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GROUND STABILITY APPRAISAL

8 PRINCES ESPLANADE
GURNARD
COWES
ISLE OF WIGHT
PO31 8LE

CLIENT : MCLEAN CONSTRUCTION

REF : 21C036

DATE : 21 APRIL 2021

Ground Stability Appraisal

8 PRINCES ESPLANADE
GURNARD, COWES
ISLE OF WIGHT
PO31 8LE

Report No: 21C036

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Prepared for McLean Construction

Filename: /Consultancy/798 8 Princes Esplanade, Gurnard/Reports/8Princes Espl 2020-21-04 Ground Stability Report.docx

Table of Contents

1. INTRODUCTION

Tari Willis Associates (TWA) was requested by the Client to carry out a site walkover and prepare a Ground Stability Appraisal report for a proposed replacement dwelling at 8 Princes Esplanade, Gurnard, Isle of Wight.

This report comments upon a visit made to the site, known slope stability issues in the area and presents the findings of some preliminary computer slope stability modelling.

At the time of writing (April 2021) no intrusive ground investigation works had been carried out at the site. However the geology of the local area is known and past boreholes have been put down near to the site for other building projects. The author has been involved with the analysis of other development schemes in the area and the analyses presented here draw partly on information gained from those works.

2. THE SITE

2.1 Site Location and Topography

8 Princes Esplanade is a detached early-20th Century chalet bungalow that sits to the east of Princes Esplanade, Gurnard near Cowes (Figures 1 & 2).

The site is raised slightly above Princes Esplanade on land towards the base of the coastal slopes that rise to the east. To the west of the site is Princes Esplanade with a moderate grassed slope beyond that leads to a concrete sea frontage and the Solent. To the east of the site land rises as moderate to steep slopes towards Gurnard Heights.

The existing property has suffered settlement in the past.

Photographs of the site taken at the site walkover in March 2021 are enclosed as **Appendix A**.

2.2 Proposed Development

Appendix B shows the architects scheme drawings. It is proposed to demolish the existing bungalow and replace it with a larger structure. A smaller annex structure or garage is proposed to the rear of the main building. Some small scale earthworks may be required at the rear of the annex building. Otherwise no major earthworks are proposed as part of the development.

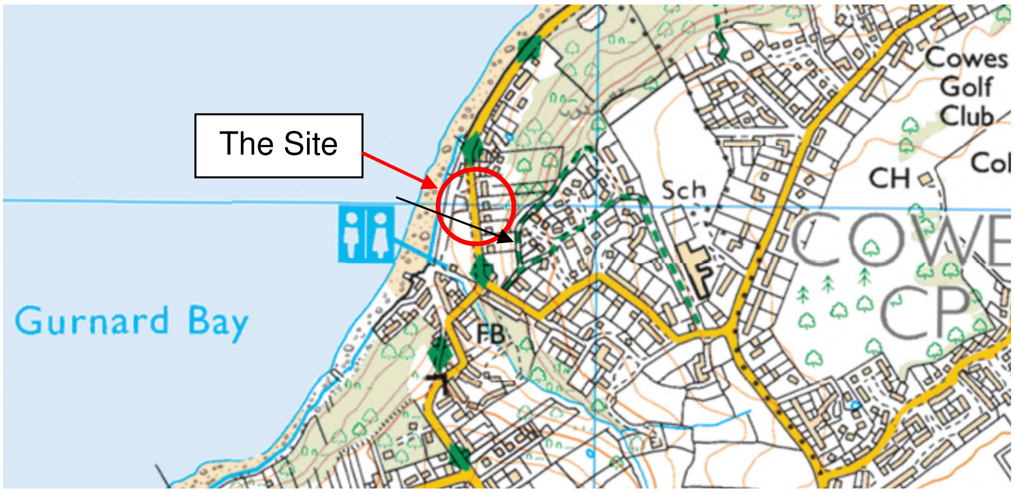


Figure 1: Site Location

Figure 2 : Aerial Image (© Google 2021)

3. DESK STUDY

3.1 Historic maps

Copies of historic OS maps from about 1865 to 2000 held by this office were reviewed.

The site was shown at **1865** as undeveloped land a short distance from the coast. Later maps for **1989** and **1909** showed no change to the site itself. Plans from the 1930's showed Princes Esplanade as having been constructed and a larger scale plan for **1947** showed development at the site and the adjacent properties to the north and south. A formal path is shown at the coast denoted as *Esplanade* suggesting the sea wall was also built at that time. A *putting green* was shown on land between Princes Esplanade and the coast. Later plans & aerial images showed no major changes to the site up to about 2000. The adjacent property to the south was redeveloped in the early 2000's and the putting green removed some time in the 1980's.

3.2 Geology

The British Geological Survey online Geology of Britain (*Figure 3*) shows the area of site for development as underlain by :

> **Superficial deposits:** No superficial deposits recorded.
>
> **Bedrock geology:** Headon Hill Formation - Mudstone and limestone, interbedded. Sedimentary bedrock formed between 37.8 and 33.9 million years ago during the Palaeogene period.

Outcrops of the *Bembridge Limestone Formation* and *The Bembridge Marls Member* are shown just upslope (east) of the site within the garden area.

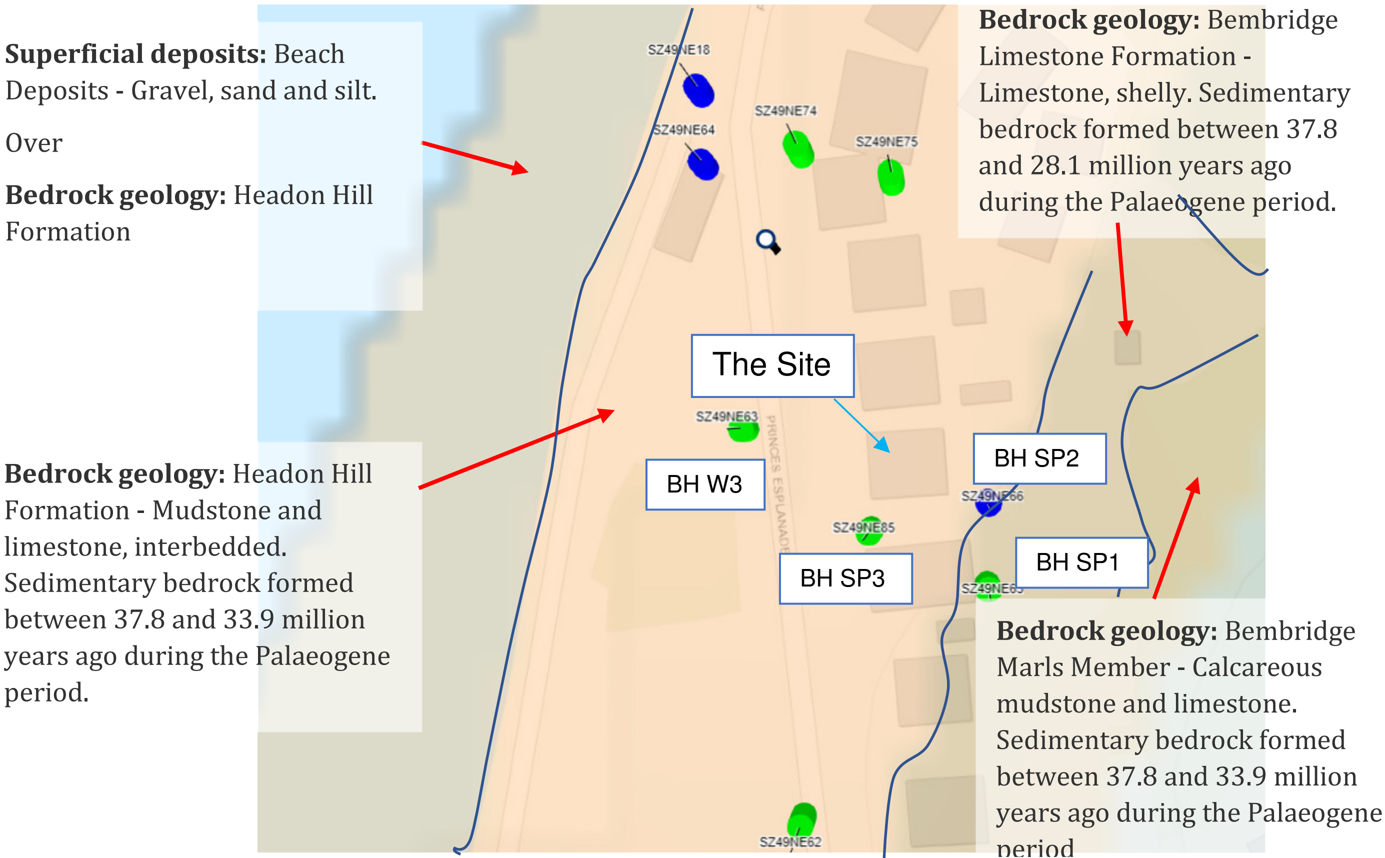


Figure 3 : Geology Strata (http://mapapps.bgs.ac.uk/geologyofbritain3d/)

3.3 Cowes to Gurnard Slope Stability Study

A report by Halcow Ltd for the IW Council (*Ref 2)* considered slope stability along the coastal fringe from Cowes to Gurnard.

The site is shown within an area described as Cliff Behaviour Model C which is defined as *deep-seated landslide (uncertain mechanism) protected by sea walls*. The Halcrow Report notes that Model C is characterised by a bench of landslide debris at the base of the Bembridge Marls Cliffs. The debris bench and the Bembridge Marls sit over the in situ Osborne Beds as shown by Figure 4).

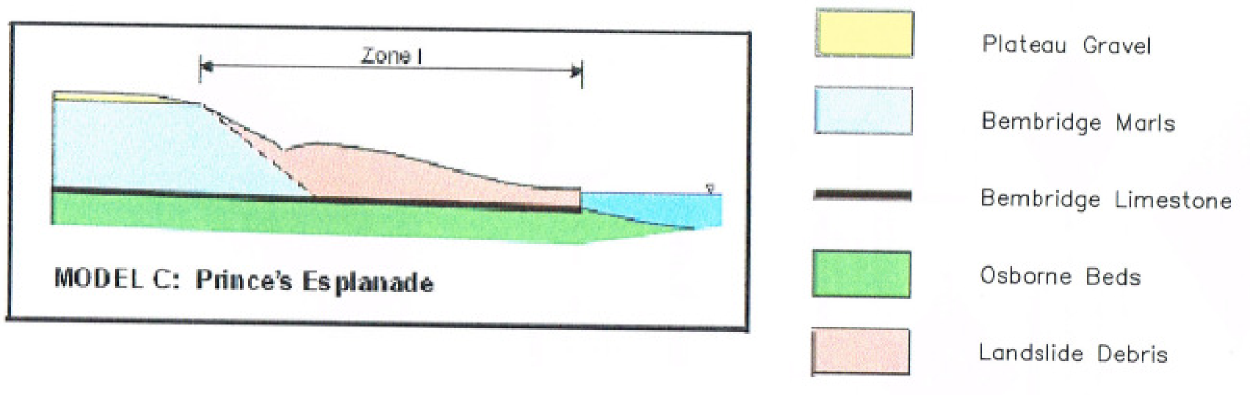


Figure 4 : Indicative Model Type C from Halcrow Report

Within the report are maps that give details of Geomorphology, Ground Behaviour, and Planning Guidance. **Appendix C** presents extracts of the maps.

The Geomorphology map shows the site as mostly within an area of *Deep seated coastal landslides formed in Bembridge Marls, Bembridge Limestone and Osborne Marls*. However an area (shown blue on the plans) is shown as *Soft Ground*.

The Ground Behaviour map shows the western part of the site as:

> *"**Landslide Bench:** area subject to recent and ongoing settlement of deep seated landslide blocks upon pre-existing shear surfaces. The exact mode of failure is uncertain. The benches are poorly drained and show signs of recent landside processes with differential shear, tension, opening of fissures, settlement, heave, development of mudslides & small rotational slides. Subsidence, ponding & infilling of soft ground deposits is apparent at rear of landslide blocks." ….*Impact is noted as *"properties situated on the benches has been affected by differential settlement, rotation, torsion,*

forward tilt and heave. The cumulative effect of ground movement has resulted in serious damage with localised cases of severe damage. Damage due to ground movement has led to demolition and redevelopment of some sites".

Land at the east of the site i.e the rear garden slope area is shown as *"**Scarp Slopes:** subject to recent and ongoing superficial ground movement. Instability is typically characterised by development of tension at the crest of slopes, differential settlement / rotation on the slope, and compression or heave at the toe of the slopes. In localised places failure of the scarp slopes through mudslides and rotational slides has taken place."* *….*Impact is noted as *"property situated on scarp slopes has been affected by ground movement, differential settlement and heave. Where scarp slopes have been developed with inadequate retaining structures, serious to severe damage due to ground movement has been recorded …"*

The Planning Guidance map within the Halcrow report suggests the site to be in an area : -

"*...unlikely to be suitable for development in accordance with the development unless the developer undertakes appropriate mitigation and stabilisation measures....Ground movement imposes major constraints that would generally require large scale mitigation / stabilisation measures to ensure the stability of the site and surrounding land. A Full Stability Report would normally be required"*.

3.4 Site reconnaissance

A walkover survey of the site and surrounding area was carried out on the 29th March 2021. Photographs taken as part of the walkover are enclosed at **Appendix A**.

8 Princes Esplanade consisted of an early-20th Century chalet bungalow to the east of Princes Esplanade. The existing house had suffered past settlement or subsidence with internal floors tilting slightly towards the rear of the property. Externally however there was no major visible damage or cracking typically associated with major ground movements. Tall trees had recently been failed or were still present that may in part have been the cause of some of the ground movements. The bungalow was on a reasonably level bench. A small area of garden to the rear of the property was also on a level bench with moderately steep slopes beyond.

The site was not showing any features indicative of recent past or imminent ground movement such as tension cracks or bulges. The slope to the rear were heavily vegetated and visually appeared stable. Trees were not showing indications of slope movement.

3.5 Previous Reports

No previous geotechnical reports pertaining to the site itself have been revealed. TWA had involvement with the adjacent property to the south (7 Princes Esplanade) in the early 2000's.

In addition, four boreholes are shown on the British Geological Survey on-shore borehole database near to the site. Three relate to the design of No7 Princes Esplanade and a fourth was for a Southern Water project in 1997. Figure 3 shows the locations and Table 1 summarises the findings. Copies of the logs are enclosed as **Appendix D**.

BH SP1 indicated some slickensided slip planes at depths below 4.5m (6.4mOD). BH SP3 also indicated slickensides below 5.7m (3.0mOD) and also noted '*evidence of old slip planes'* at between 0.2m and 5.7m depth.

No laboratory testing data or engineering reports associated with the boreholes has been revealed.

No boreholes from higher up the slope to the east have been revealed.

