Rail Central, Milton Malsor, Northamptonshire

Main Strategic Rail Freight Interchange

Conceptual Geotechnical Design

for

ASHFIELD LAND

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1.0 INTRODUCTION

Ashfield Land is planning the development of a Strategic Rail Freight Interchange (SRFI) on land to the south of the village of Milton Malsor, Northamptonshire. The development is known as Rail Central. Hydrock drawing 151171/D001 shows the site location and Michael Sparks Associates drawing 30708-FE-96A shows the Illustrative Masterplan.

Development proposals include the demolition of the majority of the buildings and cut to fill and regrade in order to construct level plateaux to accommodate the proposed buildings, cuttings and embankments for the infrastructure elements. The development will necessitate the construction of a new junction on the A43, an underpass beneath the existing road between Milton Malsor and Blisworth, and realignment of a number of junctions on the road network in the wider area.

Background information, the findings of the ground investigation and other relevant documents are presented in the following Hydrock reports:

- Hydrock Consultants. April 2015, updated July 2017. Rail Central, Milton Malsor, Northamptonshire. Desk Study Report – Main SRFI Site. Reference R/151171/001 Issue 8.
- Hydrock Consultants. May 2017, updated July 2017. Rail Central, Milton Malsor, Northamptonshire. Ground Investigation Report – Main SRFI site. Reference R/151171/002 Issue 4.
- Hydrock Consultants. July 2017. Rail Central, Milton Malsor. Ground Conditions Desk Study for M1 Junction 15A Improvements. Reference R/151171/003 Issue 2.

This GDR has been prepared to provide an outline proof of concept for geotechnics and earthworks at the site, such that detailed designs for the various elements can be prepared. The report has been prepared for Ashfield Land for the purposes of preparing the site for the proposed Strategic Rail Freight Interchange. The GDR has been written in accordance with the requirements of DMRB HD 22/08 Managing Geotechnical Risk and follows the general formulaic approach of that document. This GDR specifically covers the cut and fill earthworks associated with the development as shown on the drawings in Annex A.

BS EN ISO 1997: Eurocode 7, Section 2 advocates the use of geotechnical categorization of the proposed structures to establish the design requirements. For the purposes of the GDR the proposed earthworks associated with the have been determined to be Category 2.

It should be noted that further investigations will be required to allow designs to be finalised.

2.0 EARTHWORKS

2.1 Introduction

The current earthworks model is shown on RPS drawing NK018318-RPS-00-XX-DR-C-SK0009. The earthworks will involve the placement of approximately 1,330,000m^3 of material to form the development platforms. In addition, a surplus of approximately 100,000m^3 of material (comprising anthropogenic Made Ground and natural soil) and 360,000m^3 of topsoil will be generated that is to be used to construct vision and noise bunds along the northern edge of the development to screen Milton Malsor village from the development.

The ground investigation (Hydrock report R/151171/002 Issue 4) has identified the soils present in the various areas of the site. The great majority of the earthworks will be undertaken with material derived from Whitby Mudstone, with smaller volumes of Made Ground and naturally derived Alluvium, Glaciofluvial sand, Glacial Till, Marlstone Rock and Dyrham Formation soils present in cut areas in places.

2.2 Slope Stability

The development will necessitate construction of slopes for cuttings and embankments. A series of slope angles have been derived for the various soils present on site, included engineered earthworks material.

2.2.1 Methods of Analysis

In accordance with BS EN 1997 (EC 7), the UK has adopted Design Approach 1, which comprises the reduction of actions and soil parameters using Combination 1 and 2 (DA1/1 and DA1/2) for STR and GEO Limit States. This approach has been used for geotechnical analysis in accordance with definitions and methodology specified in EC 7.

All geotechnical and geostructural analysis undertaken as part of the assessment of slope stability has been completed using the FINE GEO5 Geostructural Software Suite 2017. The complete software suite allows the user to preselect the method of analysis, design approach and geotechnical parameters and presents the findings as a complete report for each analysis undertaken along with a drawing of the model under assessment.

2.1.2 Soil Parameters

The soil parameters used in the assessment of the slope stability are based upon the findings and recommendations of the ground investigation report presented as Hydrock Report R/151171/002 Issue 4.

On the basis of the encountered geology summarised in the ground investigation report, records presented at Annex B, and the requirements from Table 6/1, a set of geotechnical design characteristic values have been determined for each stratum to be used in the slope stability assessment. This information is summarised in Table 2.1.

Table 2.1: Design Parameters and Characteristic Values

Stratum Description	**Parameter**						
	Bulk Unit Weight	Undrained cohesion	Drained Cohesion	Effective Angle of Internal Friction	Drained Modulus	Modulus of subgrade Reaction	Source of Parameter – Measured and derived
	γ_b kN/m³	c_u kN/m²	c′ kN/m²	φ′ º	E_{oed} MN/m²	k MN/m²/m	
Topsoil / Landscaping	17.00	40	0	24	4	21	BS 8002
Made Ground (Rathvilly Farm pit)	18	-	0	29	6	30	Measured
Made Ground (Roade Cutting)	19.50	50	0	24	5	27	Measured and BS 8002
Alluvium	18.50	35	0	22	3.5	19	Measured
Glaciofluvial Deposits	19.00	-	0	33	18	52	Measured
Glacial Till	19.50	85	2	25	8	45	Measured
Whitby Mudstone	20.00	100	5	22	12.5	52	Measured
Whitby Mudstone (residual strength)	20.00	100	2	10	-	-	Measured
Marlstone Rock	21.00	130	5	30	11	68	Measured
Dyrham Formation	20.00	90	5	28	10	47	Measured
Class 1 General Fill	20.50	-	0	36	15	55	Minimum performance requirements (Table 2.3) Remoulded CBR tests
Class 2 General Fill	19.50	50	0	25	8.5	27	
Class 6 – Selected Fill 6F capping 6N/6P fill to structures	21.00	-	0	38	40	75	
Class 7A – Site won cohesive fill below structures	21.00	80	5	27	12.5	42	

In addition to being used in the slope stability analysis, the geotechnical design parameters defined in Table 2.1 have been adopted for the other subsequent analysis, including the prediction of settlement resulting from changes in imposed load.

2.2.2 Drainage Characteristics

Detailed drainage design is to be presented under a separate cover. Generally drainage is to be to surface waters with basin to provide attenuation.

Overall the soils on site are of low permeability and the majority of precipitation is anticipated to runoff the site to the Milton Malsor Brook. Groundwater is present within more permeable deposits within the Alluvium, Marlstone Rock and Dyrham Formation which is continuous with the Milton Malsor Brook. In particular, the Marlstone Rock is likely to be confined between impermeable clays and therefore may contain water under sub-artesian pressure.

The ground investigation has identified areas where the proposed cut is likely to extend below the inferred groundwater table. In the long term, decreased infiltration and the installation of the permanent drainage should lower the groundwater table. The potential for elevated pore water pressures to occur during excavation in cut areas will need to be considered in the design of slopes and drainage for temporary works.

2.2.3 Slope Angles

Analysis of indicative slope angles for the various soil types on site has been undertaken, using the software package listed in Section 2.1.1, and the geotechnical design parameters and characteristic values defined in Table 2.1 A summary of the assessment is provided in Table 2.2.

Table 2.2 Assessment of Indicative Slope Angles

Stratum	Height (m)	Slope Angle (1:x) (v:h)	Degree of Utilisation (%)		Comments
			Circular Failure	Non-circular Failure	
Topsoil / landscaping	14	3.50	116.4	115.7	Approximate maximum bund height Pore pressure ratio r_u of 0.3 Shallow seated failure excluded
Glaciofluvial Deposits	3	3.00	91.7	91.8	Approximate maximum cut depth in Glaciofluvial Deposits Pore pressure ratio r_u of 0.3 Shallow seated failure excluded
			62.0	67.4	Approximate maximum cut depth in Glaciofluvial Deposits No pore pressure ratio Shallow seated failure excluded
		2.75	99.8	102.3	Approximate maximum cut depth in Glaciofluvial Deposits Pore pressure ratio r_u of 0.3 Shallow seated failure excluded
			67.4	68.3	Approximate maximum cut depth in Glaciofluvial Deposits No pore pressure ratio, sand therefore free-draining Shallow seated failure excluded

		2.00	94.0	94.4	Approximate maximum cut depth in Glaciofluvial Deposits No pore pressure ratio, sand therefore free-draining Shallow seated failure excluded
		1.75	108.2	111.4	Approximate maximum cut depth in Glaciofluvial Deposits No pore pressure ratio, sand therefore free-draining Shallow seated failure excluded
Glacial Till	3.5	3.00	92.6	92.6	Approximate maximum thickness of Glacial Till in east of site. Pore pressure ratio r_u of 0.3
		2.75	99.4	99.3	
Whitby Mudstone	1.0	1.75	71.0	68.8	Approximate maximum cut of 9.00m anticipated. Generalised relationship between slope height and cotangent of slope angle derived for nominal groundwater conditions assumed by pore pressure ratio. Pore pressure ratio r_u of 0.3 throughout
		1.50	76.0	72.4	
		1.00	90.2	79.8	
		0.75	97.2	83.8	
	2.5	3.00	72.5	71.2	
		2.75	76.0	74.5	
		2.50	80.5	78.4	
		2.00	91.8	87.5	
		1.75	99.2	91.5	
	5	3.00	87.9	86.7	
		2.75	93.6	89.4	
		2.50	100.1	98.3	
	7.5	3.50	86.3	85.8	
		3.25	91.6	91.0	
		3.00	97.5	96.9	
		2.75	104.2	103.0	
	10	3.50	91.6	91.4	
		3.25	97.4	97.1	
		3.00	104.0	103.6	
	15	3.50	98.6	98.4	
		3.40	101.1	100.9	
Class 7A fill	7	3.00	81.5	81.0	Approximate maximum fill height Pore pressure ratio r_u of 0.3
		2.50	94.4	92.9	
		2.25	102.7	99.1	

In assessing the stability model a degree of utilisation of less than 100% is considered acceptable in terms of compliance with the requirements of EC 7.

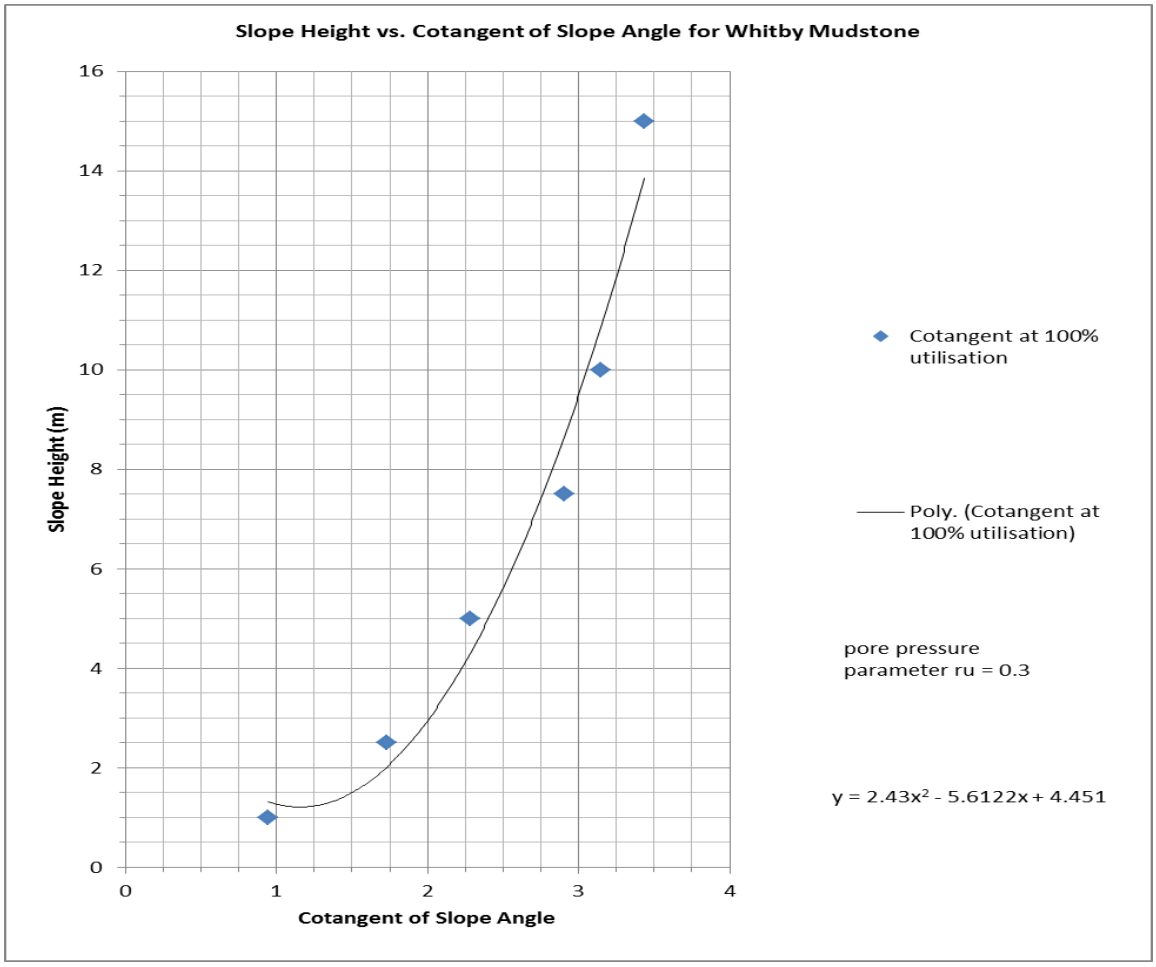
It may be necessary to encapsulate surplus topsoil and chemically unsuitable Made Ground within the screening bunds at the development. Based on a review of the utilisation indicated in Table 2.2, the assessment suggests that, for the maximum proposed height of 14m, the screening bund may not be stable at a slope angle of 1 : 3.5 (v:h) when taking a notional pore water pressure state into

consideration as represented by the r_u value of 0.3. However, it should be noted that the assessment has been undertaken with conservative parameters for topsoil and landscape fill, and it is not likely that a bund of 14m height would be constructed in its entirety from topsoil. It will be necessary to prepare a detailed Geotechnical Design for the screening bunds taking the proposed soils and profile into consideration. The design will need to provide a specification for the placement of landscape fill to ensure that the stability requirements are met in practice. In addition to slope angle, the design will need to consider the significant imposed load (280 kN/m^2) and the bearing capacity of any weak foundation soils such as Made Ground and Alluvium.

As it is anticipated that the majority of cut slopes will be in Whitby Mudstone, an approximate relationship between slope height and slope angle has been derived for the purpose of conceptual design, as shown in Figure 1. Detailed design should take into consideration the soil properties, groundwater conditions and slope heights at the given location. In particular, the use of a pore pressure ratio is not recommended for detailed design and the slope (and drainage) design should consider the specific conditions at the slope section in question.

For all soil strata it will be necessary to topsoil and plant slope faces, or provide other protection to prevent weathering and progressive deterioration of the face due to precipitation.

Figure 1. Relationship between slope height and cotangent of slope angle for Whitby Mudstone



2.3 Settlement

Embankments constructed to accommodate the proposed buildings will undergo settlement, both as self-weight within the fill placed and load induced in the underlying ground. The presence of relatively compressible Alluvium across the western side of the site needs specific consideration.

It is anticipated that the plateaux to accommodate the buildings will be constructed using Class 7A fill derived from the site won Whitby Mudstone. The building foundations will then be supported within the fill material. General Fill (predominantly Class 2) can be used for roads and in external areas where it is appropriate to define the extents of areas of different fill specifications on site.

2.3.1 Self-Weight Settlement

An assessment has been made as to the potential magnitude of self-weight settlement within the engineered fill placed during the enabling works period. A maximum height of earthworks fill of 7.00m which is anticipated at the northern edge of the southeast platform (Units 5, 6 and 7 under current proposals). Using the parameters in Table 2.1 and the following equation presented in BS6031:2009:

Total self-weight settlement = $0.5(\gamma_b \times H^2)/D$

Where

H is the fill height

D is the constrained modulus

A maximum self-weight settlement of 56mm is predicted for Class 2 fill and 41mm for Class 7A fill. Based on the anticipated duration of the earthworks program, and the effect of placing and compacting material in layers, a proportion of the self-weight settlement would occur during the construction process. Monitoring of similar soils on similar sites has returned realistic estimates of between 20 and 40% of self-weight settlement occurring during the construction process. Further to this, after a period of 6 months, the magnitude of self-weight settlement which has already occurred would be in the order of 50%.

Therefore, by assuming the most onerous combination of fill (Class 2 cohesive), and that construction would have been completed within 6 months of the completion of the earthworks, the maximum residual self-weight settlement contribution would be in the order of 25 to 30mm, which should be added to settlement induced by land raising. Where significant settlement is likely to be induced in the underlying deposits, it may be necessary to consider inclusion of drainage layers within the embankment construction in order to accelerate the rate of settlement within the fill placed, such that the overall (self-weight and load induced) settlement remains within the acceptable limit.

For Class 4 (Landscape Fill) in the screening bund, a maximum height of 14m is proposed in northeast corner of the site. Based on the equation above and the parameters in Table 2.1, a total of 400mm self-weight settlement would occur within landscape fill. However, as discussed in relation to the slope stability of the screening bund, this would be applicable to a bund constructed entirely of topsoil which

is not recommended. It is conservatively estimated that 40% of the settlement would occur during construction.

2.3.2 Settlement Due to Land Raising

An assessment of the likely settlement induced in the ground underlying the embankments has been made using the FINE GEO5 settlement program. This software package allows the user to accurately model the change in imposed load. The program employs derivatives of the adjusted elasticity method of settlement predictions and this a recognised method of analysis as per BS EN 1997-1 & 2 (EC 7).

The assessment considers the changes in imposed load from the earthworks and the application of a Uniformly Distributed Load (UDL) from the traffic using the site. In accordance with the guidance from BS 6031 Table 3, a UDL of 10kN/m² has been adopted for the traffic using the site, which includes the load imposed by Heavy Goods Vehicles (HGV).

The assessment of settlement has considered the induced settlement on the underlying natural deposits and includes the contribution from Primary (consolidation) settlement. The effect of the immediate (elastic) settlement has been considered to occur during the earthworks and any subsequent construction period, and as such is not included in the overall assessment on settlement. The assessment of long term secondary creep settlement within the recently placed fill has been undertaken in Section 2.3.4.

Considering the development platform in the southwest corner (Units 11, 12 and 13 under current proposals), based on the findings of the ground investigation, a maximum thickness of approximately 2.00m of Alluvium is present beneath the northeast corner of the embankment, and the proposed land raise is approximately 3.00m in height. The analysis indicates that a settlement in the order of 50mm may occur as a result of the land raise. Clearly this excludes any loading from the building itself and it is envisaged that the Alluvium will have to be removed from beneath the building footprints to prevent excessive settlement of the ground floor slabs. Without removal of the Alluvium, settlement in the order of 80mm to 90mm is predicted, including both from the land raise and a UDL of 50 kN/m^2 applied to represent an industrial ground floor slab.

Taking a coefficient of consolidation (c_v) of between 2.8 and 14.0 m^2/yr as determined from laboratory oedometer testing, and a maximum drainage path length of 2.00m, it would take between 1.2 months and 6 months for 45% of the consolidation settlement to occur, or 2 months using the average c_v value from oedometer tests. Typically actual c_v values are greater than those derived from laboratory tests due to features in the macrostructure that are not considered in small samples. Therefore, it is anticipated that post construction consolidation settlement is likely to be within nominally accepted limits, i.e. less than 25mm.

Where embankments are constructed on the Whitby Mudstone, for the maximum embankment height of 7.0m, a consolidation settlement in the order of 30mm is predicted.

With regard to the screening bund, the maximum proposed height of 14m constructed over a thickness of 8.50m of Glaciofluvial Deposits in the northeast of the site would induce a settlement of 135mm in the underlying soils. As the Glaciofluvial Deposits are free draining sand it would be anticipated that this settlement would occur instantaneously. In addition to the Glaciofluvial Deposits, a screening bund of

12m height is proposed in the northeast of the site overlying Rathvilly Farm pit. Based on the soil parameters derived for the Made Ground in this area, a settlement of 150mm is predicted. Again, this would be anticipated to occur instantaneously.

2.3.3 Settlement Due to Structural Loads

At this stage and in the absence of any detailed structural designs, no assessment of settlement due to imposed structural loads has been undertaken. For foundations and floor slabs supported within Class 7A earthworks fill, Glaciofluvial Deposits, Glacial Till and Whitby Mudstone, it can be reasonably assumed that settlement can be kept within nominally acceptable limits (less than 25mm), subject to detailed design.

2.3.4 Secondary Compression

When considering long term settlements within cohesive soils consideration should be given to the likely contribution of secondary compression, that is, once primary consolidation has finished and when all pore water pressures have dissipated. The general method for assessing secondary settlements uses an estimation of the coefficient of secondary compression ($\varepsilon\alpha$). In this case it is considered appropriate to use an estimate based on industry accepted correlations such as the one produced by Mesri (1973).

Based on a conservative estimate of the coefficient of secondary compression of 0.3% and a 60 year design life it is considered that secondary settlements of approximately 20mm will occur following completion of primary consolidation at the maximum height of engineered fill. For the screening bund, assuming a coefficient of secondary compression of 1.2%, creep settlement of 170mm is anticipated over the design life.

2.3.5 Settlement Summary

Table 2.5 includes a summary of the anticipated settlements based on the assessments undertaken above and assuming a 6 month construction period.

Table 2.5: Settlement Summary

	Settlement (mm)	
Element	**(7.0m high platform)**	**(14.0m topsoil bund)**
Residual Self-Weight Settlement	25	240
Residual Settlement Due to Land Raise	30	0 (immediate during construction)
Secondary Compression (60 year design life)	20	170
Total Post Construction Settlement	**75 - 80**	**410**

Where the settlements above are unacceptable for development proposals, it will be necessary to design measures to limit post construction settlement as part of the detailed Geotechnical Designs for the earthworks. It is envisaged at this stage that the most suitable options are:

- inclusion of horizontal drainage or geocomposite drainage materials within embankments;

- the use of pre-loading and surcharge in areas where significant settlement is predicted in the underlying soils; or
- removal and replacement of compressible soils, subject to their reuse elsewhere within the development.

2.4 Reuse of Materials

An assessment has been undertaken on the suitability of the site won materials to be re-used as part of the general and selected fill, required to raise the ground level in line with the proposed formation defined in the RPS Earthworks model. It is considered that the majority of soils on site are suitable for use within earthworks. However, in view of the high concentrations of gypsum present within soils on site, it is likely that the use of hydraulic binders will not be feasible to modify moisture contents or stabilise soils on site. Therefore, where drying is required it will be necessary to programme the earthworks to allow air drying.

The basis for the Specification is the Manual of Contract Documents for Highway Works (MCHW), Volume 1, and Specification for Highway Works (SHW) Series 600 published by HMSO (February 2016 update). Where appropriate additional reference has been made to the general requirements of BS 6031:2009, Code of practice for earthworks; BS 8000-1, workmanship on building sites and BS EN 13242, Hydraulically bound and unbound materials for use in civil engineering and highway construction.

The acceptability of the fill materials for re-use within the permanent works will depend on comparison of the data obtained by the source approval testing as defined in Appendix 1/5 with the compliance limits defined in Appendix 6/1. Once the material is approved for use at the source a series of compaction trials are required to determine the appropriate method of compaction required in order to achieve the requisite end performance for the particular fill class.

A number of different classes of fill have been identified to be used during the earthworks, as summarised in Table 2.3, which includes the minimum compaction requirements to be met. This information is included within the compliance criteria for each class of fill in Appendix 6/1 of the specification with the minimum testing frequency presented in Appendix 1/5.

Table 2.3: Earthworks Fill Class and Minimum Compaction Requirements

Earthworks Class and Description	Typical Use	Compaction Control
Class 1A general well graded granular fill	General Fill for access roads	SHW Table 6/4 Method 2, modified as required to ensure a minimum 95% MDD and a CBR of 5%.
Class 2A general wet cohesive fill	General Fill for access roads	SHW Table 6/4 Method 1, modified as required to ensure a minimum 95% MDD and a shear strength (Cu) of 50 kN/m² .
Class 2C general stony cohesive fill	General Fill for access roads	SHW Table 6/4 Method 2, modified as required to ensure a minimum 95% MDD and a shear strength (Cu) of 50 kN/m².
Class 6F selected granular capping	Capping	SHW Table 6/4 Method 6, modified as required to ensure a minimum 95% MDD and a layer stiffness equivalent to CBR of 15%.
Class 7A selected cohesive fill	Fill to structures, all plateaus	End Product, 100 - 105% MDD (2.5kg rammer), less than 5% Air Voids and target HSV Cu of 120kN/m² (Triaxial Cu of 100kN/m²).

Annex A of the GDR includes the appropriate Appendix 1/5 (testing to be undertaken by the Contractor) and Table 6/1 (acceptability limits), and this shall be undertaken as part of the site preparation and enabling works.

3.0 STRENGTHENED EARTHWORKS

At present, it is not proposed to utilise any strengthened or Mechanically Stabilised Earthworks (MSE). Further consideration of MSE may be made as part of detailed Geotechnical Designs for the development.

4.0 DRAINAGE

Permanent drainage design is not covered by the GDR. During the enabling and earthworks the formation should be kept free from water at all times through the use of grip drains and pumping as necessary to prevent deterioration of the subgrade. The temporary management of water on site during the earthworks is the responsibility of the contractor.

5.0 PAVEMENT DESIGN, SUBGRADE AND CAPPING

Reference should be made to the recommended subgrade surface stiffness values presented in Section 1. Pavement design, and associated specification of foundations materials is outside the scope of this report.

6.0 ASSESSMENT OF POTENTIAL CONTAMINATION

The GDR has been written in line with the findings and the recommendations of the Remediation Strategy for the site, reference R/151171/006.

All Made Ground, from whatever source, shall be tested in accordance with the requirements of the Remediation Method Statement, at a frequency of 1 contamination suite per 1000m³. Natural topsoil is to be tested at a frequency of 1 suite per 2000m^3. Natural soils to be included within earthworks are to be tested at a frequency of 1 suite per 10,000m^3.

7.0 GROUND TREATMENT

Requirements for ground treatment are to be assessed as part of the detailed Geotechnical Designs.

