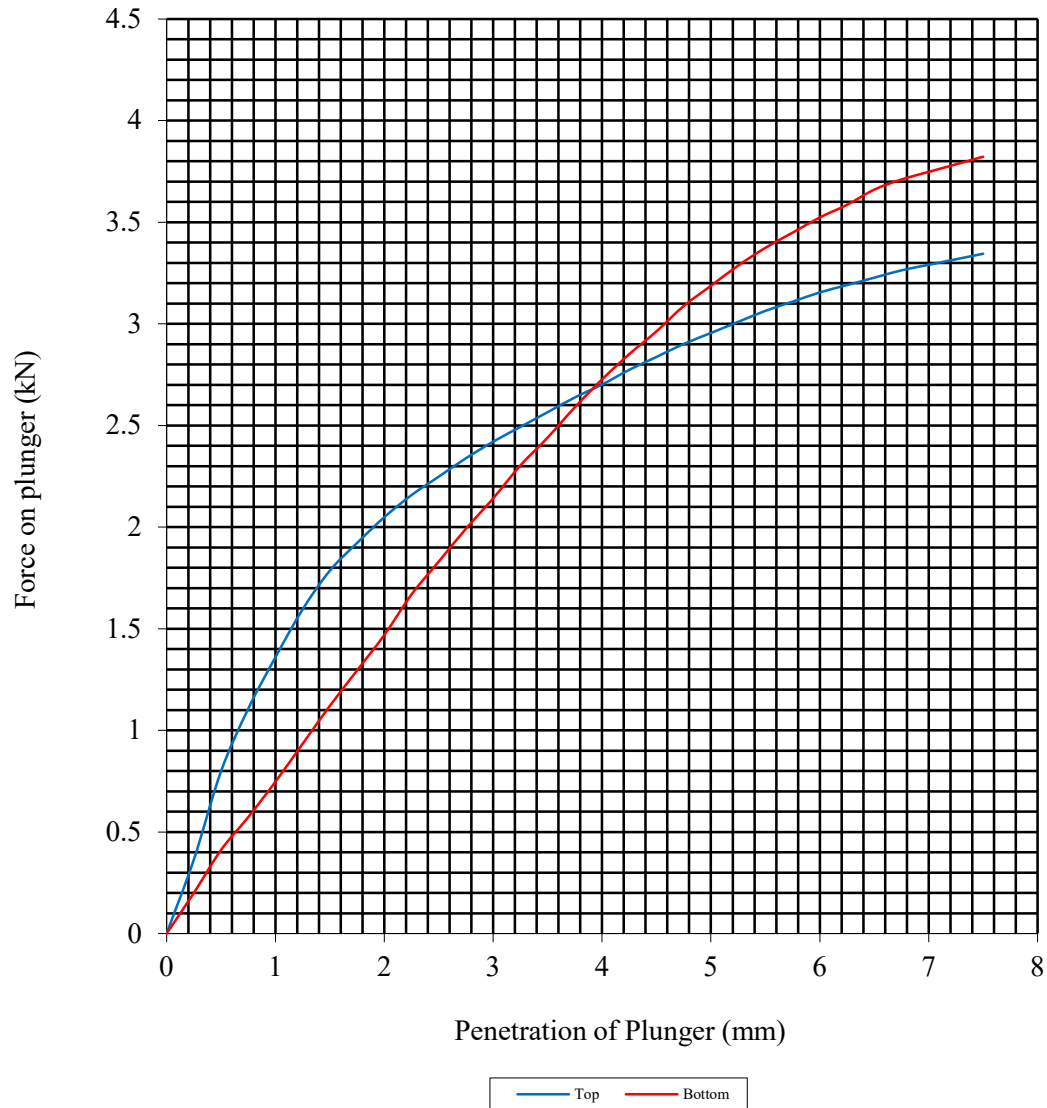
Hole Number: TP19-21

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	25	Surcharge Kg:	4.20	Sample Top	25	Sample Top	17.0
Bulk Density Mg/m ³ :	1.76	Soaking Time hrs	0	Sample Bottom	25	Sample Bottom	15.9
Dry Density Mg/m ³ :	1.40	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:			0				
Compaction Conditions		2.5kg					



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

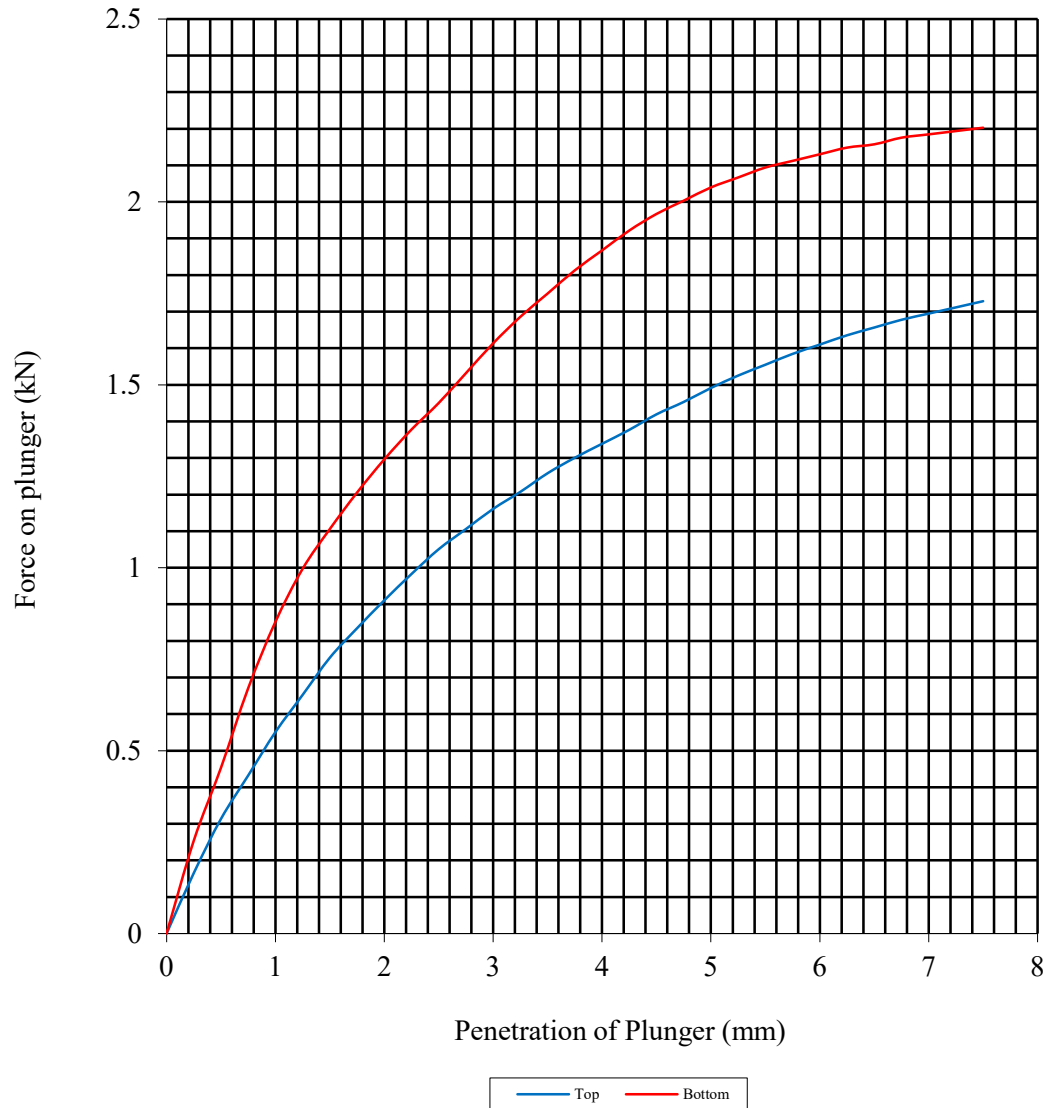
Hole Number: TP19-21

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	28	Surcharge Kg:	4.20	Sample Top	28	Sample Top	8.0
Bulk Density Mg/m ³ :	1.80	Soaking Time hrs	0	Sample Bottom	28	Sample Bottom	11.0
Dry Density Mg/m ³ :	1.41	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:		0					
Compaction Conditions		2.5kg					



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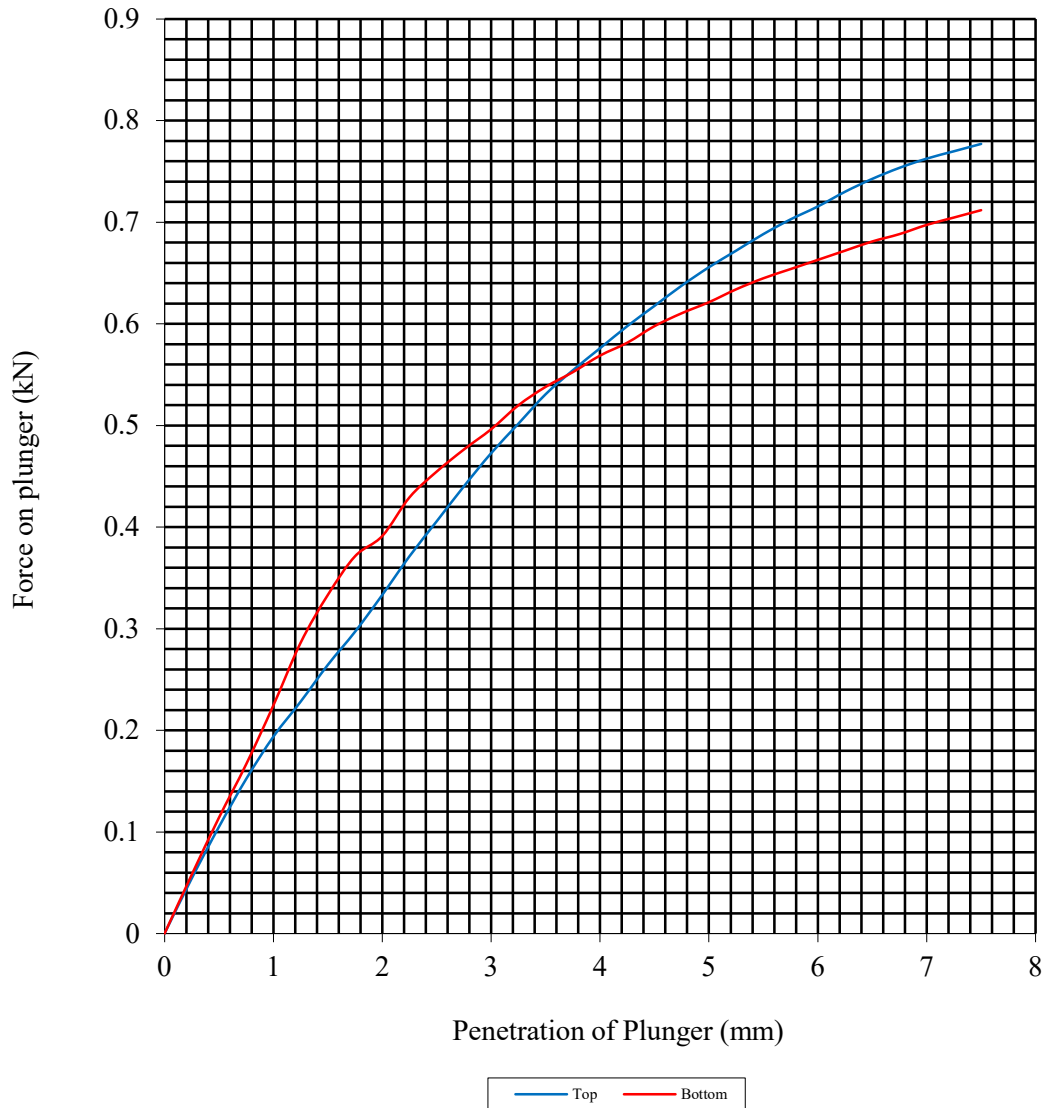
Hole Number: TP19-21

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	31	Surcharge Kg:	4.20	Sample Top	31	Sample Top	3.3
Bulk Density Mg/m ³ :	1.84	Soaking Time hrs	0	Sample Bottom	31	Sample Bottom	3.4
Dry Density Mg/m ³ :	1.40	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:		0					
Compaction Conditions		2.5kg					



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CALIFORNIA BEARING RATIO TEST