Table 1: Ground strata summarised from historic boreholes

By Elevation	**W3**	**SP1**	**SP2**	**SP3**	**Ave**	**Min**	**Max**
GL (mOD)	6.40	10.87	8.72	8.69	8.67	6.40	10.87
Stratum							
TOPSOIL	6.40	10.87	8.72	8.69	8.67	6.40	10.87
Thickness (m)	*0.30*	*0.10*	*0.20*	*0.20*	*0.20*	*0.10*	*0.30*
Soft, soft to firm & firm CLAYs	6.10	10.77	8.52	8.49	8.47	6.10	10.77
Thickness (m)	*-8.90*	*4.40*	*14.80*	*5.50*	*3.95*	*-8.90*	*14.80*
CLAYSTONE / LIMESTONE	2.80		6.92		4.86	2.80	6.92
Thickness (m)	*0.15*		*1.40*		*0.78*	*0.15*	*1.40*
Stiff (fissured) CLAY, possibly with claystone beds or limestone fragment, possibly with shells.	2.65	6.37	5.52		4.85	2.65	6.37

By Elevation

	W3	SP1	SP2	SP3	Ave	Min	Max
GL (mOD)	6.40	10.87	8.72	8.69	8.67	6.40	10.87
Stratum							
Thickness (m)	*0.95*	*10.50*	*11.80*		*7.75*	*0.95*	*11.80*
Firm to stiff & stiff dark red / grey mottled CLAY	1.70			2.99	2.35	1.70	2.99
Thickness (m)	*5.10*			*9.30*	*7.20*	*5.10*	*9.30*
Very stiff light grey & orange brown CLAY	-3.40				-3.40	-3.40	-3.40
Thickness (m)	*0.20*				*0.20*	*0.20*	*0.20*
base of hole	-3.60	-4.13	-6.28	-6.31	-5.08	-6.31	-3.60

4. SLOPE STABILITYASSESSMENT

4.1 General Setting

The Cowes to Gurnard coastal fringe is a known area of potential slope instability. The over steepened coastal slopes to the Solent have evidence of ancient and more recent ground movements. Causes vary at different parts of the area, but generally movements are in the Bembridge Marls clays or the Osborne Beds that sit below the Bembridge Marls. Some of the movements are along deep, very slow moving near horizontal slip planes that generally do not put a building at risk. Other movements are at shallower depth and have the potential to affect the utility of a building within its lifetime. At the Princes Esplanade the general of movement is for deeper slips along pre existing shear surfaces caused by past geological activity.

The general approach to dealing with the ground movements in the area is to ensure that the shallower slides are dealt with by stabilisation works and / or appropriate foundations solutions. The much deeper slides are moving at an imperceptible rate and are generally considered of no risk to a building within its lifetime.

4.2 Computer Slope Stability Analyses

Some preliminary slope stability analyses have been carried out using the commercial slope stability programme *Geo5 Slope Stability*. The following sections describe the derivation of the ground model, the selected soil shear strength parameters, pore-water conditions and present the analytical findings.

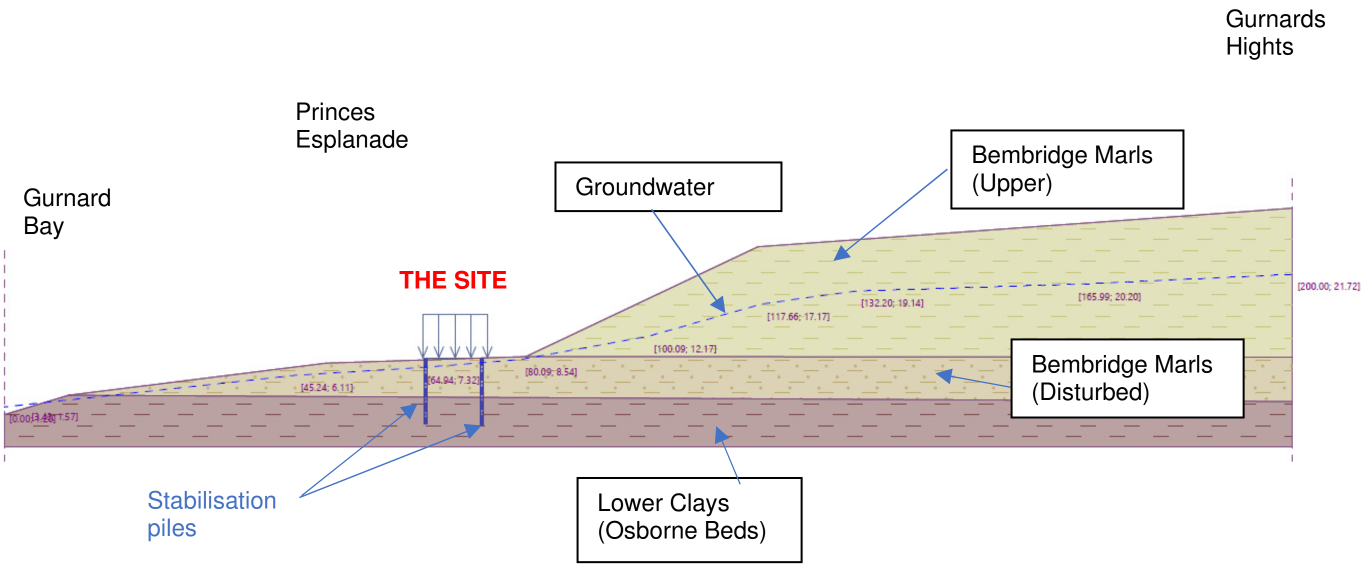


Figure 5: Simplified ground model used for preliminary analyses

No intrusive ground investigation has yet been carried out at the site. The assessments have therefore been based on a ground model extrapolated from boreholes carried out as part of other developments in the area and supplemented by local knowledge. Further computer analysis based on borehole data from the site itself shall be required prior to final foundations design.

4.3 Ground Profile

One typical section extending from Gurnard Bay to land above the site near to Gurnards Heights has been analysed. Ground levels have been interpolated from OS data and Google Earth data.

Figure 5 shows the interpolated ground profile. No significant change in ground profile is proposed as part of the development although final levels have not been set. Some small excavation may be required for the garage building to the rear of the site.

Soil strata have been interpolated from published information as discussed at Section 3.4 and 3.5. The preliminary soil model is for a downward series of:

- Bembridge Marls (clays)
- Bembridge Marls & Limestones as landslide debris
- Osborne Beds.

Table 2 shows the assumed strata for the preliminary slope stability modelling. Borehole investigations shall be required to determine if the assumptions are correct. The Halcrow Cowes to Gurnard Coastal Slope Stability Study (*Ref 2*) suggested that slips in this area are typically along pre existing shear surfaces and hence the preliminary slope stability analyses have assumed residual shear strengths. The model may need to be revised at detailed design stage and following site specific borehole investigations and laboratory testing.

Stratum	Material	Shear strength parameters (peak)	Shear strength parameters (residual)
Upper CLAY (*Bembridge Marls*)	Firm & stiff Clay	c' = 2.0kN/m^2 Φ' = 20 degrees	c' = zero Φ' = 16 degrees
LIMESTONE (Bembride Limestone)	*Weak Limestone*	*Not modelled (see text)*	
Middle CLAY (*Bembridge Clay &, landslide debris*)	Stiff to very stiff clay	c' = 0.1kN/m^2 Φ' = 20 degrees	c' = zero Φ' = 16 degrees
Lower CLAY (*Osborne Beds*)	Stiff to very stiff clay	c' = 0.1kN/m^2 Φ' = 16 degree	c' = zero Φ' = 14 degrees
V stiff & Hard CLAY at depth (*Osborne Beds*)	Stiff & hard fissured stiff clay. Strength controlled by near horizontal discontinuities	c' = 0.1kN/m^2 Φ' = 14 degrees	c' = 0.1kN/m^2 Φ' = 12 degrees

Table 2 : Soils strata & parameters for SLOPE modelling

The concrete within the computer model used to represent foundations, retaining walls and piled walls has been assumed to be resistant to slope movement. Detailed structural design for any concrete wall or wall / foundations to ensure adequate strength shall be required as a separate exercise to this ground stability assessment.

Groundwater west of the site has been assumed to be near to ground level. To the east, groundwater has been assumed to rise with the ground profile. Some allowance has been made for drainage due to more permeable layers. Pore water pressures have been assumed to be hydrostatic. The assumed groundwater conditions are considered to be only moderately conservative.

A number of the analyses assumed some loading from the existing building or the proposed development. The loads have been simplified for modelling to act as a uniformly distributed load (UDL) of 15kN/m^2 acting over the whole building width.

4.4 Analytical Methods

The analytical method used was a *Limit Equilibrium* method where by the resistance due to a soils strength is balanced against destabilising forces due to soil weight, gravity and any additional construction loading. The specific analytical methodology used was that due to Bishop.

Engineering design requires there to be a suitable reserve against failure. BS EN 1997-1 *Eurocode 7: Geotechnical Design* gives a set of partial factors to be applied to soil strengths and engineering loads i.e the process ensures that the soils strength is slightly underestimated and that the applied loads are slightly overestimated.

Where partial factors are used, the Geo5 software presents the results as a Utilisation Factor (UF). A UF of less than 100% shows a safe situation and a UF in excess of 100% shows an approaching risk of ground failure.

It should be noted that a UF>100% does not necessarily indicate an immediate risk of collapse, but does show that there is an insufficient reserve to meet current design codes. It is also possible to undertake analysis without any partial factors applied. Such analysis can give better indications of overall risk of failure.

4.5 Results of Analysis

The results of the analyses showed that the existing site is potentially only marginally stable.

Figure 6 shows an example slip from above the site. The Utilisation Factor with applied partial factors was 133% and an unfactored analysis showed F = 0.98 (noting that F>1.0 is required for balanced forces and hence theoretical 'stability').

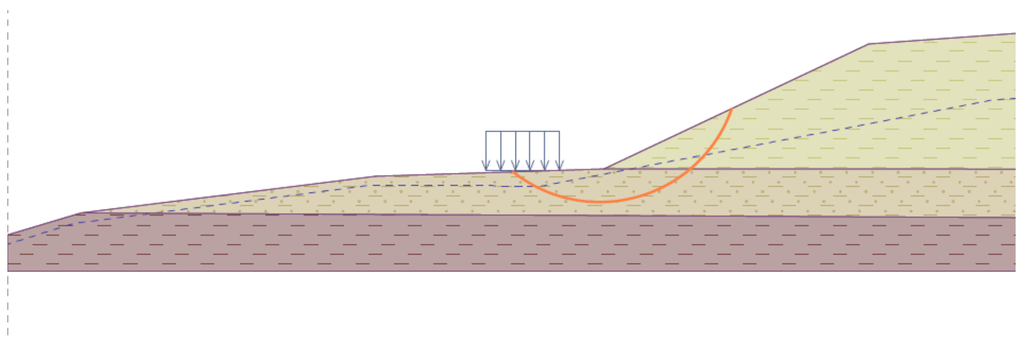


Figure 6 : Existing slope, from above

Analyses for slips from the site towards Gurnard Bay were shown with an acceptable reserve against failure. Deep seated slips had a low but acceptable reserve.

Rerunning the model for the proposed new building and assuming piled foundation or piled wall showed that a suitable factor of safety could be obtained (Figure 7). The model showed that the piles would need to be to a minimum of about 15m depth and that ideally there would be 2 rows of piles one at the rear of the site and one at the front of the site. For this preliminary modelling the piles were assumed to resist any slips that they interrupt. Detailed design would require that the piles had a size, strength and lateral spacing determined.

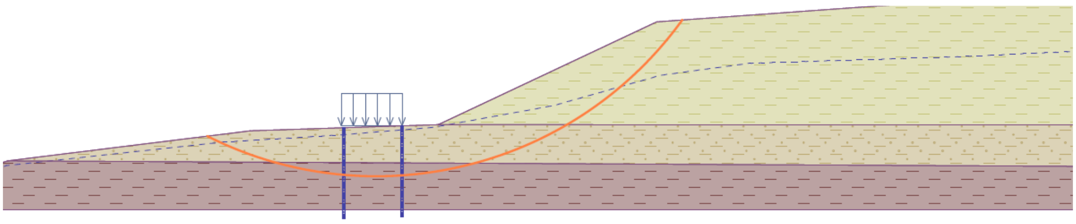


Figure 7 : Proposed site with piles, slip from above

Deeper slips seated on ancient bedding planes that may run below the piles showed a calculated reserve against failure that was much lower (Figure 8). Such slips move on residual strength ancient bedding planes and at a very slow rate. Such slip planes usually have a low calculated reserve against failure and for past schemes have been deemed acceptable as damage to a building in not likely during its lifetime.

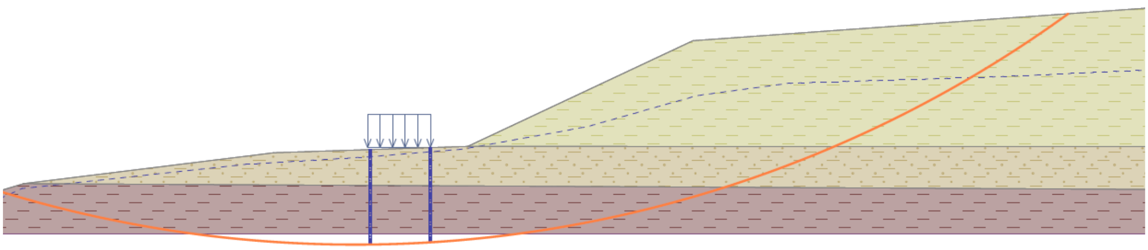


Figure 8 : Deep seated slips

5. DISCUSSION AND RECOMMENDATIONS

5.1 Slope Stability

The ground at the site appears to be stable at the current time, albeit with low calculated reserve along certain slip planes. A bungalow constructed at the site in the early 20th century has suffered some settlement or subsidence. It is not immediately clear if that distortion has been related to slope movement or was more likely due to a combination of the existing building having only shallow foundations, the soil below being soft and shrinkable, and the influence of nearby mature trees. No clear visual features typical of impending slope movement were noted during a site walkover

Any new development at the site shall need to be to modern standards and hence require a reserve against slope failure that is higher than that currently present. Computer slope stability analysis for the proposed new house showed the site as likely to be suitable for development but that a piled foundation would be required. The analyses were based on a ground model interpolated from nearby boreholes and shall need to be confirmed or amended based on site specific data (see Section 5.3).

Even with a piled foundation to protect the proposed building, a small risk will be present for slips from above impacting the site. Assuming conservative soil strength parameters for the site, the existing slope at the east is shown as only just stable (Figure 9). The slope shall require further consideration as a part of detailed design.

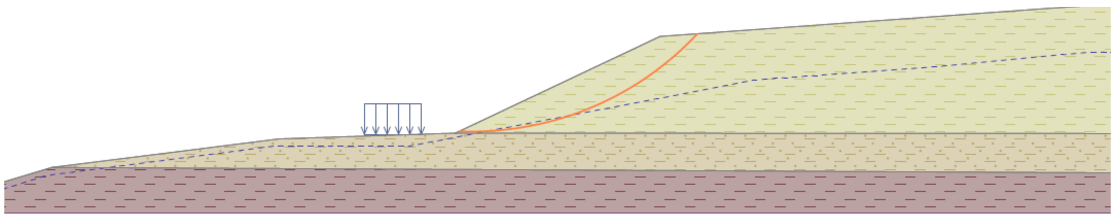


Figure 9 : Slips in slope to east

5.2 Foundations & Retaining walls

Redevelopment of the site shall require formation of new foundations and possibly retaining walls.