8.0 SPECIFICATION APPENDICES

The basis for the Specification is the Manual of Contract Documents for Highway Works (MCHW), Volume 1, and Specification for Highway Works (SHW) Series 600 published by HMSO.

Annex A contains Revision P4 of the Earthworks Specification (R/151093/006 dated April 2017), which includes Appendix 1/5 detailing the testing to be undertaken by the Contractor, Appendix 1/24 for the Quality Control measures and an up-dated Table 6/1 presenting the compliance limits to be met.

9.0 INSTRUMENTATION AND MONITORING

Requirements for instrumentation and monitoring are to be determined as part of the detailed Geotechnical Designs. In is anticipated at this stage that settlement gauges and piezometers will be required to monitor the earthworks during construction.

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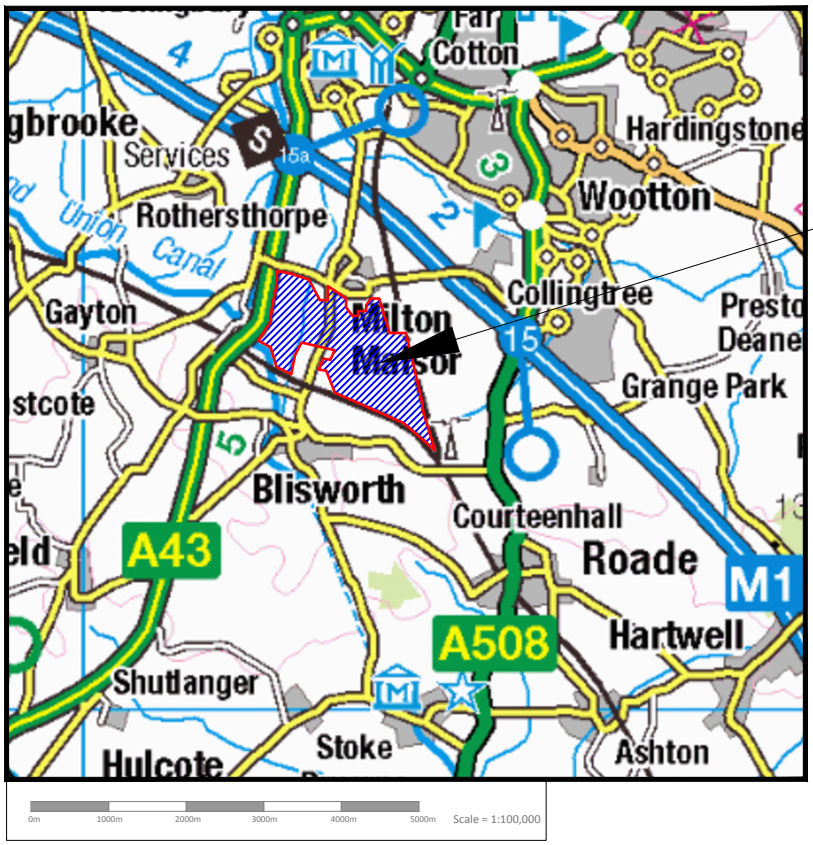
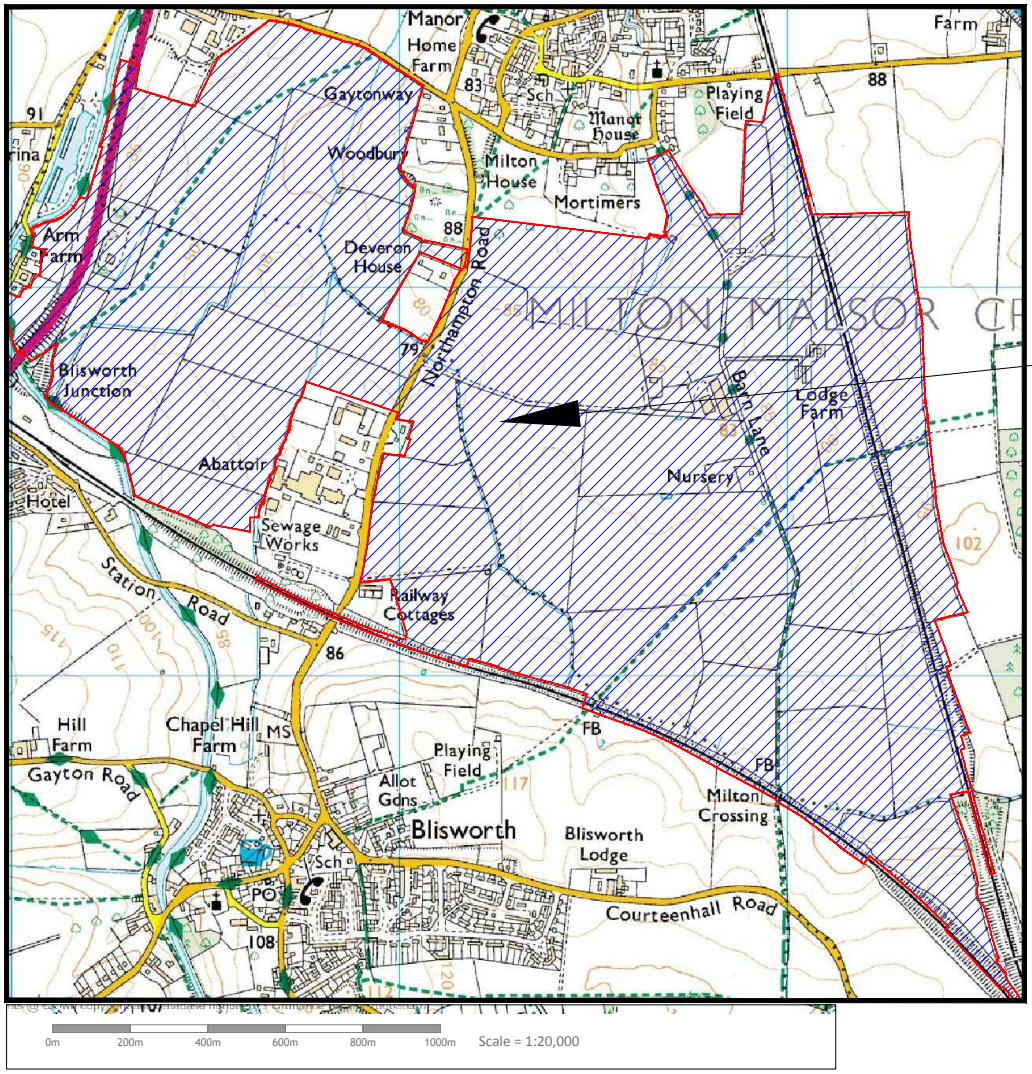
ANNEX A

EARTHWORKS SPECIFICATION

Notes:

1. Contains Ordnance Survey data © Crown copyright and database right 2015





Rev	Date	Description	By	Ckd
C	09/02/18	Boundaries revised	NS	AB
B	07/06/17	Boundaries revised	RB	AB
A	14/02/17	Boundaries revised	RB	AB

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Client : Ashfield Land

Project Title: Rail Central, Milton Malsor

Drawing Title: Site Location Plan

Drawing Status: FINAL

Hydrock Job No: C151171

Drawn	Checked	Scale @ A4	Date	Issue Date
NS	AB	See Drawing	09/02/18	09/02/18

Drawing Number: C151171/D001 Revision: C

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KEY PLAN
1:20,000

LEGEND

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BASED ON MK SURVEYS', TOPOGRAPHICAL SURVEY DRAWING. REF: 2223. DATED JULY 2016. AND ORDNANCE SURVEY INFORMATION.

- ORDER LIMITS
- ILLUSTRATIVE PROPOSED BUILDINGS
- PROPOSED PUBLIC RIGHT OF WAY
- EXISTING LANDSCAPING RETAINED
- PROPOSED LANDSCAPED OPEN SPACE (INCLUDING SCREENING AND BUNDING)
- FLOOD ATTENUATION
- INTERMODAL AREA
- AREA FOR POTENTIAL P.V. PANELS ON ROOFS
- INDICATIVE EXISTING CATENARY POSITIONS
- INDICATIVE PROPOSED CATENARY POSITIONS

REV	DATE	DETAILS OF ISSUE/REVISION	DRW	REV
0	06-02-18	FIRST ISSUE	PF	MS

ASHFIELD LAND

Rail Central
Northamptonshire

THE RAIL CENTRAL STRATEGIC FREIGHT INTERCHANGE ORDER 2018

DRAWING TITLE

ILLUSTRATIVE COLOUR MASTERPLAN - SHEET 1 OF 2

SCALE	1:2,500	DRAWN	PF
PAGE SIZE	A0	REVIEWED	MS
REGULATION	5(2)0	DOCUMENT	.

DRAWING STATUS

PLANNING

DRAWING No	REVISION
MSA-30708-PL-DCO-112	0

MILTON MALSOR

NORTHAMPTON LOOP

M1 MOTORWAY

UNIT 2

UNIT 1

UNIT 3

UNIT 4

UNIT 5

UNIT 6

UNIT 7

TERMINAL CONTROL BUILDING

POTENTIAL EXPRESS FREIGHT CROSS-DOCK PLATFORM

TRAIN MAINTENANCE DEPOT

WEST COAST MAINLINE

BLISWORTH

KEY PLAN
1:20,000

SHEET 1

SHEET 2

LEGEND

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- ORDER LIMITS
- ILLUSTRATIVE PROPOSED BUILDINGS
- PROPOSED PUBLIC RIGHT OF WAY
- EXISTING LANDSCAPING RETAINED
- PROPOSED LANDSCAPED OPEN SPACE (INCLUDING SCREENING AND BUNDING)
- FLOOD ATTENUATION
- INTERMODAL AREA
- AREA FOR POTENTIAL P.V. PANELS ON ROOFS
- INDICATIVE EXISTING CATENARY POSITIONS
- INDICATIVE PROPOSED CATENARY POSITIONS

REV	DATE	DETAILS OF ISSUE/REVISION	DRW	REV
0	06-02-18	FIRST ISSUE	PF	MS

ASHFIELD LAND

Rail Central
Northamptonshire

THE RAIL CENTRAL STRATEGIC FREIGHT INTERCHANGE ORDER 2018

DRAWING TITLE

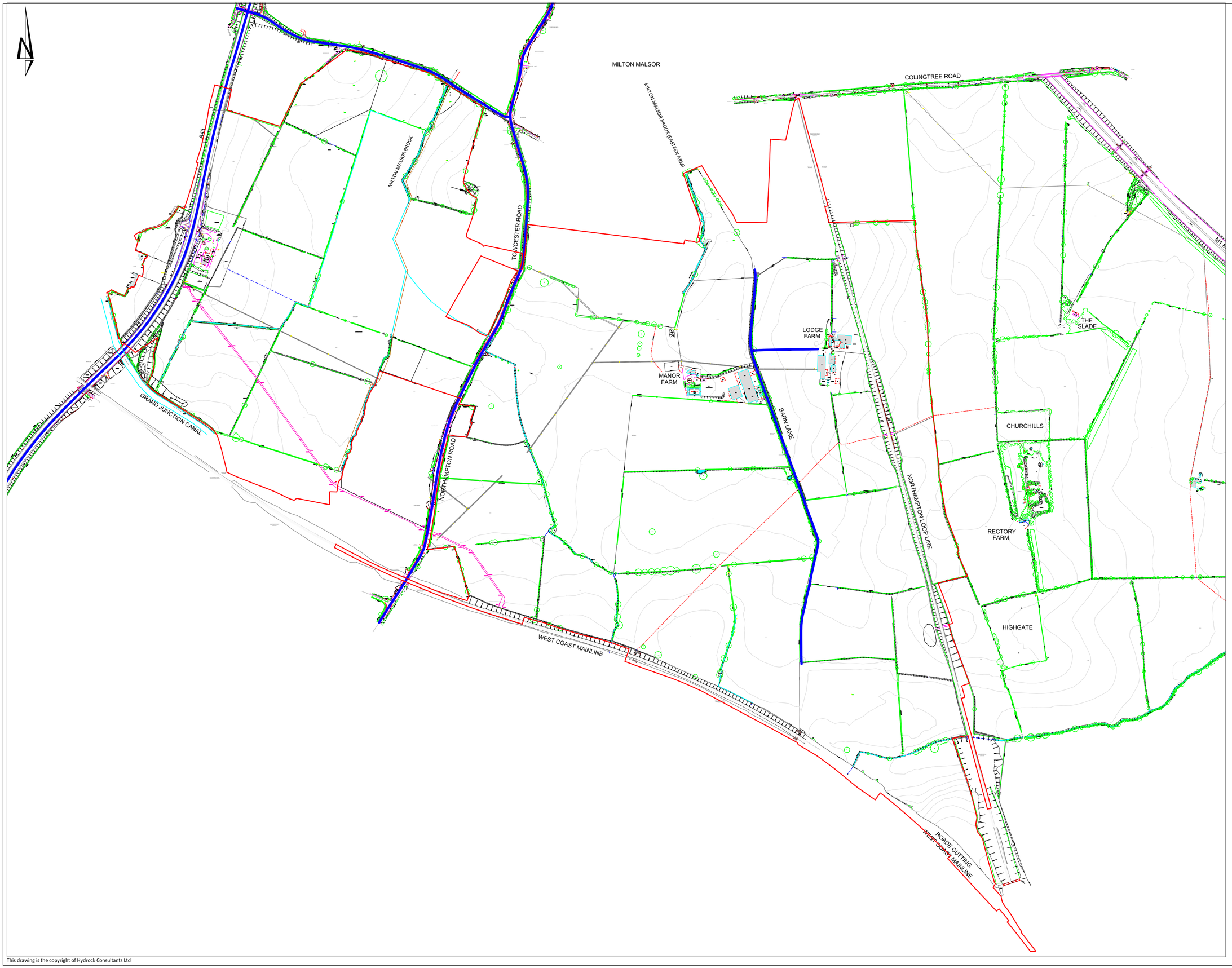
ILLUSTRATIVE COLOUR MASTERPLAN - SHEET 2 OF 2

SCALE	1:2,500	DRAWN	PF
PAGE SIZE	A0	REVIEWED	MS
REGULATION	5(2)0	DOCUMENT	.

DRAWING STATUS

FEASIBILITY

DRAWING No	REVISION
MSA-30708-PL-DCO-112	0



Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Key

- Railway line
- Road
- Footpath
- Foul sewer
- BPA Oil Pipeline
- Watercourses
- Trees/Hedges

Rev	Date	Description	By	Ckd
C	09/02/18	Updated Site Boundary	NS	AB
B	06/07/17	Updated	RB	AB
A	14/02/17	Updated	RB	AB

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Client :

ASHFIELD LAND

Project Title:

MILTON MALSOR, NORTHAMPTONSHIRE

Drawing Title:

Site Extents Plan

Drawing Status:

FINAL

Hydrock Job No:

C151171

Drawn	Checked	Scale @ A1	Date	Issue Date
NS	AB	1:5000	09/02/18	09/02/18

Drawing Number: 151171/D002

Revision: C

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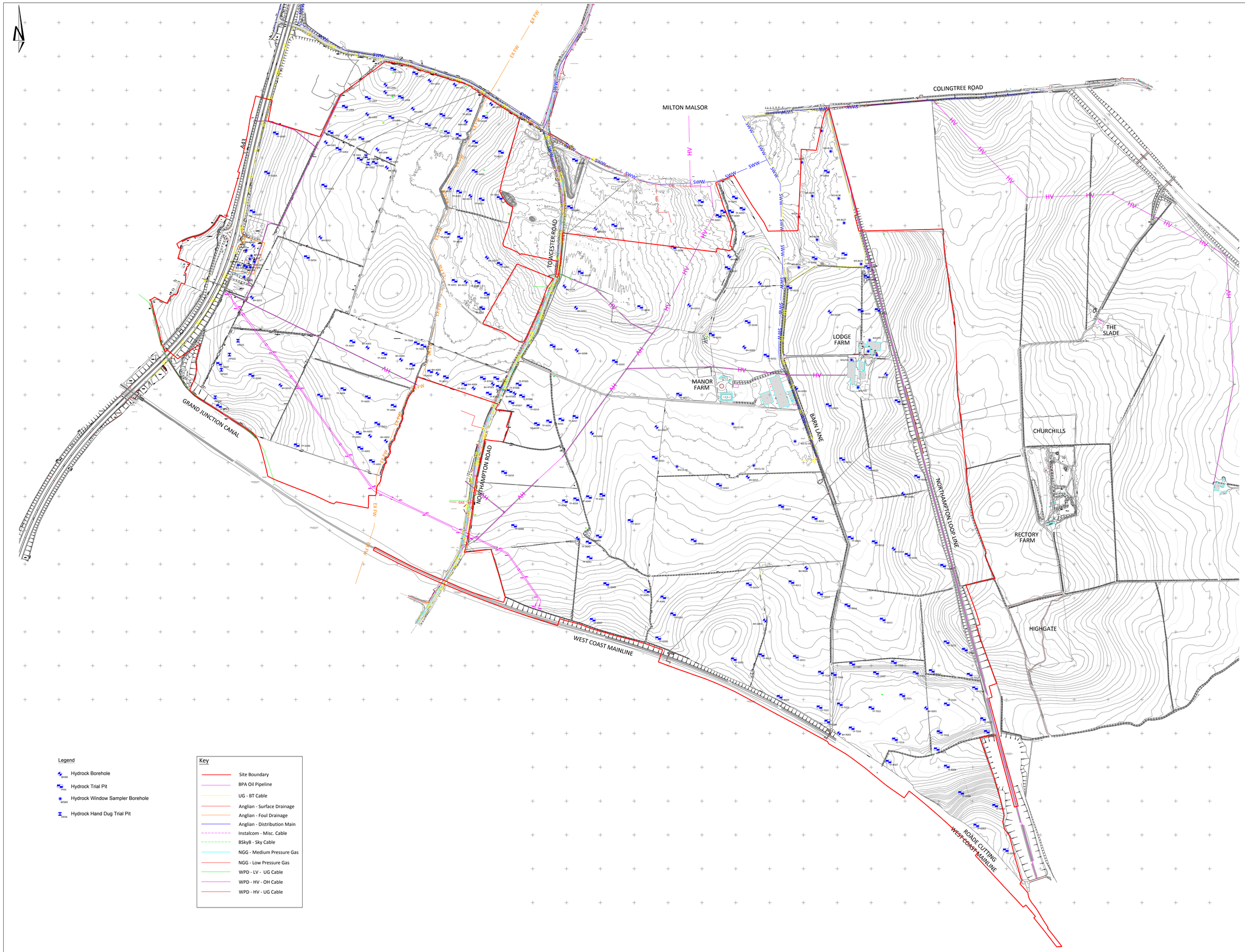

Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Rev	Date	Description	By	Ckd
H	09/02/18	Site Boundary Updated	NS	AB
G	04/07/17	Courtenhall Estates land added	RB	AB
F	02/06/17	Further works at Rathvilly Farm added	RB	AB
E	23/02/17	Works at Rathvilly Farm added	RB	AB
D	05/01/17	Further revised, land parcel and geological information removed	RB	AB
C	02/09/16	Proposed works in inaccessible land parcels added	SD	AB
B	17/08/16	Geological information added	RB	AB
A	10/08/16	Land Parcel information added	SD	RB

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Client :

ASHFIELD LAND

Project Title:

RAIL CENTRAL
MILTON MALSOR
NORTHAMPTONSHIRE

Drawing Title:

Exploratory Hole Location Plan

Drawing Status:

INFORMATION

Hydrock Job No:

C/151171

Drawn	Checked	Scale @ A0	Date	Issue Date
NS	AB	1:3500	09/02/18	09/02/18

Drawing Number: 151171/D004

Revision: H

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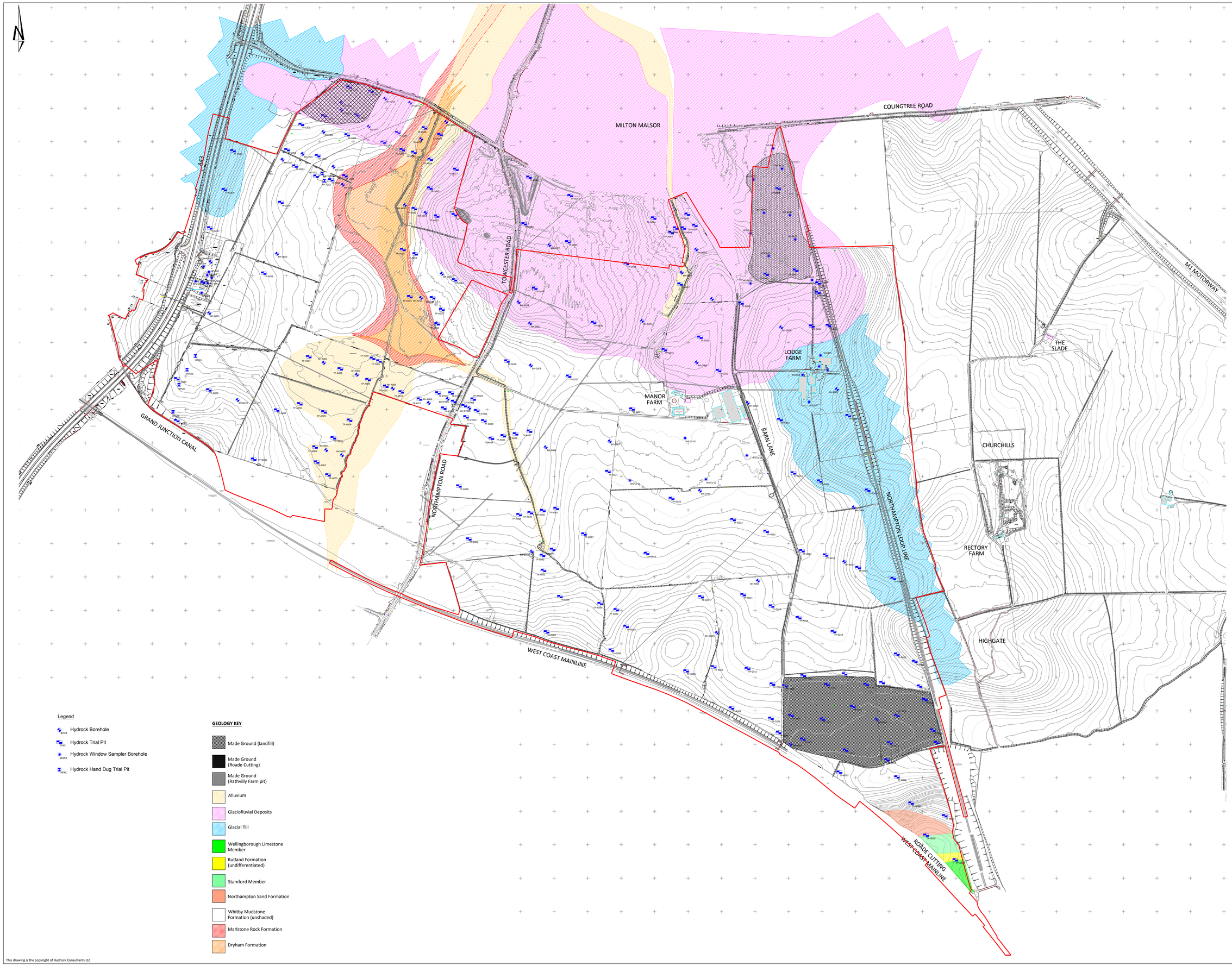

Legend

- Hydrock Borehole
- Hydrock Trial Pit
- Hydrock Window Sampler Borehole
- Hydrock Hand Dug Trial Pit

GEOLOGY KEY

- Made Ground (landfill)
- Made Ground (Roade Cutting)
- Made Ground (Rathvilly Farm pit)
- Alluvium
- Glaciofluvial Deposits
- Glacial Till
- Wellingborough Limestone Member
- Rutland Formation (undifferentiated)
- Stamford Member
- Northampton Sand Formation
- Whitby Mudstone Formation (unshaded)
- Marlstone Rock Formation
- Dryham Formation

Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Rev	Date	Description	By	Ckd
C	09/02/18	Site Boundary Updated	NS	AB
B	06/07/17	Updated following fieldworks	RB	AB
A	15/02/17	Updated following fieldworks	RB	AB

Architect :

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Client :

ASHFIELD LAND

Project Title:

RAIL CENTRAL
MILTON MALSOR
NORTHAMPTONSHIRE

Drawing Title:

Site Geology Plan

Drawing Status:

INFORMATION

Hydrock Job No:

C/151171

Drawn	Checked	Scale @ A0	Date	Issue Date
NS	AB	1:3500	09/02/18	09/02/18

Drawing Number	Revision
151171/D005	C

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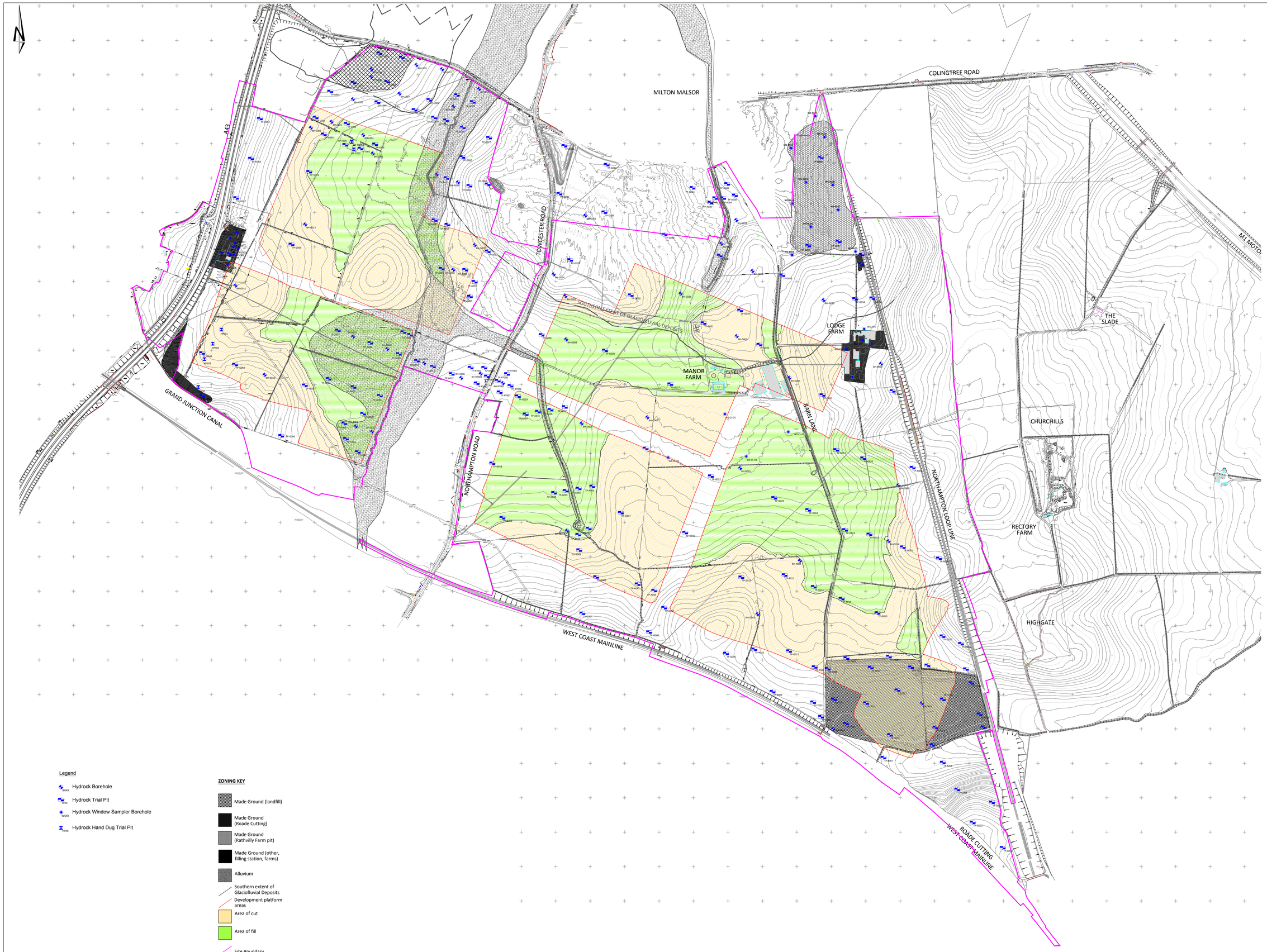

Notes:

1. All dimensions are to be checked on site before the commencement of works. Any discrepancies are to be reported to the Architect & Engineer for verification. Figured dimensions only are to be taken from this drawing.
2. This drawing is to be read in conjunction with all relevant Engineers' and Service Engineers' drawings and specifications.