BS 1377 : Part 4 : 1990

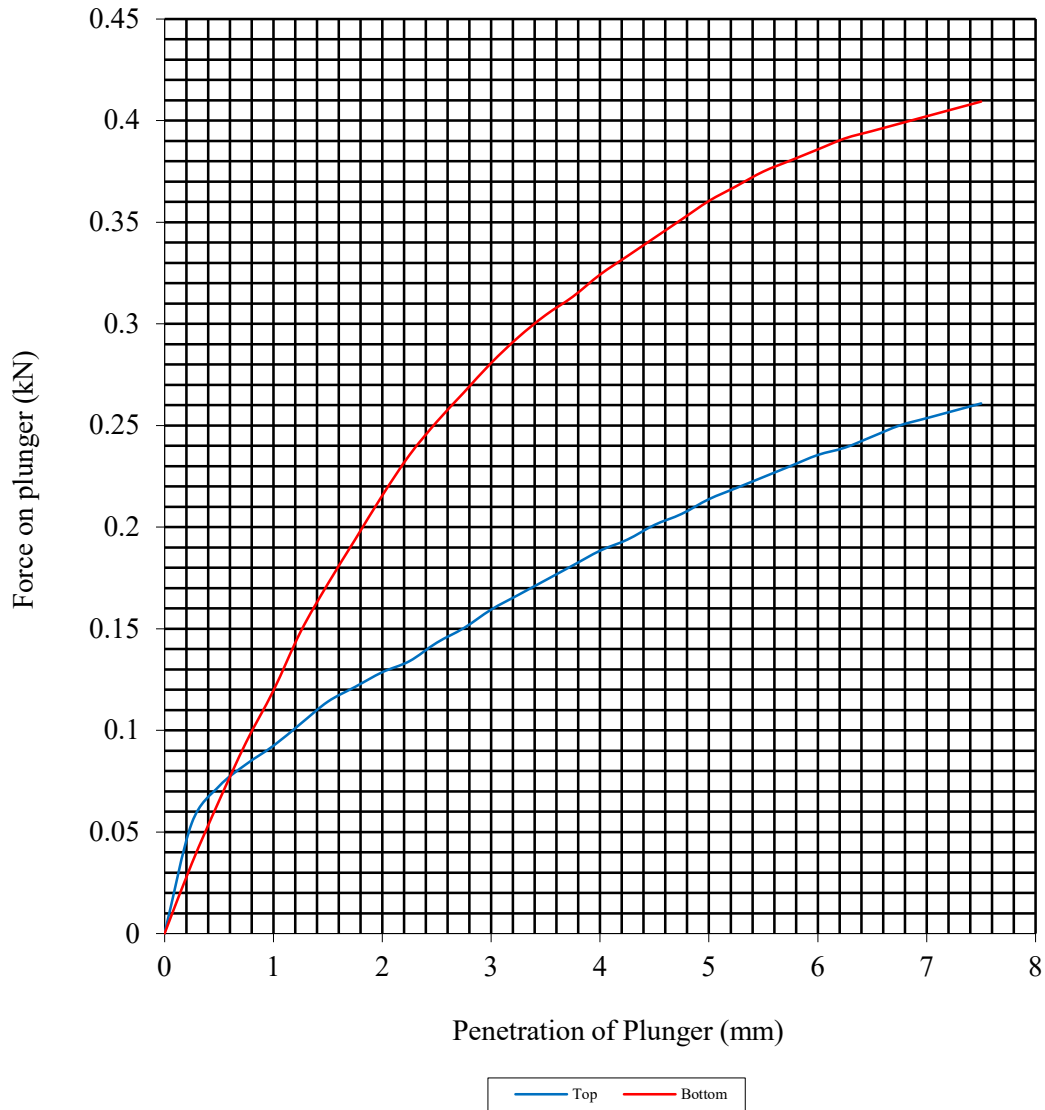
Hole Number: TP19-21

Top Depth (m):

Sample Number:

Base Depth (m):

Sample Type:



Initial Sample Conditions		Sample Preparation		Final Moisture Content %		C.B.R. Value %	
Moisture Content:	34	Surcharge Kg:	4.20	Sample Top	34	Sample Top	1.1
Bulk Density Mg/m ³ :	1.82	Soaking Time hrs	0	Sample Bottom	34	Sample Bottom	1.9
Dry Density Mg/m ³ :	1.36	Swelling mm:	0.00	Remarks : See Summary of Soil Descriptions.			
Percentage retained on 20mm BS test sieve:	0						
Compaction Conditions	2.5kg						



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MOISTURE CONDITION VALUE

BS1377 : Part 4 : 1990 Clause 5.4

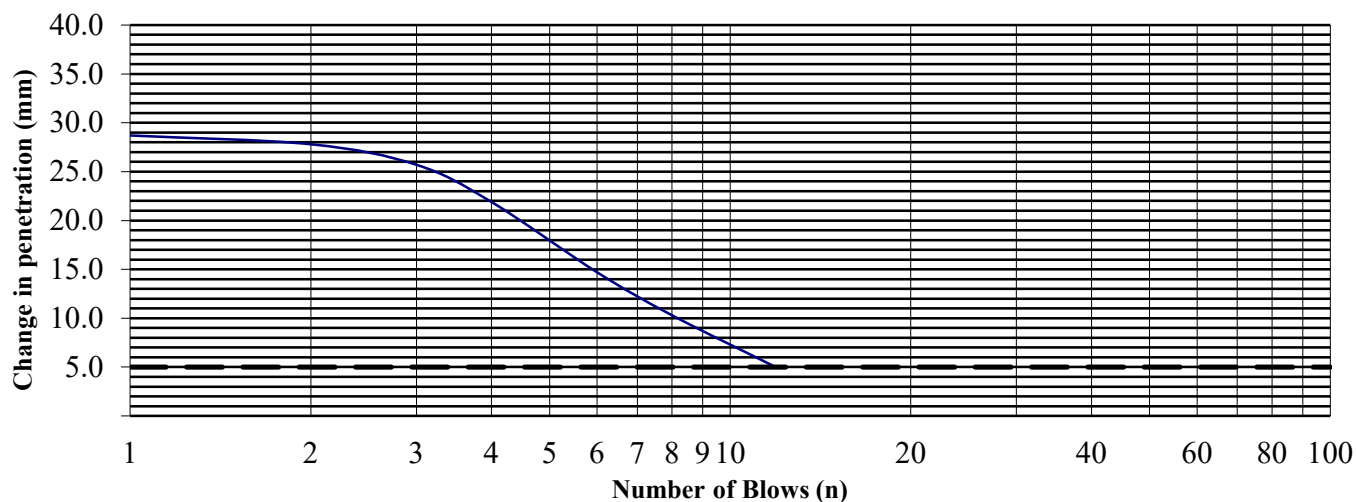
Hole Number: TP19-21 Top Depth (m):

Sample Number: Base Depth (m):

Sample Type:

Material Retained on the 20mm BS Test Sieve (%):	0
Interpretation based on steepest straight line intercept with 5mm change in penetration.	

MCV Determination



Blows (N)	Penetration (mm)	n to 4n (mm)
1	122.8	28.7
2	108.5	27.8
3	100.6	25.7
4	94.1	21.9
6	85.4	14.7
8	80.7	10.3
12	74.9	4.9
16	72.2	
24	70.7	
32	70.4	
48	70.0	
64		
96		
128		
192		
256		

Test Results.

Moisture Content (%)	28
MCV	10.2



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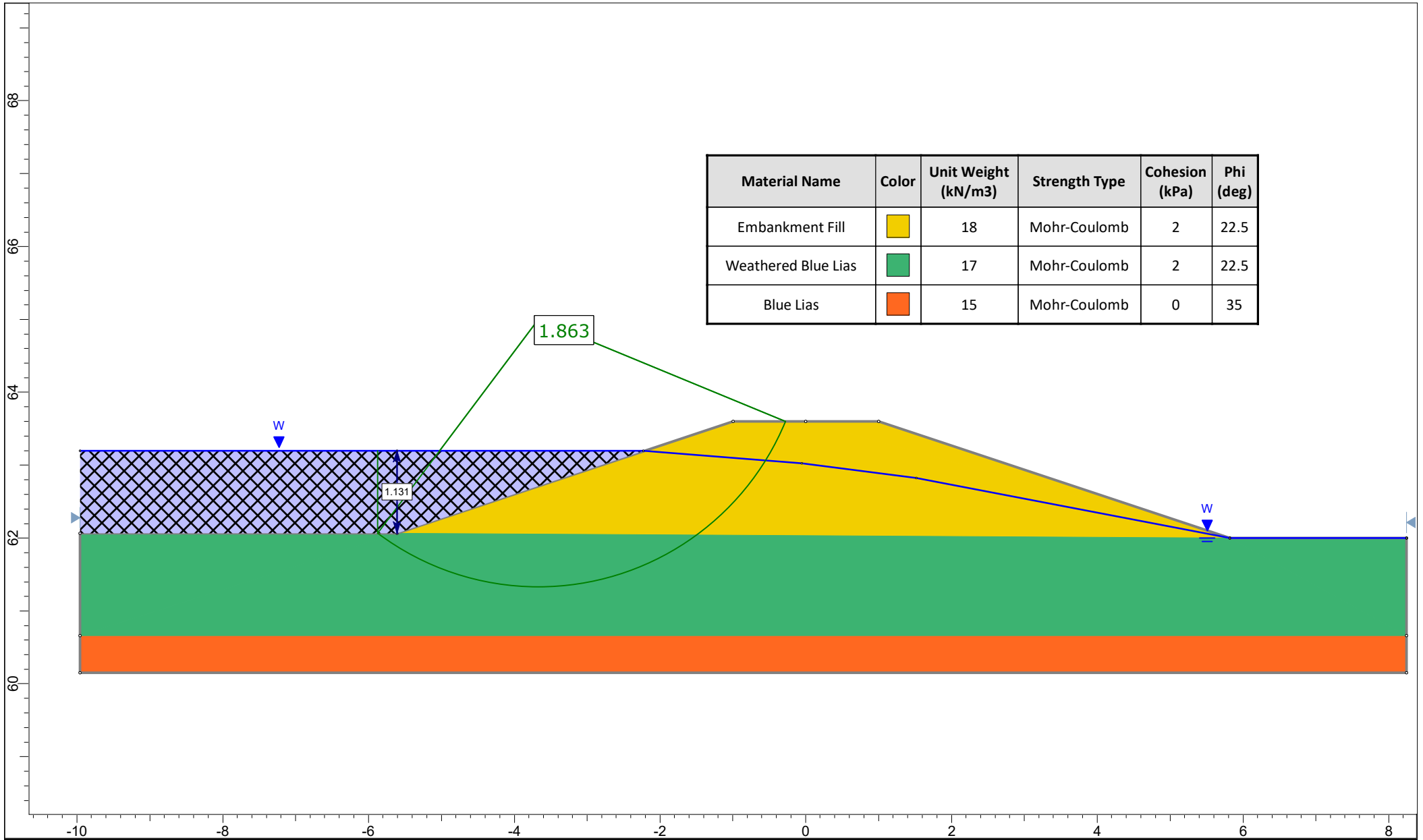
Contract No:

PSL20/5543

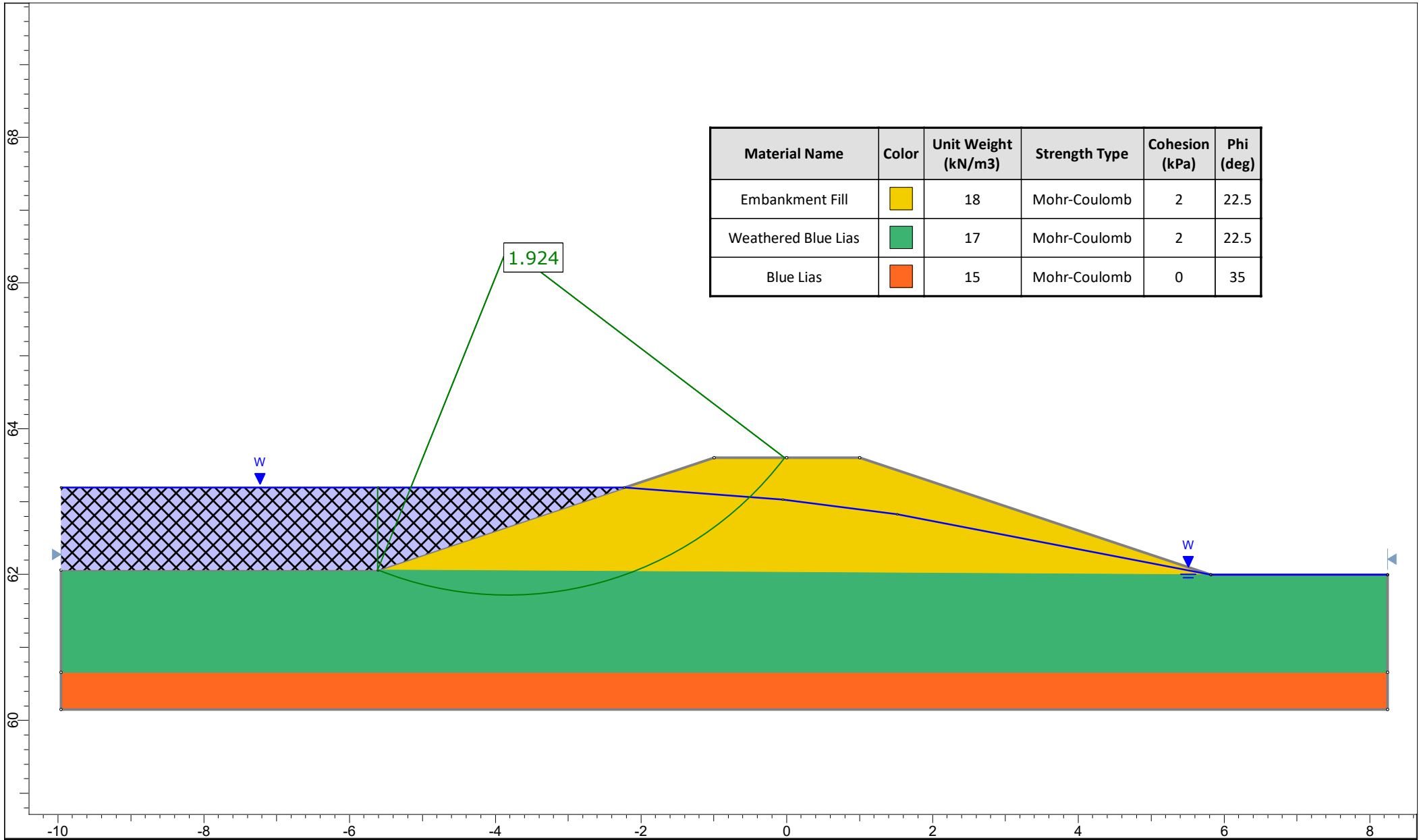
Client Ref:

Appendix C – Slope Stability Output

Bund 1, Analysis for maximum flood level

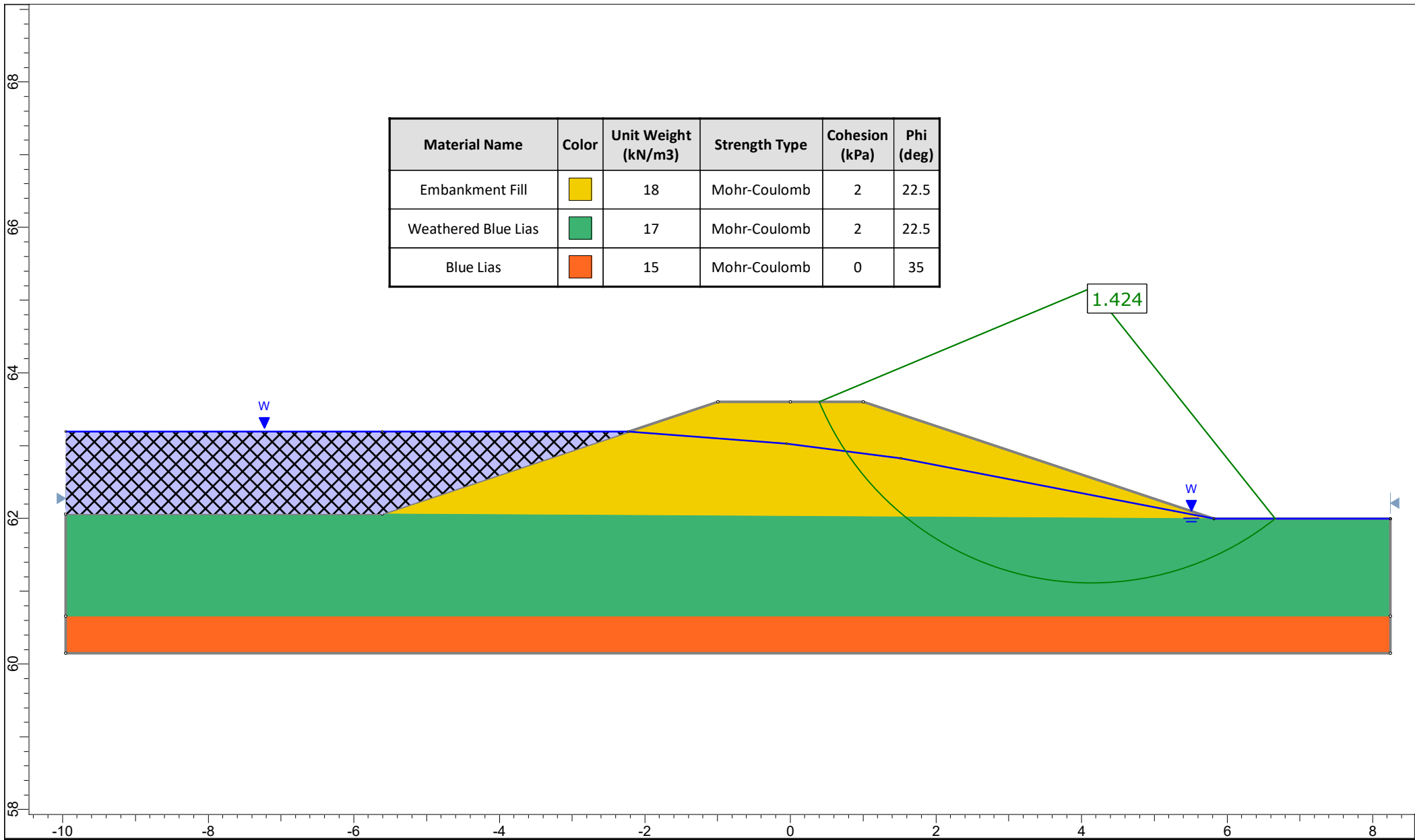


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

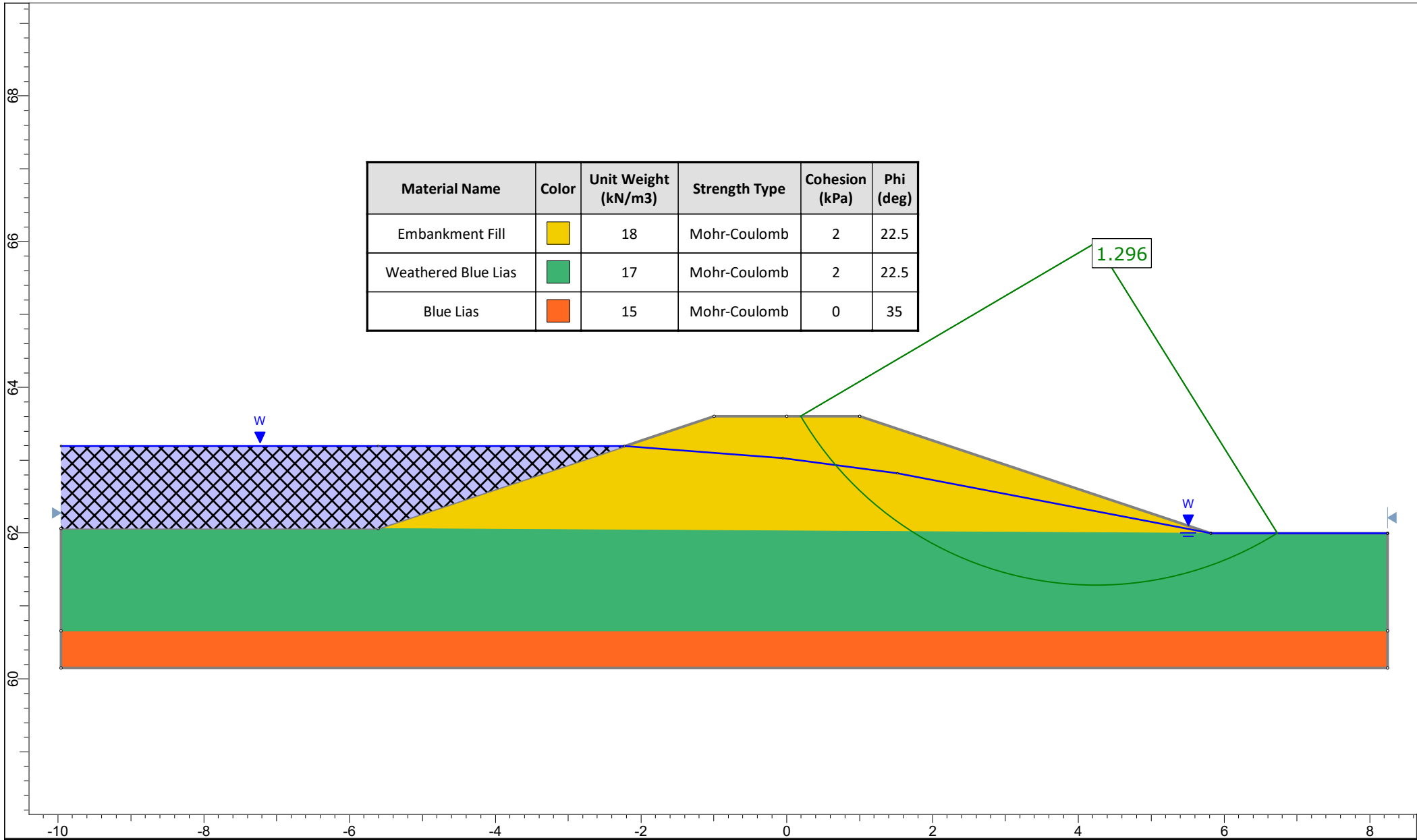


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

1.924

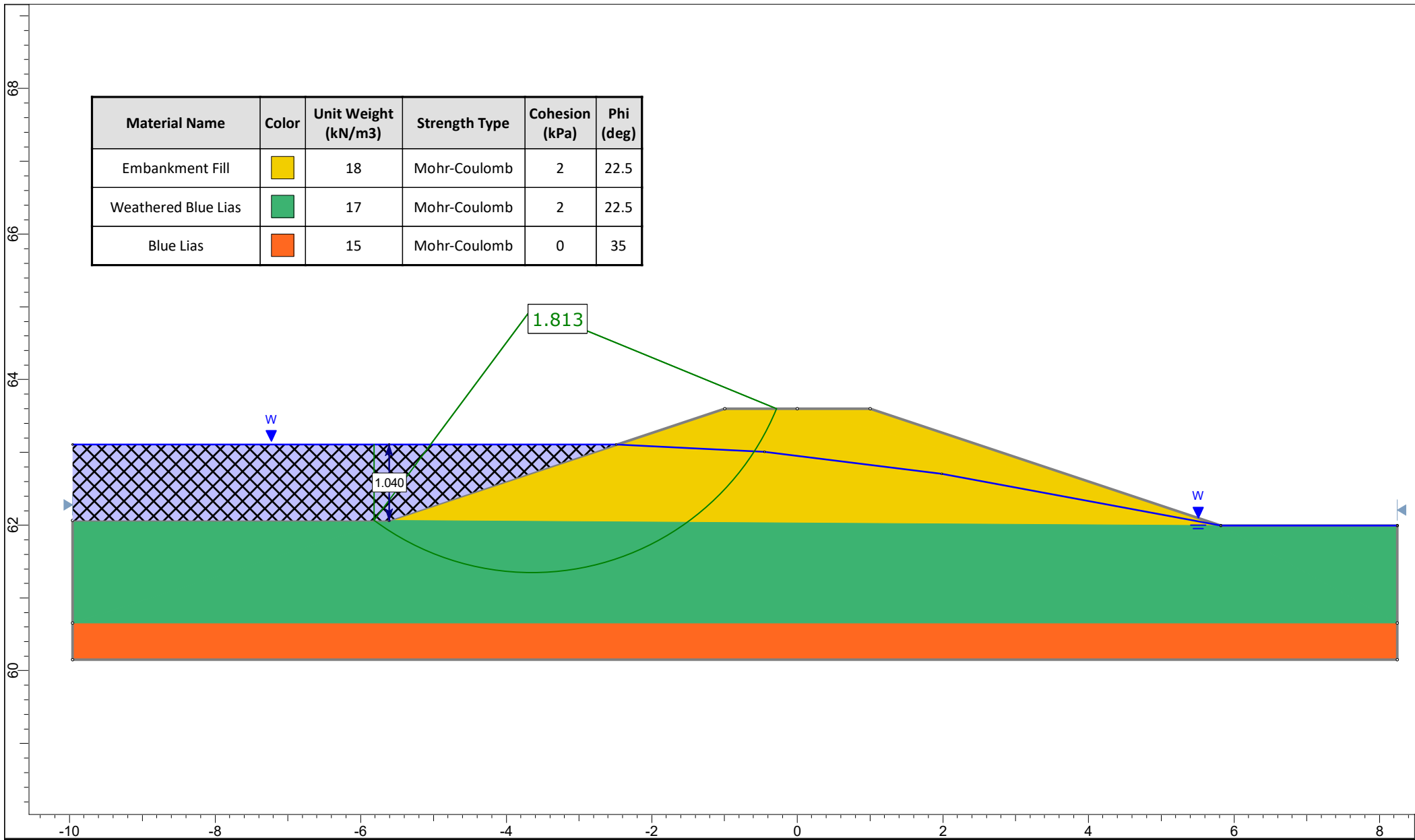


Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