Piled foundations are recommended. Subject to further assessment at detailed design stage, piles may need to be designed to support an element of lateral as well as vertical loadings.

A separate retaining wall may be required at the rear of the new garage / annex building where construction may require a small excavation into the existing slope

5.3 Further Ground Investigation

A site specific ground investigation is required to :

i. Confirm ground strata at the site of the new house and immediately upslope.

ii. Provide engineering parameters for further slope stability assessments and for detailed foundations design for new buildings

iii. Provide ground profile and soils strength information for retaining wall design at the east of the annex building.

Access for a full sized cable percussion boring rig is currently restricted. The developer has indicated that the existing driveway at the north of the site can be widened slightly to allow access for a boring rig. It is likely that the dilapidated wooden garage currently present at the rear of the existing house would need to be removed to allow room for a boring rig to operate in that area.

Two boreholes are recommended as shown by Figure 10. Boreholes should be up to 20m depth. Representative samples from the boreholes shall need to be sent for laboratory testing. Laboratory testing shall need to include specialist shear strength testing related to slope stability.

Typical costs for the ground investigation shall be provided under separate cover it is likely that the investigation would need some 8 to 12 weeks from instruction to completion & reporting but only about 1 week of that would be site based fieldwork. Water monitoring standpipes would be installed as part of the borehole works and would need to be dipped to give groundwater levels a number of times during the investigation period.

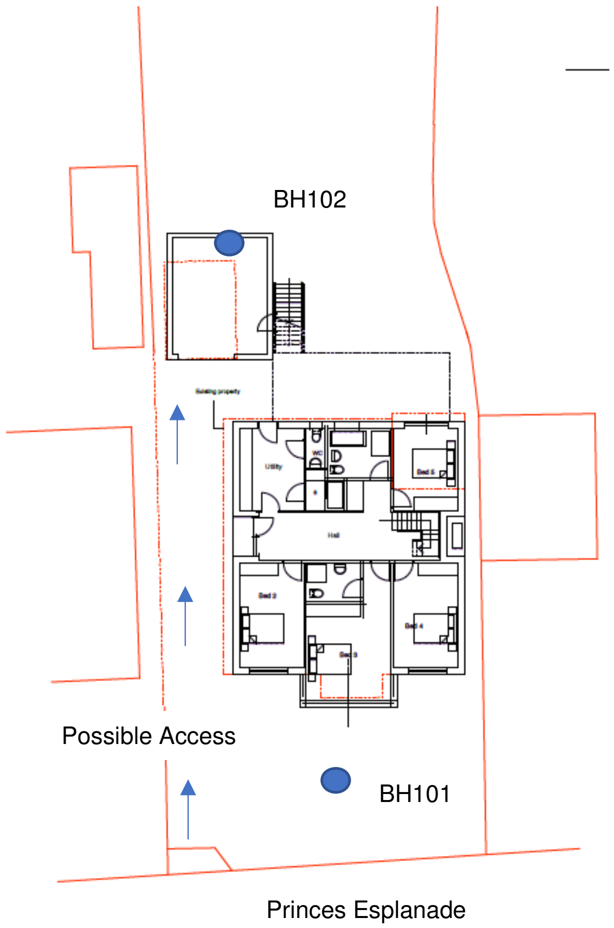


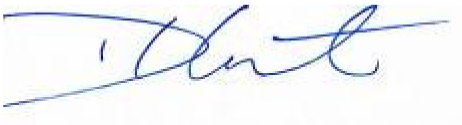
Figure 10: Proposed borehole locations

6. CONCLUSIONS

A walkover of a site at 8 Princes Esplanade, Gurnard showed no visual evidence of recent past or imminent slope instability. The existing 1920's bungalow had however undergone distortion during its lifetime. Preliminary slope stability analyses suggest that the site is suitable for development but that significant foundation works shall be required.

Detailed design shall require site specific further ground investigation and further slope stability assessments.

Report prepared by



....	21 April 2021

D I Grant BSc, PhD, GICE

References

1. British Geological Survey. (2020). *Geology of Britain viewer (beta version).* Accessed at http://mapapps.bgs.ac.uk/geologyofbritain /home.html. Accessed 10/01/2020