Legend

- BHXX Hydrock Borehole
- TPXX Hydrock Trial Pit
- WSXX Hydrock Window Sampler Borehole
- HPXX Hydrock Hand Dug Trial Pit

ZONING KEY

- Made Ground (landfill)
- Made Ground (Roade Cutting)
- Made Ground (Rathvilly Farm pit)
- Made Ground (other, filling station, farms)
- Alluvium
- Southern extent of Glaciofluvial Deposits
- Development platform areas
- Area of cut
- Area of fill
- Site Boundary

Rev	Date	Description	By	Ckd
B	09/02/18	Site Boundary Updated	NS	AB
A	06/07/17	Updated following additional works	RBI	AB

Architect :

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Client :

ASHFIELD LAND

Project Title:

RAIL CENTRAL
MILTON MALSOR
NORTHAMPTONSHIRE

Drawing Title:

Site Zonation Plan

Drawing Status:

INFORMATION

Hydrock Job No:

C/151171

Drawn	Checked	Scale @ A0	Date	Issue Date
NS	AB	1:3500	09/02/18	09/02/18

Drawing Number: 151171/D006

Revision: B

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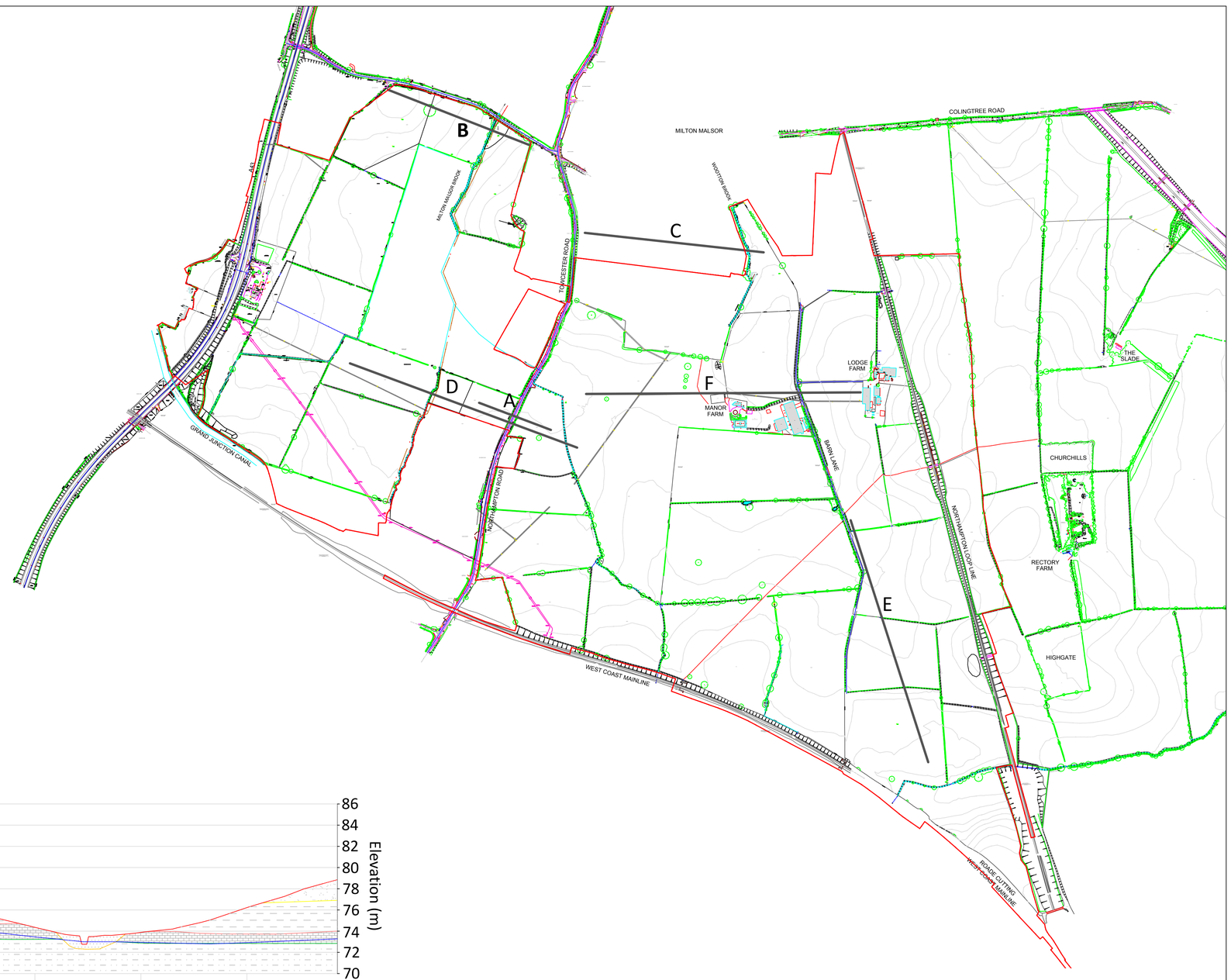
KEY

- Existing Ground Level
- Water Table
- Base Glaciofluvial
- Base Alluvium
- Base Till
- Base Whitby
- Base Marlstone
- Made Ground
- Alluvium Deposits
- Glaciofluvial Deposits
- Glacial Till
- Whitby Mudstone Formation
- Marlstone Rock Formation
- Dyrham Formation



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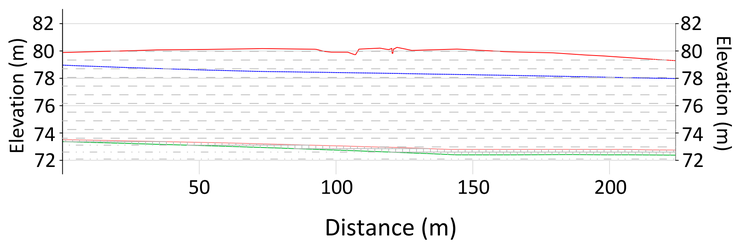

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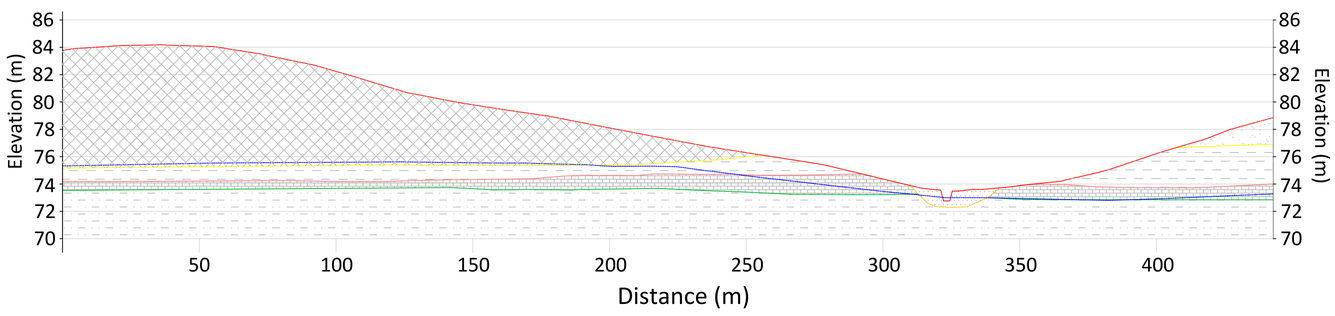

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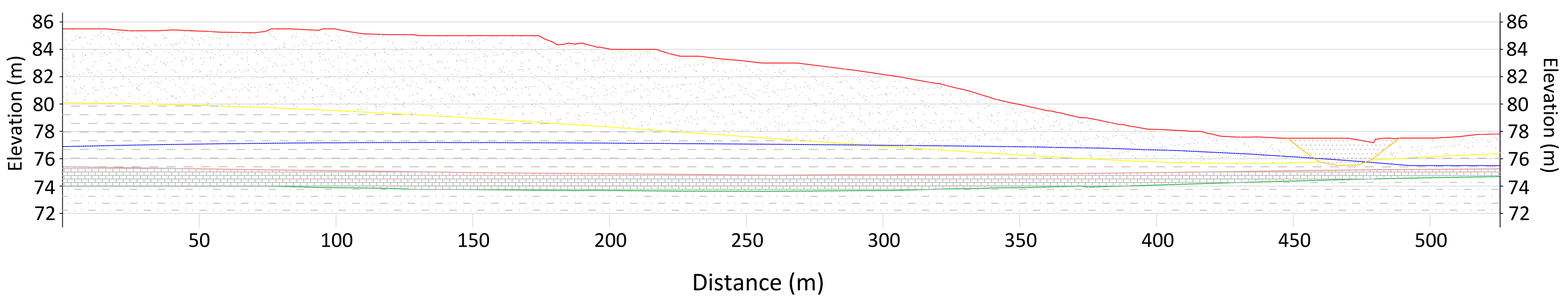

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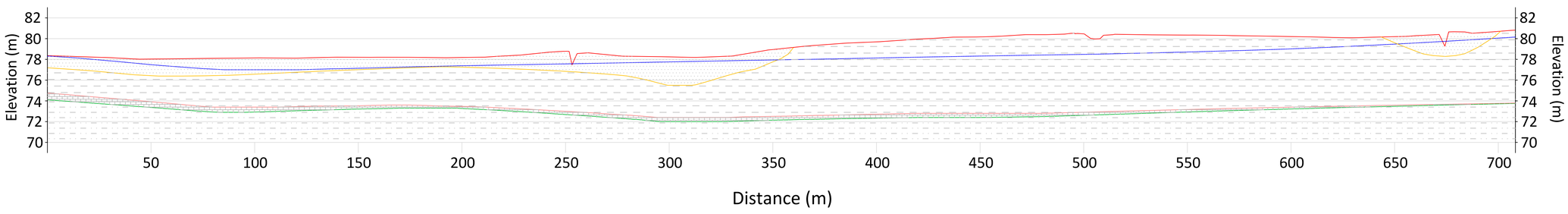

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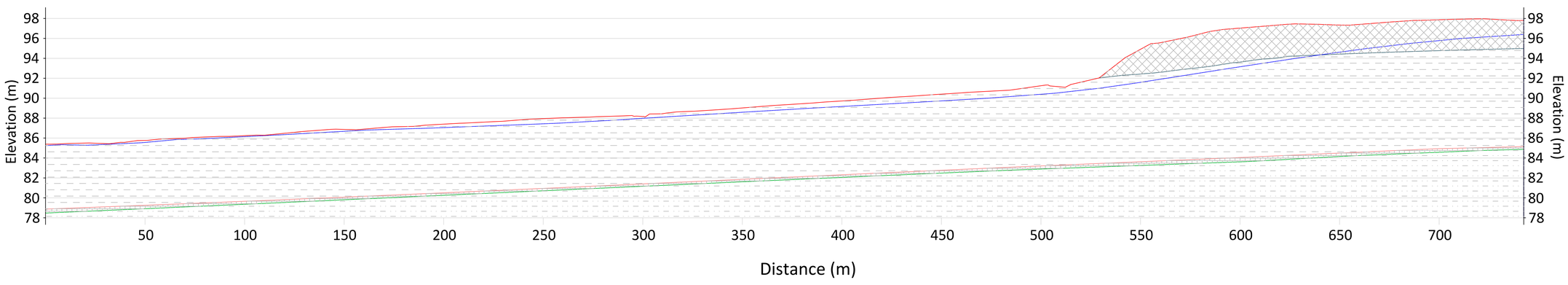

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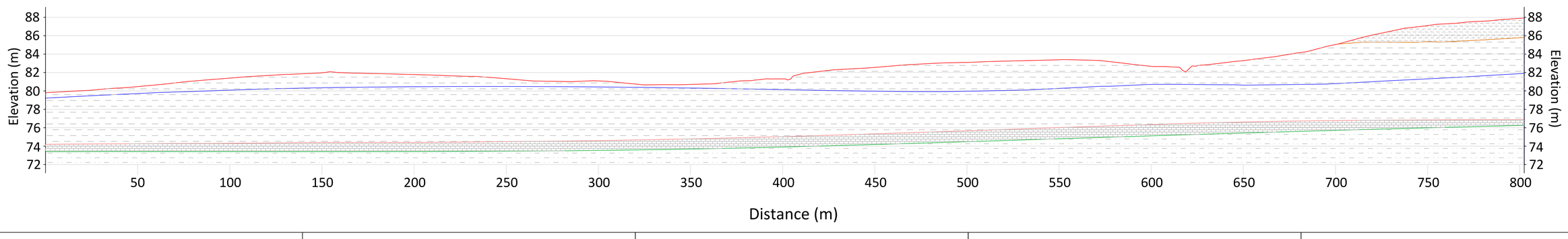

KEY PLAN

NOTES

1. The cross sections above are displayed at 5 times vertical exaggeration.

REVISIONS

P01	FIRST ISSUE	N STURMAN	17/02/17
P02	UPDATED SITE BOUNDARY	N STURMAN	09/02/18

TITLE

Interpretative Cross Sections

HYDROCK PROJECT NO. C151171

SCALE @ A0 H - 1:1100 V - 1:5

PURPOSE OF ISSUE SUITABLE FOR CO-ORDINATION

STATUS S1

DRAWING NO. (PROJECT - ORIGINATOR - VOLUME - LEVEL - TYPE - ROLE - NUMBER) C151171.D007

REVISION P02

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CLIENT

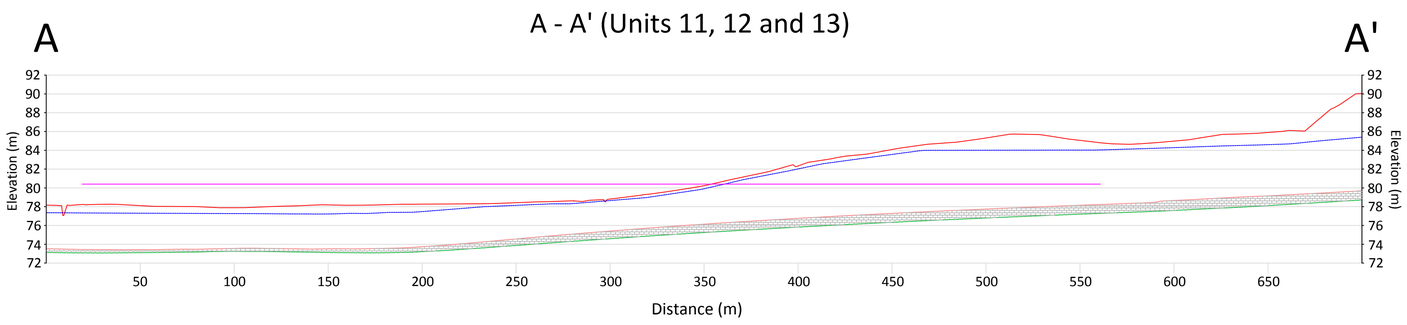
ASHFIELD LAND

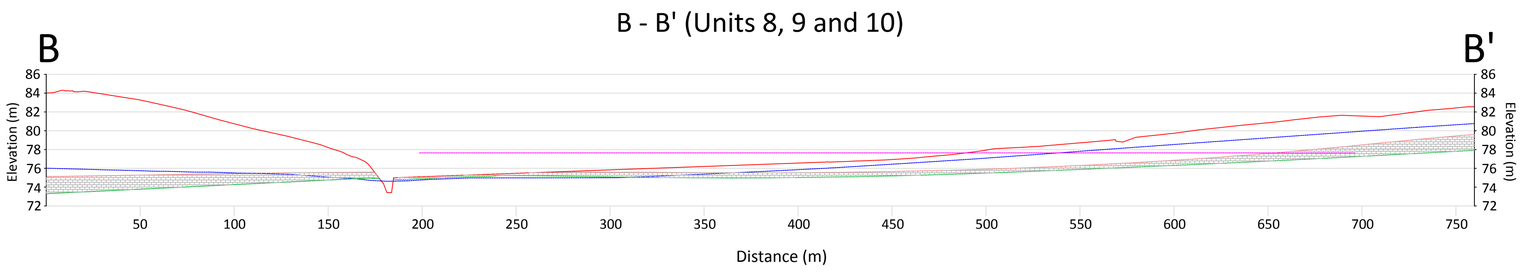
PROJECT

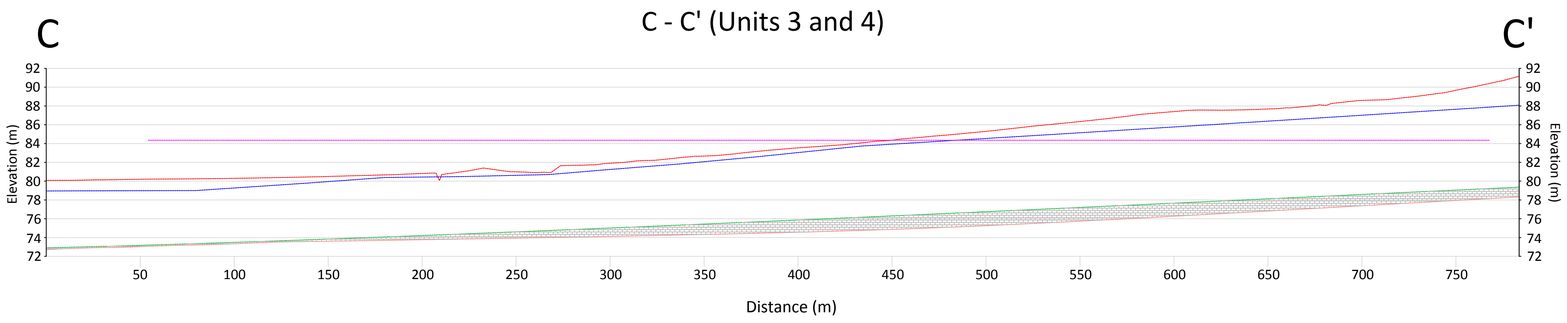
Rail Central, Milton Malsor

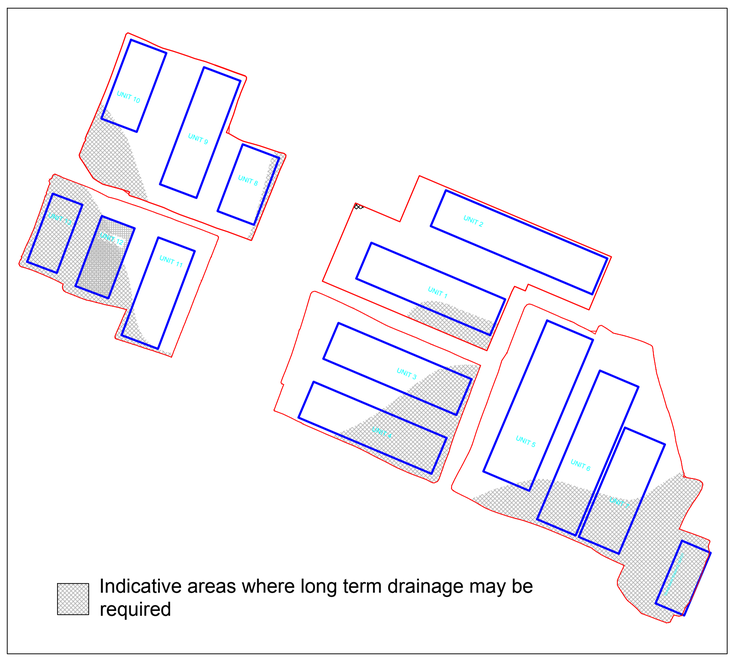
KEY

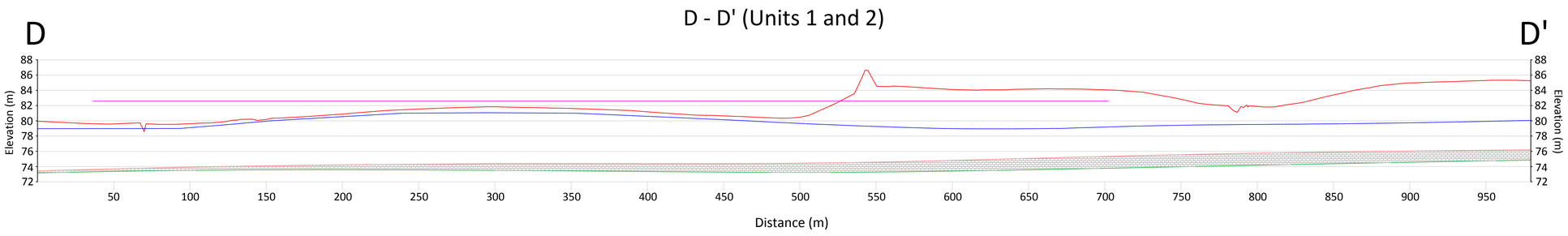
- Existing Ground Level
- Water Table
- Base Whitby
- Base Marlstone
- Unit Plateau Level
- Marlstone Rock Formation

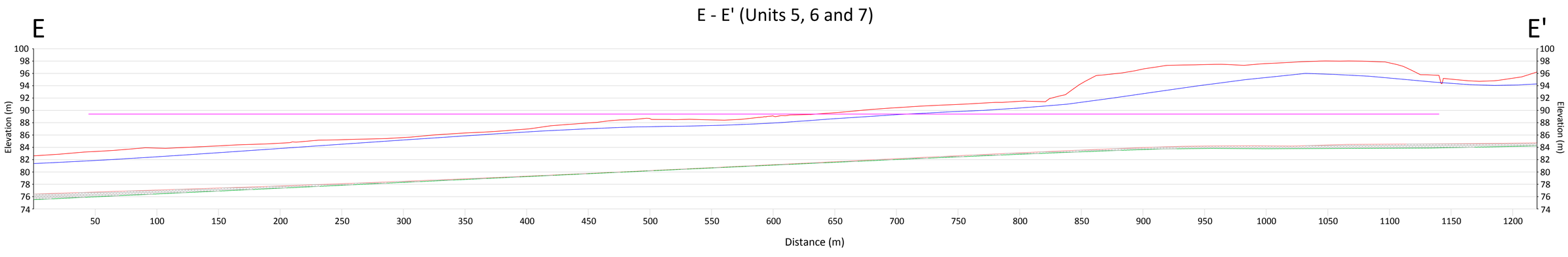












KEY PLAN

NOTES

1. The cross sections above are displayed at 5 times vertical exaggeration.

REVISIONS

P01	FIRST ISSUE					
	N STURMAN	17/02/17				
P02	UPDATED SITE BOUNDARY					
	N STURMAN	09/02/18				

TITLE

Groundwater level at development plateaus (Jan/Feb 2017)

HYDROCK PROJECT NO. C151171

SCALE @ A0 H - 1:1600 V - 1:5

PURPOSE OF ISSUE: SUITABLE FOR CO-ORDINATION

STATUS: S1

DRAWING NO. (PROJECT - ORIGINATOR - VOLUME - LEVEL - TYPE - ROLE - NUMBER): C151171.D008

REVISION: P02

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CLIENT

ASHFIELD LAND

PROJECT

Rail Central, Milton Malsor

APPENDIX 0/3: LIST OF NUMBERED APPENDICES REFERRED TO IN THE SPECIFICATION AND INCLUDED IN THE CONTRACT

Appendix No.	Title.
	INTRODUCTION
0/4	List of drawings included in the contract
	PRELIMINARIES
1/5	Testing to be carried out by the Contractor
1/24	Quality Management System
	EARTHWORKS
6/1	Requirements for Acceptability & Testing etc. of Earthworks Materials
6/2	Requirements for dealing with Class U1B and class U2 unsuitable materials
6/3	Requirements For Excavation, Deposition, Compaction (Other Than Dynamic Compaction)
6/6	Fill to Structures and Fill Above Structural Foundations
6/7	Sub-formation and Capping Preparation & Surface Treatment Formation
6/9	Earthwork Environmental Bunds, Landscape Areas and Strengthening Embankments
6/14	Limiting Values for Pollution of Controlled Waters
6/15	Limiting Values for Harm to Human Health and the Environment

APPENDIX 0/4: LIST OF DRAWINGS INCLUDED IN THE CONTRACT

A list of Drawings is included below:

Drawing Ref.	Drawing Title	Originator
151171/D001	Site Location Plan	Hydrock
30708-FE-96A	Illustrative Colour Masterplan	Michael Sparks Associates
NK018318-RPS-00-XX-DR-C-SK0009	Masterplan Bulk Earthworks	RPS