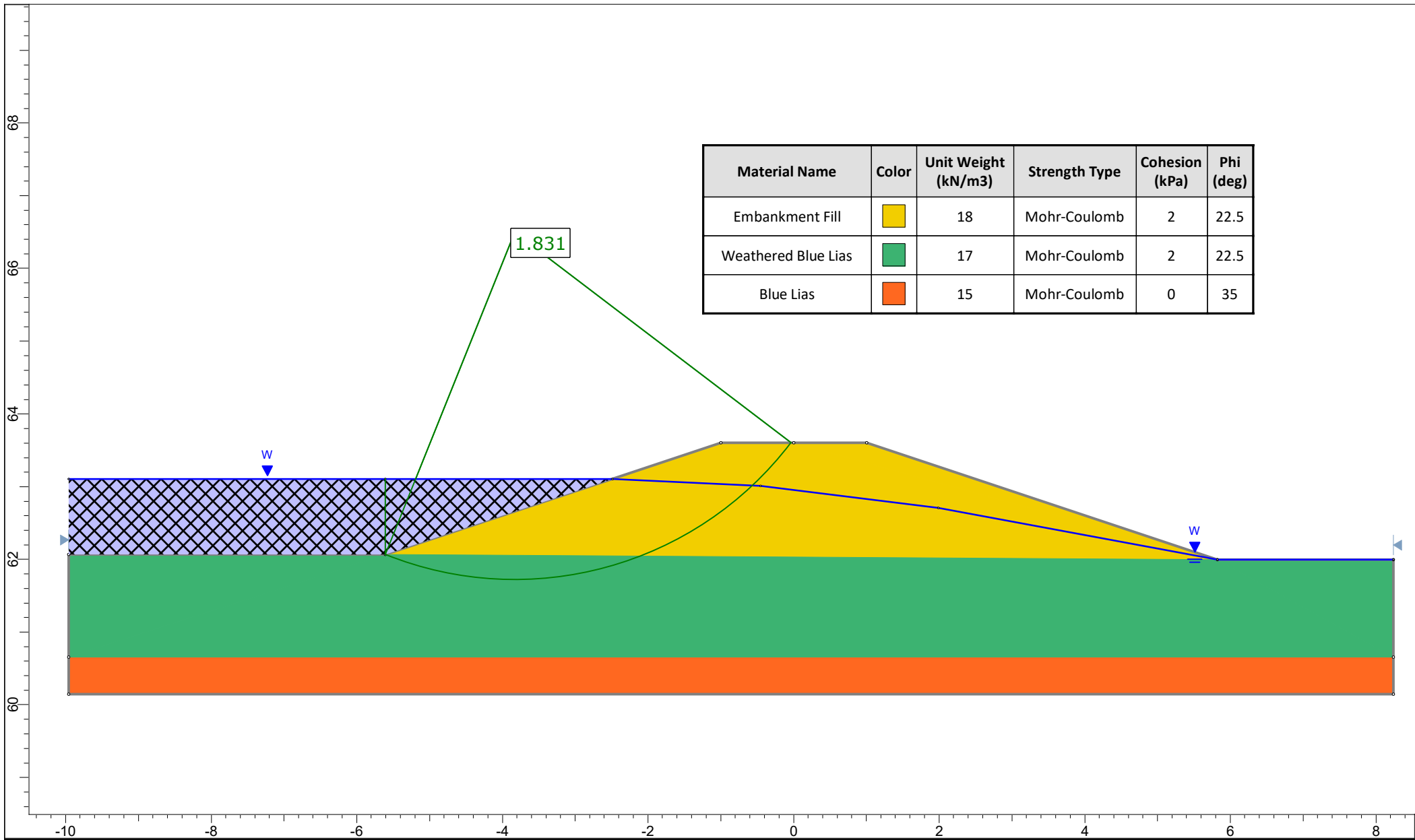


Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

Bund 2, Analysis for maximum flood level

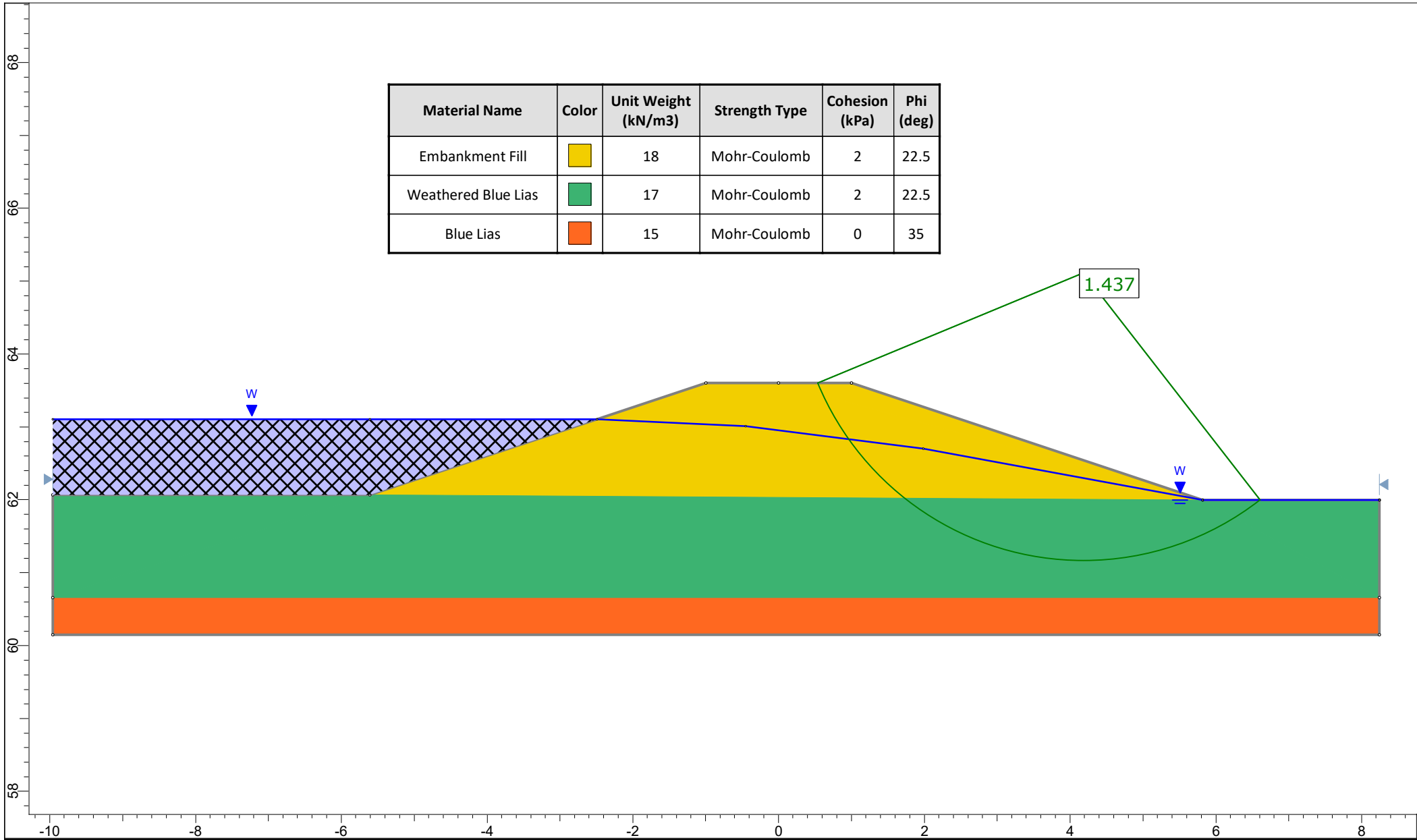


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

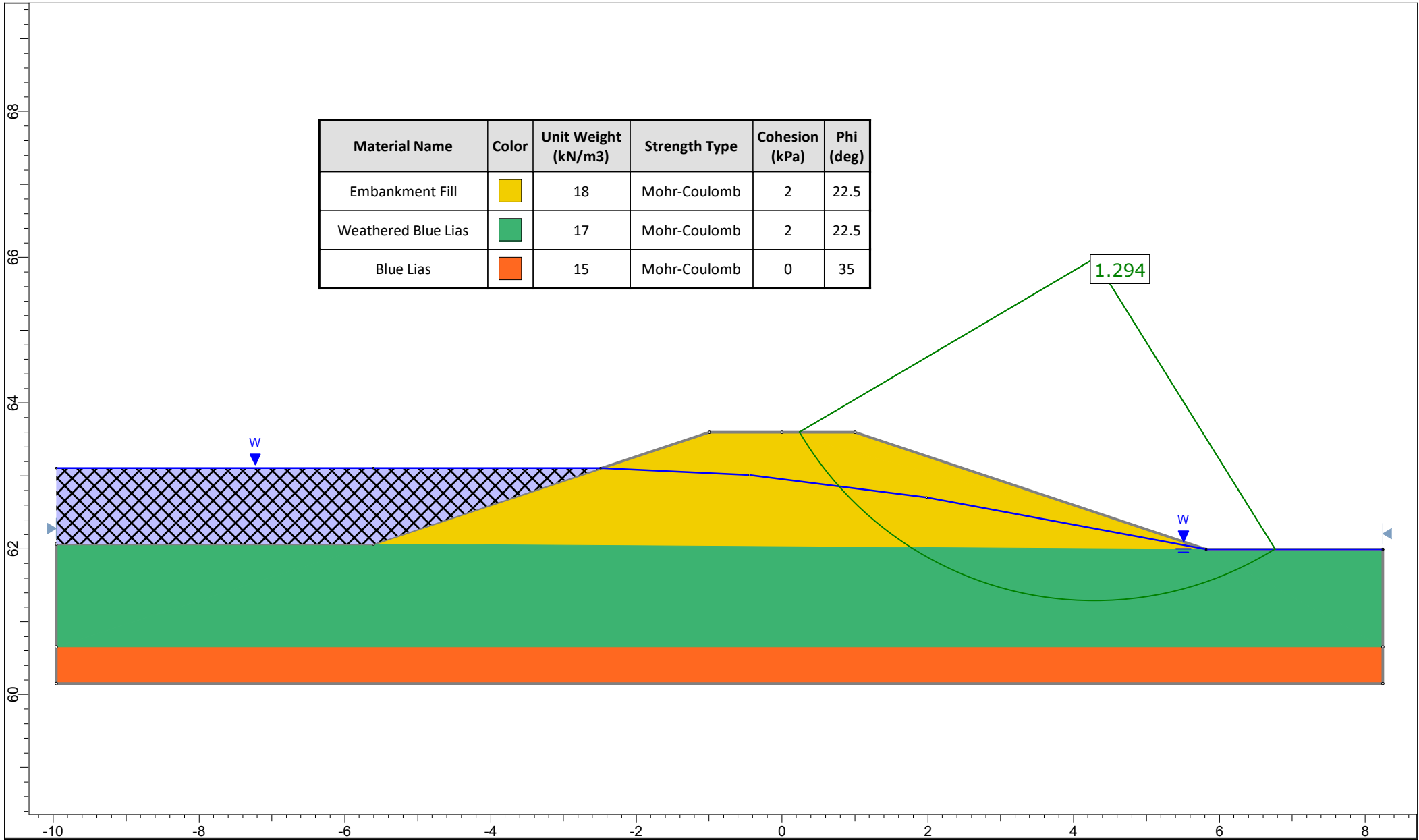


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

1.831

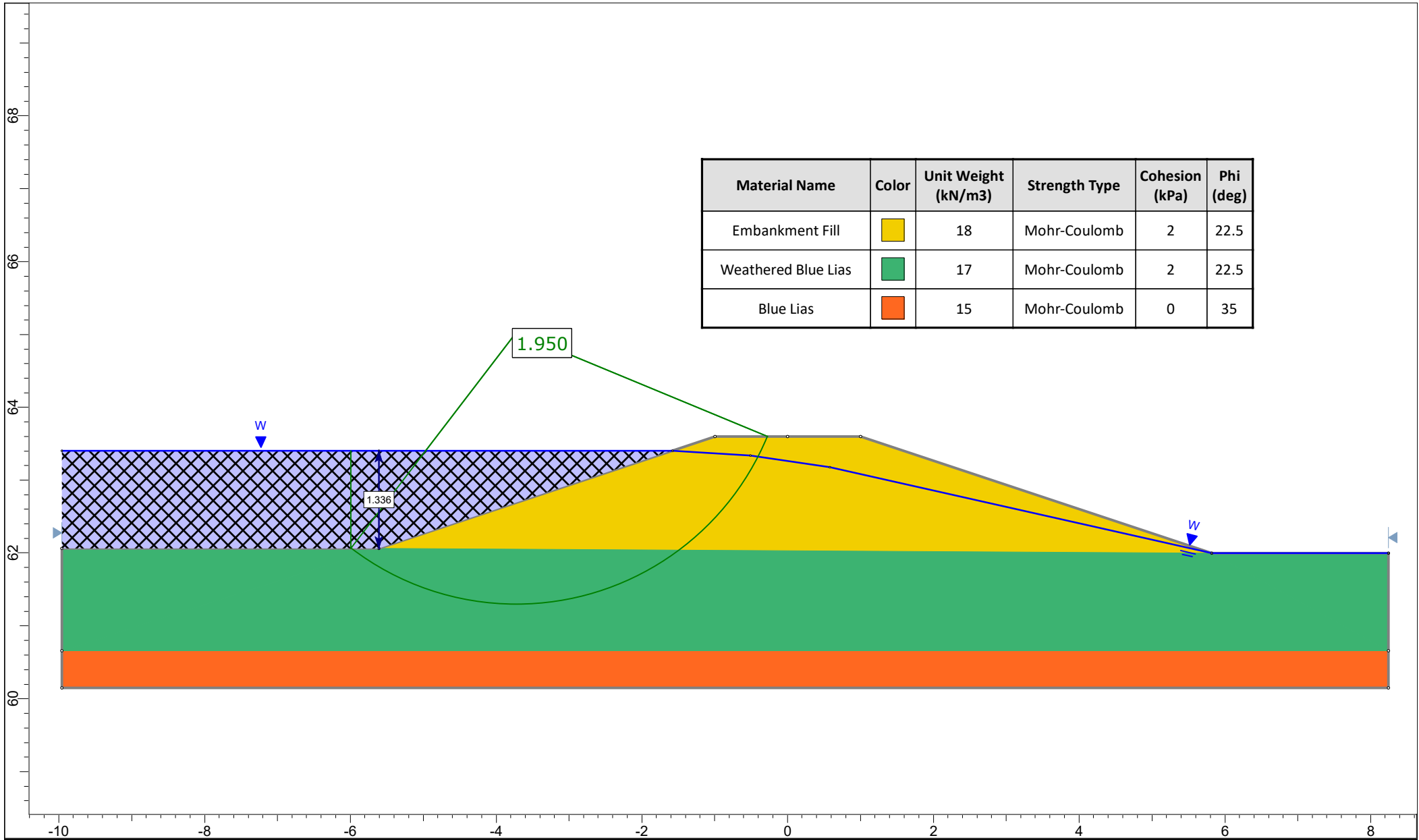


Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