2. Halcrow Group Ltd. (2000). C*owes to Gurnard Coastal Slope Stability Study* (on behalf of the Isle of Wight Council).

Appendix A - Photographs

Views from Princes Esplanade

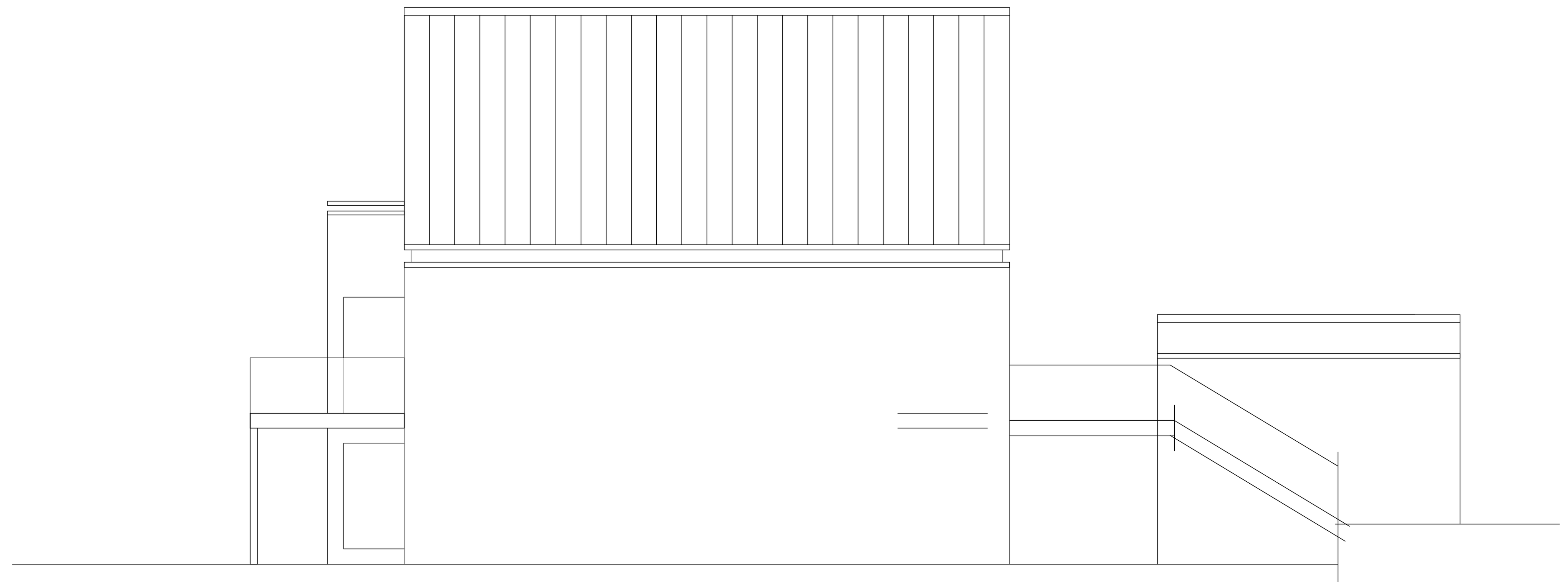
Rear garden towards existing bungalow

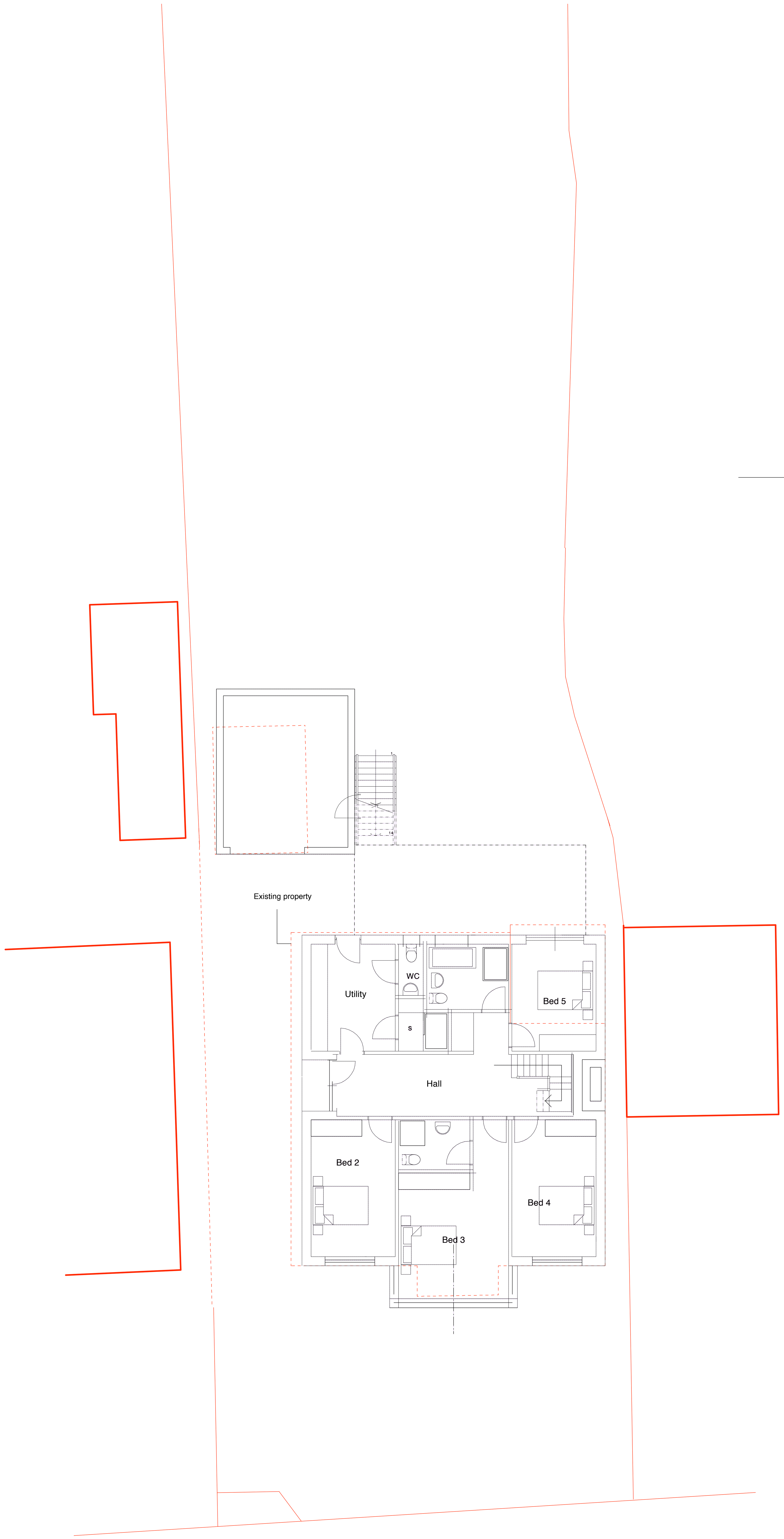
Vegetated slopes to east of site

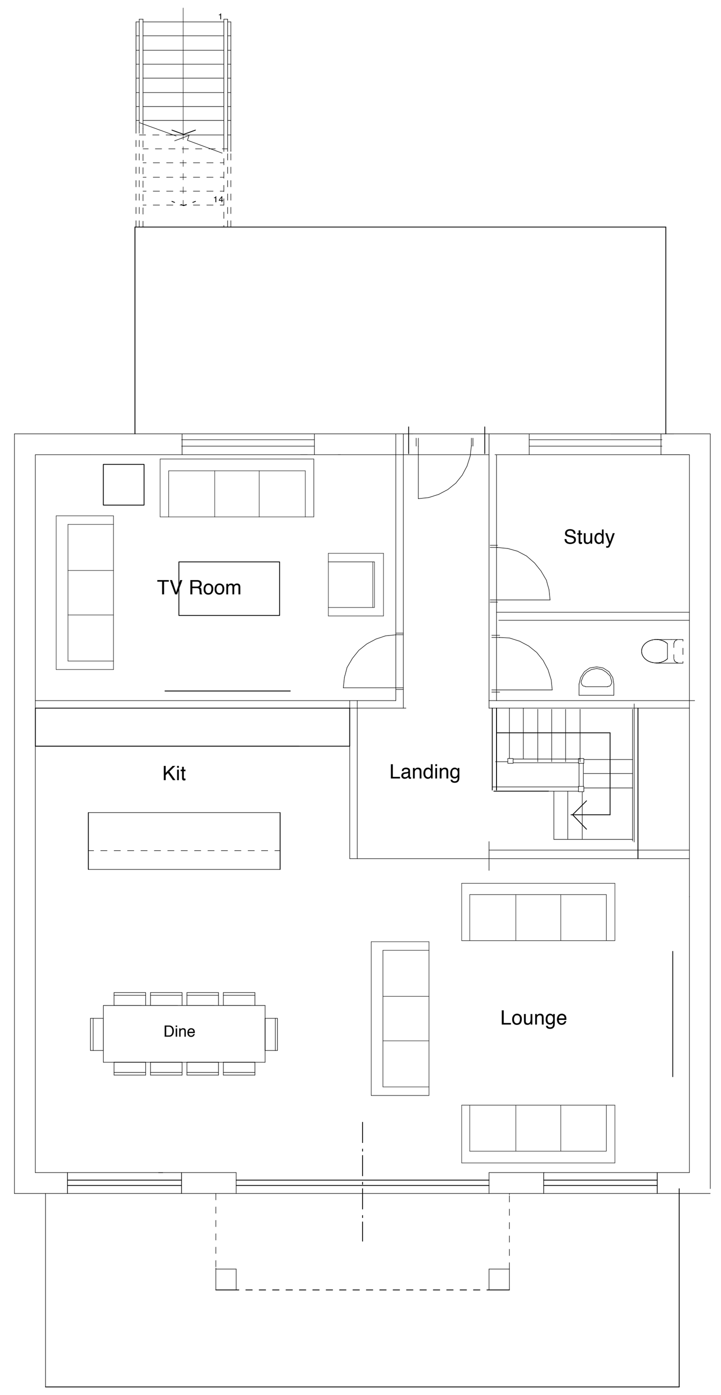
Access at north boundary

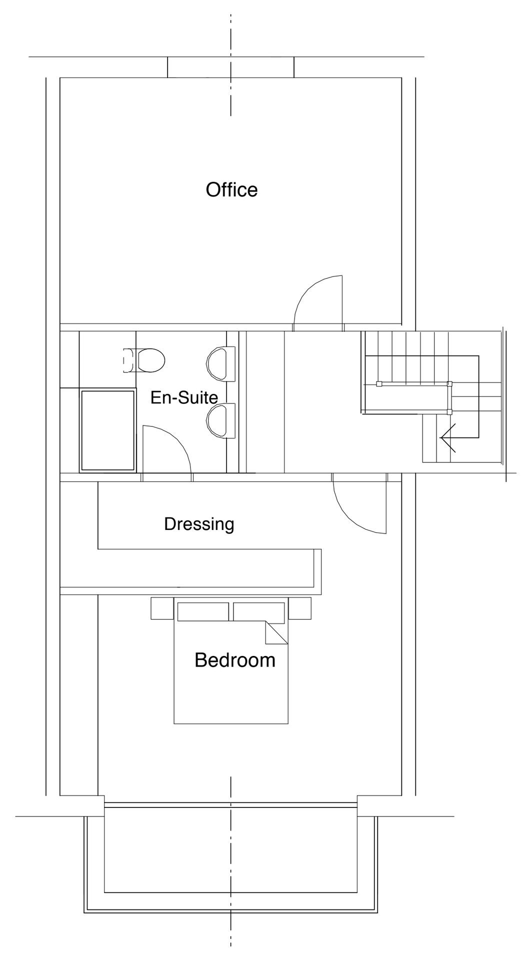
Dilapidated garage at northeast

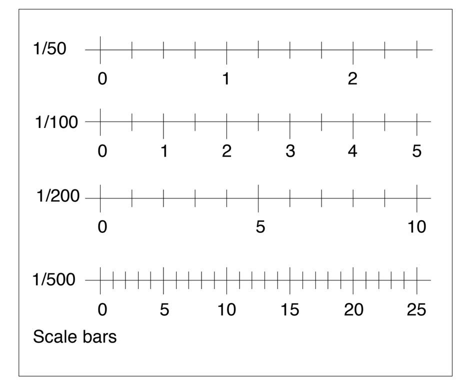
Appendix B - Architects Plans











Client
Mr John Mclean

Project

8 Princes Esplande
Gurnard
Isle of Wight

Title

Concept Drawing

Drawing no. 1509/01

Scale 1/100

Date Dec. '20

Peter Ferns Architecture

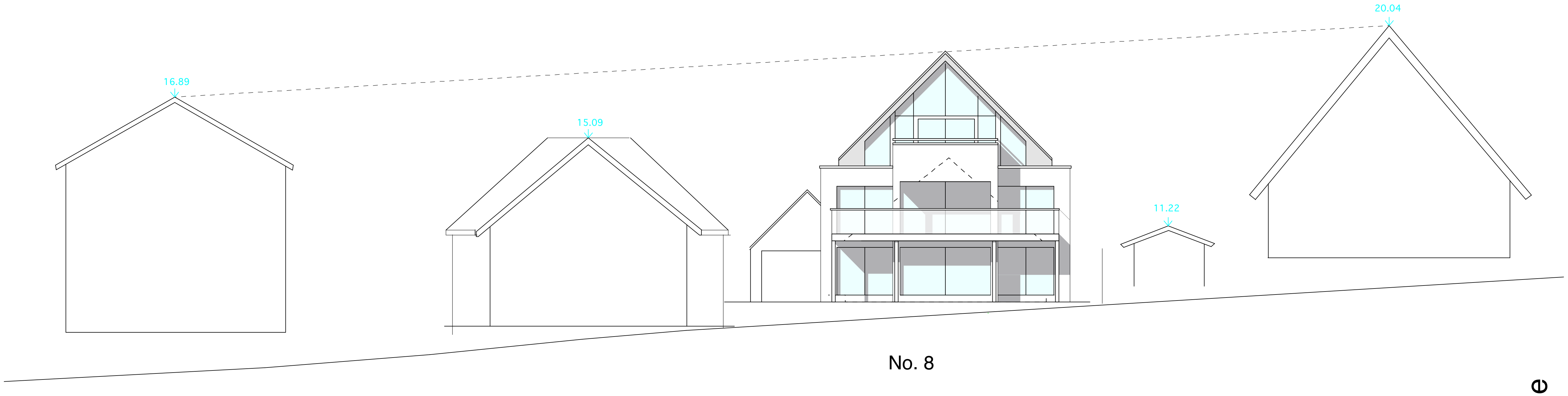
Whitegates Building
Medina Yard
Arctic road
Cowes
Isle of Wight
PO31 7PG

Tel : 01983 248866

email
team@peterfernsarchitecture.com

Note
Contractors must verify all dimensions on site before work is commenced.
Scaled dimensions must not be used.

HEALTH AND SAFETY
Contractor to refer to the requirements of the CDM (2015) Regulations with respect to the Construction Phase Plan and HSE Notification.
Clients, Designers and Builders all have duties under the Regulations.



PRINCES ESPLANADE STREET SCENE

DATUM 0.00m

0 5 10m
Scale bar

Scale 1:200

Peter Ferns Architecture
email: team@peterfernsarchitecture.com

Client
Mr J. McLean

Project

Proposed New Dwelling
8 Prince's Esplande
Gurnard
IW

Title

Street Scene

Drawing no. /01

Scale 1:200

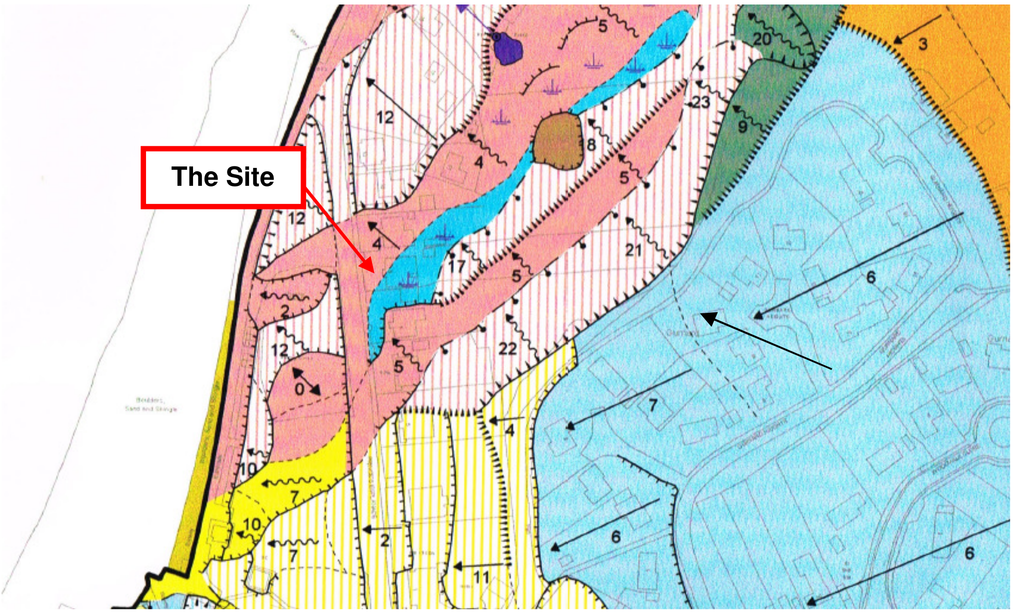
Date Jan. 2021

Whitegates Building
Medina Yard
Arctic road
Cowes
Isle of Wight
PO31 7PG

Tel : 01983 248866

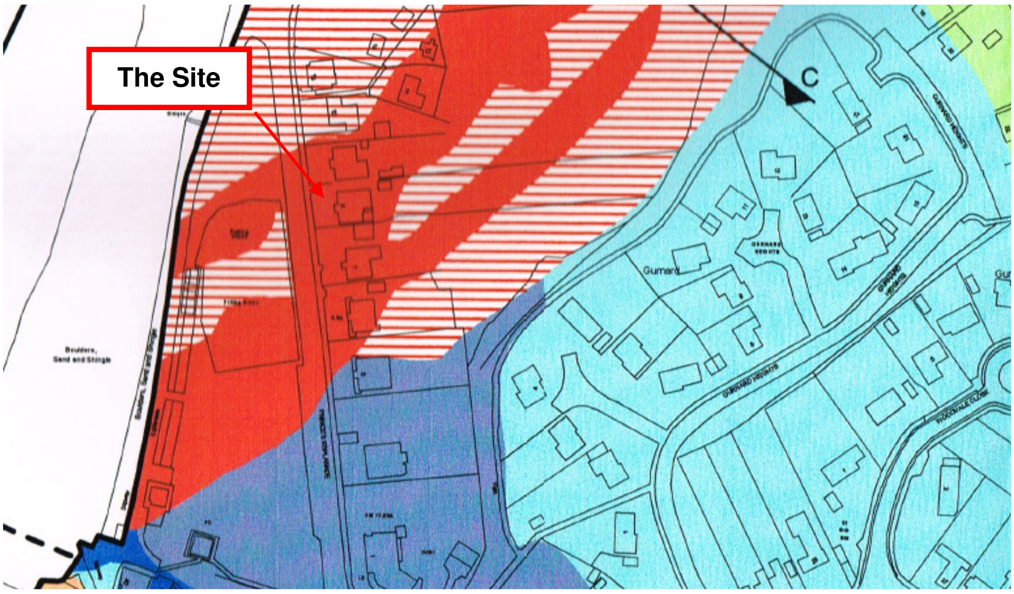
Appendix C - Extracts from Halcrow Ltd Slope stability a mapping

Geomorphology :

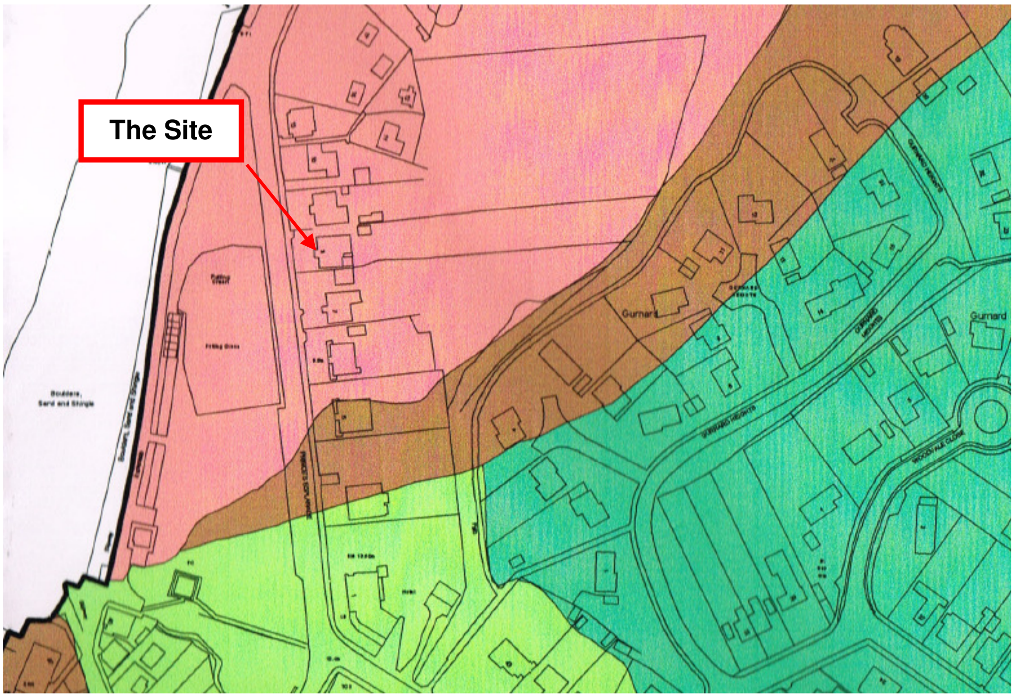


Extract from :
Halcrow Group Ltd. (2000).
Cowes to Gurnard Coastal Slope Stability Study
(on behalf of the Isle of Wight Council).

Ground Behaviour :



Planning Guidance



Extracts from :
Halcrow Group Ltd. (2000).
Cowes to Gurnard Coastal Slope Stability Study
(on behalf of the Isle of Wight Council).

Appendix D - Historic Borehole Logs

Woodvale Green, Gurnard, IOW

Borehole logs

West Wight Drilling W3 (sheet 1)

Figure 19

Record of Borehole No: W3

CLIENT: **SOUTHERN WATER SERVICES** — SHEET **1** OF **2**

PROJECT: **SEACLEAN WIGHT CSO'S** — START DATE: **25/03/97** — ORIENTATION: **Vertical**

CONTRACT No.: **936/2921B** — BOREHOLE DIA: **150mm to 10.00m** — COORDINATES:

TYPE OF BORING: **Cable Percussion** — CASING DETAILS: **150mm to 4.90m** — E 47789 N 96021

EQUIPMENT: **Dando 150** — DRILL FLUID: — GROUND LEVEL: ~~12.49m~~ ~~NOT OD~~

RL +6.4[illegible] m O[illegible] 14:04:[illegible] Halcro[illegible]

Time Date	Depth Casing	Water Levels	Samples Depth	Sample No.	In-situ Tests	Strata Description	Depth/ Thkness	Level (m)	Strata Symbol
							0.00	G.L.	
						Topsoil			
25/3			0.30-0.60	B 1			0.30	12.19	
						Firm brownish grey CLAY	(0.60)		
							0.90	11.59	
			1.20-1.65	U 2	*20	Firm greenish brown CLAY with some shell fragments	(0.70)		
			1.65	D 3			1.60	10.89	
		∇ 8/4/97				Soft to firm to firm dark grey and brown mottled CLAY with abundant white shell fragments			
			2.20-2.65	U 4	*19				
			2.65	D 5			(2.00)		
		∇ 2/7/97	3.20-3.65	U 6	*29				
	3.00	∇ 3.60	3.65	D 7			3.60	8.89	
						Light yellowish brown sandy CLAYSTONE	3.75	8.74	
26/3						Stiff brownish grey clay with claystone bands			
	4.00	∇ 3.80	4.30-4.75	U 8	*22		(0.95)		
			4.75	D 9			4.70	7.79	
						Firm to stiff and stiff dark red and grey mottled CLAY			
			5.30-5.75	U 10	*38				
			5.75	D 11					
			6.50-6.95	U 12	*40				
			6.95	D 13					
							(5.10)		
			8.00-8.45	U 14	*51				
			8.45	D 15					
			9.00	D 16					
			9.50-9.95	U 17	*60		9.50		
						Borehole Continued			

Scale: **9.50m/sheet**

Remarks: Hand dug inspection pit to 1.2m
Standpipe piezometer installed - response zone 4.0 to 5.1m
~~Levels relate to manhole cover taken as +10.00m~~

~~Some doubt, as to whether the 'benchmark' for W1 & W2 is the same as this TBM of +10m. WH Sept '97~~

Costain Building & Civil Engineering Limited, International Division, Geotechnical Services

COSTAIN ENGINEERING & CONSTRUCTION

Engineer: BS — BH. No. W3

Checked by: PJP

Woodvale Green, Gurnard, IOW

Borehole logs

West Wight Drilling W3 (sheet 2)