APPENDIX 1/5: TESTING TO BE CARRIED OUT BY THE CONTRACTOR

Table 1/5.1 – Earthworks testing requirements

CLAUSE	WORK, GOODS OR MATERIAL		TEST	FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600	Earthworks					
601, 631 to 637, 640	Acceptable Limits				Required	Test frequency relates to the class of material from each source. A minimum of 3 tests are required per material per source before that material can be approved for use. If multiple sources of the same class are used, each source shall be tested at the frequency stated in Appendix 1/5. Where the volume of a single source used in the earthworks operation is in excess of 10,000m³, once 10,000m³ has been used the rate of testing *may* be reduced by the Engineer following agreement from all relevant parties. See Table 6/1 (Specification app 6/1) for specific testing requirements for individual material subclasses. Refer to Clause 612 for in situ testing requirements during the placement and compaction of fill. Refer to Clause 710 for testing for constituent parts. All soils for reuse are to be tested for contamination as per the frequencies indicated in the Remediation Method Statement (R/151171/006): Made Ground: 1 per 1,000m³ Natural Topsoil: 1 per 2,000m³ Natural soils: 1 per 10,000m³
	Class	General Description				
	1	General Granular Fill	MC, Grading (U)	1 per 1,000m³		
			Uniformity Coefficient	Included with every grading		
			OMC/MDD (Vib Hammer)	1 per 1,000m³		
			Constituent Parts (where recycled aggregate used)	Source Approval		
			CBR at OMC (U)	Source Approval		
	2	General Cohesive Fill	MC, PI, Grading (U)	1 per 1,000m³		
			OMC/MDD (U) with Hand Vane at each compaction point. (2.5kg for 2A, 2C)	1 per 1,000m³		
			Particle Density	1 per 1,000m³		
			Undrained Triaxial Shear Strength at OMC (U)	Source Approval		
	4	Fill to Landscape Area	MC, Grading (U)	1 per 2,500m³		
			Remoulded HSV Shear Strength at NMC	1 per 2,500m³		
	6	Selected granular fill	Grading/uniformity coefficient/mc (U)	1 per 1,000m³		
			OMC/MDD (Vib Hammer)	1 per 1,000m³		
			CBR at OMC (U)	1 per 1,000m³		
			PL/LL (U)	1 per 1,000m³		
			Los Angeles Coefficient LA (U)	1 per 1,000m³		
			Constituent Parts (where recycled aggregate used)	1 per 1,000m³		
			Bitumen content (where recycled aggregate used) (U)	1 per 500m³		
			Organic matter/ total potential sulphate (TPS) content (U) water soluble sulphate (WS) content (U)/pH	1 per 1,000m³		

CLAUSE	WORK, GOODS OR MATERIAL		TEST	FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600	Earthworks					
			Oxidisable sulphides (OS) (where used within 500mm of concrete)	1 per 1,000m³		
	7	Selected cohesive fill	MC, PI, Grading (U)	1 per 1,000m³		
			OMC/MDD (U) with Hand Vane at each compaction point. (2.5kg Rammer)	1 per 1,000m³		
			Particle Density	1 per 1,000m³		
			Undrained Triaxial Shear Strength at OMC (U)	1 per 1,000m³		
			Organic matter / total potential sulphate (TPS) content (U) water soluble sulphate (WS) content (U)/pH	1 per 1,000m³		
			Oxidisable sulphides (OS) (where used within 500mm of concrete)	1 per 1,000m³		
602	Earthworks material beneath the surface of a road or paved area, if within 450mm of finished surface		Frost Heave (U)	Source Approval		For ALL material within 450mm finished level.
612	Compaction of Fills					Compaction Trial to be completed in accordance with App 6/3 and be witnessed by the Client and/or Client's Representative. CBR and undrained shear strength testing to be undertaken both on the final formation and the formation prior to the placement of fill. Plate load testing to be carried out in accordance with DMRB IAN 73/06 Rev 1 for equivalent CBR for every 1m raise in fill and at the formation of each & every class of fill material for Method Compaction. Static incremental Plate Load Tests to be undertaken for Selected Fill placed to an end product in accordance with Appendix 6/1 Clause 9.5. Refer to Appendix 6/1 and 6/3 for minimum compaction requirements to be met.
		Method Compaction	Field Dry Density	1 per 50m grid per layer or 50 linear m		
			CBR (Mexeprobe or TRL DCP) for granular fill only	1 per 50m grid per layer or 50 linear m		
			Undrained shear strength (HSV), for cohesive fill only	1 per 25m grid per layer or 50 linear m		
			Compaction Trial	1 per method per source. To be witnessed by Hydrock		
			Dual Cycle Static Plate Load Test for equivalent CBR	1 per 50 linear m or 75m grid per 1.0m lift and Final Formation of Earthworks.		

CLAUSE	WORK, GOODS OR MATERIAL		TEST	FREQUENCY	TEST CERTIFICATE	COMMENTS
Series 600	Earthworks					
		End Product	Field Dry Density	1 per 25m grid per layer		Where the Hand Shear Vane (HSV) is used to measure the undrained shear strength it should be calibrated against laboratory triaxial tests.
			CBR (Mexeprobe at TRL DCP) for granular fill only	1 per 25m grid per layer		
			Undrained shear strength (HSV), for cohesive fill only	1 per 25m grid per layer		
			Compaction Trial	1 per method per source. To be witnessed by Hydrock		
			Dual Cycle Static Incremental Plate Load Test using 0.60m Diameter Plate	1 per 50m grid per 1.0m of fill placed and at Final Formation of Earthworks.		
		Drainage layers	Grading	1 per 400 tonnes or 200m³ whichever is the lesser		

Notes:

1. The minimum number of tests will be 3 per source, before the source can be approved by Hydrock for use. 2.(U) indicates that a UKAS test report or certificate is required.

3. Unless otherwise shown in this Appendix, tests and test certificates for works, goods or materials as scheduled under any one clause are required for all such work, goods or materials in the works.

4. Frequency of testing applies to each separate earthworks material within each of the earthworks material class.

5. Unless specifically stated to the contrary, all samples used in the testing shall be taken from materials after delivery to the site for incorporation into the works.

6. The Contractors attention is drawn to the requirements of the relevant Specification Appendices for the form of all deliverables, storage of test records and storage of records of materials imported to and exported from site.

7. Where source approval is specified, source testing shall be carried out at each quarry or stockpile used for supply to site and at each location of borrow/site winnings used for on-site material.

8. Definitions of abbreviations:

   - mc: natural moisture content.
   - Organic Matter: Organic Matter Content as determined from the 'Walkley Black' Method.
   - OMC: Optimum Moisture Content.
   - MDD: Maximum Dry Density.
   - CBR: California Bearing Ratio.
   - HSV: Hand Shear Vane for assessment of undrained shear strength.
   - IDD: Intact Dry Density.
   - ACM: Asbestos and Asbestos Containing Materials.
   - MEXE: In situ assessment of equivalent CBR by MEXE Probe
   - TRL DCP: Transport Research Laboratory Dyanmic Cone Penetrometer for in situ assessment of equivalent CBR.

8. All Made Ground shall be testing in accordance chemical testing requirements refer to the relevant Appendix for class of material and the requirements of Appendix 6/14 and 6/15.

APPENDIX 1/24: QUALITY MANAGEMENT SYSTEMS

1.0 GENERAL

1.1 The Contractor shall institute and operate a quality management system complying with BS EN ISO 9001 and SHW Clause 104. The quality management system shall be described in a Quality Plan that shall be submitted to the Employers Representative for their acceptance before the commencement of any site works.

1.2 The Quality Plan shall cover the following items:

i) Contractor's organisation and management;

ii) Contractor's method statements and construction procedures

iii) Contractor's construction quality control

iv) Organisation's Quality Plans.

1.3 The Quality Plan shall conform to the requirements of 2.0, 3.0 and 4.0.

1.4 Items i) and ii) of the Quality Plan shall be submitted to the Employers Representative for its acceptance not later than 28 days after award of contract.

1.5 Method statements are required for each major activity to be undertaken by the Contractor. The Contractor shall agree in writing with the Employers Representative the full scope of activities which require the production of individual Method Statements.

2.0 CONTRACTOR'S ORGANISATION AND MANAGEMENT

2.1 This section of the Quality Plan shall include:

i) Definition of the Contract and its documentation.

ii) The organisation of the Contract, including the line of command and communication and communication links between parties involved in the Contract.

iii) Names, roles responsibilities and authority of the principals and key personnel.

iv) Control of liaison and meetings with third parties.

v) Identification of the Contractors own staff responsible for overseeing each major activity.

vi) The Contractors control systems for any sub-contractors to be appointed by them.

vii) Document control.

viii) Programme for submission of Method Statements and Organisations Quality Plans.

ix) The quality plans for subcontractors and suppliers of work, goods and materials which are the subject of quality management schemes.

x) Procedure for the preparation, review and adjustment of programmes for the effective progression of the Works and the recording of this.

xi) Control and approval of purchases of materials.

xii) Control of off-site activities (where appropriate).

xiii) Procedures for the regular review and recording by the Contractor of the quality of the works.

xiv) Control of personnel selection, based on their care, skill and experience.

xv) Management review/audits to monitor and exercise adequate control over the implementation of the Quality Plan.

xvi) Any other relevant item, specific to the methods of work proposed by the Contractor.

3.0 CONTRACTOR'S METHOD STATEMENTS AND CONSTRUCTION PROCEDURES

3.1 This section of the Quality Plan shall include:

i) Detailed method statements for each major activity whether directly controlled or subcontracted.

ii) The method statements for all activities that might affect the quality of the permanent and temporary works shall identify hold points and invoke:

(1) Work instructions.

(2) Quality control procedures.

(3) Compliance testing and inspection arrangements.

(4) Work acceptance procedures.

ii) Identify the relevant construction procedures in the Contractor's own Quality Management System, and provide copies on request.

4.0 CONTRACTOR'S CONSTRUCTION QUALITY CONTROL

4.1 This section of the Quality Plan shall include:

i) Statement of the Contractors organisation for quality control.

4.2 The Quality Plan shall identify procedures (which may be part of the Contractors general procedures) that cover the topics listed below:

i) Arrangements for 'receiving' and 'in-process' testing.

ii) Control of test laboratories.

iii) Control of test, measuring and inspection equipment.

iv) Document control.

v) Procedures for monitoring and recording the inspection, test and approval status of the constructed/installed work.

vi) Procedures for tests and inspections for the purpose of the Contractor certifying that prior to covering up, each part of the Works is complete and conforms to the Contract.

vii) Procedures for the review of work submitted for review but not accepted as conforming to the Contract.

viii) Procedure for the collation of quality records as identified in BS EN ISO 9001 and provision of copies when requested by the Employers Representative.

5.0 ORGANISATION QUALITY PLANS

5.1 The Quality Plan shall include:

i) Definition of the product or service to be provided.

ii) The organisation organogram shall describe the line of command and state the name of the senior manager responsible for the contracted Work and the name of the Organisations on-site Management representative. Contact addresses, telephone numbers etc. shall be provided.

iii) Identification of the relevant parts of the Organisations quality system relevant to the product or service being provided. Copies to be provided to the Employers Representative on request.

iv) The control of personnel selection (at works and on site), including special requirements for skilled personnel e.g. certification of welders, training of operatives, experience requirements etc.

5.2 Specific procedures shall be provided for the following:

i) Receipt and examination of certificates of conformity and test results for purchased products.

ii) Product identification and traceability.

iii) Handling, storage, packaging and delivery to site and storage and handling on site.

iv) Quality records.

6.0 TESTING

6.1 The Contractor shall undertake all compliance testing required during the course of the filling operation to check the material classification, acceptance limits and, the method of compaction control as defined by Appendix 6/1. The minimum frequency of testing is defined in Appendix 1/5 of the specification with the material acceptance and compliance limits set out in Appendix 6/1 and specifically in Table 6/1.

6.2 The compliance testing of the earthworks materials shall be carried out at a laboratory which holds UKAS (for geotechnical tests) or MCERTS (for chemical and contaminations tests) accreditation for the specific test. Where it is not possible to obtain the testing of a material for a specific property to a UKAS or MCERTS accredited method, the Contractor shall obtain permission from the Employers Representative for the test to be completed at by the proposed laboratory, before the test is undertaken.

6.3 The Contractor shall provide to the Supervisor, by mid-day on the first working day of each week, an updated electronic summary (Microsoft Excel 2010 or earlier) of all testing which has been completed up to the end of works for the previous week.

6.4 The testing summary shall be in a form agreed with the Supervisor, and shall include the results of all *in situ* test results (if the final validated report has not been issued by the appointed laboratory, these results shall be denoted with a draft to show that they are not final results). The summary shall also include a list of all samples submitted for laboratory testing, and provide the results of those laboratory tests where report certificates have been issued.

6.5 The information to be included for the summary of testing shall include, but not be limited to, the following:

i) sequential test number,

ii) date of test;

iii) coordinated position to include easting & northing, correct to National Grid Reference;

iv) reduced level, correct to m OD;

v) site reference;

vi) test grid reference;

vii) layer number (during placement of fill);

viii) test type;

ix) whether results are Draft (before the issue of certificate) or Final (certificate issued and received by Contractor); and

x) the results of the testing, compliance with the Specification and any comments relating to the test .

6.6 The contractor is to make available on site at all times a file containing all test certificates in addition to the testing summary, for inspection by the Supervisor.

6.7 The results of all testing shall be submitted to the Supervisor as soon as they are reported, and no more than 1 day after issue of the test certificate to the Contractor. It is recognised that different tests may take different time to complete; however the Contractor shall advise the Supervisor of any delay that they are aware of regarding the completion of any tests (e.g. a sample is being re-tested and the report will be delayed). The Supervisor shall be given sufficient time to review the content of the testing and the associated test results.

6.8 If in the opinion of the Supervisor, the material alters in classification or becomes unacceptable for whatever reason during the course of the filling operations, the Contractor will be required to repeat the compliance testing as required by the Supervisor. Equally, if the Contractor considers the classification of a material to have changed from that given in Appendix 6/1 they shall inform the Supervisor immediately.

6.9 The Contractor shall be responsible for removing from site any unacceptable material to suitably licensed facilities before the completion of their works.

7.0 SUPERVISOR

7.1 In addition to the detailed description of the role of the Supervisor, as defined by the NEC 3 Engineering and Construction Contract (ISBN 978 07277 3382 5), the Supervisor shall be on site with regular attendance and undertake the following role:

i) Liaison with the Contractor, Project Manager and Employers Representative.

ii) Reviewing of testing activities, this does not replace or absolve the Contractor from the responsibilities set out in the Specification requirements.

iii) Observing and commenting on the quality of the earthworks activities. This does not replace or absolve the Contractor from the responsibilities set out in the Specification requirements.

iv) Reviewing of soil/fill sampling as required under the specification and advising the Contractor of the results in order to allow the satisfactory progress of the works.

8.0 CONTRACTOR'S VALIDATION AND VERIFICATION REPORT

8.1 The Contractor will maintain records of the works to include, but not be limited to, the following:

i) daily record sheets to include a summary of the day's activities;

ii) progress photographs (not less than weekly);

iii) weather conditions;

iv) plant, personnel and visitors present;

v) aspects relating to Health and Safety, Environmental Control; and

vi) test results (refer to Sections 7.0).

8.2 The Contractor will ensure that the requirements of this Specification are complied with. Upon receipt of satisfactory demonstration that all of the works have been undertaken in accordance with the Specification, the Contractor shall provide a validation report. This report will include relevant site records and illustrate that the remedial and ground preparation works have been carried out in accordance with the Specification.

8.3 During the works and in areas of excavation, compaction or fill placement the Contractor will be required to undertake weekly topographical survey of the earthworks profile to provide a continuous record of the earthworks operations.

8.4 A verification report in accordance with the RMS and MMP is required to be prepared by the Contractor on those aspects of the works they have completed and are responsible for. The Contractor's report will include, where appropriate, the following:

i) daily record sheets to include a summary of the day's activities;

ii) progress photographs;

iii) general description of the works completed, including any earthworks, excavations (including excavations of hard obstructions or foundations), placement and compaction methodology and plant used;

iv) detailed weather conditions;

v) formation and foundation treatment, including drainage and treatment of soft areas;

vi) plant, personnel and visitors present;

vii) aspects relating to Health and Safety, Environmental control;

viii) waste transfer notes;

ix) application of acceptability criteria and summary of control test results for each specific earthworks material placed during the earthworks operations;

x) chemical and geotechnical test certificates and monitoring data including location and level with associated drawings;

xi) as built surveys, including base of excavations to include drawings;

xii) coordinates, levels, invert levels and diameters of services remaining on site;

xiii) drawings showing the location and level of each specific earthworks material placed during the earthworks operations, any feature or operation relevant to the earthworks including any instrumentation and the location of trial areas and control tests; and

xiv) all correspondence with Statutory Authorities.

APPENDIX 6/1: REQUIREMENTS FOR ACCEPTABILITY AND TESTING ETC. OF EARTHWORKS MATERIALS

1.0 ACCEPTABLE LIMITS FOR FILLS

Earthworks materials are to comply in general with the 600 series of the Highways Agency 'The Manual of Contract Documents for Highway Works', BS 6031:2009 and with the specific requirements of this appendix. Permitted classes of construction materials are defined in the following tables:

- Table 6/1 Acceptable Earthworks Materials: Classification and Compaction Requirements
- SHW Table 6/2 Grading Requirements for Acceptable Earthworks Materials

All earthworks materials are to meet the acceptability limits as set out in Table 6/1 and SHW Table 6/2

In general, engineered fill to raise site levels are to be constructed of Class 1 or Class 2 General Fill Material or Class 6 or Class 7 Selected Fill unless otherwise indicated on the Drawings. Where relevant any restrictions on the use of Class 2 and Class 3 materials are detailed in Specification Appendix 6/3, 6/14 and 6/15.

1.1 Processed Class U1A or U1B material may be used as earthworks materials subject to meeting the target acceptability limits as set out in Table 6/1, Table 6/2, Appendix 6/14, 6/15 and site specific requirements.

1.2 The Drawings show the general approach to where each Class of fill is to be used, including the requirements for zoning of general fill, selected fill and processed fill.

1.3 Earthworks materials derived from processed Class U1B material and used in the works are to be identified separately on the drawings.

1.4 Where undrained shear strength is specified as the method of acceptability testing, the Contractor may use a hand vane provided that it is initially calibrated against the unconsolidated undrained shear strength laboratory triaxial test to BS 1377:Part 7, clause 8 on 100mm nominal diameter samples, and the MCV test in accordance with BS 1377:Part 4. Otherwise, shear strength testing requirements is to be as set out in 633 of the SHW.

1.5 Where 'recycled aggregate' is used in this Specification, the material shall be aggregate resulting from the processing of material used in a construction process. The aggregate shall have been tested in accordance with SHW Clause 710, and the content of other materials (Class X) including wood, plastic and metal shall not exceed 1% by mass. Where 'recycled aggregate except recycled asphalt' is used in this Series, the aggregate shall have been tested in accordance with SHW Clause 710. Content of asphalt (mineral aggregate with a bituminous binder) shall not exceed 2% by mass, and the content of other materials (Class X) including wood, plastic and metal shall not exceed 1% by mass.

2.0 SPECIAL REQUIREMENTS FOR DETERMINING ACCEPTABILITY, WHO CLASSIFIES WHERE, AND WHETHER TRIAL PITTING IS REQUIRED

2.1 Acceptability testing is to be the responsibility of the Contractor and be carried out in accordance with Specification Appendix 6/1 and at the frequencies given in Appendix 1/5 in a UKAS accredited testing

laboratory. The Contractor is to include the location for each sampling point or in situ test position with the relevant test result which shall have a unique identification number.

2.2 Where source approval of imported material is shown, the testing is to be the responsibility of the Contractor and be carried out in accordance with Specification Appendix 6/1. Source approval will comprise (as a minimum) 3 sets of the relevant test on each sub-unit of material to be used in the Contract.

2.3 The Contractor is to maintain full records on each sub-unit of imported materials including but not limited to, the location of the sources, the suppliers details, the acceptability testing and the location it has been incorporated within the works.

2.4 On completion of each site specific earthworks operations a Geotechnical Feedback Report (GFR) is to be prepared by the Contractor and submitted to the Project Manager and is to comply with the requirements of HD 22/08 and shall include as a minimum the following information:

a) General description of the earthworks, excavations, placement and compaction methodology and plant used;

b) Detailed weather conditions;

c) Formation and foundation treatment including ground improvement, drainage measures and treatment of soft areas;

d) Application of acceptability criteria and summary of the control test results for each specific earthworks material placed during the earthworks operations;

e) A copy of all relevant test results including grid location and level;

f) Drawings showing the location of each specific earthworks material placed during the earthworks operations, any feature or operation relevant to the earthworks including instrumentation and the location of the trial areas and control tests; and

g) An electronic copy of all the test results and monitoring associated with the earthworks operations

2.5 Should any material be placed which has not been given prior written approval from Hydrock, the Contractor will have done this at their own risk and they will be responsible for any and all remedial works required to rectify the situation. All costs associated with this remedial work are to be borne by the Contractor.

3.0 RENDERING UNACCEPTABLE MATERIAL ACCEPTABLE

3.1 The Engineer must be informed if Class U1B material is to be processed to meet the target acceptability limits as set out in Table 6/1 so that appropriate acceptability criteria for the control of contamination can be set and agreed upon by all parties before the commencement of such remedial works.

3.2 Earthworks materials generated by demolition works or from excavation of concrete hardstanding/foundations/piles, not classified as Class U1B or Class U2, are to be classified as Class U1A and be processed to meet the 'recycled aggregate' requirements of Clause 601.12 of SHW and the target acceptability limits as set out in Table 6/1, Table 6/2 and site specific requirements. As far as it is practical, the Contractor should process Class U1A Made Ground material or excavated material into Selected Fill in preference to General Fill.

3.3 Rendering Class U1A material acceptable by lime (quicklime) modification is not permitted.

4.0 REQUIREMENTS FOR GROUNDWATER LOWERING OR OTHER TREATMENT

4.1 The Contractor is responsible for all groundwater lowering where this is required for the purposes of the construction works. This is particularly relevant, but is not limited to, dewatering of deep excavations and trenches.

4.2 The Contractor is responsible for obtaining all permits and/or licences required to undertake groundwater lowering and for treatment and/or disposal of said groundwater.

4.3 Where earthworks operations or ground improvement measures result in the expelling of groundwater into drainage layers or onto earthworks surfaces the discharged water shall be collected, treated if necessary and disposed of by the Contractor.

5.0 REQUIREMENTS FOR REMOVAL OFF SITE OF EXCAVATED ACCEPTABLE MATERIAL OR UNACCEPTABLE MATERIAL REQUIRING PROCESSING OR RETENTION OF SURPLUS MATERIAL ON SITE

5.1 No material is to be removed off site without the agreement of the Employer or NR.

5.2 Surplus material is to be temporarily stockpiled in areas designated for spoil storage. The earthworks design of the temporary stockpile is the responsibility of the Earthworks Contractor's Temporary Works Designer.

6.0 PERMITTED USE OF ACCEPTABLE MATERIAL OR UNACCEPTABLE MATERIAL REQUIRED TO BE PROCESSED FOR PURPOSES OTHER THAN GENERAL FILL

6.1 Earthworks materials derived from processed Class U1B material is to be used in the works only where shown on the Drawings or where agreed with the NR.

7.0 REQUIREMENTS FOR IN SITU RESISTIVITY TESTS

7.1 Where required, the determination of resistivity is to be measured by in situ testing.

8.0 REQUIREMENTS FOR IN SITU REDOX POTENTIAL TESTS

8.1 Where required, the determination of redox potential is to be measured by in situ testing

9.0 REQUIREMENTS FOR PLATE LOAD TESTING

9.1 Plate load testing is required to validate the performance of the earthworks at the formation and every 1m rise in fill.

9.2 Where Class 1 or 2 General Fill is used below highway corridors the plate load test shall be undertaken in accordance with Clause 10.4 for equivalent CBR.

9.3 Where Class 6 or 7 Selected fill is used below development plots the plate load tests shall be undertaken in accordance with Clause 9.5 for increments of working load.

9.4 Plate load tests for equivalent CBR is to be undertaken with a minimum 0.60m diameter plate. Smaller plate diameters may be used, but with any reduction, the lower the confidence in the result. The method of analysis should follow DMRB IAN 73/06 Rev 1 for an equivalent CBR. The modulus of subgrade reaction is an elastic modulus, and can only be proven if the test is done cyclically to ensure repeatable results. Therefore, the recommended testing protocols are as follows:

1. The initial seating stress is to be based upon the stress required to induce at least 1.5mm.

2. The first load cycle is applied incrementally, to achieve cumulate settlement intervals of 0.25, 0.50, 0.75, 1.00, 1.25 and 1.5mm respectively. Each incremental stress is maintained until there is less than 0.05mm per minute per increment before the next load is applied.

3. Upon achieving the 1.50mm settlement and less than 0.05mm per minute requirement, the plate is unloaded back to zero and the non-recoverable settlement at a stress of 0 kPa is recorded.

4. The dial gauges are re-set to zero, and the test is repeated to achieve the same number of increments with the corresponding same level of deformation (e.g. stress applied to achieve 0.25mm increments, up to a maximum nominal deformation of 1.50mm).

5. The results are assessed by:

    a. Checking that the non-recoverable settlement after the first cycle is less than 50% of the total (e.g. if the total settlement was 1.50mm, then after unloading back to zero the gauges should return to less than 0.75mm). If this is not achieved, additional stress cycles can be undertaken as this is indicative of poor compaction, until repeatable values are recorded.

    b. Compare the stiffness (E, Eplt) of the final cycle divided by the stiffness of the previous cycle. The target ratio for floor slabs should be less than 2.2, and never above 2.5.

    c. The modulus of subgrade reaction (ks, k760) for the final cycle, as the design value of the subgrade and checked against the slab design requirements. This can be converted to equivalent CBR if required by the design, using the equation in DMRB IAN 73/06 Rev 1.

9.5 Incremental plate load tests for confirmation of allowable bearing capacity should be undertaken in accordance with the ICE Specification for Ground Treatment 1987. Clause 6.17.1: Plate Bearing Test. There are two options defined in the ICE:

1. Method 1:

    a. Maximum applied stress is equal to 3 x working stress.

    b. Applied in six equal increments.