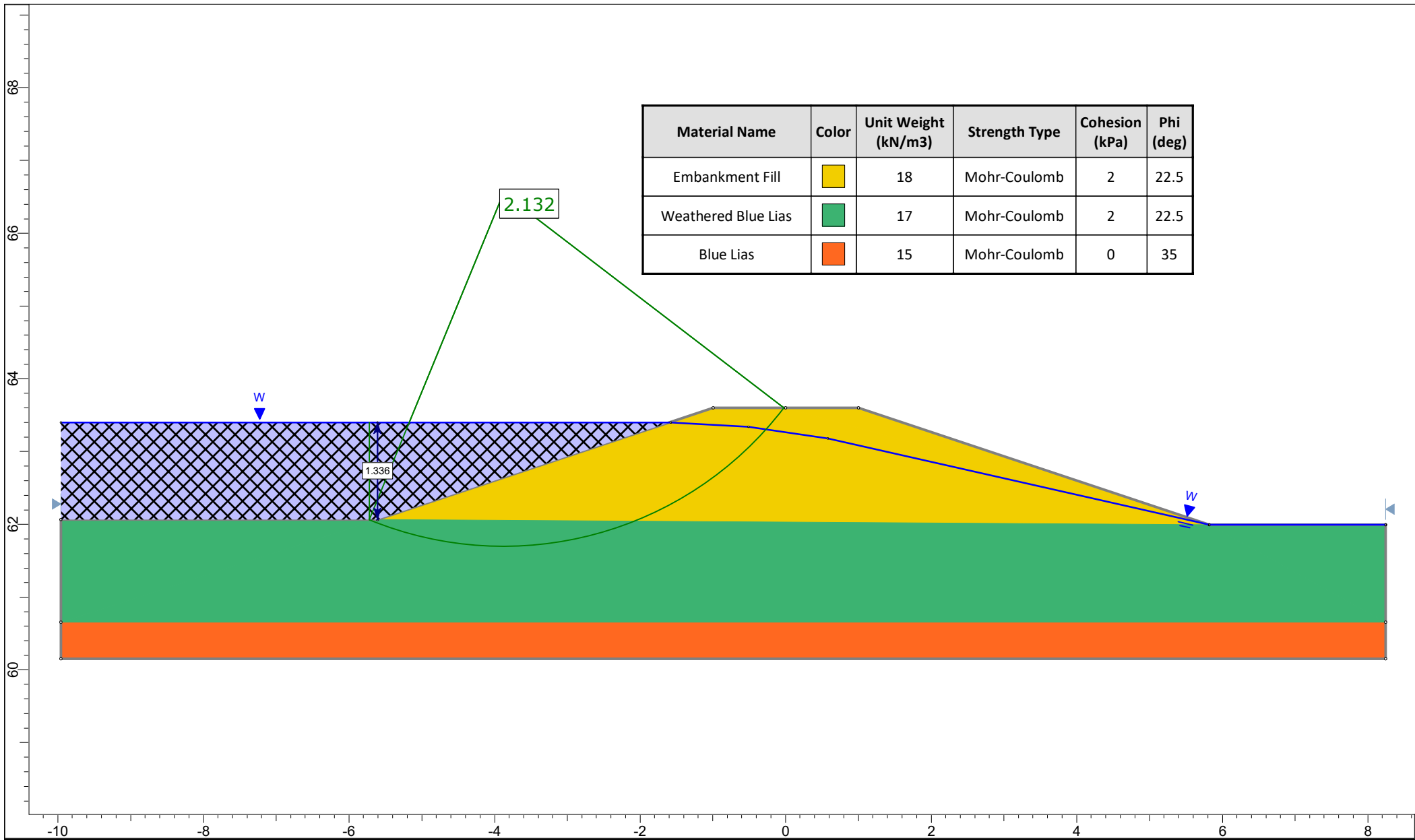


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

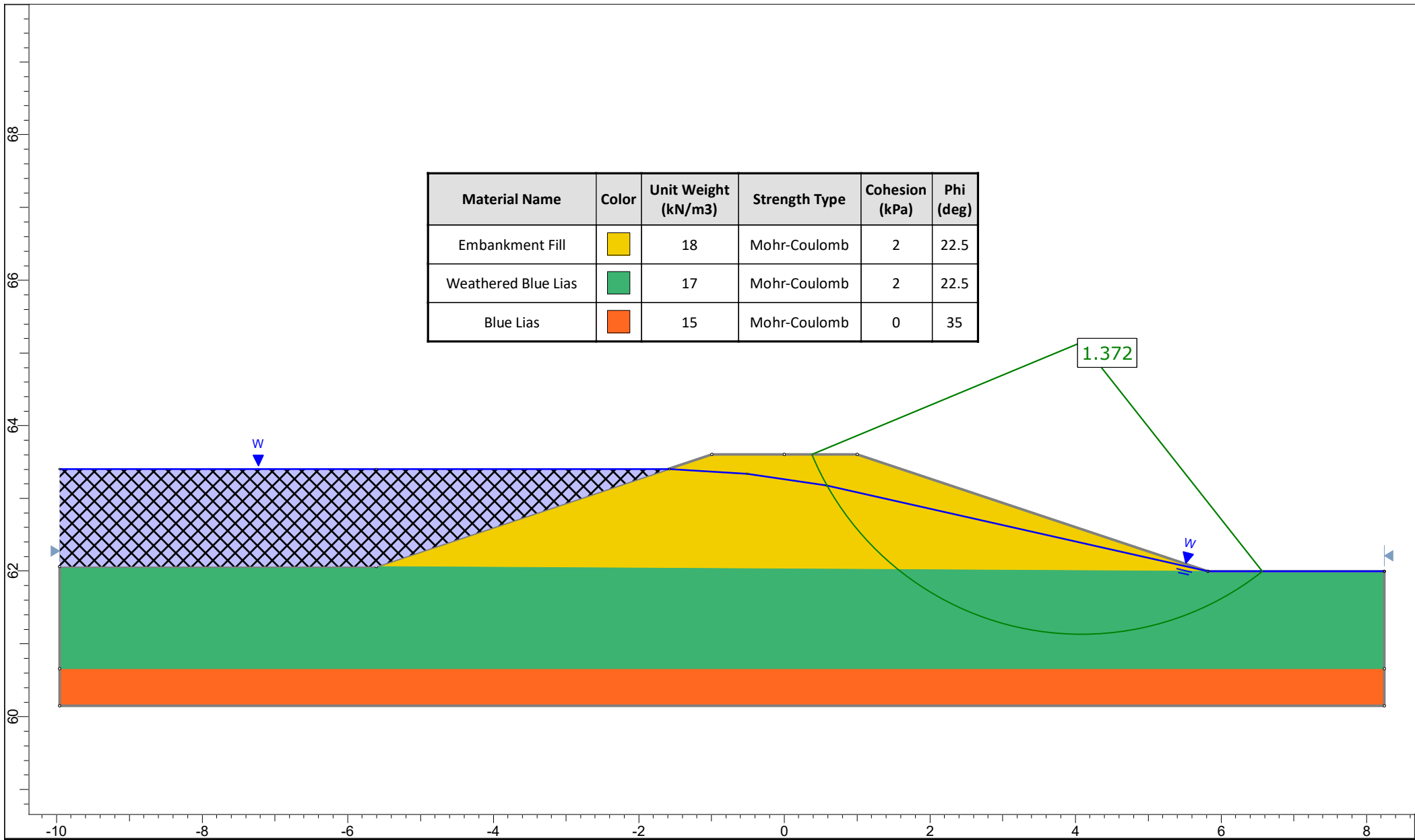
Bund 3, Analysis for maximum flood level

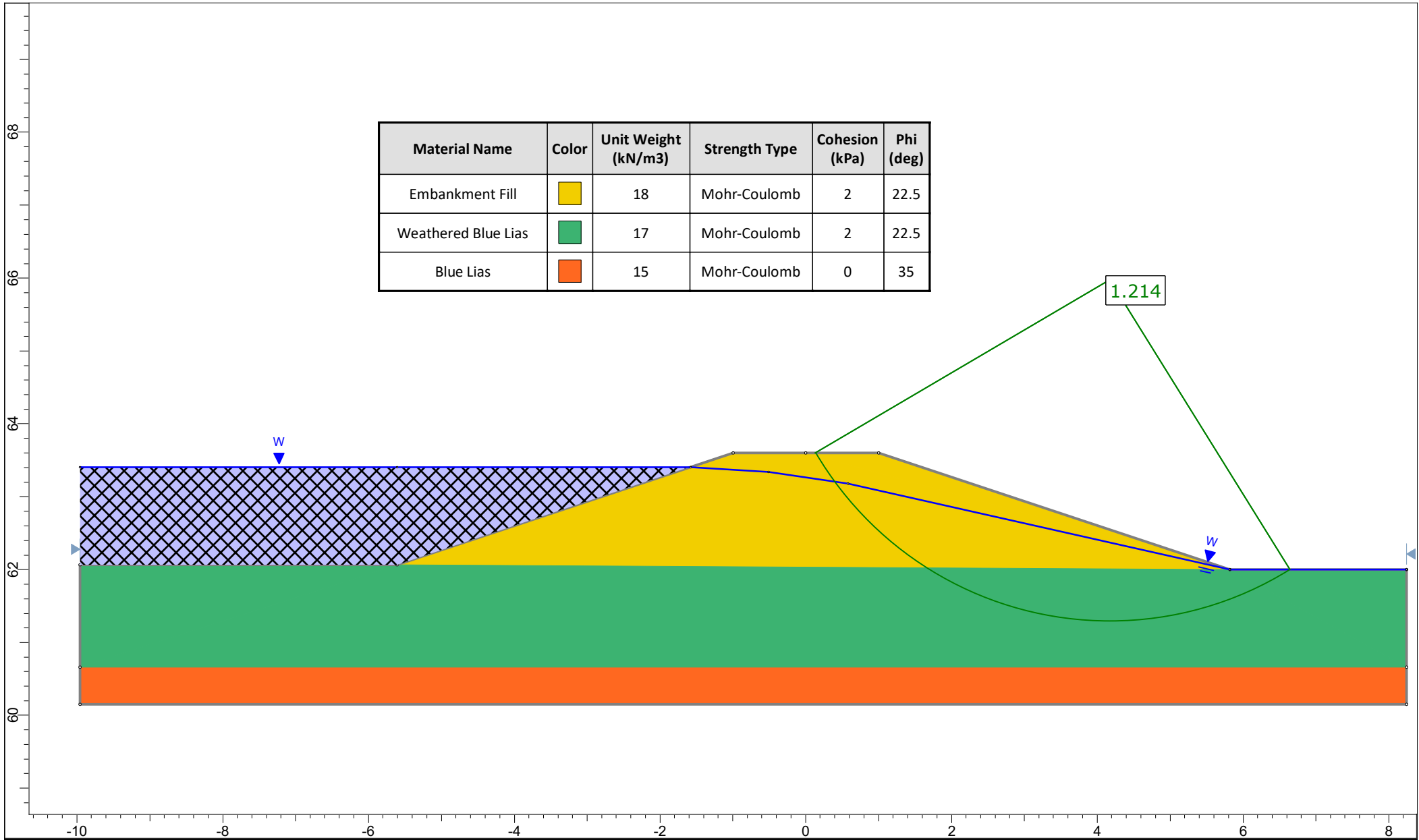


Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35



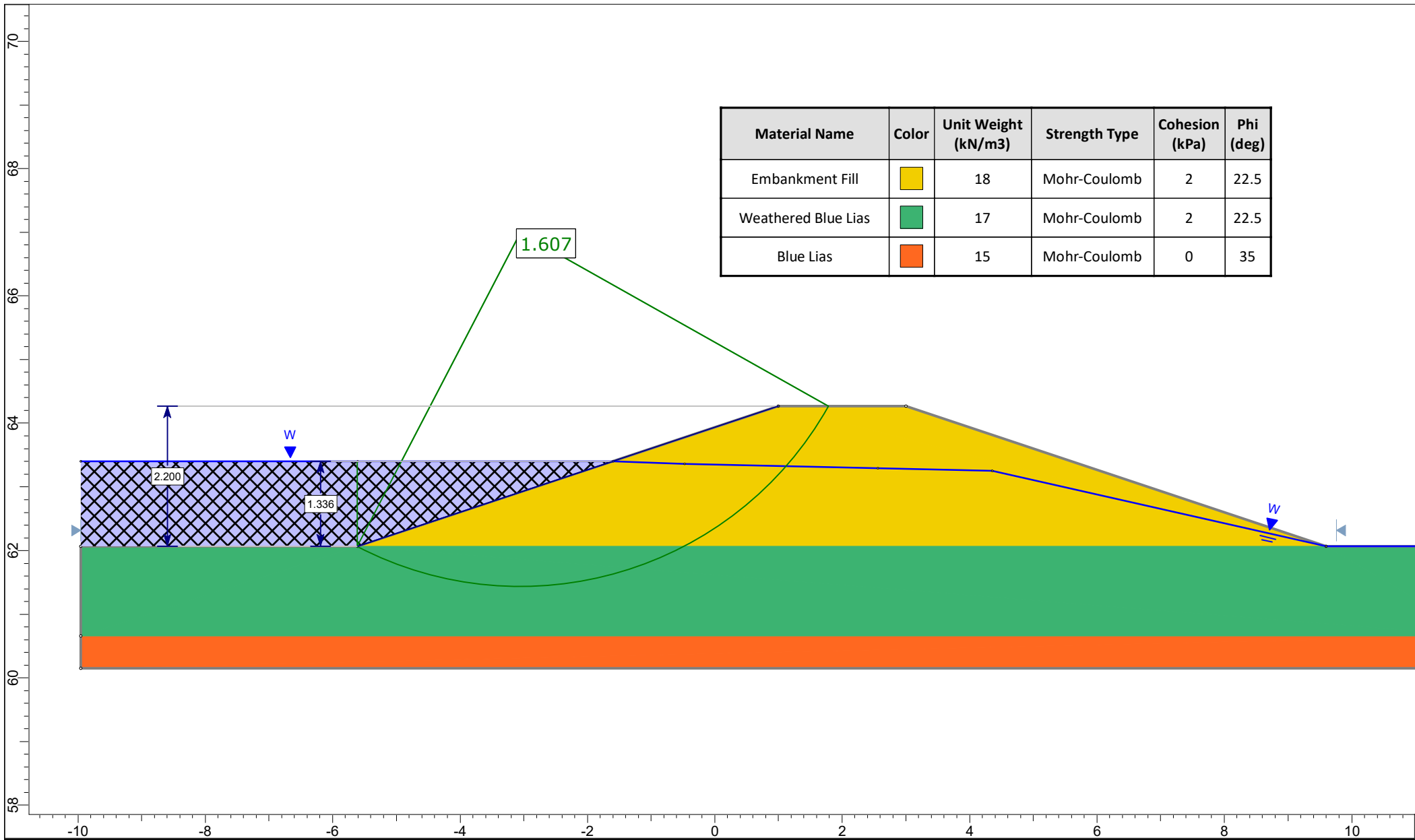
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35