Figure 20

Record of Borehole No: W3

CLIENT: **SOUTHERN WATER SERVICES** SHEET 2 OF 2

PROJECT: **SEACLEAN WIGHT CSO'S** START DATE: **25/03/97** ORIENTATION: **Vertical**

CONTRACT No.: **936/2921B** BOREHOLE DIA: **150mm to 10.00m** COORDINATES:

TYPE OF BORING: **Cable Percussion** CASING DETAILS: **150mm to 4.90m** E 47789 N 96021

EQUIPMENT: **Dando 150** DRILL FLUID: GROUND LEVEL: ~~12.49m~~ ~~NOT OD~~

RL +6.4: m O 14.04 Halcn

Time Date	Depth Casing	Water Levels	Samples Depth	Sample No.	In-situ Tests	Strata Description	Depth/ Thkness	Level (m)	Strata Symbol
						- - - - - - - - - - - - - - - -	9.50		
							9.80	2.69	
	4.90		9.95	D 18		Very stiff light grey and orange brown mottled CLAY	10.00	2.49	
						End of Borehole			

Scale: **9.50m/sheet**

Remarks: Hand dug inspection pit to 1.2m
Standpipe piezometer installed - response zone 4.0 to 5.1m
~~Levels relate to manhole cover taken as +10.00m~~
~~See note W3 1/2. WH Sept. '97.~~

COSTAIN ENGINEERING & CONSTRUCTION

Engineer: BS | BH. No. W3 | Checked by: PJP

Costain Building & Civil Engineering Limited, International Division, Geotechnical Services

Woodvale Green, Gurnard, IOW

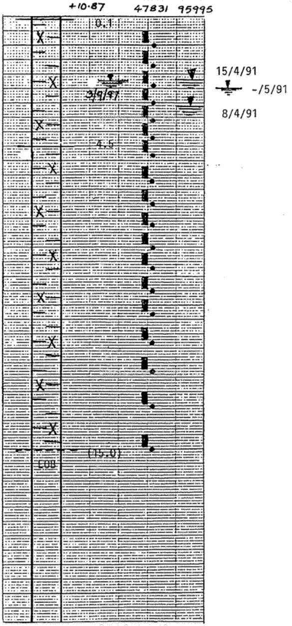
Borehole logs

Sifeg Partnership SP1 **Figure 22**

SITE 7 PRINCES ESPLANADE, GURNARD IOW FIGURE 3a

BOREHOLE 1 DIAMETER 150 mm DEPTH 15.0 m DATE 3-5/4/91

Scale: 1:100



TOPSOIL

Firm grey/brown mottled fissured silty CLAY with shell fragments and occasional flints. Numerous old roots and signs of disturbance. Some gypsum crystals.

Firm/stiff grey/orange/brown mottled and/or grey/blue/green fissured very silty CLAY with numerous shells and shell fragments. Occasional limestone nodules and some slickensided slip planes. Thinly laminated in places.

Borehole cased to 2.5 m.

Standpipe/slip indicator tube installed to 14.0 m.

Standpipe still intact 3/9/97.

Sifeg Partnership

▮ 100mm diameter core sample

• disturbed sample

I N (Test 19, BS 1377.1975)

NR ... non-recovery

•W ... water sample

•B ... bulk sample

Woodvale Green, Gurnard, IOW

Borehole logs

Sifeg Partnership SP2

Figure 23

SITE 7 PRINCES ESPLANADE, GURNARD *IOW* FIGURE 3b

BOREHOLE 2 DIAMETER 150 mm DEPTH 9.0 m DATE 8-10/4/91

Scale: 1:100

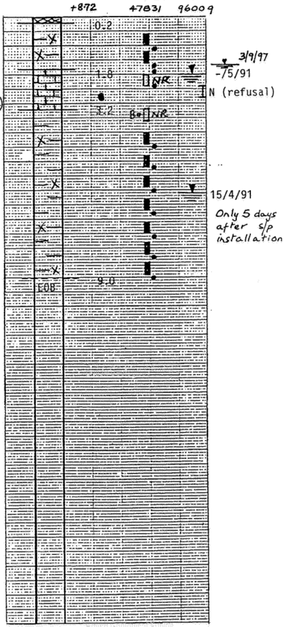
TOPSOIL and FILL

Soft/firm grey/green/brown mottled silty CLAY with some gravel and shell fragments.

Brown LIMESTONE

(Believed to be part of talus. WH 3/9/97.)

Firm/stiff grey/green fissured/ highly fissured silty CLAY



Borehole cased to 1.0 m.

Standpipe/slip indicator tube installed to 9.0 m.

Standpipe still intact 3/9/97.

Sifeg Partnership

▮ 100mm diameter core sample

• disturbed sample

I N (Test 19, BS 1377.1975)

NR ... non-recovery

•W ... water sample

•B ... bulk sample

Woodvale Green, Gurnard, IOW

Borehole logs

Sifeg Partnership SP3

Figure 24

SITE 7 PRINCES ESPLANADE, GURNARD *IOW* FIGURE 3c

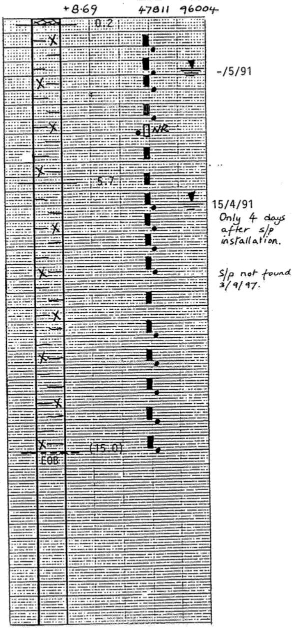
BOREHOLE 3 DIAMETER 150 mm DEPTH 15.0 m DATE 10-11/4/91

Scale: 1:100

TOPSOIL

Soft/firm grey/blue/brown mottled silty CLAY with shell fragments with occasional flints and limestone nodules. Some old roots and <u>evidence of old slip zones.</u>

Stiff grey/brown/red/green mottled fissured silty CLAY. Thinly laminated in places. <u>Some slickensided slip planes</u> and some shell fragments.



Borehole cased to 4.5 m.

Standpipe/slip indicator tube installed to 15.0 m.

Standpipe not found 3/9/97. Removed by householder?

Sifeg Partnership

▌100mm diameter core sample

• disturbed sample

I N (Test 19, BS 1377.1975)

NR ... non-recovery

•W ... water sample

•B ... bulk sample

Appendix E - Computer slopes stability output

Slope stability analysis

Input data

Project

Task : Preliminary Analyses
Description : Existing Site
Date : 21/04/2021
Project ID : 8 Princes Esplanade Gurnard
Project number : 21C036 (DG798)

Settings

United Kingdom - EN 1997

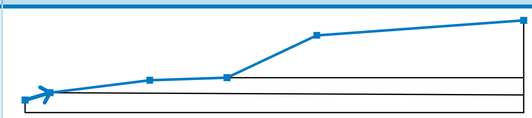
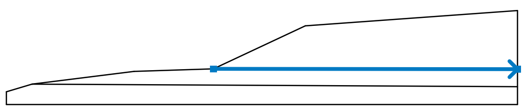
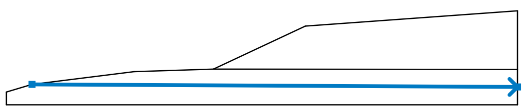
Stability analysis

Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)									
Permanent design situation									
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	10.00	3.00	50.00	8.00
		81.00	9.00	117.00	26.00	200.00	32.00
2		81.00	9.00	200.00	8.94		
3		10.00	3.00	200.00	2.03		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m3]
1	Stiff CLAY (Bembridge Marls in slope)		16.00	0.05	19.00
2	Firm CLAY, possibly disturbed		14.00	0.00	19.00
3	Stiff CLAY, (Osborne Beds)		12.00	0.00	19.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m3]	γ_s [kN/m3]	n [–]
1	Stiff CLAY (Bembridge Marls in slope)		19.00		
2	Firm CLAY, possibly disturbed		19.00		
3	Stiff CLAY, (Osborne Beds)		19.00		

Soil parameters

Stiff CLAY (Bembridge Marls in slope)

Unit weight : γ = 19.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 16.00 °
Cohesion of soil : c_{ef} = 0.05 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m3

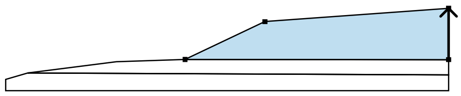
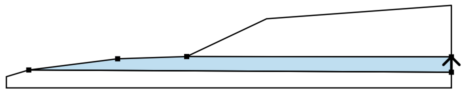
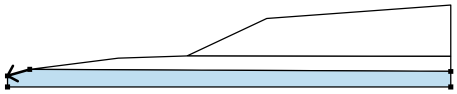
Firm CLAY, possibly disturbed

Unit weight : γ = 19.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 14.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m3

Stiff CLAY, (Osborne Beds)

Unit weight : γ = 19.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 12.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Surcharge

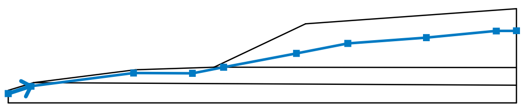
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m^2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.28	8.99	1.55	49.32	6.76
		72.50	6.64	84.80	9.01	113.42	14.45
		133.65	18.35	164.52	20.60	192.08	23.20
		200.00	23.32				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1 (stage 1)

Circular slip surface

Slip surface parameters							
Center :	x =	80.47	[m]	Angles :	α_1 =	-38.55	[°]
	z =	23.45	[m]		α_2 =	70.84	[°]
Radius :	R =	18.99	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 775.68 kN/m
Sum of passive forces : F_p = 579.62 kN/m

Sliding moment : M_a = 14731.86 kNm/m
Resisting moment : M_p = 11008.20 kNm/m
Utilization : 133.8 %

Slope stability NOT ACCEPTABLE

Combination 2

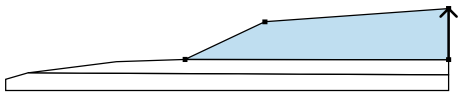
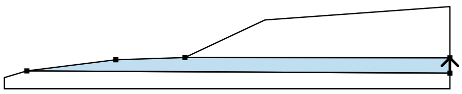
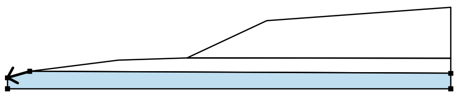
Sum of active forces : F_a = 536.40 kN/m
Sum of passive forces : F_p = 421.37 kN/m

Sliding moment : M_a = 10187.38 kNm/m
Resisting moment : M_p = 8002.67 kNm/m
Utilization : 127.3 %

Slope stability NOT ACCEPTABLE

Input data (Stage of construction 2)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Surcharge

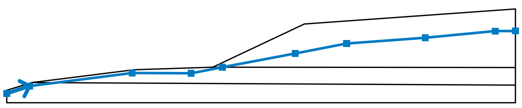
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.28	8.99	1.55	49.32	6.76
		72.50	6.64	84.80	9.01	113.42	14.45
		133.65	18.35	164.52	20.60	192.08	23.20
		200.00	23.32				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	45.40	[m]	Angles :	α_1 =	-15.79	[°]
	z =	61.55	[m]		α_2 =	24.85	[°]
Radius :	R =	58.31	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)
Combination 1

Sum of active forces : F_a = 244.07 kN/m
Sum of passive forces : F_p = 388.44 kN/m

Sliding moment : M_a = 14231.54 kNm/m
Resisting moment : M_p = 22650.12 kNm/m
Utilization : 62.8 %

Slope stability ACCEPTABLE

Combination 2

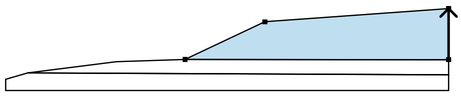
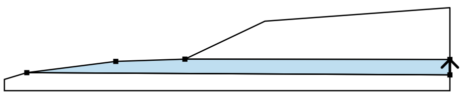
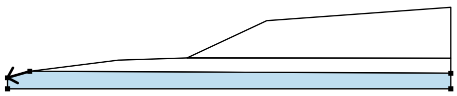
Sum of active forces : F_a = 197.06 kN/m
Sum of passive forces : F_p = 329.05 kN/m

Sliding moment : M_a = 11490.50 kNm/m
Resisting moment : M_p = 19187.10 kNm/m
Utilization : 59.9 %

Slope stability ACCEPTABLE

Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Surcharge

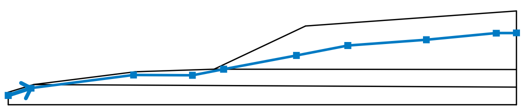
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.28	8.99	1.55	49.32	6.76
		72.50	6.64	84.80	9.01	113.42	14.45
		133.65	18.35	164.52	20.60	192.08	23.20
		200.00	23.32				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters								
Center :	x =	31.72	[m]	Angles :	α_1 =	-19.28	[°]
	z =	73.20	[m]		α_2 =	31.11	[°]
Radius :	R =	75.37	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 959.69 kN/m

Sum of passive forces : F_p = 878.89 kN/m

Sliding moment : M_a = 72331.84 kNm/m

Resisting moment : M_p = 66242.21 kNm/m

Utilization : 109.2 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 711.91 kN/m

Sum of passive forces : F_p = 746.52 kN/m

Sliding moment : M_a = 53656.30 kNm/m

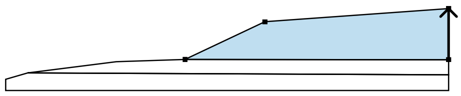
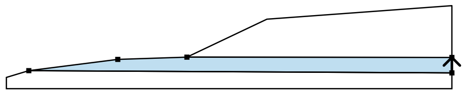
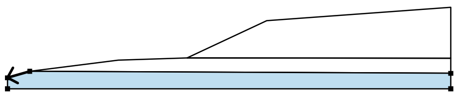
Resisting moment : M_p = 56265.51 kNm/m

Utilization : 95.4 %

Slope stability ACCEPTABLE

Input data (Stage of construction 4)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Surcharge

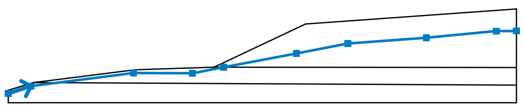
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.28	8.99	1.55	49.32	6.76
		72.50	6.64	84.80	9.01	113.42	14.45
		133.65	18.35	164.52	20.60	192.08	23.20
		200.00	23.32				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 4)

Analysis 1 (stage 4)

Circular slip surface

Slip surface parameters							
Center :	x =	42.04	[m]	Angles :	α_1 =	-16.34	[°]
	z =	129.54	[m]		α_2 =	39.70	[°]
Radius :	R =	133.59	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 4492.36 kN/m
Sum of passive forces : F_p = 3049.04 kN/m

Sliding moment : M_a = 600134.04 kNm/m
Resisting moment : M_p = 407320.83 kNm/m
Utilization : 147.3 %