2. Method 2:

a. Plate diameter of 600mm.

b. Maximum applied load 11 tonnes (equivalent to a stress of 382 kPa).

c. Applied in five equal increments.

3. Both methods should employ a Dual Load Cycle, with the following requirements:

a. Settlement measured at 1 minute intervals until no more than 0.02mm is detected then over 5 minute intervals.

b. Stress held for 10 minutes or until two successive readings at 5 minute intervals are the same (deemed to be within 0.02mm) whichever is the greater.

c. Maximum stress held for 15 minutes or until three successive readings at 5 minute intervals are the same, whichever is the greater.

d. Settlement measured on release of load and then after 5 minutes

4. The compliance requirements when used to check the performance of the ground following this procedure are:

a. Less than 8mm for 1 x Design Verification Stress (DVS).

b. Less than 16mm for 2 x DVS.

c. Less than 24mm for 3 x DVS.

d. More than 50% recovery of induced settlement upon unloading back to 0 kPa.

e. The DVS is based upon the Design Stress of the Foundation + Design Stress of Floor Slab + Any Engineered Fill (where the ground is cut, the normal reduction in imposed allowed for this is usually limited to only 25% of the unit weight; however, where it is filled, it is based on 100% of the unit weight of the engineered fill).

10.0 RESPONSIBILITY FOR THE WORKS

10.1 The Contractor is responsible for the works covered by the specification and is permitted to self certify the works, in accordance with the requirements of the specification. The right of self certification is not to be delegated or extended to any of the following parties:

- Subcontractors, employed by the Contractor,
- Service owners contractors undertaking backfilling of diverted service trenches,
- Other third party contractors undertaking works on the site.

TABLE 6/1: ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within: Lower	Acceptable limits Within: Upper				
GENERAL GRANULAR FILL	1	A	-	Well graded granular material	General fill	Any material, or combination of material designated as Class 3 in the Contract. Recycled aggregate	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 modified as required to ensure minimum 95% of MDD OMC/MDD determined using Vibrating Hammer	1	A	-
							(ii) uniformity coefficient	See note 5	10	-				
							(iii) mc	BS 1377-2	OMC -2%	OMC +2%				
							(iv) OMC / MDD	BS 1377-4	Declared	Declared				
							(v) CBR at OMC	BS 1377-4	5%	-				
	1	B	-	Uniformly graded granular material	General fill	Any material, or combination of material designated as Class 3 in the Contract. Recycled aggregate	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 modified as required to ensure minimum 95% MDD OMC/MDD determined using Vibrating Hammer	1	B	-
							(ii) uniformity coefficient	See note 5	-	10				
							(iii) mc	BS 1377-2	OMC -2%	OMC +2%				
							(iv) OMC / MDD	BS 1377-4	Declared	Declared				
							(v) CBR at OMC	BS 1377-4	5%	-				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	A	-	Wet cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 1 modified as required to ensure minimum 95% MDD or Cu of 50kN/m² (subject to prior agreement with the Engineer) OMC/MDD determined using 2.5kg Rammer Except for materials with liquid limit greater than 50, only deadweight tamping or vibratory tamping rollers or grid rollers shall be used	2	A	-
							(ii) plasticity index (PI)	BS 1377-2	Declared	Declared				
							(iii) mc	BS 1377-2	105% MDD or <10% Air Voids	Min cu of 50kN/m²				
							(iv) undrained shear strength (c)	SHW Clause 633	50 kN/m²	-				
							(v) OMC/MDD	BS 1377-4	Declared	Declared				
							(vi) Particle Density	BS 1377-2	Declared	Declared				
	2	B	-	Dry cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 modified as required to ensure 95% MDD or minimum Cu of 80kN/m² (subject to prior agreement with the Engineer) OMC/MDD determined using 4.5kg Rammer	2	B	-
							(ii) plasticity index (PI)	BS 1377-2	Declared	Declared				
							(iii) mc & MCV	BS 1377-2	105% MDD or <10% Air Voids	Min cu of 80kN/m²				
							(iv) undrained shear strength (c)	SHW Clause 633	80 kN/m²	-				
							(v) OMC/MDD	BS 1377-4	Declared	Declared				
							(vi) Particle Density	BS 1377-2	Declared	Declared				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
GENERAL COHESIVE FILL	2	C	-	Stony cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 2 modified as required to ensure 95% MDD or Cu of 50kN/m² (subject to prior agreement with the Engineer) OMC/MDD determined using 2.5kg Rammer.	2	C	-
							(ii) plasticity index (PI)	BS 1377-2	Declared	Declared				
							(iii) mc	BS 1377-2	105% MDD or <10% Air Voids	Min cu of 50kN/m²				
							(iv) undrained shear strength (c)	SHW Clause 633	50 kN/m²	-				
							(v) OMC/MDD	BS 1377-4	Declared	Declared				
							(vi) Particle Density	BS 1377-2	Declared	Declared				
	2	D	-	Silty cohesive material	General fill	Any material, or combination of materials other than material designated as Class 3 in the contract	(i) grading & sedimentation analysis	BS 1377-2	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 3 modified as required to ensure 95% MDD or Cu of 50kN/m² (subject to prior agreement with the Engineer) OMC/MDD determined using 2.5kg Rammer.	2	D	-
							(ii) plasticity index (PI)	BS 1377-2	Declared	Declared				
							(iii) mc	BS 1377-2	105% MDD or <10% Air Voids	Min cu of 50kN/m²				
							(iv) undrained shear strength (c)	SHW Clause 633	50 kN/m²	-				
							(v) OMC/MDD	BS 1377-4	Declared	Declared				
							(vi) Particle Density	BS 1377-2	Declared	Declared				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
LANDSCAPE FILL	4	-	-	Various	Fill to landscape areas	Any material, or combination of materials	(i) grading	BS 1377-2	Declared	Declared	SHW Clause 620 Material to be placed to an appropriate method so as to ensure a minimum undrained shear of 40kN/m² is achieved. Maximum particle size to be limited to 300mm	4	-	-
							(ii) MC	BS 1377-2	-	Equivalent of Cu of 40kN/m²				
							(iii) undrained shear strength by HSV	Manufacturers Instruction	40kN/m²	-				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
	6	F	1	Selected granular material (fine grading)	Capping	Any material, or combination of materials (other than colliery spoil, argillaceous rock or chalk). Recycled aggregate	(i) grading	BS 1377-2	Table 6/2	Table 6/2	SHW Table 6/4 Method 6 modified as required to ensure minimum 95% MDD OMC/MDD to be determined using Vibrating Hammer Constituent materials determined in accordance with SHW Clause 710	6	F	1
							(ii) OMC/MDD	BS 1377-4: 3.7	Declared					
							(iii) mc	BS 1377-2	OMC -2%	OMC				
							(iv) Los Angeles coefficient	SHW Clause 635	-	60				
							(v) Class Ra (asphalt) content	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697-1	-	2.0%				
	6	F	2	Selected granular material (fine grading)	Capping	Any material, or combination of materials (other than colliery spoil, argillaceous rock or chalk). Recycled aggregate	(i) grading	BS 1377-2	Table 6/2	Table 6/2	SHW Table 6/4 Method 6 modified as required to ensure minimum 95% MDD OMC/MDD to be determined using Vibrating Hammer Constituent materials determined in accordance with SHW Clause 710	6	F	2
							(ii) OMC/MDD	BS 1377-4: 3.7	-	-				
							(iii) mc	BS 1377-2	OMC -2%	OMC				
							(iv) Los Angeles coefficient	SHW Clause 635	-	50				
							(v) Class Ra (asphalt) content	Clause 710	-	50%				
							(vi) bitumen content	BS EN 12697-1	-	2.0%				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED GRANULAR FILL	6	F	3	Selected granular material	Capping (Not to be used below structures)	Recycled bituminous road planings and granulated asphalt, but excluding materials containing tar or tar-bitumen binders. Recycled aggregates	(i) grading and constituent parts	BS 1377-2 (on-site)	SHW Table 6/2	SHW Table 6/2	SHW Table 6/4 Method 6 modified as required to ensure minimum 95% MDD OMC/MDD to be determined using the Vibrating Hammer Maximum compacted layer thickness shall be 200mm Constituent materials determined in accordance with SHW Clause 710	6	F	3
								BS EN 933-2 (Off-site)	SHW Table 6/5	SHW Table 6/5				
							(ii) OMC/MDD	BS 1377-4: 3.7	-	-				
							(iii) mc	BS 1377-2	OMC -2%	OMC				
							(iv) Class Ra (asphalt) content	Clause 710	50	-				
							(v) bitumen content	BS 598-102	-	10%				
	6	F	4	Selected granular material (fine grading)	Imported Capping	Unbound mixtures complying with BS EN 13285	Size designation and overall category	BS EN 13285- 0/31.5 and G_E	SHW Table 6/5	SHW Table 6/5	SHW Table 6/4 Method 6 modified as required to ensure minimum 95% MDD OMC/MDD to be determined in accordance with BS EN 13285-5.3 Constituent materials determined in accordance with SHW Clause 710	6	F	4
						Any material or combination of materials – including recycled aggregate, but excluding colliery spoil, argillaceous rock, chalk, recycled bituminous planings and granulated asphalt	Maximum fines and oversize categories	BS EN 13285- UF_{15} and OC_{75}	SHW Table 6/5	SHW Table 6/5				
							Los Angeles coefficient	BS EN 13242-LA_{60}	-	60				
							Volume stability of blast furnace slag	BS EN 13242	Free from dicalcium silicate and iron disintegration					
							Volume stability of steel (BOF) and EAF slag	BS EN 13242 - V_5	-	-				
							Other aggregate requirements	BS EN 13242	Category $_{NR}$ (no requirement)					
							Laboratory dry density and OMC	BS EN 13285-Clause 5.3 -	Declared values					
							Water content	BS EN 1097-5	OMC-2%	OMC				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED GRANULAR FILL	6	F	5	Selected granular material (fine grading)	Imported Capping	Unbound mixtures complying with BS EN 13285	Size designation and overall category	BS EN 13285- 0/80 and G_E	SHW Table 6/5	SHW Table 6/5	SHW Table 6/4 Method 6 modified as required to ensure minimum 95% MDD OMC to be determined in accordance with BS EN 13285-5.3 Constituent materials determined in accordance with SHW Clause 710	6	F	5
						Any material or combination of materials – including recycled aggregate, but excluding colliery spoil, argillaceous rock, chalk, recycled bituminous planings and granulated asphalt	Maximum fines and oversize categories	BS EN 13285- UF_{12} and OC_{75}	SHW Table 6/5	SHW Table 6/5				
							Los Angeles coefficient	BS EN 13242-LA_{50}	-	50				
							Volume stability of blast furnace slag	BS EN 13242	Free from dicalcium silicate and iron disintegration					
							Volume stability of steel (BOF) and EAF slag	BS EN 13242 - V_5	-	-				
							Other aggregate requirements	BS EN 13242	Category $_{NR}$ (no requirement)					
							Laboratory dry density and OMC	BS EN 13285-Clause 5.3 -	Declared values					
							Water content	BS EN 1097-5	OMC-2%	OMC-2%				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED GRANULAR FILL	6	N	-	Selected well graded granular material	Fill to structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, slag, well burnt colliery spoil or any combination thereof. None of these constituents shall include any argillaceous rock. Recycled aggregate except recycled asphalt.	(i) grading	BS1377-2 (On-site)	SHW Tab 6/2	SHW Tab 6/2	End product 95% MDD OMC/MDD determined using Vibrating Hammer Constituent materials determined in accordance with SHW Clause 710	6	N	-
								BS EN 933-2 (Off-site)	SHW Tab 6/5	SHW Tab 6/5				
							(ii) uniformity coefficient	See note 5	10	-				
							(iii) Los Angeles coefficient	Clause 635	-	40				
							(iv) MC	BS 1377-2	OMC -2%	OMC +1%				
							(v) OMC/MDD	BS 1377-4: 3.7	Declared	Declared				
							(vi) CBR at OMC	BS 1377-4	12%	-				
							(vii) Sulphate (SO_4) total sulphur (S) and Total Potential Sulphate (TPS)	TRL 447	Declared	Declared				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED GRANULAR FILL	6	P	-	Selected granular material	Fill to structures	Natural gravel, natural sand, crushed gravel, crushed rock, crushed concrete, slag, well burnt colliery spoil or any combination thereof. None of these constituents shall include any argillaceous rock. Recycled aggregate except recycled asphalt.	(i) grading	BS1377-2 (On-site)	SHW Tab 6/2	SHW Tab 6/2	End product 95% MDD OMC/MDD determined using Vibrating Hammer Constituent materials determined in accordance with SHW Clause 710	6	P	-
								BS EN 933-2 (Off-site)	SHW Tab 6/5	SHW Tab 6/5				
							(ii) uniformity coefficient	See note 5	5	-				
							(iii) Los Angeles coefficient	Clause 635	-	60				
							(iv) MC	BS 1377-2	OMC -2%	OMC +1%				
							(v) OMC/MDD	BS 1377-4: 3.7	Declared	Declared				
							(vi) CBR at OMC	BS 1377-4	8%	-				
							(vii) Sulphate (S04) total sulphur (S) and Total Potential Sulphate (TPS)	TRL 447	Declared	Declared				

TABLE 6/1 (continued): ACCEPTABLE EARTHWORKS MATERIALS: CLASSIFICATION AND COMPACTION REQUIREMENTS (SEE FOOTNOTES)

Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and Appendix 6/1)	Material Properties Required for Acceptability in Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631				COMPACTION REQUIREMENTS IN CLAUSE 612 & ADDITIONAL NOTES	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable limits Within:					
									Lower	Upper				
SELECTED COHESIVE FILL	7	A	-	Selected cohesive material	Fill to structures	Any material, or combination of materials, other than argillaceous rock, chalk or colliery spoil	(i) grading	BS 1377-2	SHW Table 6/2	SHW Table 6/2	End product of 100% of MDD and/or minimum undrained shear strength of 100 kN/m² (subject to prior agreement with the Engineer) with less than 5% air voids. *Where the undrained shear strength is measured by Hand Shear Vane (HSV) the target cu is 120kN/m² (subject to calibration with triaxial tests) MDD to be determined using 2.5kg Rammer and to include measurement of particle density ² Where the Liquid Limit and/or plasticity index are in excess of the values defined in this Table, the Contractor shall inform Hydrock for further guidance on the use of this material.	7	A	-
							(ii) mc	BS 1377-2	Equivalent to 105% MDD and max of 5% air voids	Equivalent to 100% MDD and/or cu of *100 kN/m²				
							(iii) Sulphate (SO_4) total sulphur (S) and Total Potential Sulphate (TPS)	TRL 447	Declared	Declared				
							(iv) undrained shear parameters (cu)	SHW Clause 633	cu = *100kN/m²	-				
							(v) liquid limit	BS 1377-2	-	² 45				
							(vi) plasticity index	BS 1377-2	-	² 25				

Footnotes to Table 6/1:

1. App = Appendix
2. Tab = Table
3. Where in the Acceptable Limits column reference is made to App 6/1, only those properties having limits ascribed to them in Appendix 6/1 shall apply. Where Appendix 6/1 gives limits for other properties not listed in this Table such limits shall also apply.
4. Where BS 1377: Part 2 is specified for mc, this shall mean BS 1377:Part 2 or BS EN 1097-5 as appropriate.
5. Uniformity coefficient is defined as the ratio of the particle diameters D60 to D10 on the particle-size distribution curve, where: D60 = particle diameter at which 60% of the soil by weight is finer and D10 = particle diameter at which 10% of the soil by weight is finer.
6. The limiting values for Class U1B material are given in Appendix 6/14 and Appendix 6/15.
7. Where undrained shear strength is specified as the method of acceptability testing, the Contractor may use a hand vane provided that it is initially calibrated against the unconsolidated undrained shear strength laboratory triaxial test to BS 1377:Part 7, clause 8 on 100mm nominal diameter samples, and the MCV test in accordance with BS 1377:Part 4. Otherwise, shear strength testing requirements is to be as set out in 633 of the Specification.
8. The contents of this table may be revised following periodic engineering assessments and design by the Project Manager.
9. Where supplementary clauses and tables are reference in Table 6/1 above, they shall refer to the equivalent clause or table from the Manual of Contract Documents for Highway Works, Specification for Highway Works: Volume 1: (SHW).

APPENDIX 6/2: REQUIREMENTS FOR DEALING WITH CLASS U1B AND CLASS U2 UNSUITABLE MATERIALS

1.0 General

1.1 Unacceptable material, Class U2 shall be defined as in SHW Clause 601.3. The Contractor is referred to the site specific earthworks and remediation method statements and specifications for the requirements regarding Class U1B and Class U2 Unacceptable Material.

1.2 If unacceptable material is encountered within the works, a risk assessment will be carried out and the contractor shall make all necessary arrangements for their safe handling and disposal after consultation with the appropriate environmental authority in accordance with SHW Clause 602. As such the Contractor shall put in place contingency measures to deal with U2 materials if encountered during the earthworks.

1.3 The Contractor shall make all necessary enquiries and arrangements for the transfer of U1B and U2 materials for their disposal off-site and shall liaise with the relevant regulatory bodies prior to initiating removal of any material from site.

1.4 Where Class U1B material is identified and are unsuitable for treatment on site, the Contractor shall undertake appropriate testing including Waste Acceptance Criteria (WAC) Tests to determine the waste type and whether the waste will comprise U2 material, i.e. Hazardous Waste.

1.5 The Contractor shall inform the Engineer immediately of the discovery of U1B or U2 materials, asbestos or other gross contamination. The Contractor shall define in their Method Statement the procedures for handling asbestos, U1B or U2 materials or other waste.

1.6 No groundwater or surface water encountered during excavation shall be discharged to foul or storm sewer, nor to watercourses without the prior written approval of the Sewer provider or the Environment Agency respectively.

1.7 The Contractor shall ensure at all times that:

- The exposure of site personnel and the general public to hazards is avoided; and
- Contamination or pollution migrating within the site or beyond the site boundaries is prevented.

1.8 Throughout the Works the Contractor shall pay particular attention to the following:

Handling and disposal of contaminated soils and water

a) Keep the waste safe. Holders should protect the waste both whilst in their possession and for its future handling requirements. Security precautions where waste is to be held prior to removal from site should prevent theft, vandalism, waste scavenging and fly tipping. Waste shall be removed from site in appropriate containers.

b) Transfer to the correct person. Waste may only be handed on to authorised persons or to persons authorised for transport purposes. The Contractor shall pay due regard to Duty of Care and associated regulations.

c) The Contractor shall ensure that waste is collected regularly. The maximum volume of material in a single stockpile on site at any time shall not exceed 500m³.

d) The Contractor shall ensure that all waste is stockpiled in accordance with a method statement approved by the Engineer and shall as a minimum included for bunding, basal membrane and top cover membrane to prevent rainfall infiltration and run-off.

e) The Contractor shall comply with Duty of Care Regulations and shall keep records of waste dispatched from site, including waste transfer notes. All records are to be made available to the Engineer and/or Regulator upon request. The Contractor shall ensure that all landfill gate receipts are copied to the Engineer within two working days of dispatch from site.

(f) The Contractor shall ensure that all waste is taken to a disposal facility which is licensed to receive that specific waste type (as determined by chemical analyses and WAC tests).

g) All waste leaving the site shall be sheeted, without holes or tears in the sheeting fabric. Where possible, the Contractor shall use self sheeting lorries to haul waste from the site. Where these are not available, the Contractor shall take appropriate measures to construct a safe and suitable sheeting gantry. Where sheets are to be laid over the container, they shall be secured in place. In the event of any loss of waste during transit, the Contractor shall ensure that the lost waste is collected and transported correctly to the receiving facility.

h) The Contractor shall supply the Engineer with a schedule containing vehicle registration number, owner, weight (unladen and gross maximum permitted) and driver details of each vehicle used for transport of materials off-site.

Sub-contracting

a) In order to ensure compliance with the Duty of Care Regulations, the Contractor must nominate all Sub-Contractors before a contract is entered into for undertaking this work.

Site Monitoring

a) The Contractor shall be responsible for all documentation of waste leaving the site and for validation of the chemical composition of waste.

b) A designated person must be made responsible for co-ordinating and ensuring that all appropriate precautions are taken against the escape of hazardous substances. This designated person shall maintain an up to date site record. The Contractor shall demonstrate the competence of this person to the satisfaction of the Engineer.

c) Only authorised persons shall be allowed access to the site. All site personnel shall be required to attend a sire safety induction prior to commencement of works on the site.

d) All persons entering the site must be made fully aware of the hazards and risks on site prior to entering the site. Instructions shall be issued by the Contractor regarding Health and Safety

precautions required. All persons will be required to sign a declaration of understanding and acceptance of site instructions. This is to protect both the individual and other personnel on the site. Non-compliance with this regime must in all cases result in refused entry to site.

e) If any person fails to comply with the health and safety precautions that person is to be removed from site immediately. Return to site would be at the discretion of the Engineer. The Contractor shall ensure that any individual who deliberately flaunts the health and safety precautions is dismissed from site and not permitted to return to the site.

f) In the instance of a possible danger occurring, safety on site shall be of utmost priority. Immediate action must be taken for the health and safety of all personnel on site. The location of the danger and any exclusion zone shall be evacuated immediately. The Contractor shall produce a method statement to set out the measures and steps to be followed in the event of such an occurrence and shall include, where applicable, for notification of emergency services, HSE, Planning Co-ordinator and the like.

g) All persons entering the site shall wear appropriate Personal Protective Equipment (PPE), which is to include but not be limited to: safety Wellingtons or boots (steel mid-sole and toe caps); overalls and/or impermeable outer garments; nitrile or other suitable gloves; safety goggles; and ear defenders.

h) First Aid facilities and suitably competent personnel shall be available at clearly identifiable locations on site.

i) A Site Safety Officer shall be appointed by the Contractor and shall be responsible for health surveillance on the site.

j) The Contractor shall take appropriate measures to avoid and prevent cross contamination of plant and personnel and also to ensure that all plant and personnel are free from contaminants and mud upon exiting the site.

APPENDIX 6/3: REQUIREMENTS FOR EXCAVATION, DEPOSITION, COMPACTION (OTHER THAN DYNAMIC COMPACTION)

1.0 EARTHWORKS GENERAL

1.1 Earthworks requirements including constraints on earthworks in relation to structures and water courses are shown on Drawings.

1.2 No ground disturbing activities, including any earthmoving activities, are to commence prior to the Contractor obtaining any necessary permits or licences relating to protected species or habitats. If a licence or permit for such works is granted, those works shall only be undertaken during the periods as stated on the licence or permit under the direction of the licence or permit holder. A copy of the licence and/or permit shall be provided to the Employer prior to commencement of the relevant activities.

1.3 Material excavated and designated for processing shall be transported to the appropriate process area for stockpiling and treatment. Clearly defined segregated stockpiles are required for different sub-classes of processed material. The maximum permitted height of stockpiles, excluding topsoil Class 5, shall be 5.0 m unless otherwise agreed. The maximum volume of any single stockpile shall not exceed 500m^3.

1.4 For temporary storage of earthworks materials, except topsoil Class 5, maximum permitted height of stockpiles shall be 5.0 metres unless otherwise agreed, subject to other restrictions noted elsewhere in this specification. Earthworks materials requiring to be stockpiled shall be stored in individual stockpiles for each earthworks class and end-use.

1.5 On completion of a stockpile the slopes shall be trimmed to falls to shed rain water and the surface sealed to limit infiltration. Temporary drainage shall be provided at the base of the stockpile to collect runoff from the stockpile and to carry any surface water away from the base of the stockpile.

1.6 The Contractor shall provide and maintain such measures as necessary to eliminate the production of dust from the stockpile during the life of the stockpile.

2.0 CUTTING FACES

2.1 No specific limitations or restrictions on undercutting are included, but the Contractor shall comply with the Temporary Works Designer requirements when excavating trenches at the toe of any slopes.

2.2 Clearing loose material from cutting slopes by airline hose is not permitted.

2.3 The Contractor shall provide additional drainage measures to intercept and discharge seepages from cutting slopes in general accordance with the details provided in the Drawings. The Contractor is responsible for all drainage required to carry out the works and to protect them upon completion, which will include, where necessary, temporary drainage measures.

2.4 Cutting faces which are to have topsoil shall be made good prior to topsoil placement as shown on the Drawings. If the drawings do not show details then any of the methods set out in Clause 603.7 of SHW

shall be used as required except that the use of concrete, grout, masonry infill and sprayed concrete is not permitted.

3.0 WATER COURSES

3.1 Details of regarding existing water courses, construction of new water courses and earthworks drainage ditches are shown on the Drawings.

3.2 Redundant watercourses shall be drained and cleaned as described on the Drawings. Excavated arisings are to be treated as described in Appendix 6/2. Watercourses shall be filled with earthworks materials as shown on the Drawings.

3.3 The Contractor shall provide for such measures as may be necessary to ensure that water, whether ground water, from precipitation or any other source does not accumulate in excavations or on sub-grades.

3.4 The Contractor shall arrange for the rapid dispersal of water shed on to the surface of earthworks or completed formation during construction or which enters the earthworks from any other source.

3.5 The Contractor shall provide where necessary temporary watercourses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall include carrying out the work of forming the earthworks in such a manner that their surfaces have at all times a sufficient minimum cross-fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding. This shall include the provision of temporary measures to remove water expelled from the ground due to the change in imposed load from the construction or construction activities (including ground improvement).

3.6 All works and associated costs relating the control and management of water on site, from existing, proposed or redundant watercourses or from any other sources including groundwater, rainfall and surface water is the responsibility of the Contractor. All costs are to be borne by the Contractor and the Contractor is deemed to have read, understood and fully accounted for these costs within their Tender submission. Any uncertainty over the issues associated with water or groundwater control should be submitted to the Engineer for clarification, as soon as any such issue is noted or identified by any party.

4.0 CONSTRUCTION GENERAL REQUIREMENTS

4.1 Location of fill types are shown on the Drawings. In addition to this, General fill is only to be used in areas outside of the influence of the proposed structures. Any fill placed within the influencing zone of structures shall comply with the requirements of Class 6 or Class 7.

4.2 The Contractor is responsible for agreeing with the Supervising Engineer the extents of the General Fill and Selected Fill.

4.3 Locations of starter layers are shown on Drawings.

4.4 Details of benching are to be a maximum of 0.50m in height with the length of the bench cut to meet the profile of the excavation. In addition to this, where structural loads may span across an excavation where benching has been employed, the length of each bench must be at least twice the height.