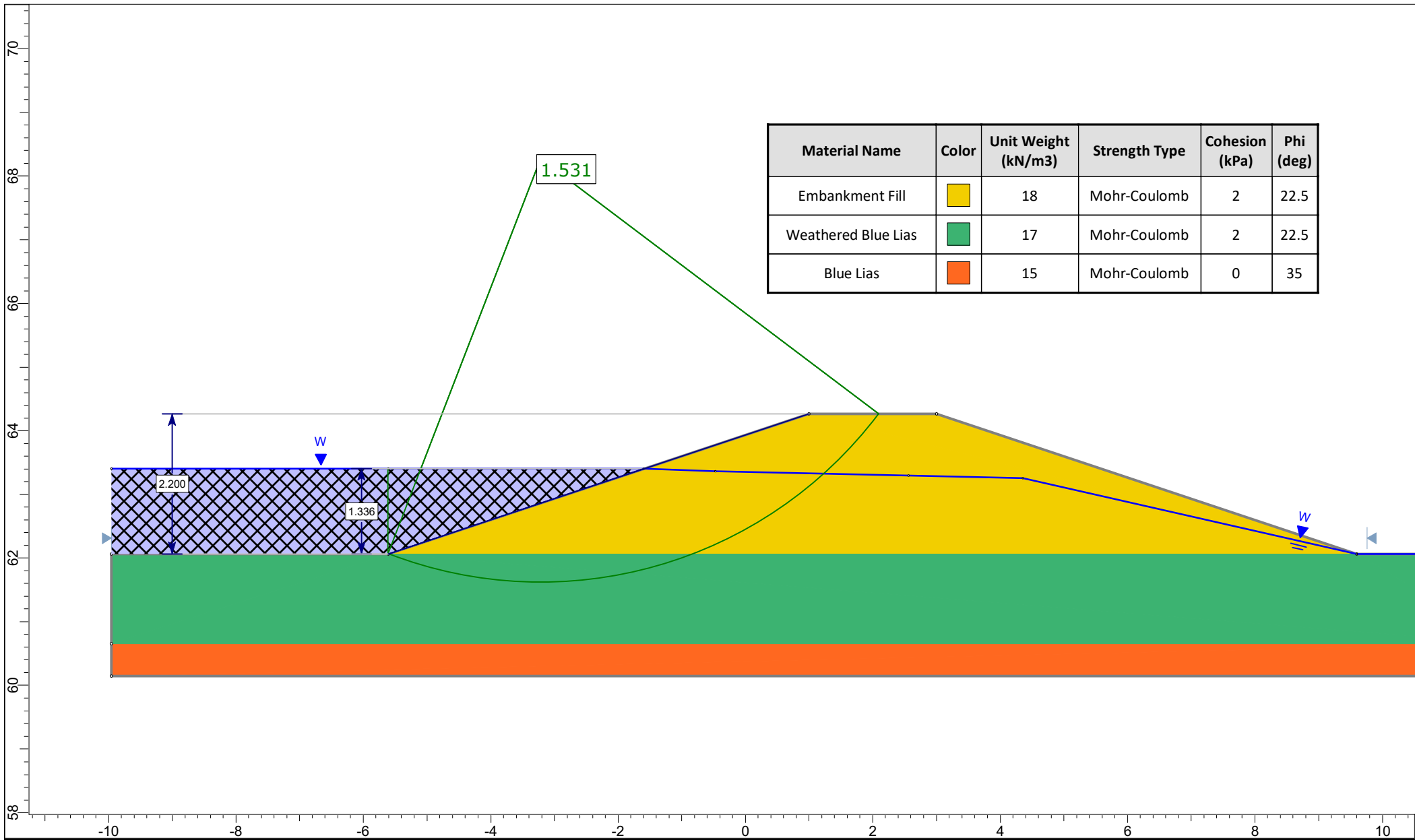


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

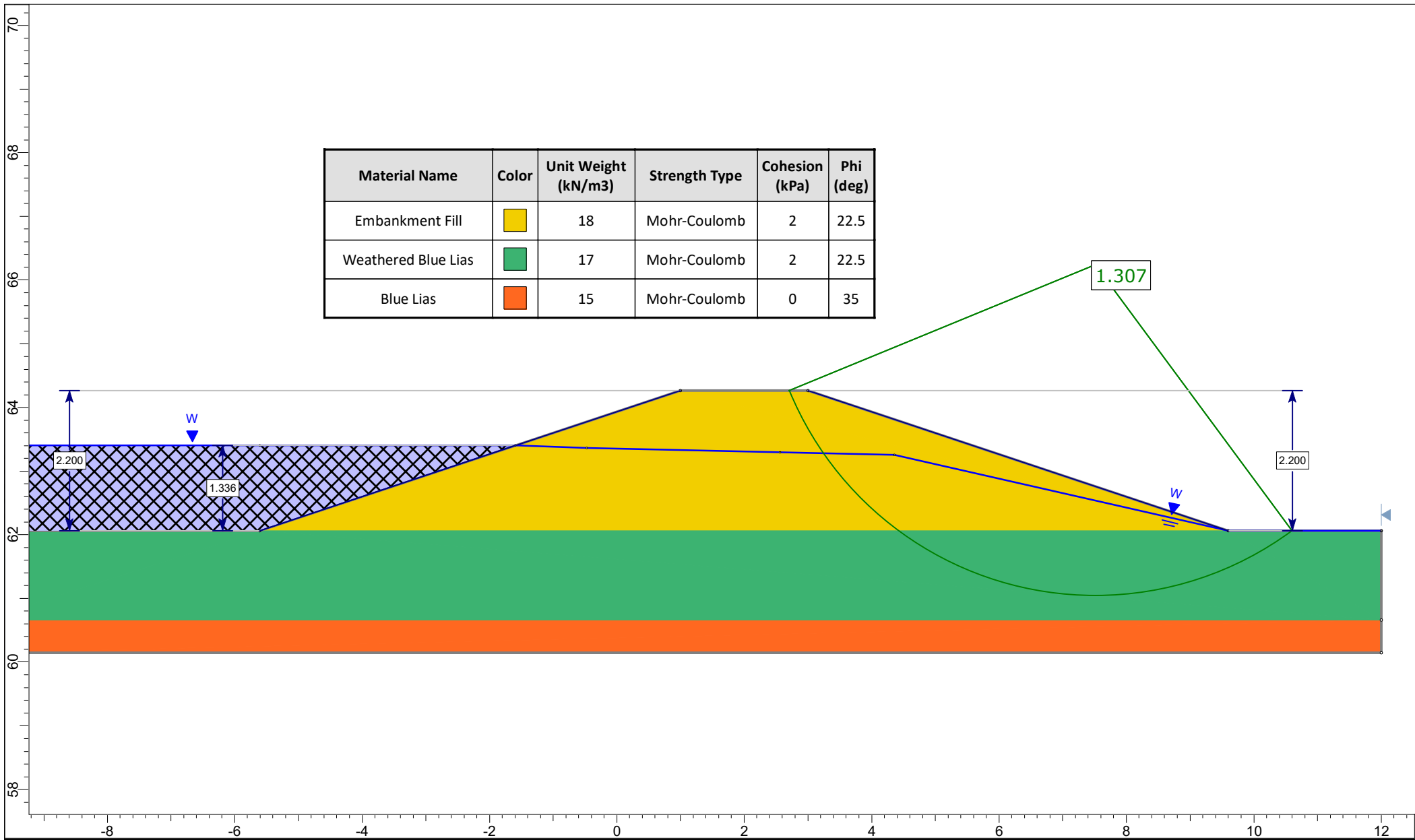
Bund 3 - 2.2m high
Analysis for maximum flood level



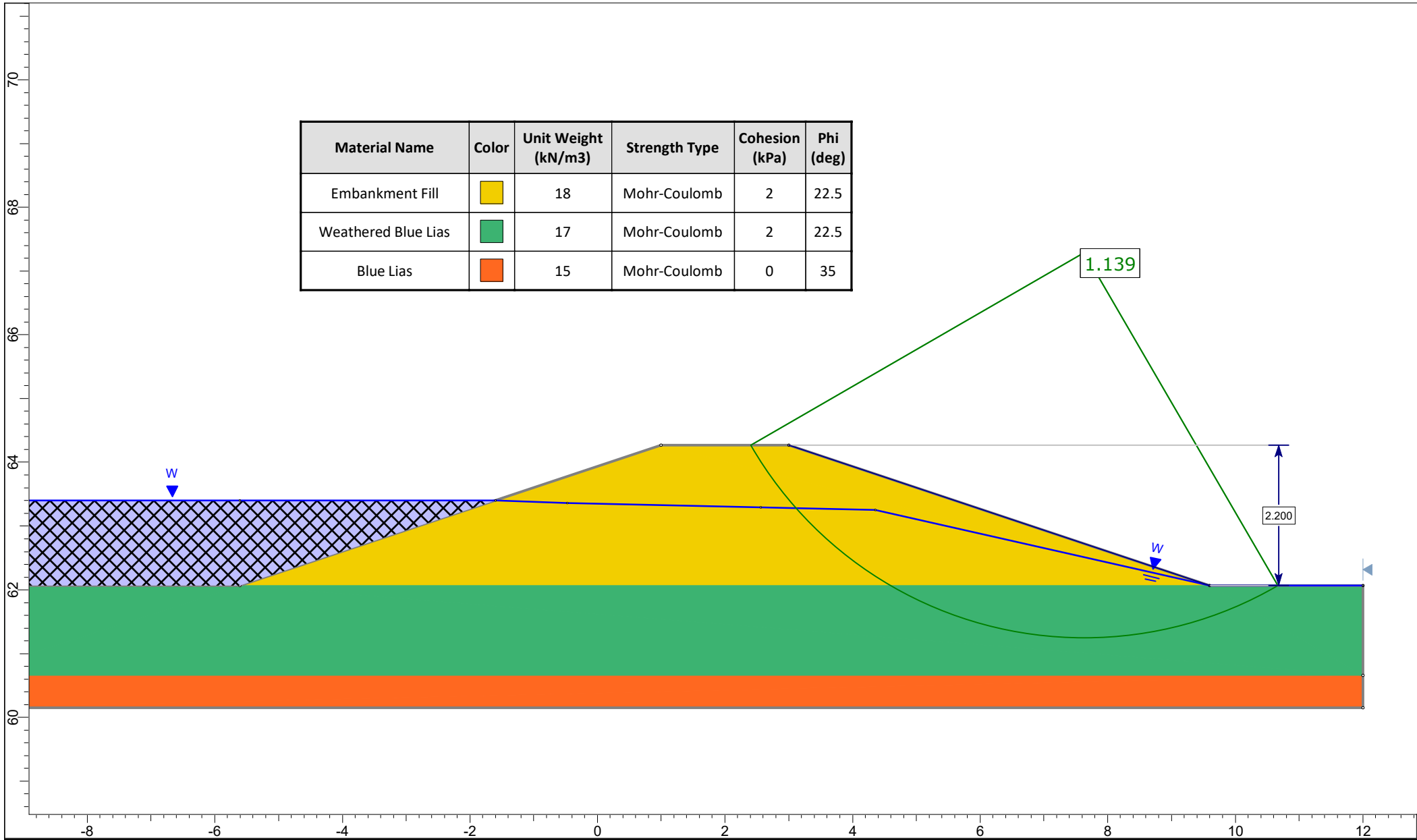
Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