Slope stability NOT ACCEPTABLE

Combination 2

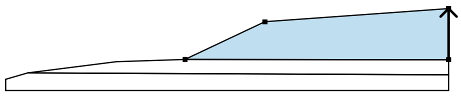
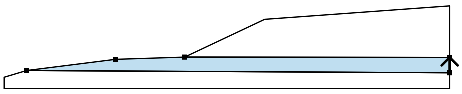
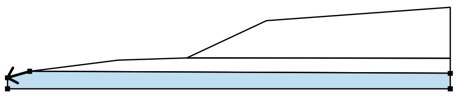
Sum of active forces : F_a = 3380.17 kN/m
Sum of passive forces : F_p = 2354.59 kN/m

Sliding moment : M_a = 451556.89 kNm/m
Resisting moment : M_p = 314549.88 kNm/m
Utilization : 143.6 %

Slope stability NOT ACCEPTABLE

Input data (Stage of construction 5)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00 117.00	8.94 26.00	200.00 81.00	32.00 9.00	Stiff CLAY (Bembridge Marls in slope)
2		200.00 81.00 10.00	2.03 9.00 3.00	200.00 50.00	8.94 8.00	Firm CLAY, possibly disturbed
3		10.00 0.00 200.00	3.00 -5.00 2.03	0.00 200.00	0.00 -5.00	Stiff CLAY, (Osborne Beds)

Surcharge

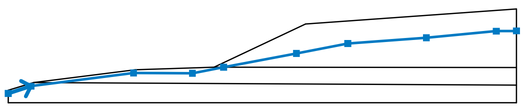
No.	Surcharge new	change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.28	8.99	1.55	49.32	6.76
		72.50	6.64	84.80	9.01	113.42	14.45
		133.65	18.35	164.52	20.60	192.08	23.20
		200.00	23.32				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 5)

Analysis 1 (stage 5)

Circular slip surface

Slip surface parameters							
Center :	x =	81.66	[m]	Angles :	α_1 =	0.24	[°]
	z =	66.36	[m]		α_2 =	45.39	[°]
Radius :	R =	56.94	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 1568.35 kN/m
Sum of passive forces : F_p = 1041.61 kN/m

Sliding moment : M_a = 89297.72 kNm/m
Resisting moment : M_p = 59306.85 kNm/m
Utilization : 150.6 %

Slope stability NOT ACCEPTABLE

Combination 2

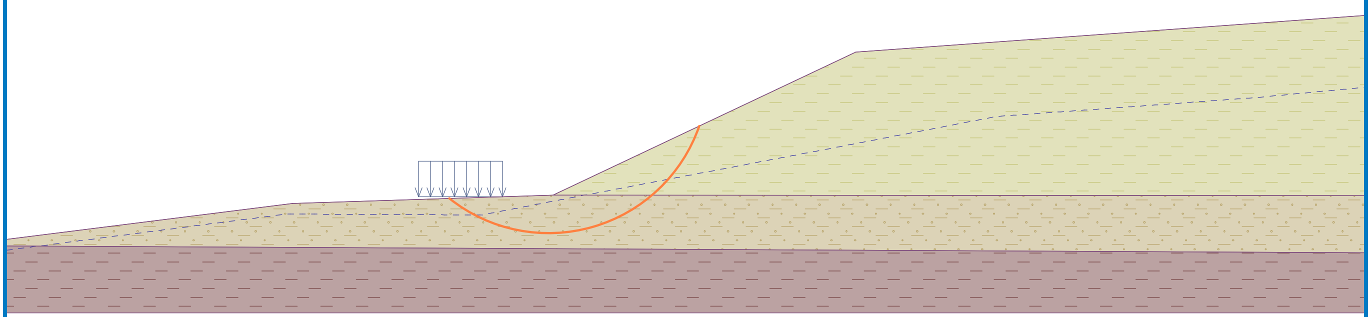
Sum of active forces : F_a = 1206.00 kN/m
Sum of passive forces : F_p = 674.28 kN/m

Sliding moment : M_a = 68666.59 kNm/m
Resisting moment : M_p = 38391.65 kNm/m
Utilization : 178.9 %

Slope stability NOT ACCEPTABLE

Annexes

Name :	Stage - analysis : 1 - 1



Stiff CLAY (Bembridge Marls in slope)

Firm CLAY, possibly disturbed

Stiff CLAY, (Osborne Beds)

Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 775.96 kN/m

Sum of passive forces : F_p = 579.65 kN/m

Sliding moment : M_a = 14735.42 kNm/m

Resisting moment : M_p = 11007.57 kNm/m

Utilization : 133.9 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 536.59 kN/m

Sum of passive forces : F_p = 421.41 kN/m

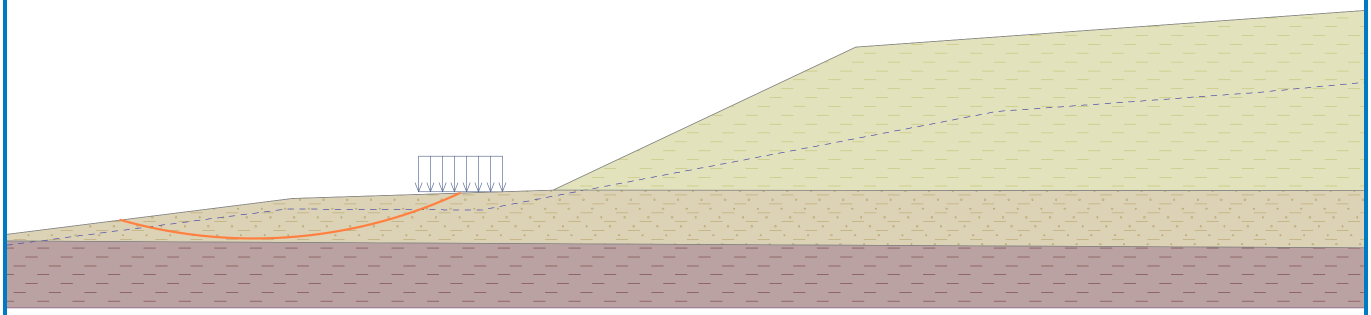
Sliding moment : M_a = 10189.80 kNm/m

Resisting moment : M_p = 8002.50 kNm/m

Utilization : 127.3 %

Slope stability NOT ACCEPTABLE

Name :	Stage - analysis : 2 - 1



Stiff CLAY (Bembridge Marls in slope)

Firm CLAY, possibly disturbed

Stiff CLAY, (Osborne Beds)

Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 244.07 kN/m
Sum of passive forces : F_p = 388.44 kN/m

Sliding moment : M_a = 14231.54 kNm/m
Resisting moment : M_p = 22650.12 kNm/m
Utilization : 62.8 %

Slope stability ACCEPTABLE

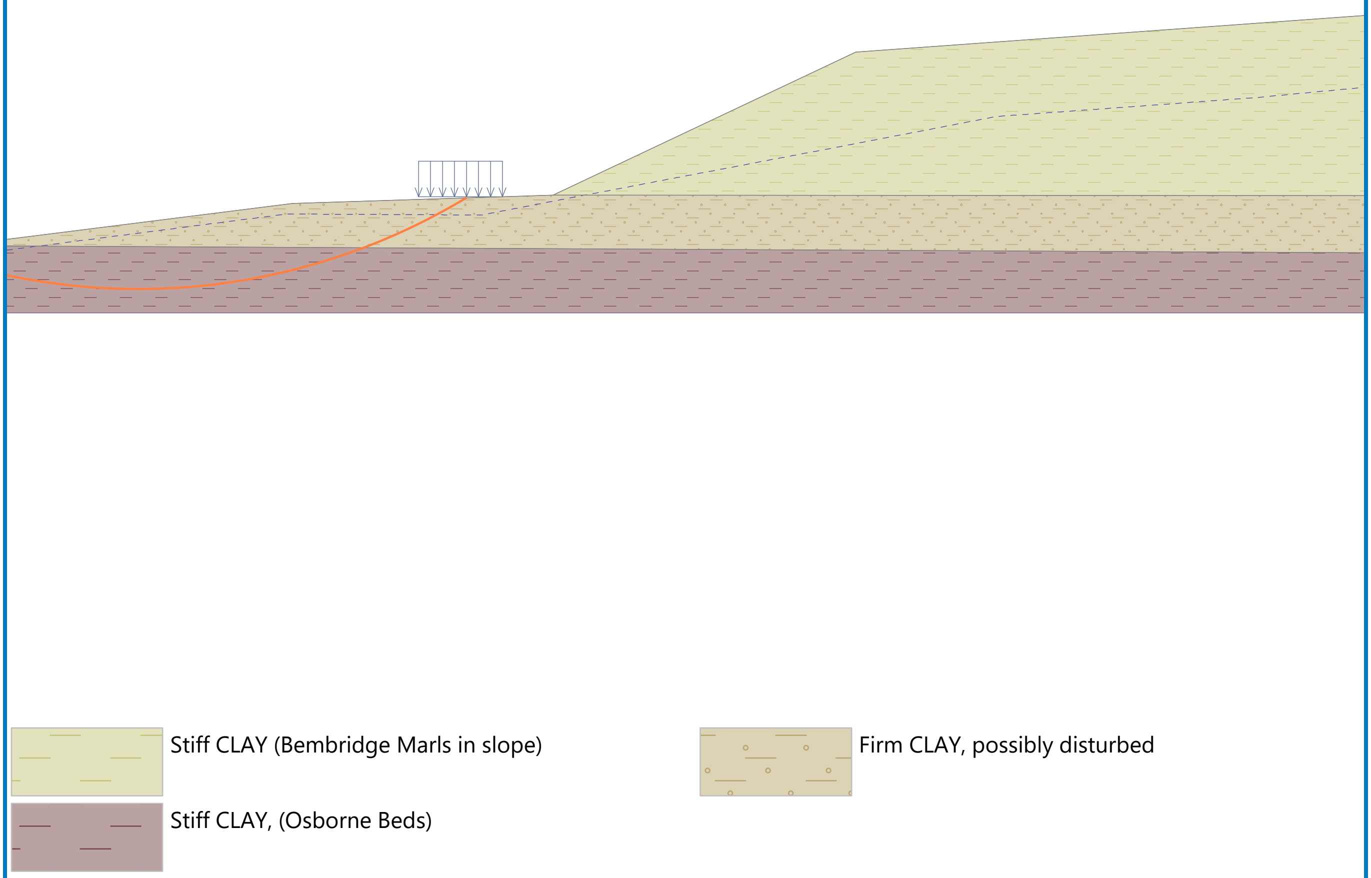
Combination 2

Sum of active forces : F_a = 197.06 kN/m
Sum of passive forces : F_p = 329.05 kN/m

Sliding moment : M_a = 11490.50 kNm/m
Resisting moment : M_p = 19187.10 kNm/m
Utilization : 59.9 %

Slope stability ACCEPTABLE

Name :	Stage - analysis : 3 - 1



Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 959.69 kN/m

Sum of passive forces : F_p = 878.89 kN/m

Sliding moment : M_a = 72331.84 kNm/m

Resisting moment : M_p = 66242.21 kNm/m

Utilization : 109.2 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 711.91 kN/m

Sum of passive forces : F_p = 746.52 kN/m

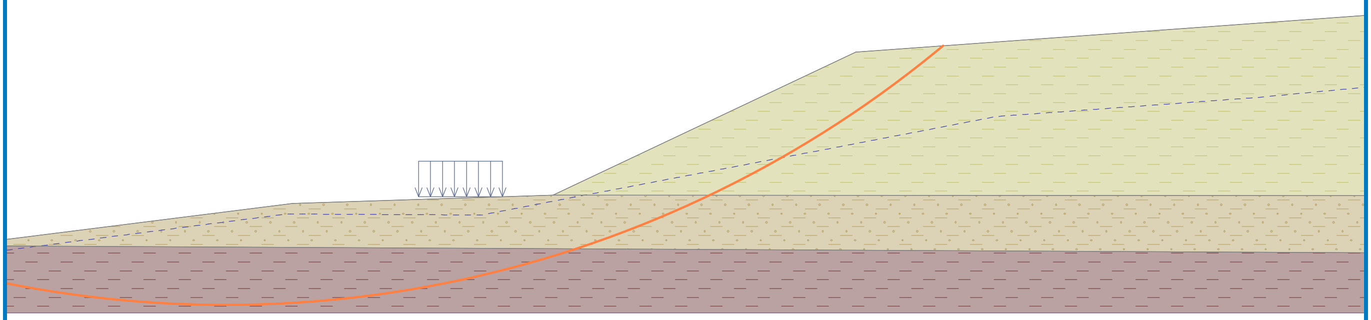
Sliding moment : M_a = 53656.30 kNm/m

Resisting moment : M_p = 56265.51 kNm/m

Utilization : 95.4 %

Slope stability ACCEPTABLE

Name : | **Stage - analysis : 4 - 1**



Stiff CLAY (Bembridge Marls in slope)

Firm CLAY, possibly disturbed

Stiff CLAY, (Osborne Beds)

Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 4492.36 kN/m

Sum of passive forces : F_p = 3049.04 kN/m

Sliding moment : M_a = 600134.04 kNm/m

Resisting moment : M_p = 407320.83 kNm/m

Utilization : 147.3 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 3380.17 kN/m

Sum of passive forces : F_p = 2354.59 kN/m

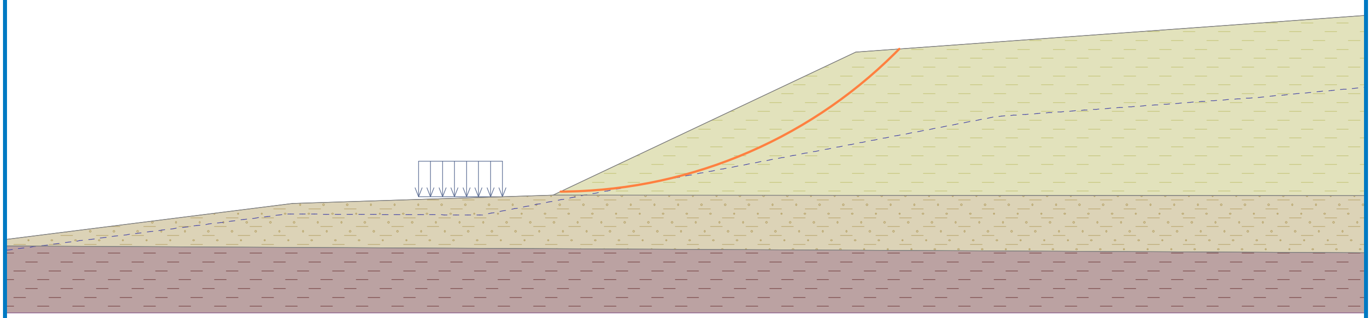
Sliding moment : M_a = 451556.89 kNm/m

Resisting moment : M_p = 314549.88 kNm/m

Utilization : 143.6 %

Slope stability NOT ACCEPTABLE

Name : **Stage - analysis : 5 - 1**



Stiff CLAY (Bembridge Marls in slope)

Firm CLAY, possibly disturbed

Stiff CLAY, (Osborne Beds)

Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 1570.38 kN/m

Sum of passive forces : F_p = 1043.09 kN/m

Sliding moment : M_a = 89417.62 kNm/m

Resisting moment : M_p = 59393.31 kNm/m

Utilization : 150.6 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 1207.58 kN/m