4.5 The height of each bench shall reflect the thickness of the compacted layer, and shall be no more than 2 compacted layers in height.

4.6 All bench details shall be agreed with the Engineer.

4.7 Over-steepening of embankment side slopes shall only be permitted with the approval of the Engineer.

5.0 CONSTRUCTION OF FILL

5.1 Embankment slopes shall not be constructed steeper than that shown on the Drawings. Temporary over-widening or steepening to achieve adequate compaction of the shoulders of the embankment is permitted.

5.2 Any areas requiring staged construction of fills then the details for the staged construction and hold periods are shown on the Drawings and are to be under the direction of the Engineer.

5.3 Any areas requiring surcharging, details including levels, time periods for surcharging, type of surcharge material are shown on the Drawings.

5.4 Any areas requiring protection to the formation or sub-formation against weather, carried out in accordance with Clause 608.9(ii) of SHW, are shown on the Drawings.

5.5 Any areas requiring starter layer, together with class type and thicknesses are shown on the Drawings.

5.6 The proposed staged process of earthworks are as detailed within this Specification.

5.7 Formation for earthworks construction and cutting formations shall be proof-rolled using a minimum compactive effort as detailed in Specification Clause 613.11 and 613.12. This minimum compactive effort shall be increased for cutting formations where different compactive efforts, dependent on the type of follow-on earthworks operations, are required by the Specification. The identification of a ‘soft spot’ is qualitative and depends on the response of the ground to the compactive effort during the proof-rolling.

5.8 For the purposes of this contract, the definition of a soft area will correspond to a CBR of less than 2%. As a minimum excessive mattressing, bow-waving or ground heave shall be indicative of a ‘soft spot’ which will then require testing by the contractor to determine the CBR of the subgrade. The Contractor is to agree with the Supervising Engineer the extent of ‘soft spot’ treatment.

5.8 it is considered likely that localised ‘soft spots’ may occur during the during the proof rolling exercise and as such detailed discussion and agreement will be required with the Supervising Engineer at the outset in order to adopt a standardised procedure for dealing with this occurrence.

6.0 COMPACTION

General

6.1 It is envisaged that most of the fill to be used on this site will be derived from site won materials which will either be classed as general fill to external areas, or as selected fill to form the capping below the sub base in the highway pavement. Requirements for compaction of earthworks materials shall comply with Clause 612 of SHW and HA 70. Compaction requirements shall be as described below.

Method Compaction

6.2 For method compaction of earthworks materials extra compaction in the top 600mm for a Class 1A, 1B, 2A, 2B, 2C and 2D **is** required unless otherwise shown on the Drawings. Requirements for compaction of drainage material, if a geocomposite is not used, are shown on the Drawings. The frequency of field dry density testing shall be as set out in Appendix 1/5.

6.3 A series of Compaction Compliance Envelopes, presented as figures, have been produced which represent the requirements from Table 6/1 on the compaction requirements for the main types of fill to be used in this project. Reference shall be made to these figures and a source specific envelope shall be provided by the Contractor based upon the results of the classification testing for each material and shall be used in the assessment of compliance.

6.4 The in situ testing shall be undertaken in accordance with the frequency defined in Appendix 1/5 and shall demonstrate that the adopted method achieves the minimum end product performance detailed in Table 6/1. Where the testing identifies that the minimum end product performance is not being met, then the method of compaction shall change, and a new compaction trial shall be undertaken

End Product Compaction

6.6 Where the compaction requirements specified in Table 6/1 state that End Product Compaction is required, the fill shall be tested in accordance with the frequency defined in Appendix 1/5.

6.7 The minimum compliance requirements to be met by fill placed to either Method Placement to End Product Compaction are defined in Section 6.26 of this Appendix.

Compaction Trial

6.8 A compaction trial is required to be completed for each compaction method to be used and for each source of material. Prior to undertaking the trial, the Contractor shall confirm to the Hydrock the following:

- What method of compaction is to be used in the trial and whether or not it has been based upon the guidance from SHW Table 6/4.
- What compaction plant is to be used, including but not limited to the type of equipment, manufacture, mass per meter width and any other relevant information which can be used to assess its suitability for the material to be compacted.

- Confirmation of the source of material to be used, and whether or not there are any geotechnical results available from source suitability testing prior to the commencement of the trial.
- Confirmation that they understand the minimum specification requirements for end-performance of the fill which are to be assessed and demonstrated during the trial.
- The methodology for assessing fill, including test type and frequency and who will be undertaking the testing both on site and for the subsequent laboratory analysis.
- Confirmation that all parties who are to attend the trial have been informed of when and where the trial will be undertaken.

6.9 For each Class of material as defined in Table 6/1, and each proposed compaction method, a number of test panels shall be constructed in order to allow a full assessment to be completed. Key criteria to identify during the compaction trial will be:

- Change in density and air voids against number of passes.
- Change in density and air voids against depth of layer.
- Change in engineering performance against compactive effort.
- Identification of point of over-compaction/softening of fill.
- Comparative analysis between different plant [where more than one roller is proposed]
- Suitability of material for use on site for the proposed end-use.
- Confirmation of classification and engineering performance of material, including sampling, laboratory testing and classification of the material.
- Comparison of actual performance of material against specification design values.
- Calibration of testing equipment, in particular where the use of a Nuclear Density Gauge [NDG] is proposed for the monitoring of earthworks operation.

Selection of End Product Requirements to be Demonstrated during Compaction Trial

6.10 Reference shall be made to the Compaction Compliance Envelopes presented as Figures 6/3-1 to 6/3-5 inclusive.

6.11 For the Class 1 General Fill material, it shall be placed and compacted at a moisture content equivalent to the OMC-2% to the OMC+2% and that it should achieve an *in situ* dry density greater than 95% of the MDD when determined using the Vibrating Hammer.

6.12 For Class 2A, 2C, 2D and 2E General Fill, it shall achieve an *in situ* dry density of at least 95% of the MDD determined using the 2.5kg Rammer and have a minimum undrained shear strength in accordance with Table 6/1 of this Specification.

6.13 For Class 2B and Class 7 selected fill, the degree of compaction shall be either 100% of the MDD from the 2.5kg Rammer or 95% of the MDD determined from the 4.5kg Rammer. The Contractor is to confirm with the Engineer/NR which method of laboratory compaction is to be used for Class 2B material before it is tested. Additional requirements for the fill such as strength, bearing capacity and settlement are shown on the Drawings.

6.14 This degree of compaction and additional requirements from Table 6/1 shall form the basis of the compaction specification of Class 1, Class 2, Class 6 and Class 7 fill used as part of the earthworks operation.

6.15 The Contractor shall carry out a compaction trial for each type of material and compaction method to be used to demonstrate that the required degree of compaction and additional requirements can be met. The site of the trials shall be clearly marked and levels taken to determine the thickness of each layer before and after compaction.

Construction of Compaction Trial Test Panels

6.16 For each material type, a number of test panels may be required in order that a full assessment of the material and compaction method can be completed, which would then constitute the Compaction Trial. Although the size of each panel will need to reflect the size of the compaction plant and methodology of work proposed, a minimum width of 8m by 20m in length is recommended, with a number of different layer depths as indicated in Figure 6/3-1.

6.17 Each test panel should be laid out and clearly identified and defined separately from any other test panel to avoid cross-contamination, accidental influence from adjacent works and located on site away from other works.

6.18 The depth of each layer forming the test panel should reflect the likely depth of compacted material, post completion of the compaction trial, i.e. sufficient material should be placed so that the final depth of the compacted layer is in accordance with the guidance provided in Table 6/4 of the SHW. In the unlikely event that a material is proposed to be compacted and it is not possible to classify the material in order to identify the most likely method of compaction, a significantly higher number of test panels will be required in order to identify the optimum plant, layer thickness and number of passes.

Compaction of Test Panels

6.19 Unless specifically instructed within the site specific documentation, earthmoving plant shall not be accepted as compaction equipment, nor the use of lighter compaction plant to provide any preliminary compaction prior to the use of heavier equipment.

6.20 Although the guidance from Table 6/4 of the SHW may indicate the optimum number of passes of the appropriate plant, it is important that the progression of improvement of the material is monitored throughout the compaction process. Therefore, after each and every two passes of the appropriate roller, *in situ* assessment of the density of the material is to be undertaken. One pass of the roller is defined as a single movement of the compaction plant, in one direction, over a given strip of the test panel.

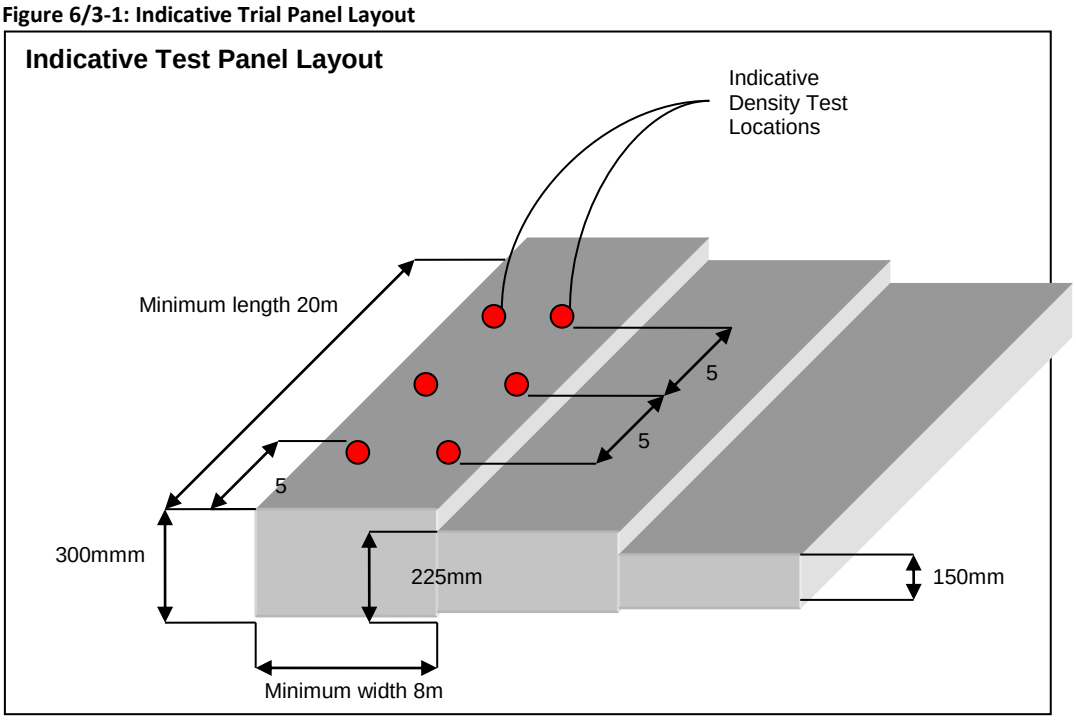
6.21 Where the width of the test panel or roller requires a number of passes in order to ensure the full width of the surface is compacted, it is acceptable for the roller to overlap the previous strip by a small margin (no more than 25% of the maximum roller width). However it should be ensured that no in situ testing is undertaken in this zone to prevent the effect of over-compaction influencing the assessment of the performance of the plant and material.

6.22 The compaction of the test panel should continue incrementally until a clear indication has been obtained to show that the soil has either achieved a maximum density, i.e. where after a number of repeat passes is completed no change is identified or has been over compacted and the performance of the material begins to deteriorate. The exception to this will be where the final performance of the test panel is required to be confirmed using plate load testing, and in this instance it is recommended that a separate panel is constructed, to the same specification as has been identified during the compaction trial, in order that the assessment of the performance can be completed without the detrimental influence of over-compacted material.

6.23 Guidance on the point of over compaction may be readily identifiable on site from a number of key parameters:

- Reduction in bulk density/dry density with increasing compaction.
- Increase in moisture content, where the over-compaction of the material drives moisture up through the material to the surface [mobilisation of excess pore pressure]. This may also be observed during the passage of the roller, with material adhering to the roller, and/or the surface of the compacted layer beginning to tear.
- Reduction in engineering performance of the material with increasing compaction.
- Visible movement of the surface of the material during the passage of the compaction plant, typically exhibited as a 'bow wave' in front of the roller.

Figure 6/3-1: Indicative Trial Panel Layout



6.24 The importance of identifying the point at which the materials become over-compacted is important for a number of reasons. Should the material not be competent to undergo additional compaction and/or trafficking, then an engineering decision will be required by the Supervising Engineer prior to the commencement of the main earthworks program.

Assessment of Test Panels

6.25 In order to assess the compaction trials fully, a stringent series of *in situ* testing after each incremental compactive effort. The type and nature of the tests which can be used to achieve this will be dependent upon the material type/class, proposed end-use of the material and the adopted specification requirements as detailed within this site documentation.

6.26 For each compaction increment the determination of in situ density should be completed with a minimum of 6 number of tests evenly spaced in two rows at distances of 5m, 10m and 15m along the test panel. Each row shall be separated by sufficient distance in order to prevent accidental influence from overlapping roller passes and adjacent test panels. Given the high number of tests that this requires and unless the nature of the material precludes its use, testing shall be undertaken using a Nuclear Density Gauge [NDG]. The results of this test are to be used to assess the following key engineering parameters:

- Bulk Density;
- Moisture Content;
- Dry Density;
- Air Void Content; and
- Degree of Compaction, compared against the MDD.

6.27 In conjunction with the assessment of the density of the material, the following tests shall be included as part of the compaction trial:

- 2 no bulk samples for lab classification, 1 to be sampled prior to compacting the test panel and 1 post completion of the test panel. In order to confirm the engineering characteristics of the material, each source should be sampled and submitted to the laboratory and the scope of testing shall be to determine the grading before and after compaction as well as the MDD using the using the method defined in Table 6/1.
- For Class 1 General Granular Fill & Class 6 Selected Granular Fill, measurement of the CBR using the Mexe Probe equipment, completed at each and every location of the in situ density measurement.
- For Class 2 General Cohesive Fill & Class 7 Selected Cohesive Fill, measurement of the undrained shear strength using the hand vane equipment, completed at each and every location of the in situ density measurement.
- Plate Load Testing, to be completed at the end of the trial in order to define the following:
    - Equivalent CBR;
    - Modulus of Subgrade Reaction, k; and

- Modulus of Subgrade Reaction, k_{760} based on 760mm diameter plate.

6.28 For the purposes of the compaction trials only, the plate load tests should be completed in accordance with IAN 73/06 in order to determine the Modulus of Sub-grade Reaction and Equivalent CBR value. This testing will require multiple cycles to be completed and as such consideration of the time element to complete each test should be taken.

6.29 In order to adopt a standard procedure for assessing compaction trials, Table 6/3-1 summarises the recommended testing requirements.

6.30 The purpose of the compaction trials will be to prove the engineering performance of the placed and compacted fill and the suitability of the method to be adopted by the Contractor. The method to be adopted for the main earthworks program should satisfy the following key criteria, which will be further reviewed upon receipt of the results of the compaction trials:

- No single dry density result shall be less than 92% of the MDD, and no more than 10% of results of any one layer shall fall between 92% and 95% MDD. Where the 2.5kg rammer is used for Class 2B and 7A, the compliance requirement shall increase to no results less than 98% of the MDD and no more than 10% of results of any one layer shall fall between 98% and 100% MDD.

- For Class 1 granular fill, the compliance criteria for CBR is no single result shall be less than 3% CBR, and no more than 10% of results of any one layer shall fall between 3% and 5% CBR.

- For Class 6 granular fill, the compliance criteria for CBR is no single result shall be less than 8% and no more than 10% of results of any one layer shall fall between 8% and 12% CBR.

- For Class 2A and Class 2C Cohesive fill, the compliance criteria for the Hand Vane shear strength shall be no single result below 45kN/m², and no more than 10% of results of any one layer shall fall between 45kN/m² and 50kN/m².

- For Class 2B and Class 7 cohesive fill, the compliance criteria for the Hand Vane shear strength shall be no single result below 100kN/m², and no more than 10% of results of any one layer shall fall between 100kN/m² and 120kN/m².

- For Class 2 and Class 7 Cohesive fill, no single air void content result shall be greater than 10%, and no more than 10% of results of any one layer shall fall between 5% and 10%.

6.31 Plate load test completed in accordance with IAN 73/06 Rev 1 and HD25/94 using cyclic loading and shall be used to assess the equivalent CBR value and compared against the data recorded using the other *in situ* apparatus.

Table 6/3-1 Compaction Trial Testing Requirements

Test Property	Recommended Frequency of Testing
Bulk Sample before compaction	1 sample per material for MC, PSD, OMC and particle density
Bulk Sample post compaction	1 sample per material for MC, PSD, OMC and particle density
Bulk Sample for MC/MCV Calibration	1 sample per cohesive material

Test Property	Recommended Frequency of Testing
Bulk Density	6 tests per compaction increment per layer using NDG
Moisture Content	6 tests per compaction increment per layer using NDG
Dry Density	6 tests per compaction increment per layer using NDG
NDG Calibration	1 per material/test panel.
CBR by Mexe Probe (Granular Fill)	1 test per density location.
Cu by Hand Vane (Cohesive Fill)	1 test per density location.
Plate Load Test to IAN 73/06	1 per trial panel, multiple cycles as defined in IAN 73/06

Earthworks Testing

6.32 The Contractor will be required to undertake material acceptability testing of all earthworks materials used in the Works. The testing requirements, including the test type and frequency of testing, are described Appendix 1/5, 6/1 & 6/3 of the Earthworks Specification.

6.33 It should be noted that *in situ* testing will be required even where Method Placement is to adopted by the Contractor, in order to monitor and check that the adopted method is achieving the requisite end-performance. The testing to be undertaken is to demonstrate the method achieves the minimum requirements as detailed in Table 6/1 of this Specification.

6.34 The *in situ* measurement of the material will be required to confirm the applied loadings on the ground and the suitability of the imported material for subsequent inclusion within the permanent works.

6.35 The selected method of placement, depth of layer and selection of compaction plant may be derived initially from Table 6/1 and SHW Table 6/4 but will be subject to confirmation following site compaction trials to prove this method can achieve the required end-performance. Any necessary amendments to the guidance from SHW Table 6/4 to ensure the requisite end-performance of the fill material will be made and issued as part of the adopted earthworks specification.

Placing and Compacting Fill

6.36 Where different classes of fill material are to be employed, they shall be deposited in such a way that all parts of the fill area receive roughly equal amounts of a given material in roughly the same sequence, thus ensuring a uniform distribution of fill types over the whole fill thickness unless otherwise shown on the Drawings.

6.37 The Contractor shall take all necessary steps to ensure that the fill is placed at the moisture content necessary to achieve the compaction specification and shall, where necessary, add water to or dry the fill, in order to obtain this value. Where it is necessary to add water, this shall be done as a fine spray and in such a way that there is time for the water to be absorbed into the fill before being rolled by the plant.

6.38 Compaction plant and compaction method shall be selected having regard to the proximity of existing trenches, excavations, retaining walls or other structures and all work shall be performed in such a way as to ensure that their stability is not impaired. Any restrictions on size of compaction plant shall be shown on the Drawings. Each compaction method shall only be approved through the completion of a satisfactory compaction trial which can demonstrate that the minimum engineering performance can be met.

6.39 If the results of control tests indicate that the fill is being placed and compacted in such a way that the desired end product is not being achieved, the Contractor shall further compact or, if necessary, shall excavate the affected work and replace with new fill, compacted to meet the specification requirements.

6.40 If the results of control tests indicate that antecedent weather conditions (such as frost or heavy rain) have caused deterioration of finished work such that the work no longer meets specification, the Contractor shall take such steps as are necessary to bring the fill to the specification requirements.

Control Testing

6.41 The compliance of the fill meeting the compaction specification shall be demonstrated by undertaking the *in situ* and laboratory testing as detailed in Appendix 1/5 and meet the requirements of Table 6/1 and Appendix 6/3.

6.42 Plate bearing tests (in accordance with BS1377-9, 1990 method 4.1) shall be undertaken to demonstrate compliance with the additional requirements for the fill shown on the Drawings. The test requirements for the plate loading tests are shown on the Drawings.

6.43 Test locations shall be evenly distributed throughout the fill area at the frequency defined in Table 1/5. The earthworks fill shall comply with the following minimum requirements:

- No single dry density result shall be less than 92% of the MDD, and no more than 10% of results of any one layer shall fall between 92% and 95% MDD. Where the 2.5kg rammer is used for Class 2B and 7, the compliance requirement shall increase to no results less than 98% of the MDD and no more than 10% of results of any one layer shall fall between 98% and 100% MDD.

- For Class 1 granular fill, the compliance criteria for CBR is no single result shall be less than 3% CBR, and no more than 10% of results of any one layer shall fall between 3% and 5% CBR or where the fill is palced below adoptable highways, this shall be increased to no result below 12% and no more than 10% of the results for any layer between 12% and 15%.

- For Class 6N granular fill, the compliance criteria for the Mexe Probe CBR is no single result shall be less than 8% and no more than 10% of results of any one layer shall fall between 8% and 12% CBR. For Class 6P, this shall be reduced to no single CBR below 5% and no more than 10% of results of any one layer shall be between 5% and 8%.

- For Class 2A and Class 2C Cohesive fill, the compliance criteria for the Hand Vane shear strength shall be no single result below 45kN/m², and no more than 10% of results of any one layer shall fall between 45kN/m² and 50kN/m².

- For Class 2B and Class 7 cohesive fill, the compliance criteria for the Hand Vane shear strength shall be no single result below 100kN/m², and no more than 10% of results of any one layer shall fall between 100kN/m² and 120kN/m².

- For Class 2 and Class 7 Cohesive fill, no single air void content result shall be greater than 10%, and no more than 10% of results of any one layer shall fall between 5% and 10%.

6.44 All earthworks materials used shall comply with the earthworks specification. Prior to the commencement of the placement of the bulk fill, for each and every compaction method and each material source a compaction trial will be required to be completed.

7.0 ADDITIONAL LIMITATIONS OF DEPOSITION OF MATERIALS REFERRED TO IN 601.13, 601.14 AND 601.17

7.1 Cobbles having an equivalent diameter of more than 150mm shall not be deposited within 1.3 m of the finished surface at any location.

8.0 RESTRICTIONS ON BATTERING OF EXCAVATIONS FOR FOUNDATIONS AND TRENCHES AND REQUIREMENTS FOR BENCHING

8.1 No specific limitations or restrictions are included for the battering of excavations for foundations, but the Contractor shall comply with the Temporary Works Designer's requirements. Battered excavations are to be benched prior to backfilling. Benching requirements are shown on the Drawings.

9.0 EXCAVATION SUPPORTS TO BE LEFT IN PLACE

9.1 No excavation supports are to be left in place.

10.0 BENCHING OR SHAPING OF EARTHWORKS SLOPE FACES TO RECEIVE FILL

10.1. Where existing embankments are to be extended and where embankments are to be constructed on ground with a slope steeper than one in eight, such slope being measured at right angles across the width of the embankment, benching of the existing slope shall be formed as shown on the Drawings. Bench heights are to be a multiple of the relevant compaction layer thickness.

10.2 Fill material in areas of benching shall be carefully placed and compacted to ensure that no voids occur at the upright steps of the benching.

10.3 Placing and compaction of the fill material shall continue to a level above an adjacent bench before material is placed upon that bench.

10.4 Four additional passes of the roller shall be made on the area within two metres each side of the upright face immediately following the compaction of the first layer of fill material on each bench.

11.0 MIXING OF EXCAVATED MATERIALS

11.1 Mixing of acceptable and unacceptable excavated material is not permitted. All excavated material are to be stored in individual stockpiles, not exceeding 500m³.

12.0 FILL TO EXCAVATED VOIDS OR NATURAL VOIDS IN FOUNDATION EXCAVATIONS

12.1 Areas of inadequate strength shall be removed and backfilled. For small areas and depths, blinding concrete class ST1 shall be used. For more extensive areas and depths, backfill shall be 6N granular material compacted to Table 6/1 of the Specification unless otherwise shown on the drawings.

13 FILL TO LANDSCAPE AREAS

13.1 Where landscape fill material (Class 4) is to be used within approved locations on site, the material shall be placed in accordance with Clause 620 of the SHW.

APPENDIX 6/6: FILL TO STRUCTURES AND FILL ABOVE STRUCTURAL FOUNDATIONS

1. FILL TO STRUCTURES

1.1 Requirements and material classes for fill to structures and fill above structural foundations are shown on the relevant substructure drawings.

1.2 Prior to placing blinding concrete at the design foundation level, or immediately prior to filling the excavation where no blinding layer is required, the formation shall be investigated by the Contractor in the presence of the Supervising Engineer to confirm that the design assumptions with regard to formation strength have been met as follows:

i) Cohesive Soils: by use of a shear vane test to prove that the undrained shear strength value at a depth of 0.2m below excavation formation level is greater than the minimum stated on the substructure drawings.

ii) Granular Soils: by use of a Dynamic Probe to prove that the equivalent SPT 'N' value is greater than the minimum stated on the substructure drawings.

iii) Plate Load Testing using 600mm diameter plate, to the loads defined in Appendix 1/5 and on the drawings and to achieve the associated settlement requirements.

1.3 The tests referred to above shall be taken at representative locations across the formation in accordance with Appendix 1/5 or as directed by the Supervising Engineer. The tests shall undertake using suitably calibrated equipment. Additional tests shall be undertaken at any apparent areas of inadequate strength identified visually by the Supervisor.

1.4 The locations, results and correlation of the equipment used shall be recorded. The Contractor shall keep records of the inspections, testing and any subsequent remedial measures, including the test locations, test values and calibrations of the equipment used.

2. FULL SCALE DETERMINATION OF SLOPE STABILITY

2.1 Material for use as 'Fill to Structures' does not require full scale determination of slope stability in accordance with Clause 610.6 of SHW unless this is a specific requirement of the Contractors alternative design.

APPENDIX 6/7: SUB-FORMATION AND CAPPING AND PREPARATION AND SURFACE

1.0 TREATMENT OF FORMATION

GENERAL REQUIREMENTS

1.1 The locations and required thickness of capping and/or sub-base thickness are shown on the Engineer's Drawings.

1.2 Cut to fill transitions zones shall be constructed as shown on the Engineer's Drawings.

1.3 Final preparation of the sub-formation and formation shall only be carried out after installation of the scheduled drainage at that location.