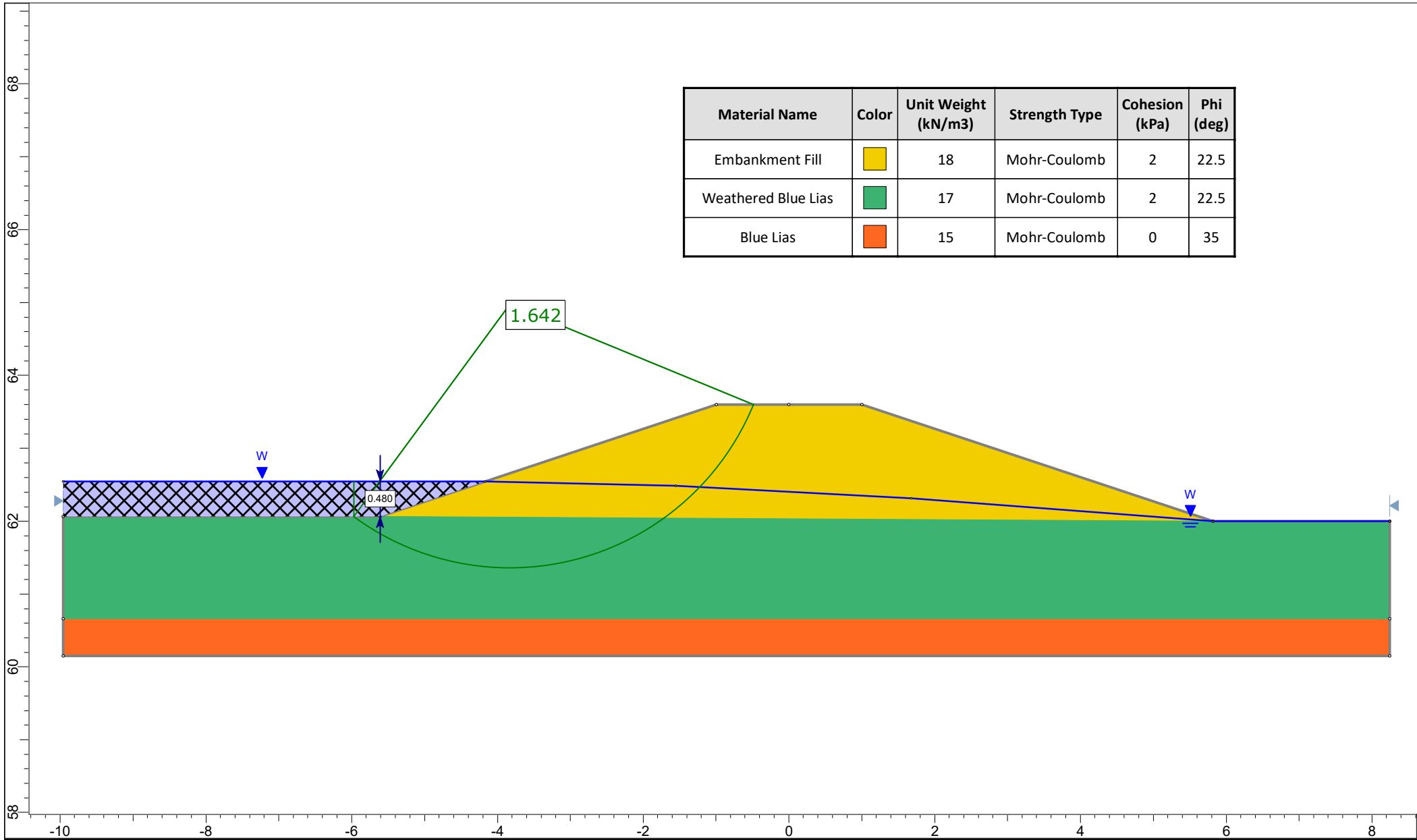


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

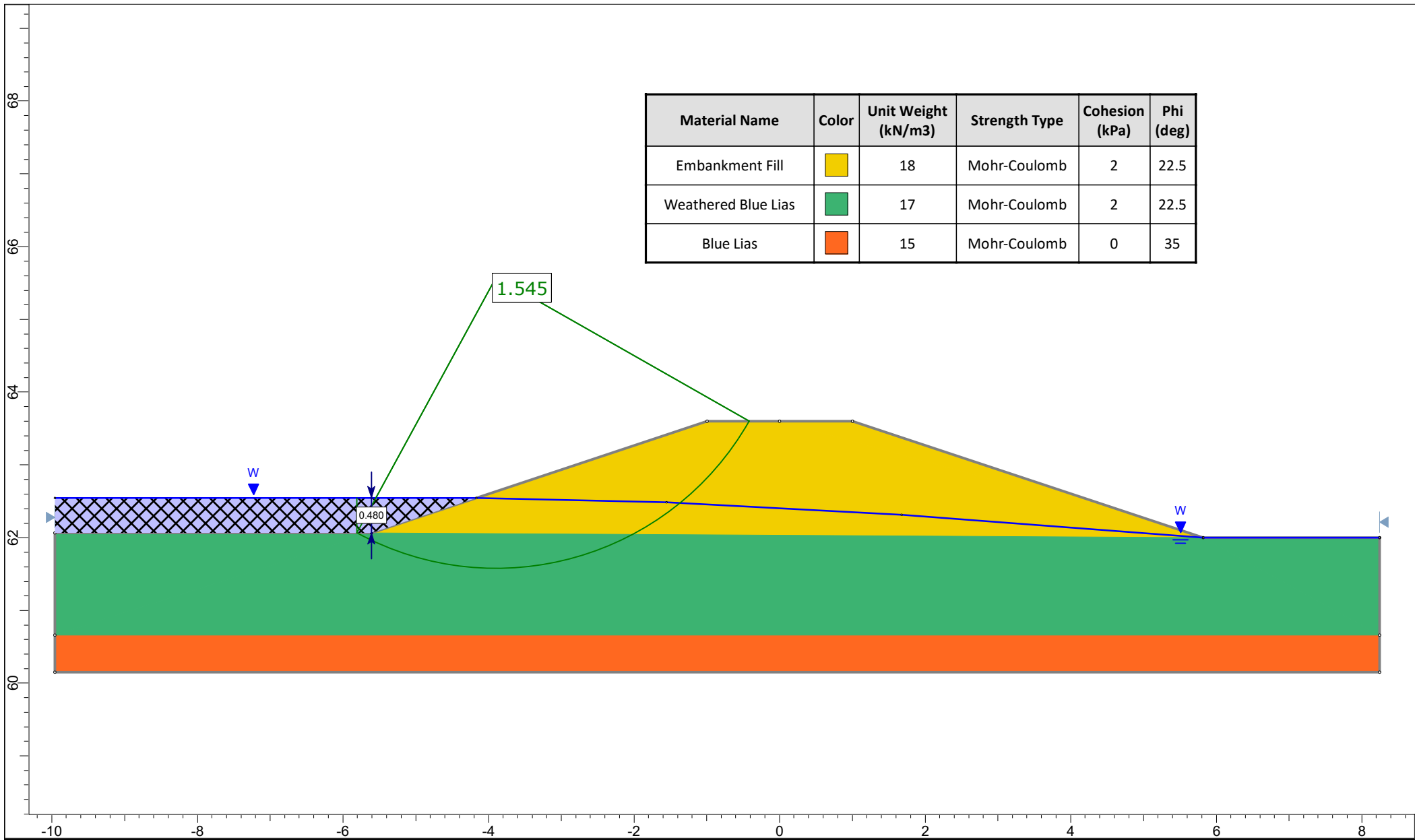


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

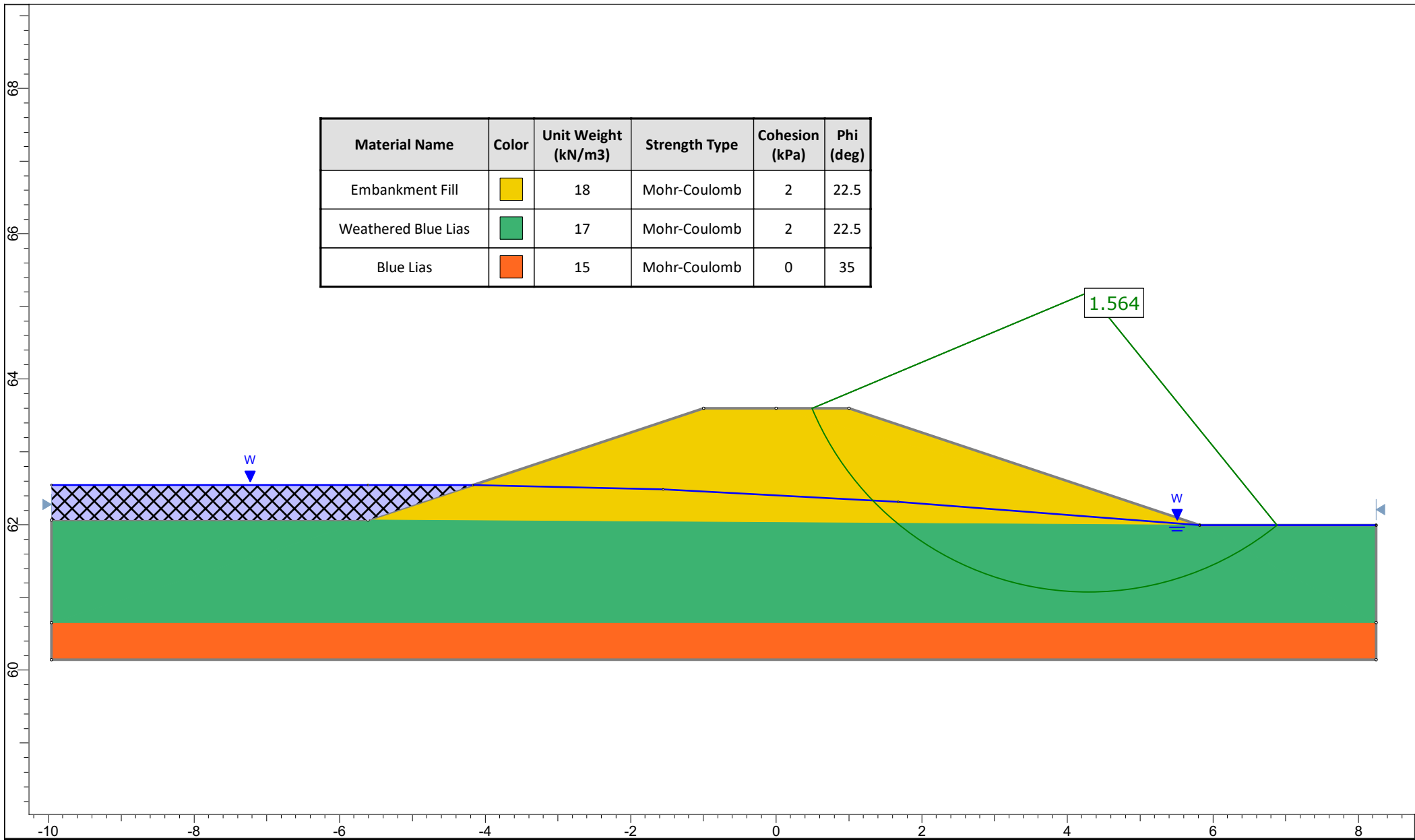
Bund 4, Analysis for maximum flood level