Sum of passive forces : F_p = 675.27 kN/m

Sliding moment : M_a = 68759.49 kNm/m

Resisting moment : M_p = 38449.61 kNm/m

Utilization : 178.8 %

Slope stability NOT ACCEPTABLE

Slope stability analysis

Input data

Project

Task : Preliminary Analyses
Description : Piles asdded to stabilise Proposed Site
Date : 21/04/2021
Project ID : 8 Princes Esplanade Gurnard
Project number : 21C036 (DG798)

Settings

United Kingdom - EN 1997

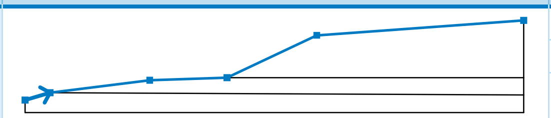
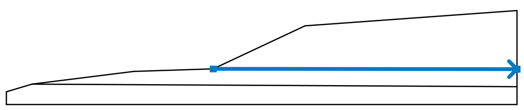
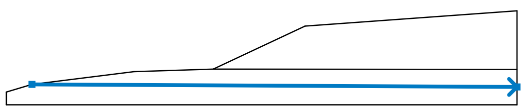
Stability analysis

Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)					
Permanent design situation					
		Combination 1		Combination 2	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions :	γ_G =	1.35 [–]	1.00 [–]	1.00 [–]	1.00 [–]
Variable actions :	γ_Q =	1.50 [–]	0.00 [–]	1.30 [–]	0.00 [–]
Water load :	γ_w =	1.35 [–]		1.00 [–]	

Partial factors for soil parameters (M)			
Permanent design situation			
		Combination 1	Combination 2
Partial factor on internal friction :	γ_ϕ =	1.00 [–]	1.25 [–]
Partial factor on effective cohesion :	γ_c =	1.00 [–]	1.25 [–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00 [–]	1.40 [–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	10.00	3.00	50.00	8.00
		81.00	9.00	117.00	26.00	200.00	32.00
2		81.00	9.00	200.00	8.94		
3		10.00	3.00	200.00	2.03		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Stiff CLAY (Bembridge Marls in slope)		16.00	0.05	19.00
2	Firm CLAY, possibly disturbed		14.00	0.00	19.00
3	Stiff CLAY, (Osborne Beds)		12.00	0.00	19.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Stiff CLAY (Bembridge Marls in slope)		19.00		
2	Firm CLAY, possibly disturbed		19.00		
3	Stiff CLAY, (Osborne Beds)		19.00		

Soil parameters

Stiff CLAY (Bembridge Marls in slope)

Unit weight :	γ =	19.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	16.00 °
Cohesion of soil :	c_{ef} =	0.05 kPa
Saturated unit weight :	γ_{sat} =	19.00 kN/m^3

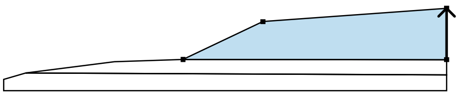
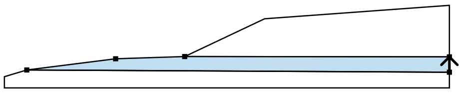
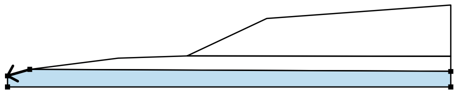
Firm CLAY, possibly disturbed

Unit weight :	γ =	19.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	14.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	19.00 kN/m^3

Stiff CLAY, (Osborne Beds)

Unit weight :	γ =	19.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	12.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	19.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Anti-Slide piles

No.	Point		Length	Pile spacing	Cross-section	Pile bearing capacity			
	x [m]	z [m]	l [m]	b [m]	[m]	Distribution along the pile	Max. bearing capacity V_u [kN]	Gradient K [–]	Passive force direction
1	65.39	8.50	15.00	1.50	d = 0.40	linear	1500.00	0.50	perpendicular to pile
2	75.00	8.78	15.00	1.50	d = 0.50	linear	1500.00	0.50	perpendicular to pile

Surcharge

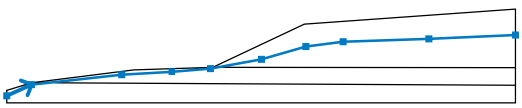
No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-2.22	9.79	2.26	45.24	6.11
		64.94	7.32	80.09	8.54	100.09	12.17
		117.66	17.17	132.20	19.14	165.99	20.20
		200.00	21.72				

Tensile crack
Tensile crack not input.

Earthquake
Earthquake not included.

Settings of the stage of construction
Design situation : permanent

Results (Stage of construction 1)

Analysis 1 (stage 1)
Circular slip surface

Slip surface parameters							
Center :	x =	70.81	[m]	Angles :	α_1 =	-26.66	[°]
	z =	62.73	[m]		α_2 =	54.18	[°]
Radius :	R =	62.24	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)
Combination 1
Sum of active forces : F_a = 3481.54 kN/m
Sum of passive forces : F_p = 4145.14 kN/m
Sliding moment : M_a = 216691.15 kNm/m
Resisting moment : M_p = 257993.67 kNm/m
Utilization : 84.0 %

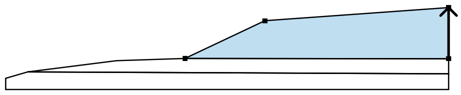
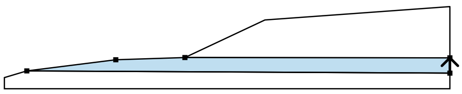
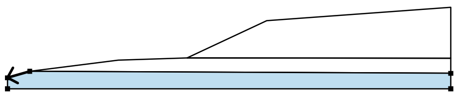
Slope stability ACCEPTABLE
Combination 2
Sum of active forces : F_a = 2489.23 kN/m
Sum of passive forces : F_p = 3485.03 kN/m
Sliding moment : M_a = 154929.48 kNm/m
Resisting moment : M_p = 216908.32 kNm/m
Utilization : 71.4 %

Slope stability ACCEPTABLE

Piles verification 1 (stage 1)
Anti-Slide pile : Anti-Slide Pile No. 1 (65.39; 8.50 [m])
Analysis : Calculation 1 (slip surface circular)
Method : Bishop

Input data (Stage of construction 2)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Anti-Slide piles

No.	Anti-Slide pile new	Point x [m]	z [m]	Length l [m]	Pile spacing b [m]	Cross-section [m]	Pile bearing capacity: Distribution along the pile	Max. bearing capacity V_u [kN]	Gradient K [–]	Passive force direction
1	No	65.39	8.50	15.00	1.50	d = 0.40	linear	1500.00	0.50	perpendicular to pile
2	No	75.00	8.78	15.00	1.50	d = 0.50	linear	1500.00	0.50	perpendicular to pile

Surcharge

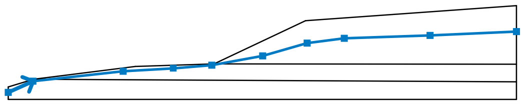
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m^2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-2.22	9.79	2.26	45.24	6.11
		64.94	7.32	80.09	8.54	100.09	12.17
		117.66	17.17	132.20	19.14	165.99	20.20
		200.00	21.72				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

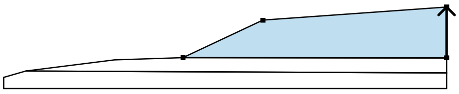
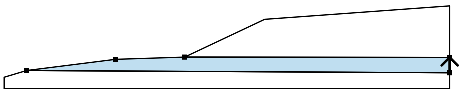
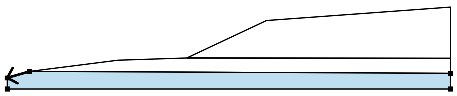
Slip surface parameters								
Center :	x =	45.40	[m]	Angles :	α_1 =	-15.79	[°]	
	z =	61.55	[m]		α_2 =	24.85	[°]	
Radius :	R =	58.31	[m]					
Specified slip surface.								

Slope stability verification (Bishop)

Analysis has not been performed.

Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Anti-Slide piles

No.	Anti-Slide pile new	Point x [m]	z [m]	Length l [m]	Pile spacing b [m]	Cross-section [m]	Pile bearing capacity: Distribution along the pile	Max. bearing capacity V_u [kN]	Gradient K [–]	Passive force direction
1	No	65.39	8.50	15.00	1.50	d = 0.40	linear	1500.00	0.50	perpendicular to pile
2	No	75.00	8.78	15.00	1.50	d = 0.50	linear	1500.00	0.50	perpendicular to pile

Surcharge

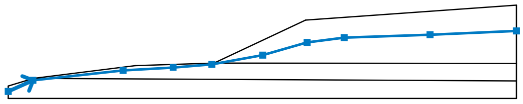
No.	Surcharge new	change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-2.22	9.79	2.26	45.24	6.11
		64.94	7.32	80.09	8.54	100.09	12.17
		117.66	17.17	132.20	19.14	165.99	20.20
		200.00	21.72				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

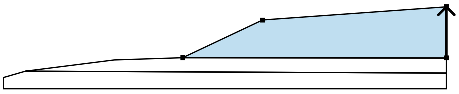
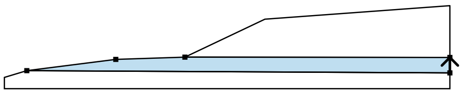
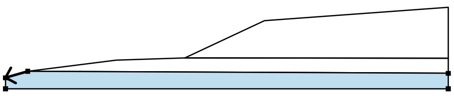
Slip surface parameters								
Center :	x =	31.72	[m]	Angles :	α_1 =	-19.28	[°]
	z =	73.20	[m]		α_2 =	31.11	[°]
Radius :	R =	75.37	[m]				
Specified slip surface.							

Slope stability verification (Bishop)

Analysis has not been performed.

Input data (Stage of construction 4)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		200.00	8.94	200.00	32.00	Stiff CLAY (Bembridge Marls in slope)
		117.00	26.00	81.00	9.00	
2		200.00	2.03	200.00	8.94	Firm CLAY, possibly disturbed
		81.00	9.00	50.00	8.00	
		10.00	3.00			
3		10.00	3.00	0.00	0.00	Stiff CLAY, (Osborne Beds)
		0.00	-5.00	200.00	-5.00	
		200.00	2.03			

Anti-Slide piles

No.	ti-Slide pile new	Point x [m]	z [m]	Length l [m]	Pile spacing b [m]	Cross-section [m]	Pile bearing capacity istributio along the pile	Max. bearing capacity V_u [kN]	Gradient K [–]	Passive force direction
1	No	65.39	8.50	15.00	1.50	d = 0.40	linear	1500.00	0.50	perpendicular to pile
2	No	75.00	8.78	15.00	1.50	d = 0.50	linear	1500.00	0.50	perpendicular to pile

Surcharge

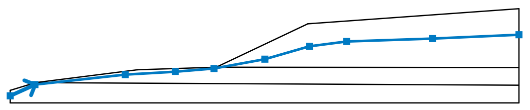
No.	Surcharge new	change	Type	Type of action	ocatior z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	No	No	strip	permanent	on terrain	x = 65.00	l = 10.00		0.00	15.00		kN/m2

Surcharges

No.	Name
1	Existing Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-2.22	9.79	2.26	45.24	6.11
		64.94	7.32	80.09	8.54	100.09	12.17
		117.66	17.17	132.20	19.14	165.99	20.20
		200.00	21.72				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 4)

Analysis 1 (stage 4)

Circular slip surface

Slip surface parameters							
Center :	x =	63.15	[m]	Angles :	α_1 =	-17.17	[°]
	z =	186.45	[m]		α_2 =	36.11	[°]
Radius :	R =	193.23	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 11237.61 kN/m
Sum of passive forces : F_p = 7354.30 kN/m

Sliding moment : M_a = 2171485.69 kNm/m
Resisting moment : M_p = 1421099.05 kNm/m
Utilization : 152.8 %

Slope stability NOT ACCEPTABLE

Combination 2

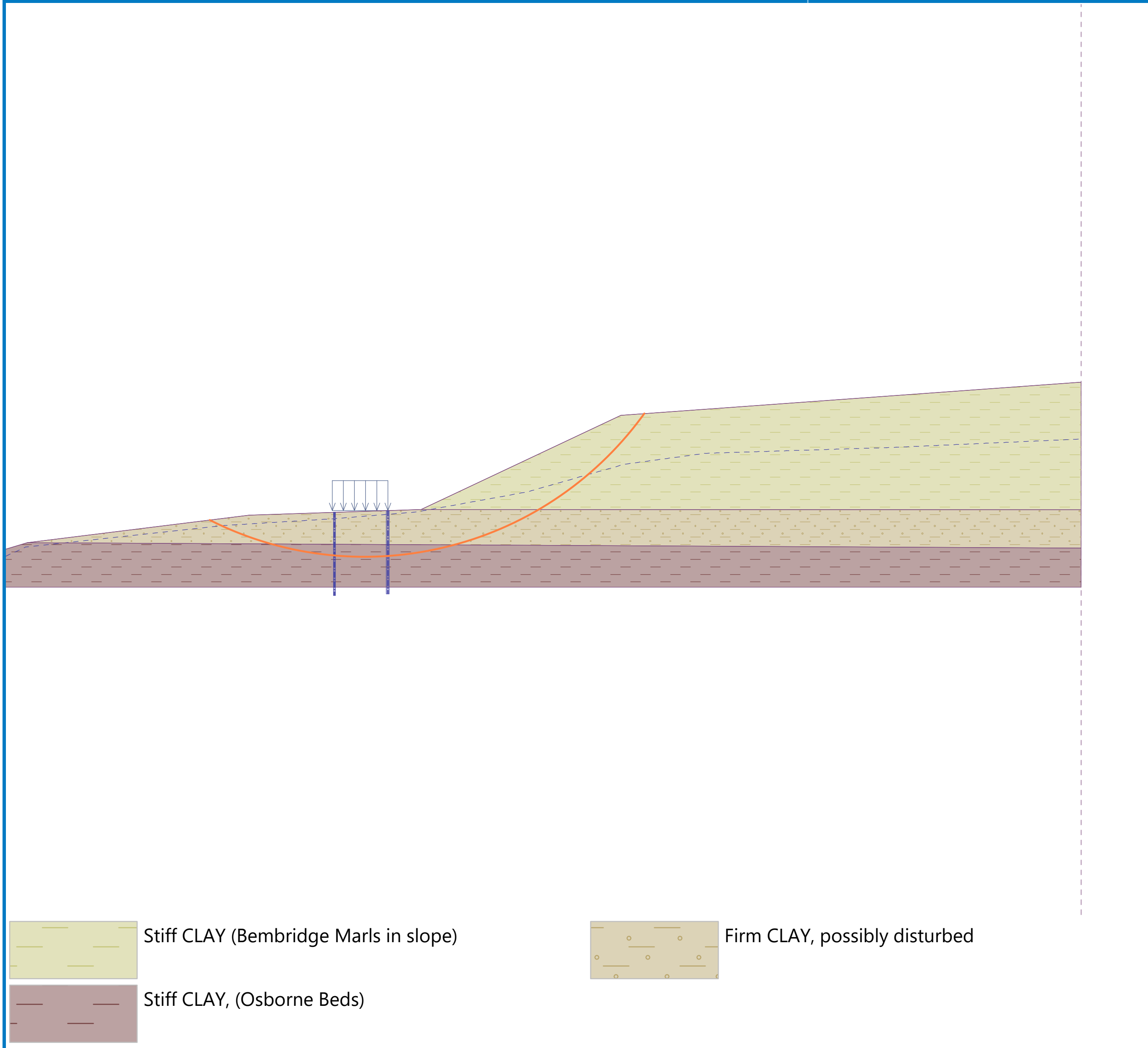
Sum of active forces : F_a = 8329.39 kN/m
Sum of passive forces : F_p = 5451.53 kN/m