1.4 The minimum California Bearing Ratio (CBR) or undrained shear strength of the subgrade for each location is given on the Engineer's Drawings and in Table 6/1. Areas of subgrade that are below the minimum shall be improved by the methods shown on the Engineer's Drawings.

1.5 The CBR of the subgrade shall be determined at the frequency shown on the Drawings and as required by the Supervising Engineer. The Contractor shall test the subgrade to determine the CBR value using one of the following test methods appropriate to the subgrade material being tested in accordance with IAN 73/06 Rev 1:

- Dual Cycles Static Plate Load Test (PLT)

2.0 ALLOWED SURFACE LEVEL TOLERANCES

2.1 Surface level tolerances shall comply with Clause 616.1

3.0 CAPPING MATERIALS

3.1 The permitted capping materials are shown as described in Clause 613.3 of SHW.

3.2 Material used within 450mm of the designated final road or external surface level shall not be frost susceptible.

4.0 PROCEDURE FOR CONSTRUCTION OF CAPPING FOR CUTTINGS AND EMBANKMENTS

4.1 The procedures for construction of capping for cuttings and embankments are as stated in Clauses 613.11 and 613.12 respectively of SHW unless otherwise shown on the Drawings.

5.0 DEMONSTRATION AREA AND TESTING

5.1 The Contractor shall provide a demonstration area to trial the proposed capping materials. If the trial area is outside the location of the permanent works the trial area formation shall be of similar strength and

characteristics as to the permanent works formation. The laying and compaction methods used within the trial area shall be the same as those proposed for the permanent works.

5.2 The demonstration area may form part of the permanent works but shall only be accepted if the results of testing comply with the Specification.

6.0 SUB-FORMATION SHAPING

6.1 The sub-formation shall be shaped as Clause 613.8 of SHW unless shown otherwise on the Drawings.

7.0 LIME STABILISATION

7.1 Modification and stabilisation with lime is not permitted.

8.0 TREATMENT OF FORMATION

8.1 Treatment of soft spots shall be completed prior to final preparation of sub-formation. Replacement of soft materials, to formation level, shall be with either additional approved Class 6F Selected Capping Material or as agreed with the Supervising Engineer using selected granular material with geosynthetic reinforcement.

8.2 Areas of formation that do not have a surface tolerance within the limits stated in Clause 616.1 of SHW are to be excavated to depths given on the Drawings and infilled with either additional approved capping or as agreed with the Supervising Engineer using selected granular material with geosynthetic reinforcement.

8.3 Details and locations of formation treatment and removal of soft material are to be kept by the Contractor.

9.0 CHEMICAL ANALYSIS REPORTS

9.1 Chemical analysis reports for ‘available lime’ are to be provided weekly in accordance with Clause 615.4 of SHW.

10.0 PREPARATION OF FORMATION ON EXISTING SUB-BASE MATERIAL

10.1 Preparation of formation on existing sub-base material shall be in accordance with Clause 616 of SHW.

APPENDIX 6/9: EARTHWORK ENVIRONMENTAL BUNDS, LANDSCAPE AREAS & STRENGTHENING EMBANKMENTS

1. EARTHWORK ENVIRONMENTAL BUNDS

Location and types of construction

1.1 Requirements for Earthwork Environmental Bunds are shown on the Drawings.

1.2 Earthwork Environmental Bunds are to be constructed of materials as shown on the Drawings.

Requirements for topsoiling

1.3 Environmental Bunds that are to be topsoiled are to be agreeed with the requirements of the landscape Consultant.

2. LANDSCAPE AREAS

Locations

2.1 Locations of Landscape Areas are shown on the landscape Drawings.

Requirements for Compaction

2.2 Class 4 material shall be compacted in accordance with Clause 620 of SHW.

Construction requirements

2.3 Construction requirements and contouring of Landscape Areas are shown on the landscape Drawings.

Requirements for topsoiling

2.4 The requirements for topsoiling Landscape Areas are shown on the landscape Drawings.

2.5 Where slopes are to be formed steeper than 1:2 (26.6º) geosynthetic matting (Enkamat, or similar as approved by Hydrock) shall be installed in accordance with manufacturer's instructions on exposed faces prior to the placement of any topsoil. This will result in a maximum topsoil thickness of these slopes of no more than 50mm.

APPENDIX 6/14: LIMITING VALUES FOR POLLUTION OF CONTROLLED WATERS

1.0 Refer to Hydrock Remediation Method Statement, reference R/151171/006.

APPENDIX 6/15: LIMITING VALUES FOR HARM TO HUMAN HEALTH AND THE ENVIRONMENT

1.0 Refer to Hydrock Remediation Method Statement, reference R/151171/006.

ANNEX B

GEOSTRUCTURAL ANALYSIS REPORTS

Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Class 7A fill 7m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

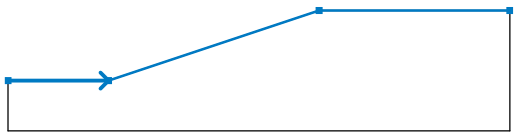
Stability analysis

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

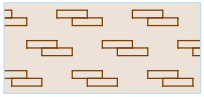
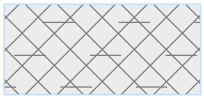
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	0.00	31.00	7.00
		50.00	7.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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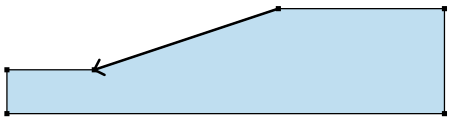
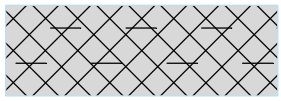
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		31.00	7.00	10.00	0.00	Class 7A Fill
		0.00	0.00	0.00	-5.00	
		50.00	-5.00	50.00	7.00	

Surcharge

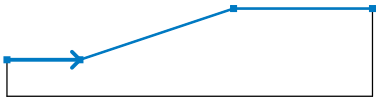
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 31.00	l = 19.00		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	31.00	7.00	0.300
		50.00	7.00					

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 =	14.84	[m]	Angles :	α_1 =	-10.80	[°]
	z =	25.53	[m]		α_2 =	44.52	[°]
The slip surface after optimization.							

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Slip surface parameters				
Radius :	R =	25.99	[m]	
The slip surface after optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 79.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 81.5 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
9.97	0.00	12.24	-0.43	16.75	-0.36	20.65	0.28	24.08	1.32
27.33	2.76	30.70	4.67	32.97	7.00				
The slip surface after optimization.									

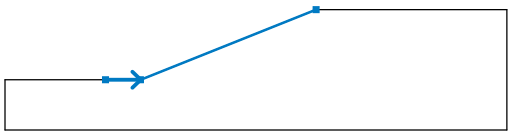
Slope stability verification (Sarma)
Combination 1
Utilization : 79.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 81.0 %

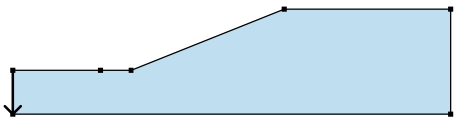
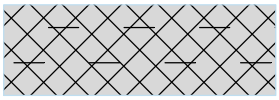
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.00	0.00	13.50	0.00	31.00	7.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Class 7A Fill 
		50.00	-5.00	50.00	7.00	
		31.00	7.00	13.50	0.00	
		10.00	0.00			

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Surcharge

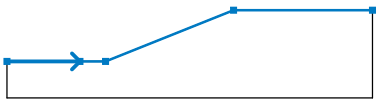
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 31.00	l = 19.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	13.50	0.00	0.300
		31.00	7.00	50.00	7.00			

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 =	16.82	[m]	Angles :	α_1 =	-9.00	[°]
	z =	20.94	[m]		α_2 =	48.89	[°]
Radius :	R =	21.20	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 91.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 94.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m] x	z	x	z	x	z	x	z	x	z
12.56	0.00	12.61	-0.01	15.66	-0.50	20.24	0.02	24.30	1.12
27.82	2.66	30.83	4.64	32.99	7.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1

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Utilization : 90.4 %

Slope stability ACCEPTABLE

Combination 2

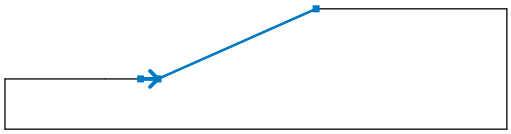
Utilization : 92.9 %

Slope stability ACCEPTABLE

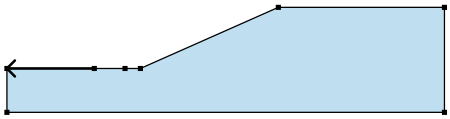
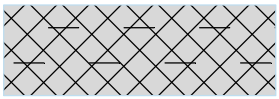
Optimized slip surface for : Combination 2

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		13.50	0.00	15.25	0.00	31.00	7.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.00	0.00	0.00	0.00	Class 7A Fill 
		0.00	-5.00	50.00	-5.00	
		50.00	7.00	31.00	7.00	
		15.25	0.00	13.50	0.00	

Surcharge

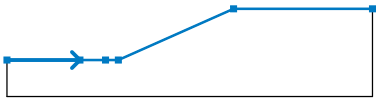
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 31.00	l = 19.00		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	10.00	0.00	13.50	0.00	0.300
		15.25	0.00	31.00	7.00	50.00	7.00	

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

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Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	17.59	[m]	Angles :	α_1 =	-6.84	[°]
	z =	19.52	[m]		α_2 =	50.44	[°]
Radius :	R =	19.66	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 99.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 102.7 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
13.02	0.00	13.07	-0.01	17.13	-0.50	20.58	-0.14	24.30	0.86
28.03	2.53	30.89	4.53	33.03	7.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 95.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 99.1 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Glaciofluvial Deposits 3m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

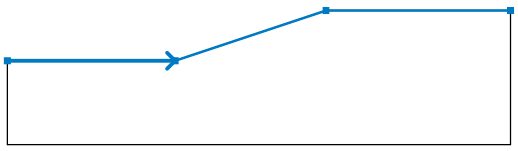
Stability analysis

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

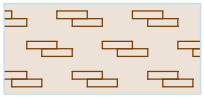
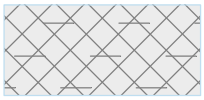
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	0.00	19.00	3.00
		30.00	3.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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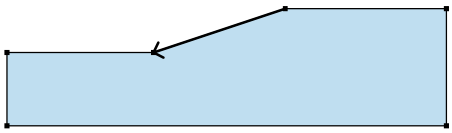
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		19.00	3.00	10.00	0.00	Glaciofluvial Deposits
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	3.00	

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	q_2	unit
1	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : No water

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 =	9.66	[m]	Angles :	α_1 =	-3.97	[°]
	z =	16.85	[m]		α_2 =	34.91	[°]
Radius :	R =	16.90	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 50.3 %

Slope stability ACCEPTABLE
Combination 2

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Utilization : 62.0 %

Slope stability ACCEPTABLE

Analysis 2 (stage 1)

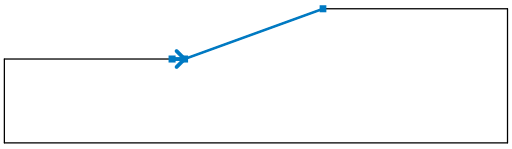
Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
11.20	0.40	11.40	0.40	12.48	0.42	13.45	0.55	14.61	0.99
16.73	1.85	19.06	3.00						
Specified slip surface.									

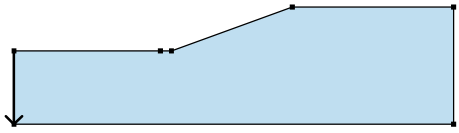
Slope stability verification (Sarma)
Analysis has not been performed.

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.00	0.00	10.75	0.00	19.00	3.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Glaciofluvial Deposits
		30.00	-5.00	30.00	3.00	
		19.00	3.00	10.75	0.00	
		10.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : No water

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

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Results (Stage of construction 2)

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	9.66	[m]	Angles :	α_1 =	-4.41	[°]
	z =	16.85	[m]		α_2 =	34.96	[°]
Radius :	R =	16.90	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 54.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 67.4 %

Slope stability ACCEPTABLE

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
11.87	0.41	12.48	0.42	13.45	0.55	14.61	0.99	16.73	1.85
19.06	3.00								
Analysis of the slip surface without optimization.									

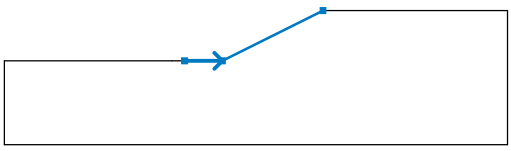
Slope stability verification (Sarma)
Combination 1
Utilization : 54.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 68.3 %

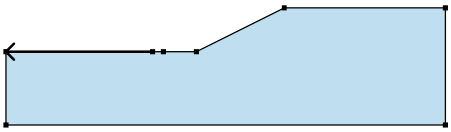
Slope stability ACCEPTABLE

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.75	0.00	13.00	0.00	19.00	3.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.00	0.00	0.00	0.00	Glaciofluvial Deposits
		0.00	-5.00	30.00	-5.00	
		30.00	3.00	19.00	3.00	
		13.00	0.00	10.75	0.00	

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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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : No water

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 =	10.47	[m]	Angles :	α_1 =	11.12	[°]
	z =	12.87	[m]		α_2 =	41.19	[°]
Radius :	R =	13.12	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 77.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 94.0 %

Slope stability ACCEPTABLE

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
14.32	0.66	14.65	0.74	15.34	0.88	16.27	1.33	17.03	1.67
17.78	2.03	18.39	2.48	19.07	3.00				
Analysis of the slip surface without optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 78.0 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 94.4 %

Slope stability ACCEPTABLE

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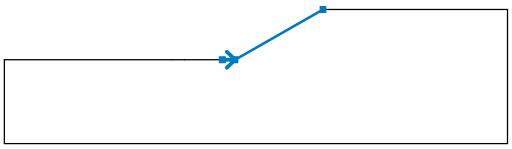
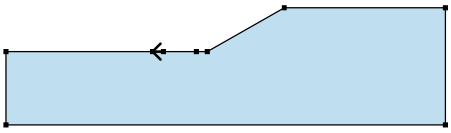
Input data (Stage of construction 4)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		13.00	0.00	13.75	0.00	19.00	3.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.75	0.00	10.00	0.00	Glaciofluvial Deposits
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	3.00	
		19.00	3.00	13.75	0.00	
		13.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : No water

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 =	10.08	[m]	Angles :	α_1 =	15.99	[°]
	z =	12.90	[m]		α_2 =	42.39	[°]
Radius :	R =	13.41	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 89.0 %

Slope stability ACCEPTABLE
Combination 2

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Utilization : 108.2 %

Slope stability NOT ACCEPTABLE

Analysis 2 (stage 4)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
15.12	0.78	15.37	0.87	15.90	1.07	16.56	1.43	17.13	1.75
17.73	2.09	18.58	2.56	19.11	3.00				
Analysis of the slip surface without optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 91.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 111.4 %

Slope stability NOT ACCEPTABLE

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Glaciofluvial Deposits 3m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

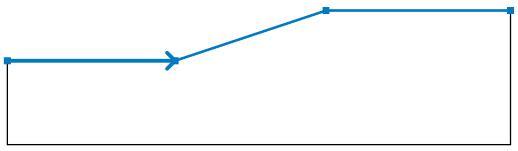
Stability analysis

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

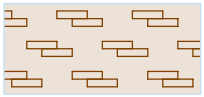
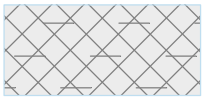
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	0.00	19.00	3.00
		30.00	3.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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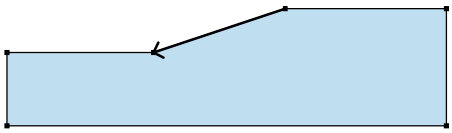
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		19.00	3.00	10.00	0.00	Glaciofluvial Deposits
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	3.00	

Surcharge

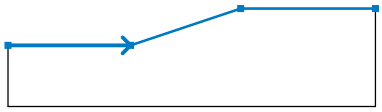
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	19.00	3.00	0.300
		30.00	3.00					

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 =	9.66	[m]	Angles :	α_1 =	-3.97	[°]
	z =	16.85	[m]		α_2 =	34.91	[°]
Analysis of the slip surface without optimization.							

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Slip surface parameters				
Radius :	R =	16.90	[m]	
Analysis of the slip surface without optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 87.9 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.4 %

Slope stability ACCEPTABLE

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
11.20	0.40	11.40	0.40	12.48	0.42	13.45	0.55	14.61	0.99
16.73	1.85	19.06	3.00						
Analysis of the slip surface without optimization.									

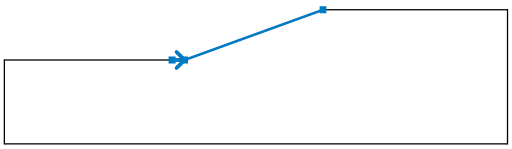
Slope stability verification (Sarma)
Combination 1
Utilization : 88.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.8 %

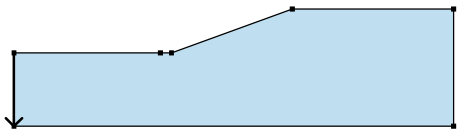
Slope stability ACCEPTABLE

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.00	0.00	10.75	0.00	19.00	3.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Glaciofluvial Deposits
		30.00	-5.00	30.00	3.00	
		19.00	3.00	10.75	0.00	
		10.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 19.00	l = 11.00		0.00	10.00		kN/m^2

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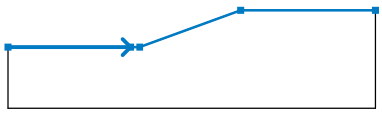
Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	10.00	0.00	10.75	0.00	0.300
		19.00	3.00	30.00	3.00			

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 =	9.66	[m]	Angles :	α_1 =	-4.41	[°]
	z =	16.85	[m]		α_2 =	34.96	[°]
Radius :	R =	16.90	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 96.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 99.8 %

Slope stability ACCEPTABLE

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
11.87	0.41	12.48	0.42	13.45	0.55	14.61	0.99	16.73	1.85
19.06	3.00								
Analysis of the slip surface without optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 99.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 102.3 %

Slope stability NOT ACCEPTABLE

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Glacial Till 3.5m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

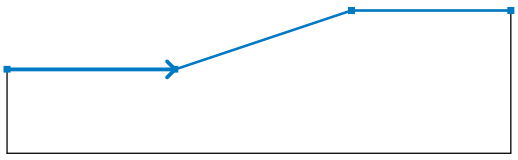
Stability analysis

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

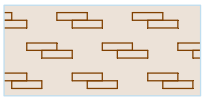
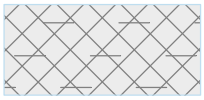
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	0.00	20.50	3.50
		30.00	3.50				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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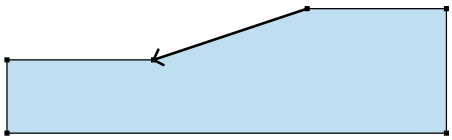
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		20.50	3.50	10.00	0.00	Glacial Till
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	3.50	

Surcharge

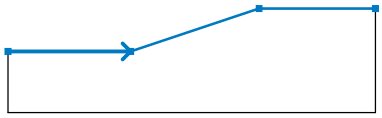
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 20.50	l = 9.50		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	20.50	3.50	0.300
		30.00	3.50					

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 =	12.46	[m]	Angles :	α_1 =	-10.62	[°]
	z =	13.20	[m]		α_2 =	43.76	[°]
The slip surface after optimization.							

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Slip surface parameters				
Radius :	R =	13.43	[m]	
The slip surface after optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 90.3 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 92.6 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
9.99	0.00	11.43	-0.23	13.61	-0.12	15.41	0.21	17.15	0.71
18.89	1.40	20.52	2.30	21.61	3.50				
The slip surface after optimization.									

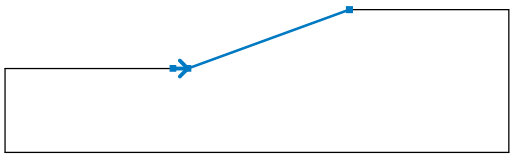
Slope stability verification (Sarma)
Combination 1
Utilization : 90.2 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 92.6 %

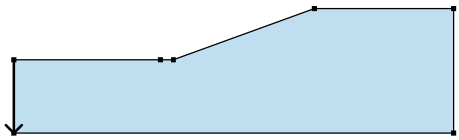
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.00	0.00	10.88	0.00	20.50	3.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Glacial Till
		30.00	-5.00	30.00	3.50	
		20.50	3.50	10.88	0.00	
		10.00	0.00			

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Surcharge

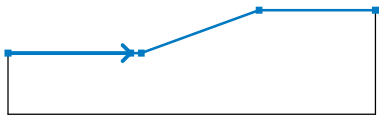
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 20.50	l = 9.50		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	10.88	0.00	0.300
		20.50	3.50	30.00	3.50			

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 =	12.86	[m]	Angles :	α_1 =	-9.23	[°]
	z =	12.19	[m]		α_2 =	45.28	[°]
Radius :	R =	12.35	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 96.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 99.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m] x	z	x	z	x	z	x	z	x	z
10.87	0.00	11.77	-0.16	13.42	-0.15	15.51	0.21	17.30	0.73
18.97	1.42	20.52	2.31	21.59	3.50				
The slip surface after optimization.									

Slope stability verification (Sarma)

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Combination 1
Utilization : 95.8 %

Slope stability ACCEPTABLE

Combination 2
Utilization : 99.3 %

Slope stability ACCEPTABLE

Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Topsoil / Landscape Bund 14m 1:3.5
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

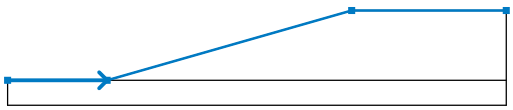
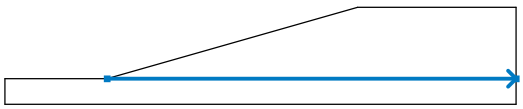
Stability analysis

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

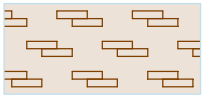
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	20.00	20.00	20.00	69.00	34.00
		100.00	34.00				
2		20.00	20.00	100.00	20.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping (2)		24.00	0.00	17.00

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
2	Made Ground (Roade Cutting) (2)		24.00	0.00	19.50
3	Alluvium (2)		22.00	0.00	18.50
4	Glaciofluvial Deposits (2)		33.00	0.00	19.00
5	Glacial Till (2)		25.00	2.00	19.50
6	Whitby Mudstone (2)		22.00	5.00	20.00
7	Marlstone Rock (2)		30.00	5.00	21.00
8	Dyrham Formation (2)		28.00	5.00	20.00
9	Class 1 Fill (2)		36.00	0.00	20.50
10	Class 2 Fill (2)		25.00	0.00	19.50
11	Class 6P Fill (2)		38.00	0.00	21.00
12	Class 7A Fill (2)		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping (2)		17.00		
2	Made Ground (Roade Cutting) (2)		19.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
3	Alluvium (2)		18.50		
4	Glaciofluvial Deposits (2)		19.00		
5	Glacial Till (2)		19.50		
6	Whitby Mudstone (2)		20.00		
7	Marlstone Rock (2)		21.00		
8	Dyrham Formation (2)		20.00		
9	Class 1 Fill (2)		20.50		
10	Class 2 Fill (2)		20.50		
11	Class 6P Fill (2)		21.00		
12	Class 7A Fill (2)		21.00		

Soil parameters

Topsoil / landscaping (2)

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting) (2)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium (2)

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Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits (2)
Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till (2)
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone (2)
Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock (2)
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation (2)
Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill (2)
Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill (2)
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

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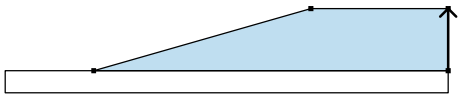
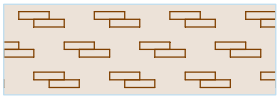
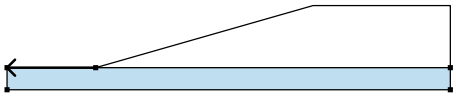
Class 6P Fill (2)

Unit weight :	γ =	21.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	38.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	21.00 kN/m^3

Class 7A Fill (2)

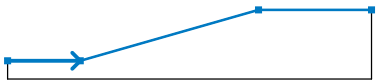
Unit weight :	γ =	21.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	27.00 °
Cohesion of soil :	c_{ef} =	5.00 kPa
Saturated unit weight :	γ_{sat} =	21.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		100.00	20.00	100.00	34.00	Topsoil / landscaping (2)
		69.00	34.00	20.00	20.00	
2		20.00	20.00	0.00	20.00	Glaciofluvial Deposits (2)
		0.00	15.00	100.00	15.00	
		100.00	20.00			

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	20.00	20.00	20.00	69.00	34.00	0.300
		100.00	34.00					

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

Circular slip surface

Slip surface parameters							
Center :	x =	10.02	[m]	Angles :	α_1 =	4.39	[°]
	z =	150.72	[m]		α_2 =	27.08	[°]
Analysis of the slip surface without optimization.							

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Slip surface parameters				
Radius :	R =	131.09	[m]	
Analysis of the slip surface without optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 111.5 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 116.4 %

Slope stability NOT ACCEPTABLE

Analysis 2

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
32.95	23.70	33.26	23.69	36.17	23.60	40.86	23.78	50.55	26.99
56.03	28.56	61.33	30.86	69.62	33.99	69.65	34.00		
Analysis of the slip surface without optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 110.9 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 115.7 %

Slope stability NOT ACCEPTABLE

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 1m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

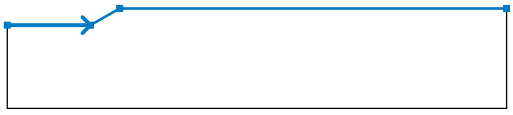
Stability analysis

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

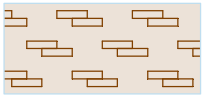
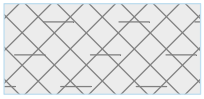
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	5.00	0.00	6.75	1.00
		30.00	1.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		6.75	1.00	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	1.00	

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	q_2	unit
1	strip	permanent	on terrain	x = 6.75	l = 23.25		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	6.75	1.00	0.300
		30.00	1.00					

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 =	5.68	[m]	Angles :	α_1 =	-18.24	[°]
	z =	2.08	[m]		α_2 =	60.45	[°]
Radius :	R =	2.19	[m]				
The slip surface after optimization.							