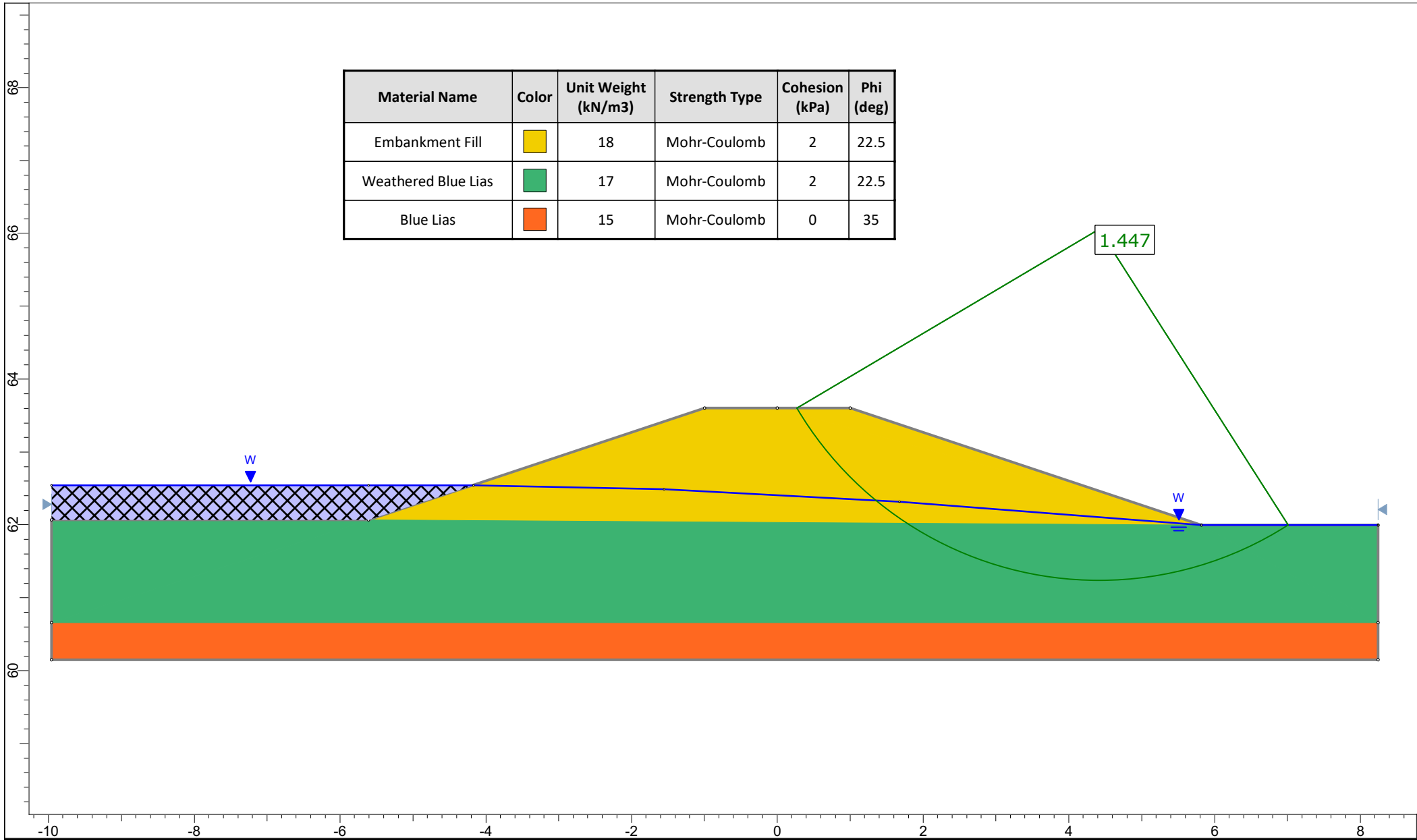


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

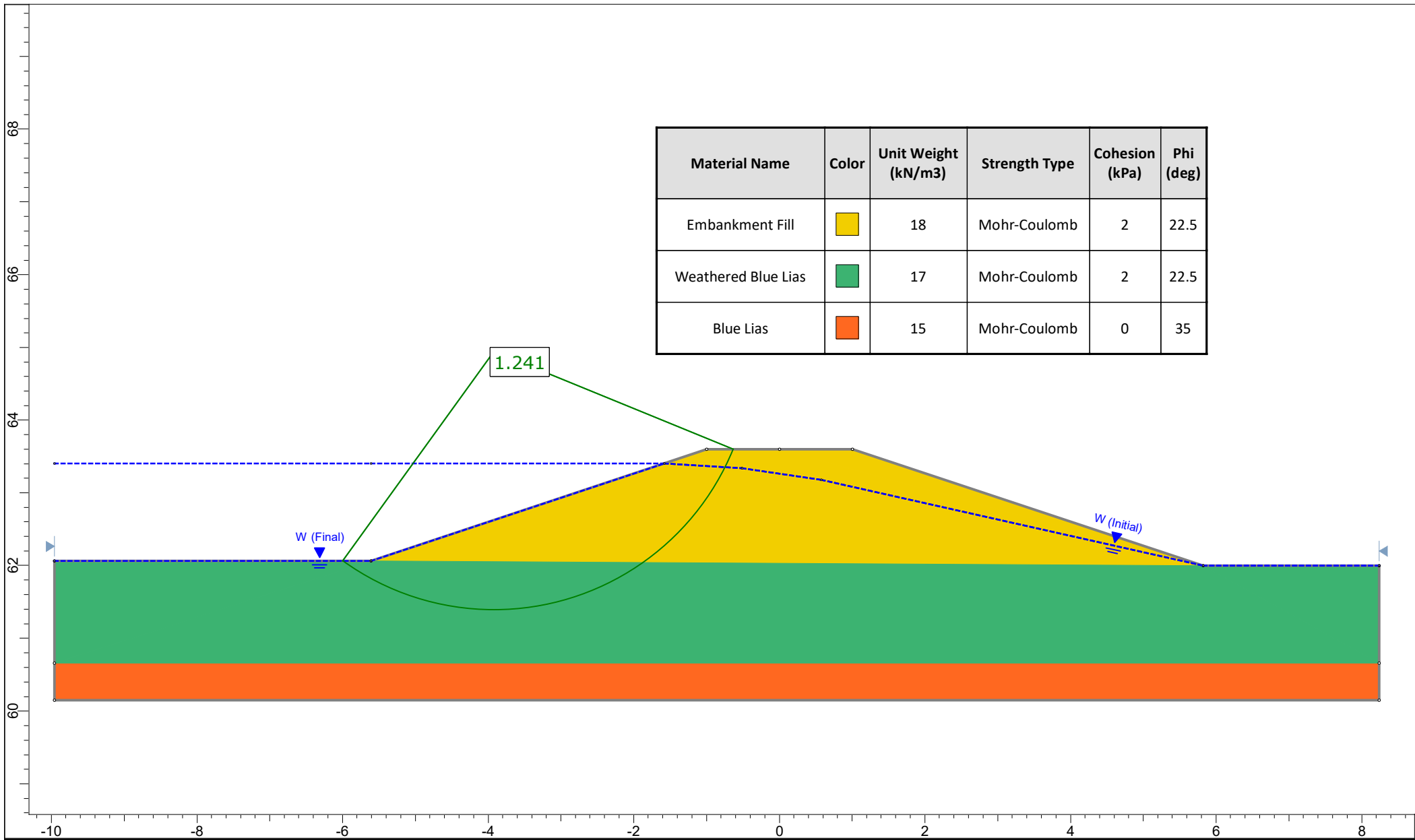


Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35

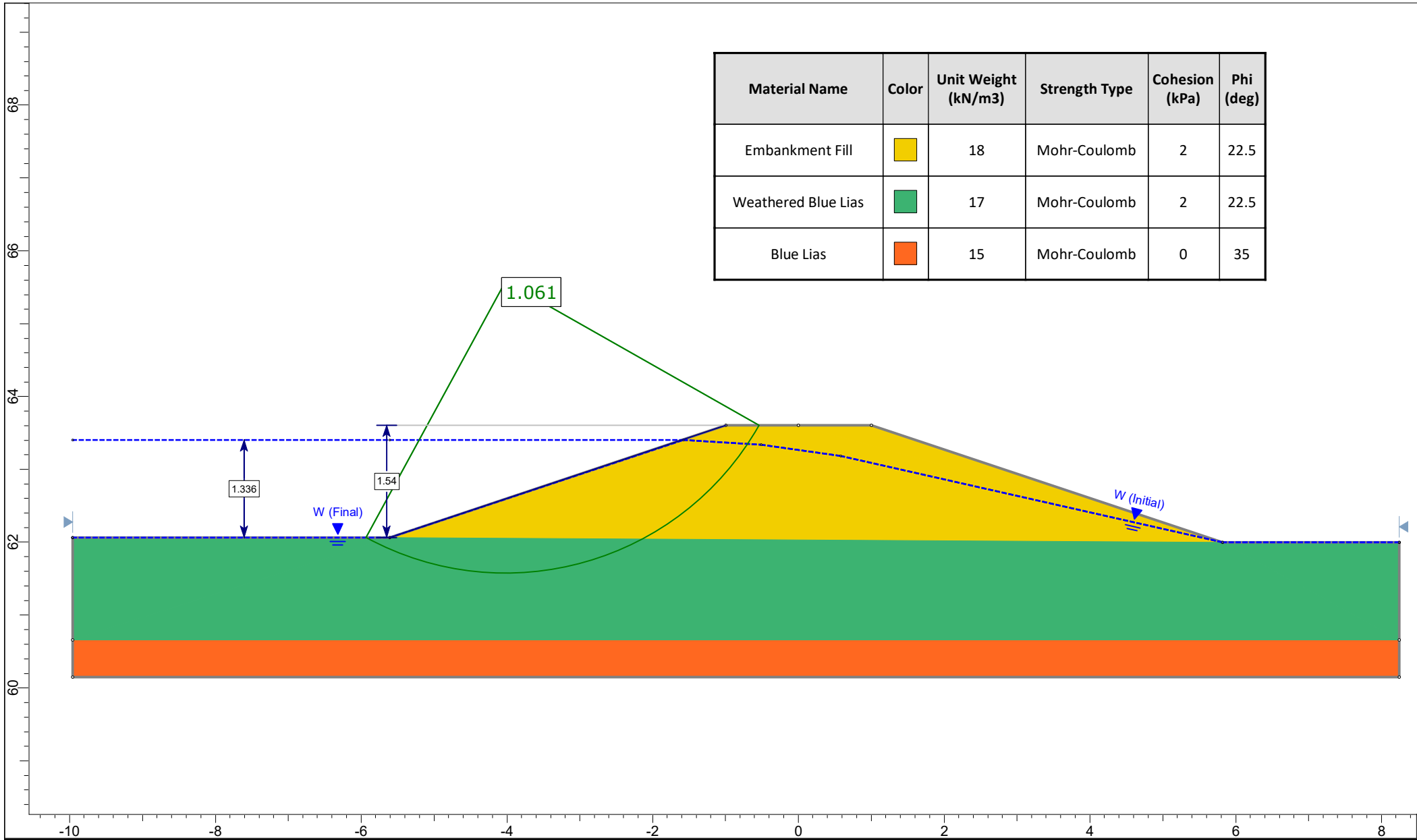




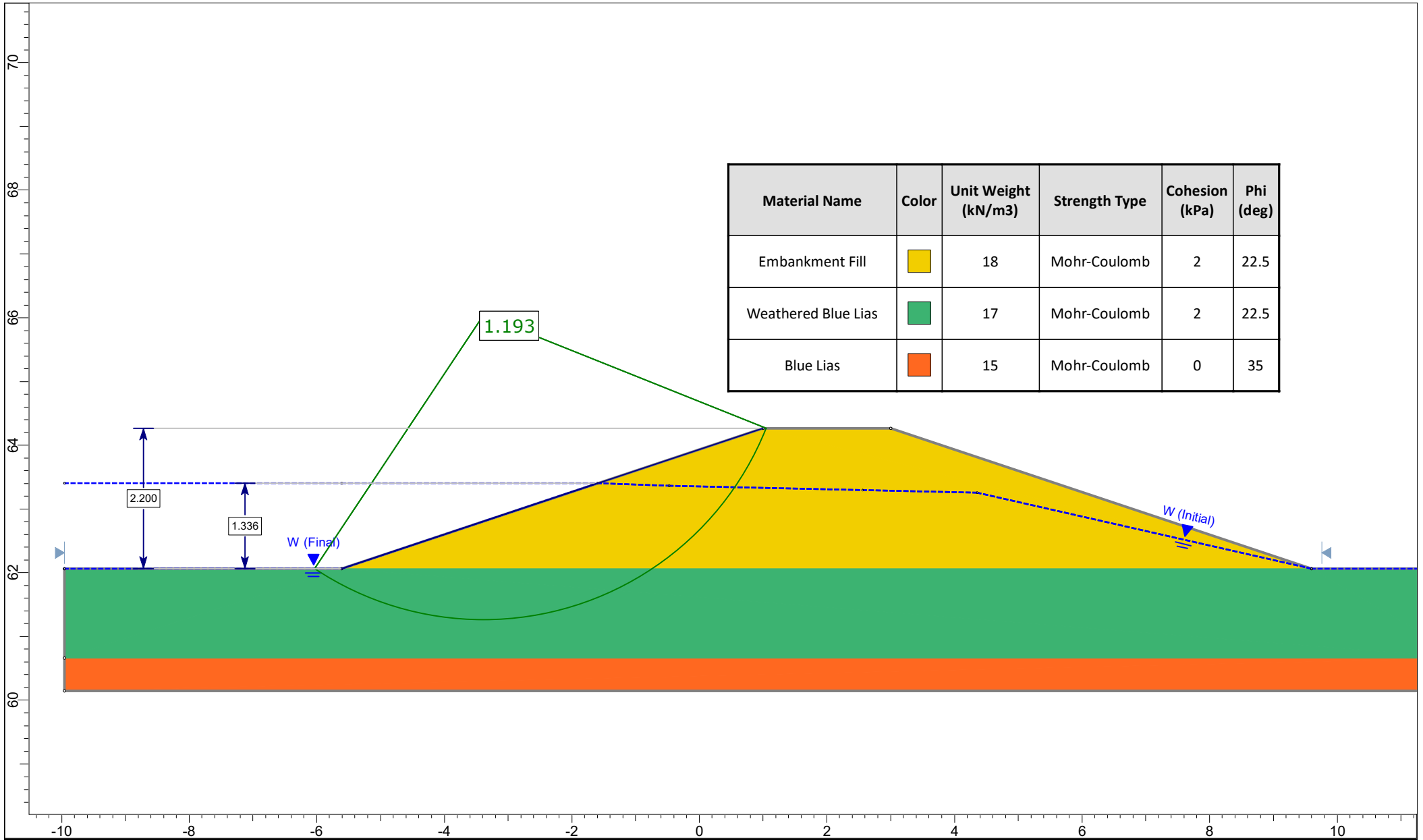
Bund 3, Rapid Drawdown Analysis



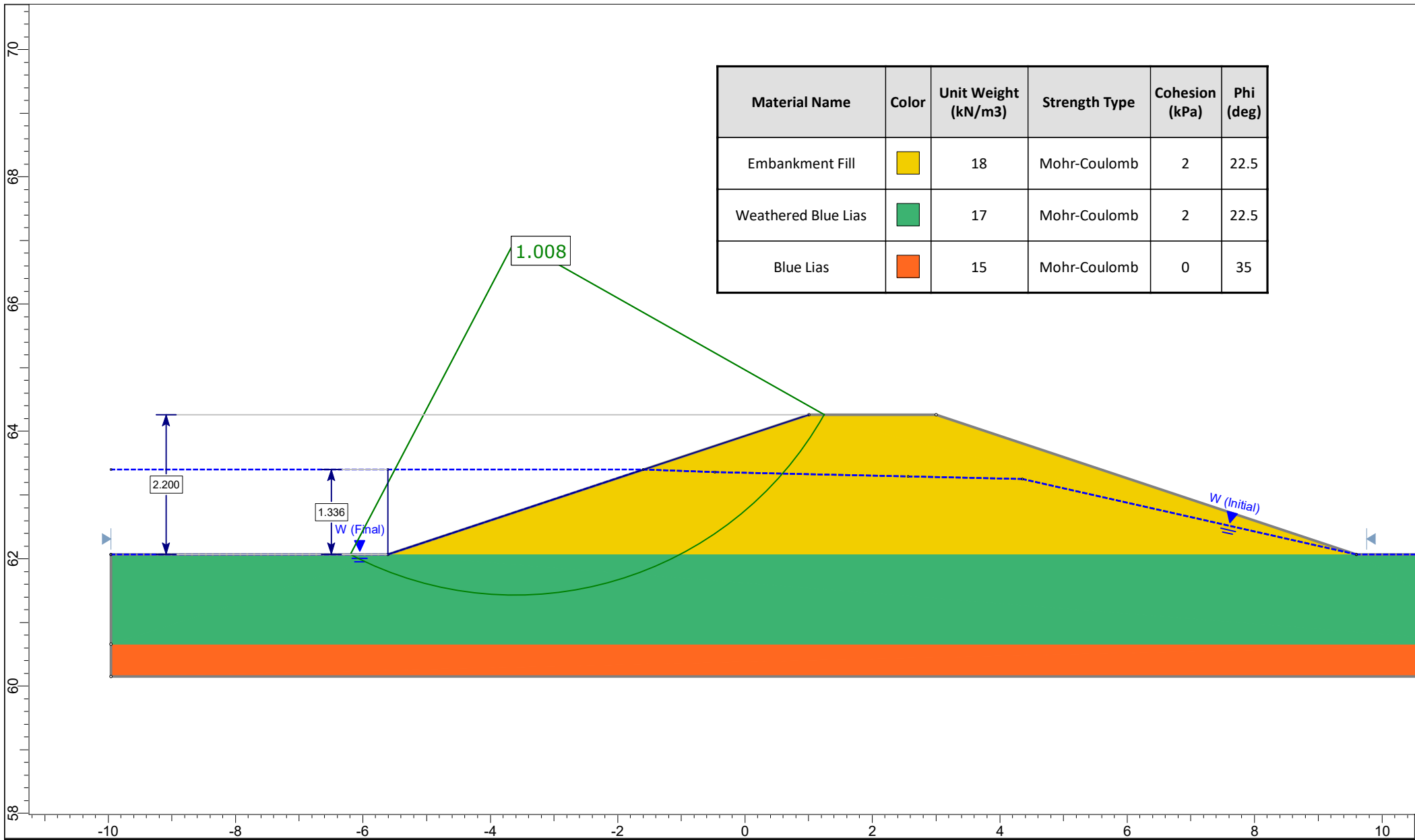
Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35



Bund 3 - 2.2m high
Rapid Drawdown Analysis



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35



Material Name	Color	Unit Weight (kN/m ³)	Strength Type	Cohesion (kPa)	Phi (deg)
Embankment Fill	Yellow	18	Mohr-Coulomb	2	22.5
Weathered Blue Lias	Green	17	Mohr-Coulomb	2	22.5
Blue Lias	Orange	15	Mohr-Coulomb	0	35