Sliding moment : M_a = 1609520.52 kNm/m
Resisting moment : M_p = 1053419.53 kNm/m
Utilization : 152.8 %

Slope stability NOT ACCEPTABLE

Annexes

Name :	Stage - analysis : 1 - 1



Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 3481.54 kN/m
Sum of passive forces : F_p = 4145.14 kN/m

Sliding moment : M_a = 216691.15 kNm/m
Resisting moment : M_p = 257993.67 kNm/m
Utilization : 84.0 %

Slope stability ACCEPTABLE

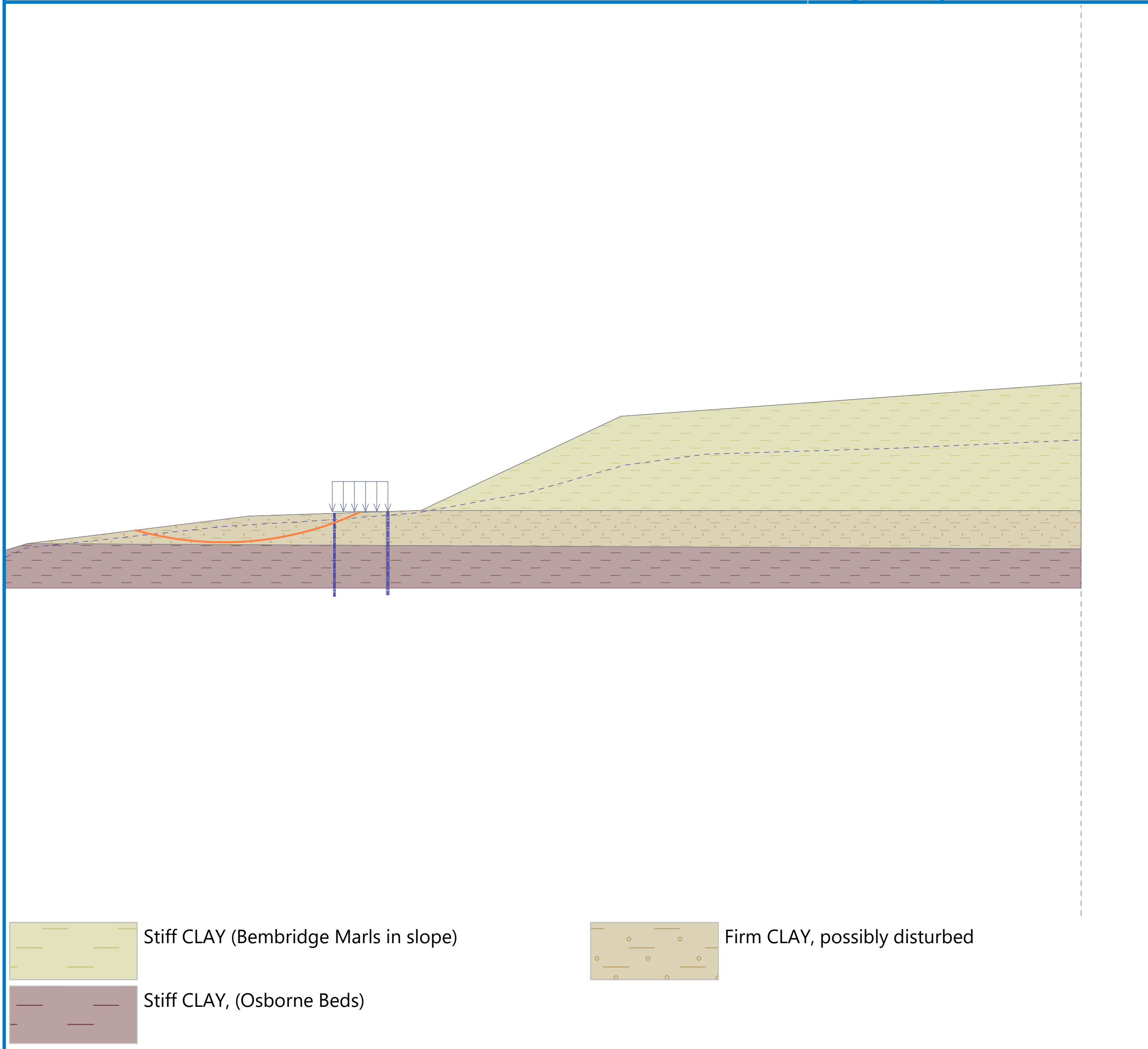
Combination 2

Sum of active forces : F_a = 2489.23 kN/m
Sum of passive forces : F_p = 3485.03 kN/m

Sliding moment : M_a = 154929.48 kNm/m
Resisting moment : M_p = 216908.32 kNm/m
Utilization : 71.4 %

Slope stability ACCEPTABLE

Name : | **Stage - analysis : 2 - 1**



Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 244.08 kN/m
Sum of passive forces : F_p = 1326.21 kN/m

Sliding moment : M_a = 14232.12 kNm/m
Resisting moment : M_p = 77331.59 kNm/m
Utilization : 18.4 %

Slope stability ACCEPTABLE

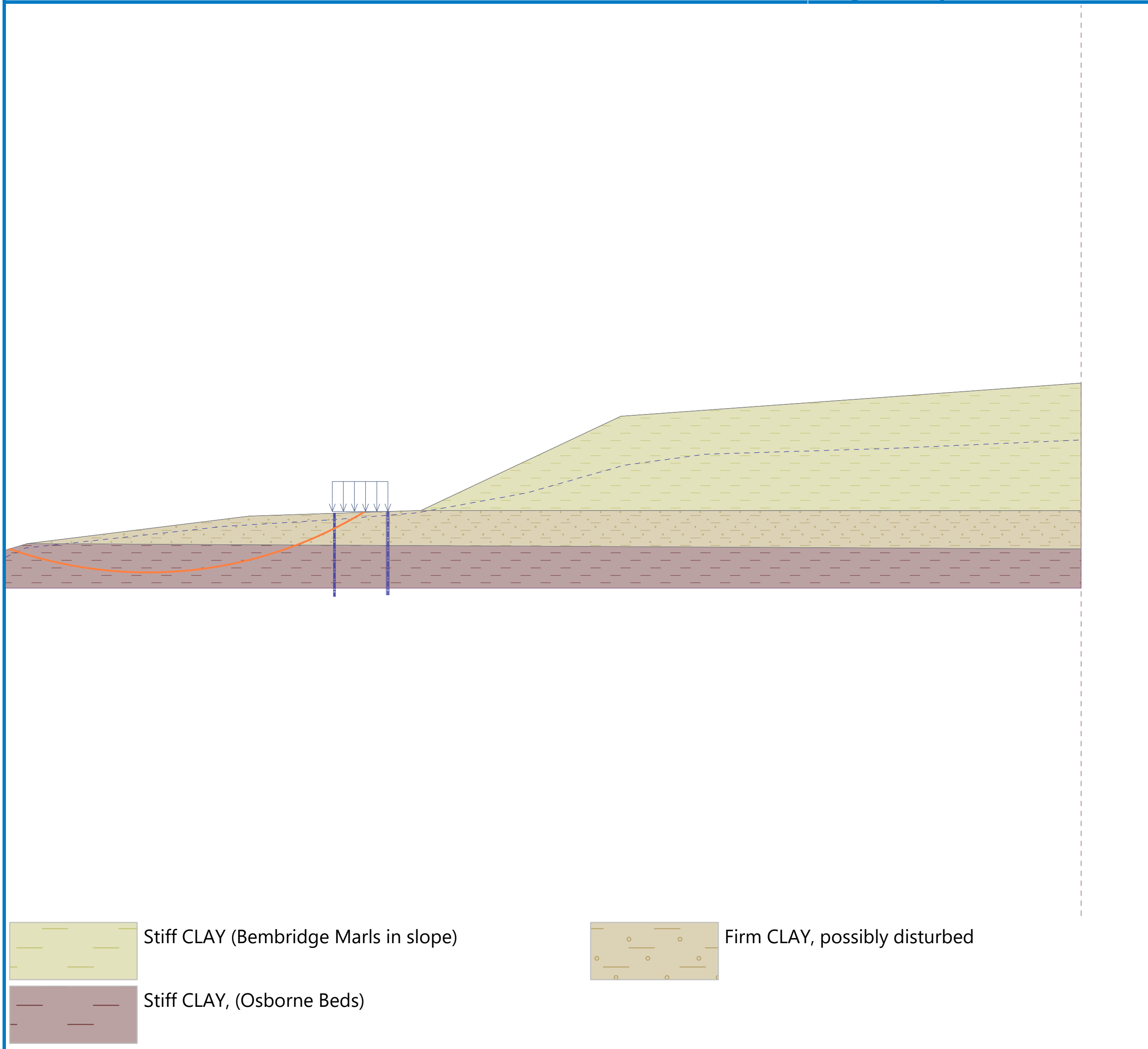
Combination 2

Sum of active forces : F_a = 197.07 kN/m
Sum of passive forces : F_p = 1267.10 kN/m

Sliding moment : M_a = 11490.92 kNm/m
Resisting moment : M_p = 73884.59 kNm/m
Utilization : 15.6 %

Slope stability ACCEPTABLE

Name :	Stage - analysis : 3 - 1



Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 959.73 kN/m

Sum of passive forces : F_p = 1749.40 kN/m

Sliding moment : M_a = 72335.13 kNm/m

Resisting moment : M_p = 131852.00 kNm/m

Utilization : 54.9 %

Slope stability ACCEPTABLE

Combination 2

Sum of active forces : F_a = 711.94 kN/m

Sum of passive forces : F_p = 1624.54 kN/m

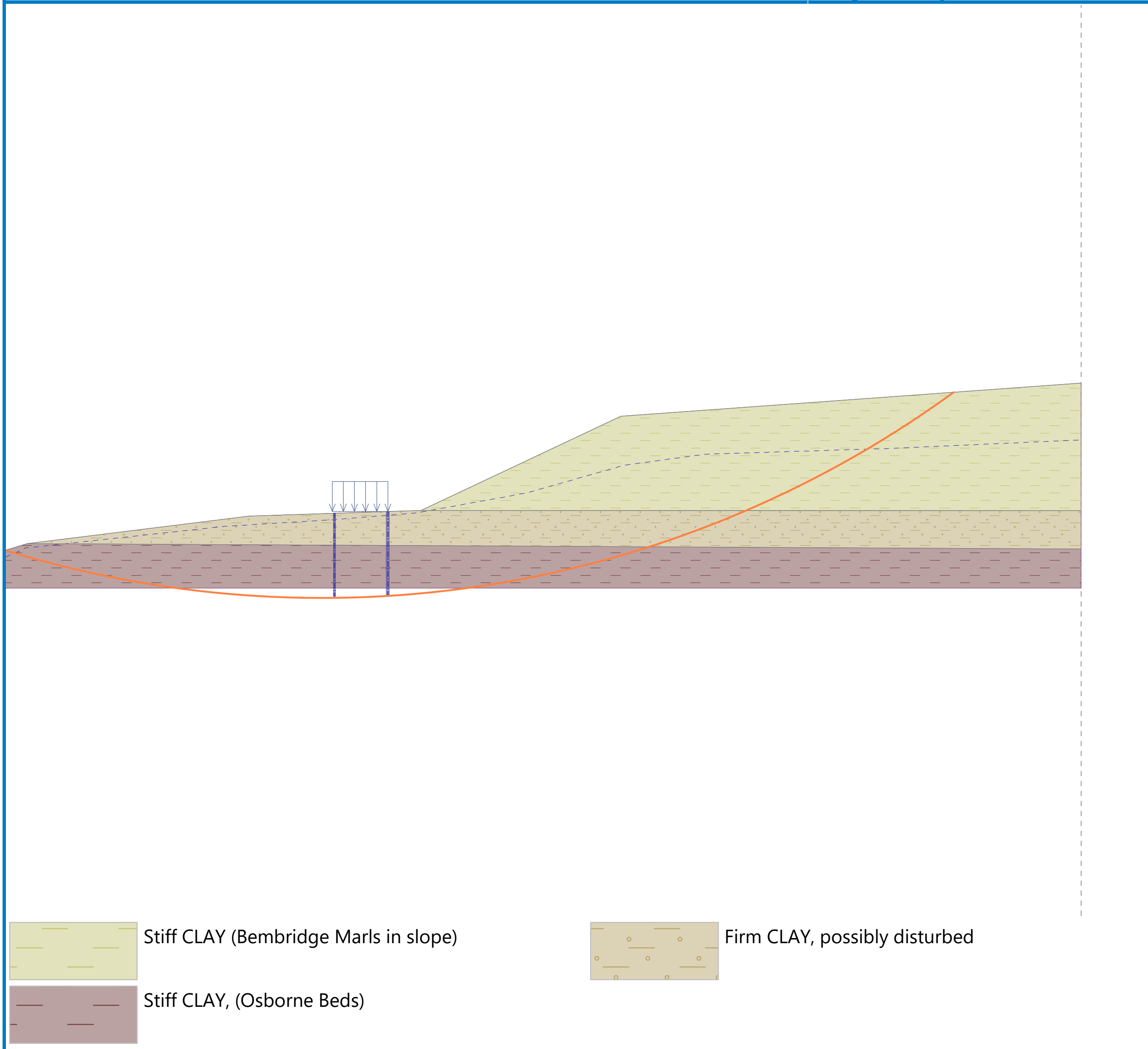
Sliding moment : M_a = 53658.73 kNm/m

Resisting moment : M_p = 122441.92 kNm/m

Utilization : 43.8 %

Slope stability ACCEPTABLE

Name : | **Stage - analysis : 4 - 1**



Analysis of the slip surface without optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 11237.92 kN/m
Sum of passive forces : F_p = 7350.51 kN/m

Sliding moment : M_a = 2171502.98 kNm/m
Resisting moment : M_p = 1420339.39 kNm/m
Utilization : 152.9 %

Slope stability NOT ACCEPTABLE

Combination 2

Sum of active forces : F_a = 8329.60 kN/m
Sum of passive forces : F_p = 5449.36 kN/m

Sliding moment : M_a = 1609529.47 kNm/m
Resisting moment : M_p = 1052980.04 kNm/m
Utilization : 152.9 %

Slope stability NOT ACCEPTABLE