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Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 70.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 71.0 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
4.99	0.00	5.41	-0.09	5.84	-0.10	6.26	-0.03	6.66	0.12
7.03	0.35	7.34	0.65	7.59	1.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 67.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 68.8 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.00	0.00	5.25	0.00	6.75	1.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		30.00	-5.00	30.00	1.00	
		6.75	1.00	5.25	0.00	
		5.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 6.75	l = 23.25		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

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Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	5.00	0.00	5.25	0.00	0.300
		6.75	1.00	30.00	1.00			

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 =	5.74	[m]	Angles :	α_1 =	-14.15	[°]
	z =	1.94	[m]		α_2 =	61.97	[°]
Radius :	R =	2.00	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 74.9 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 76.0 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
5.24	0.00	5.38	-0.05	5.84	-0.09	6.26	-0.03	6.74	0.15
7.00	0.39	7.28	0.65	7.64	1.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 70.9 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 72.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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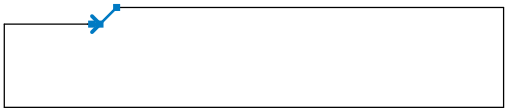
Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.25	0.00	5.75	0.00	6.75	1.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		5.00	0.00	0.00	0.00	Whitby Mudstone
		0.00	-5.00	30.00	-5.00	
		30.00	1.00	6.75	1.00	
		5.75	0.00	5.25	0.00	

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 6.75	l = 23.25		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	5.00	0.00	5.25	0.00	0.300
		5.75	0.00	6.75	1.00	30.00	1.00	

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 =	5.82	[m]	Angles :	α_1 =	-2.25	[°]
	z =	1.75	[m]		α_2 =	64.62	[°]
Radius :	R =	1.75	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)

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Combination 1
Utilization : 88.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 90.2 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
5.34	0.00	5.42	-0.02	5.76	-0.11	6.26	-0.07	6.74	0.14
7.00	0.39	7.27	0.65	7.63	1.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 78.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 79.8 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 4)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.75	0.00	6.00	0.00	6.75	1.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		5.25	0.00	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	1.00	
		6.75	1.00	6.00	0.00	
		5.75	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 6.75	l = 23.25		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

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Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	5.00	0.00	5.25	0.00	0.300
		5.75	0.00	6.00	0.00	6.75	1.00	
		30.00	1.00					

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 =	5.44	[m]	Angles :	α_1 =	16.08	[°]
	z =	2.02	[m]		α_2 =	60.63	[°]
Radius :	R =	2.08	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 92.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 97.7 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 4)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
5.42	0.00	5.47	-0.01	6.01	-0.12	6.32	-0.09	6.74	0.11
7.01	0.39	7.27	0.65	7.62	1.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 83.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 83.8 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 2.5m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

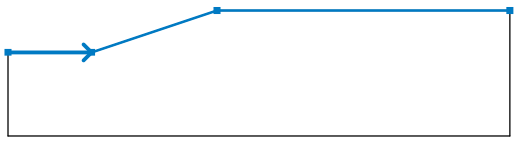
Stability analysis

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

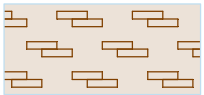
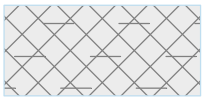
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	5.00	0.00	12.50	2.50
		30.00	2.50				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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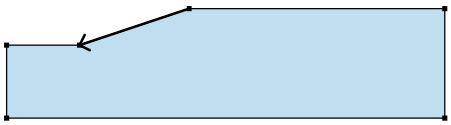
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		12.50	2.50	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	2.50	

Surcharge

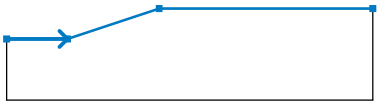
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 12.50	l = 17.50		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	12.50	2.50	0.300
		30.00	2.50					

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 =	8.18	[m]	Angles :	α_1 =	-27.15	[°]
	z =	6.46	[m]		α_2 =	56.94	[°]
The slip surface after optimization.							

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Slip surface parameters				
Radius :	R =	7.26	[m]	
The slip surface after optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 72.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 72.0 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 1

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
4.93	0.00	6.28	-0.41	7.78	-0.60	9.11	-0.62	10.55	-0.50
12.34	0.50	13.31	1.43	14.35	2.50				
The slip surface after optimization.									

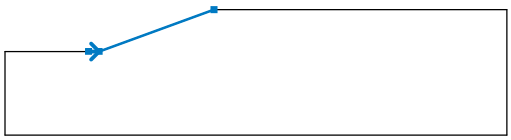
Slope stability verification (Sarma)
Combination 1
Utilization : 71.2 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 70.3 %

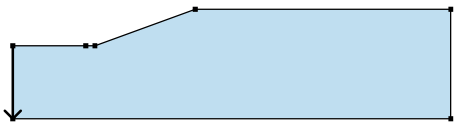
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 1

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.00	0.00	5.63	0.00	12.50	2.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		30.00	-5.00	30.00	2.50	
		12.50	2.50	5.63	0.00	
		5.00	0.00			

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Surcharge

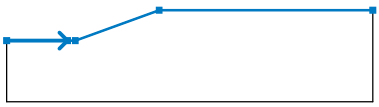
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 12.50	l = 17.50		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	5.63	0.00	0.300
		12.50	2.50	30.00	2.50			

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 =	8.46	[m]	Angles :	α_1 =	-25.03	[°]
	z =	6.08	[m]		α_2 =	57.76	[°]
Radius :	R =	6.71	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 76.0 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 76.0 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 1

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m] x	z	x	z	x	z	x	z	x	z
5.52	0.00	6.47	-0.32	7.78	-0.55	9.10	-0.60	10.60	-0.48
12.45	0.57	13.30	1.43	14.33	2.50				
The slip surface after optimization.									

Slope stability verification (Sarma)

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Combination 1
Utilization : 74.5 %

Slope stability ACCEPTABLE

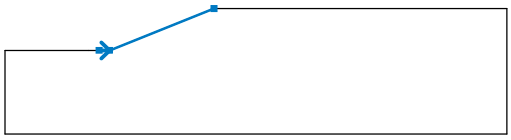
Combination 2
Utilization : 74.2 %

Slope stability ACCEPTABLE

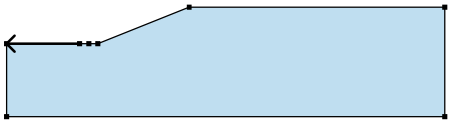
Optimized slip surface for : Combination 1

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.63	0.00	6.25	0.00	12.50	2.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		5.00	0.00	0.00	0.00	Whitby Mudstone
		0.00	-5.00	30.00	-5.00	
		30.00	2.50	12.50	2.50	
		6.25	0.00	5.63	0.00	

Surcharge

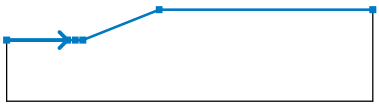
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 12.50	l = 17.50		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru [–]
		x	z	x	z	x	z	
1		0.00	0.00	5.00	0.00	5.63	0.00	0.300
		6.25	0.00	12.50	2.50	30.00	2.50	

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

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Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	8.44	[m]	Angles :	α_1 =	-18.69	[°]
	z =	6.47	[m]		α_2 =	54.46	[°]
Radius :	R =	6.83	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 80.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 80.5 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
6.13	0.00	6.90	-0.26	7.90	-0.40	9.10	-0.37	10.61	-0.05
12.46	0.78	13.15	1.44	14.22	2.50				
The slip surface after optimization.									

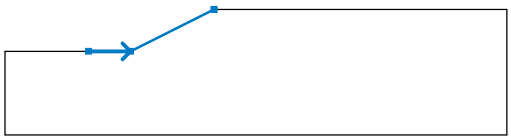
Slope stability verification (Sarma)
Combination 1
Utilization : 78.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 78.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 4)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.00	0.00	7.50	0.00	12.50	2.50

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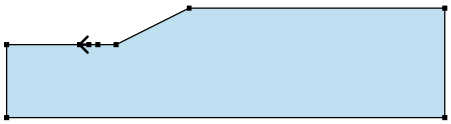
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		5.63	0.00	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	2.50	
		12.50	2.50	7.50	0.00	
		6.25	0.00			

Surcharge

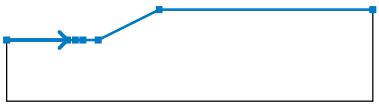
No.	Surcharge new	change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 12.50	l = 17.50		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	5.63	0.00	0.300
		6.25	0.00	7.50	0.00	12.50	2.50	
		30.00	2.50					

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 =	9.02	[m]	Angles :	α_1 =	-15.03	[°]
	z =	5.66	[m]		α_2 =	57.37	[°]
Radius :	R =	5.86	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 90.7 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.8 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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Analysis 2 (stage 4)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
6.83	0.00	6.90	-0.03	8.11	-0.35	9.42	-0.36	10.89	-0.03
12.46	0.76	13.15	1.44	14.19	2.50				
The slip surface after optimization.									

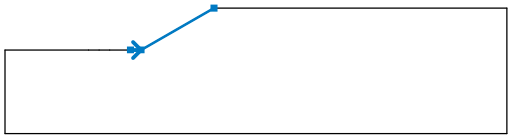
Slope stability verification (Sarma)
Combination 1
Utilization : 86.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 87.5 %

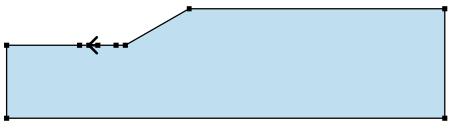
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 5)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		7.50	0.00	8.13	0.00	12.50	2.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		6.25	0.00	5.63	0.00	Whitby Mudstone
		5.00	0.00	0.00	0.00	
		0.00	-5.00	30.00	-5.00	
		30.00	2.50	12.50	2.50	
		8.13	0.00	7.50	0.00	

Surcharge

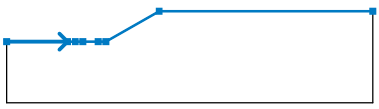
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 12.50	l = 17.50		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru [–]
		x	z	x	z	x	z	
1		0.00	0.00	5.00	0.00	5.63	0.00	0.300
		6.25	0.00	7.50	0.00	8.13	0.00	
		12.50	2.50	30.00	2.50			

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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 =	9.26	[m]	Angles :	α_1 =	-12.11	[°]
	z =	5.27	[m]		α_2 =	59.08	[°]
Radius :	R =	5.39	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 97.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 99.2 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 5)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
6.83	0.00	6.90	-0.03	8.11	-0.35	9.42	-0.36	10.89	-0.03
12.46	0.76	13.15	1.44	14.19	2.50				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 91.3 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.5 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 5m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

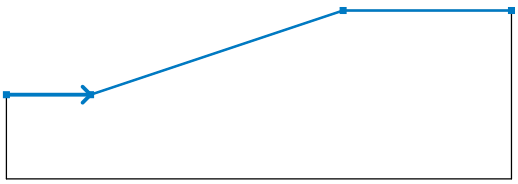
Stability analysis

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

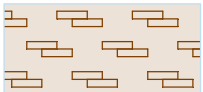
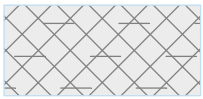
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	5.00	0.00	20.00	5.00
		30.00	5.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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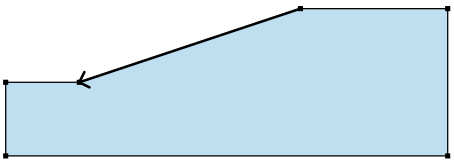
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		20.00	5.00	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	5.00	

Surcharge

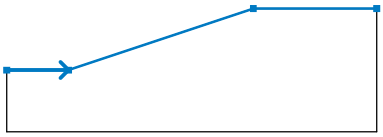
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 20.00	l = 10.00		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	20.00	5.00	0.300
		30.00	5.00					

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

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Slip surface parameters							
Center :	x =	9.58	[m]	Angles :	α_1 =	-15.90	[°]
	z =	16.09	[m]		α_2 =	48.48	[°]
Radius :	R =	16.73	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 87.2 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 87.9 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
4.89	0.00	6.93	-0.54	9.80	-0.67	13.42	-0.16	17.03	1.05
19.94	2.69	22.25	5.00						
The slip surface after optimization.									

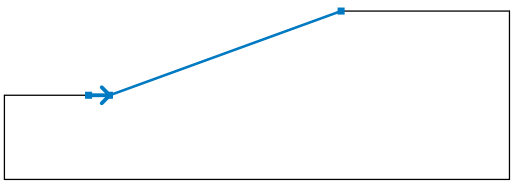
Slope stability verification (Sarma)
Combination 1
Utilization : 86.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 86.7 %

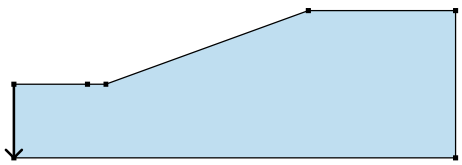
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.00	0.00	6.25	0.00	20.00	5.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		30.00	-5.00	30.00	5.00	
		20.00	5.00	6.25	0.00	
		5.00	0.00			

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Surcharge

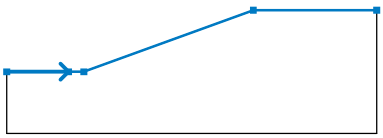
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 20.00	l = 10.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	6.25	0.00	0.300
		20.00	5.00	30.00	5.00			

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 =	10.17	[m]	Angles :	α_1 =	-14.53	[°]
	z =	15.13	[m]		α_2 =	49.60	[°]
Radius :	R =	15.63	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 92.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 93.6 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m] x	z	x	z	x	z	x	z	x	z
6.25	0.00	9.86	-0.47	15.00	0.50	19.82	3.31	20.90	4.99
20.91	5.00								
The slip surface after optimization.									

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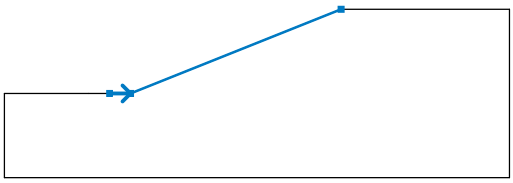
Slope stability verification (Sarma)
Combination 1
Utilization : 89.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 89.4 %

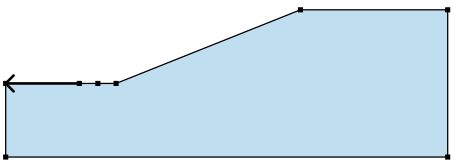
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		6.25	0.00	7.50	0.00	20.00	5.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		5.00	0.00	0.00	0.00	Whitby Mudstone
		0.00	-5.00	30.00	-5.00	
		30.00	5.00	20.00	5.00	
		7.50	0.00	6.25	0.00	

Surcharge

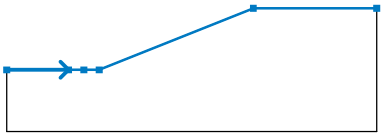
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 20.00	l = 10.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru [–]
		x	z	x	z	x	z	
1		0.00	0.00	5.00	0.00	6.25	0.00	0.300
		7.50	0.00	20.00	5.00	30.00	5.00	

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

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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 =	10.87	[m]	Angles :	α_1 =	-13.55	[°]
	z =	13.98	[m]		α_2 =	51.36	[°]
Radius :	R =	14.38	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 98.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 100.1 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
7.38	0.00	9.93	-0.50	12.93	-0.27	15.75	0.47	18.14	1.53
19.99	2.75	22.12	5.00						
The slip surface after optimization.									

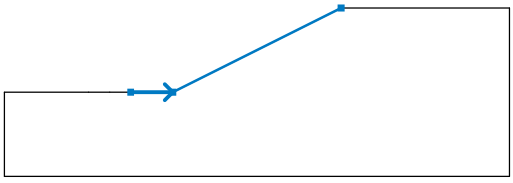
Slope stability verification (Sarma)
Combination 1
Utilization : 96.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 98.3 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 4)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		7.50	0.00	10.00	0.00	20.00	5.00

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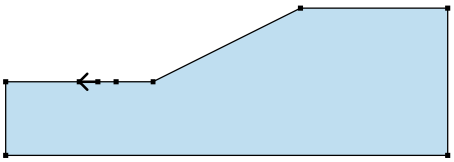
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		6.25	0.00	5.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		30.00	-5.00	30.00	5.00	
		20.00	5.00	10.00	0.00	
		7.50	0.00			

Surcharge

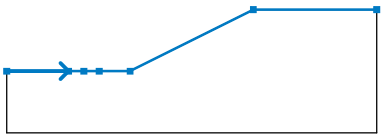
No.	Surcharge new	change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 20.00	l = 10.00		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	5.00	0.00	6.25	0.00	0.300
		7.50	0.00	10.00	0.00	20.00	5.00	
		30.00	5.00					

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 =	13.01	[m]	Angles :	α_1 =	-15.89	[°]
	z =	10.57	[m]		α_2 =	59.55	[°]
Radius :	R =	10.99	[m]				
Specified slip surface.							

Slope stability verification (Morgenstern-Price)
Analysis has not been performed.

Analysis 2 (stage 4)

Polygonal slip surface

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Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
10.02	0.01	11.99	-0.37	14.63	-0.24	17.34	0.59	19.74	1.98
22.81	5.00								
Specified slip surface.									

Slope stability verification (Sarma)

Analysis has not been performed.

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 7.5m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

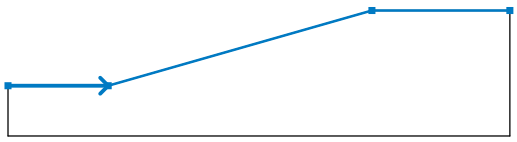
Stability analysis

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

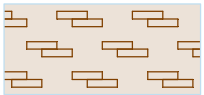
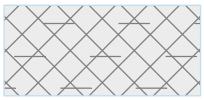
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	0.00	36.25	7.50
		50.00	7.50				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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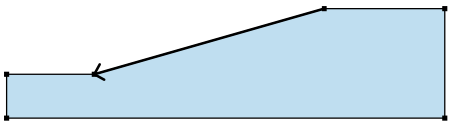
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		36.25	7.50	10.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		50.00	-5.00	50.00	7.50	

Surcharge

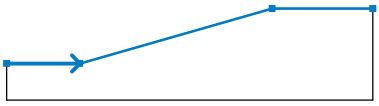
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 36.25	l = 13.75		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	36.25	7.50	0.300
		50.00	7.50					

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 =	17.64	[m]	Angles :	α_1 =	-14.30	[°]
	z =	30.03	[m]		α_2 =	43.36	[°]
The slip surface after optimization.							

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Slip surface parameters				
Radius :	R =	30.99	[m]	
The slip surface after optimization.				

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 85.8 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 86.3 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
9.99	0.00	13.48	-0.83	17.68	-0.94	22.50	-0.39	27.37	0.77
31.66	2.36	35.85	4.68	38.78	7.50				
The slip surface after optimization.									

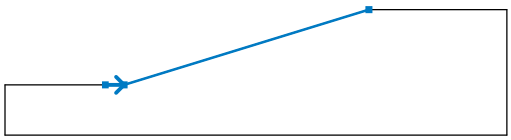
Slope stability verification (Sarma)
Combination 1
Utilization : 85.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 85.8 %

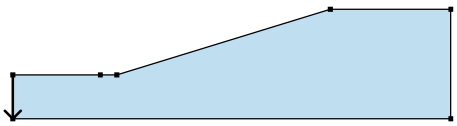
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		10.00	0.00	11.88	0.00	36.25	7.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		50.00	-5.00	50.00	7.50	
		36.25	7.50	11.88	0.00	
		10.00	0.00			

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Surcharge

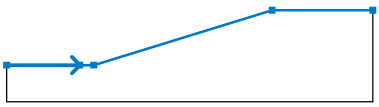
No.	Surcharge new	Surcharge change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 36.25	l = 13.75		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	11.88	0.00	0.300
		36.25	7.50	50.00	7.50			

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 =	18.67	[m]	Angles :	α_1 =	-13.77	[°]
	z =	27.73	[m]		α_2 =	44.88	[°]
Radius :	R =	28.55	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 90.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.6 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m] x	z	x	z	x	z	x	z	x	z
11.81	0.00	13.88	-0.59	17.55	-0.88	22.50	-0.45	27.38	0.67
31.88	2.36	35.85	4.65	38.73	7.50				
The slip surface after optimization.									

Slope stability verification (Sarma)

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Combination 1
Utilization : 90.1 %

Slope stability ACCEPTABLE

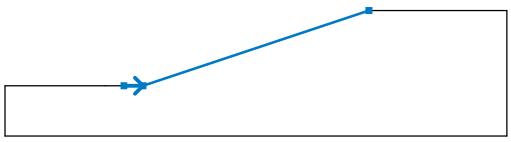
Combination 2
Utilization : 91.0 %

Slope stability ACCEPTABLE

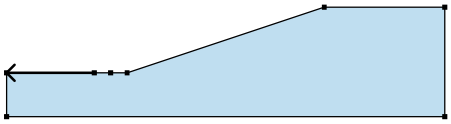
Optimized slip surface for : Combination 2

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		11.85	0.00	13.75	0.00	36.25	7.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		10.00	0.00	0.00	0.00	Whitby Mudstone
		0.00	-5.00	50.00	-5.00	
		50.00	7.50	36.25	7.50	
		13.75	0.00	11.88	0.00	

Surcharge

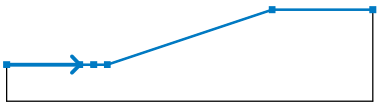
No.	Surcharge		Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
	new	change			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 36.25	l = 13.75		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru [–]
		x	z	x	z	x	z	
1		0.00	0.00	10.00	0.00	11.88	0.00	0.300
		13.75	0.00	36.25	7.50	50.00	7.50	

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

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Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	19.71	[m]	Angles :	α_1 =	-13.18	[°]
	z =	25.51	[m]		α_2 =	46.57	[°]
Radius :	R =	26.20	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 96.1 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 97.5 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
13.67	0.00	15.40	-0.46	18.08	-0.72	22.60	-0.42	27.43	0.64
31.95	2.34	35.85	4.62	38.73	7.50				
The slip surface after optimization.									

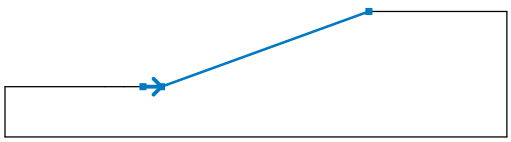
Slope stability verification (Sarma)
Combination 1
Utilization : 95.3 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 96.9 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 4)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		13.75	0.00	15.60	0.00	36.25	7.50

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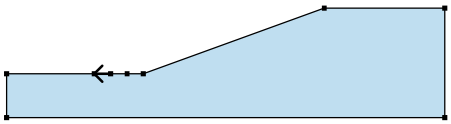
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		11.88	0.00	10.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		50.00	-5.00	50.00	7.50	
		36.25	7.50	15.60	0.00	
		13.75	0.00			

Surcharge

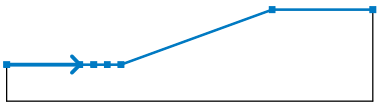
No.	Surcharge new	change	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	No	No	strip	permanent	on terrain	x = 36.25	l = 13.75		0.00	10.00		kN/m²

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	10.00	0.00	11.88	0.00	0.300
		13.75	0.00	15.60	0.00	36.25	7.50	
		50.00	7.50					

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 =	20.54	[m]	Angles :	α_1 =	-11.76	[°]
	z =	23.77	[m]		α_2 =	47.93	[°]
Radius :	R =	24.28	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 102.2 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 104.2 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

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Analysis 2 (stage 4)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
14.71	0.00	16.24	-0.46	19.08	-0.72	22.89	-0.46	27.43	0.53
32.10	2.31	35.85	4.58	38.73	7.50				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 101.2 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 103.0 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 10m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

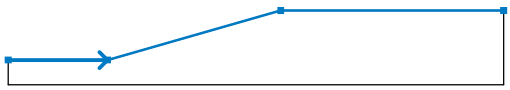
Stability analysis

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

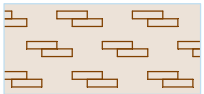
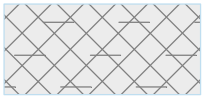
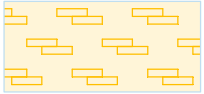
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	20.00	0.00	55.00	10.00
		100.00	10.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50
3	Alluvium		22.00	0.00	18.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		
4	Glaciofluvial Deposits		19.00		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

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Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone
Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation
Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill
Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill
Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

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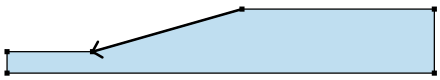
Class 7A Fill

Unit weight :	γ =	21.00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	27.00 °
Cohesion of soil :	c_{ef} =	5.00 kPa
Saturated unit weight :	γ_{sat} =	21.00 kN/m^3

Assigning and surfaces

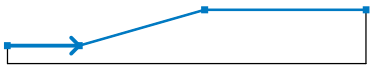
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		55.00	10.00	20.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		100.00	-5.00	100.00	10.00	

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	q_2	unit
1	strip	permanent	on terrain	x = 55.00	l = 45.00		0.00	10.00		kN/m^2

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	20.00	0.00	55.00	10.00	0.300
		100.00	10.00					

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 =	29.12	[m]	Angles :	α_1 =	-12.22	[°]
	z =	42.29	[m]		α_2 =	41.73	[°]
Radius :	R =	43.27	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 90.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.6 %

Slope stability ACCEPTABLE

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Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
19.96	0.00	23.87	-0.85	30.16	-0.91	35.93	-0.20	42.67	1.45
48.49	3.55	53.88	6.43	57.74	10.00				
The slip surface after optimization.									

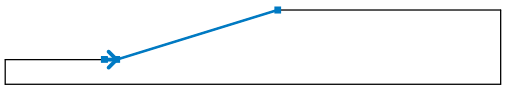
Slope stability verification (Sarma)
Combination 1
Utilization : 90.4 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 91.4 %

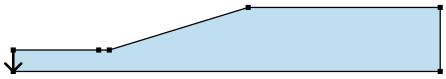
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		20.00	0.00	22.50	0.00	55.00	10.00

Assigning and surfaces

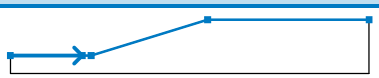
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		100.00	-5.00	100.00	10.00	
		55.00	10.00	22.50	0.00	
		20.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 55.00	l = 45.00		0.00	10.00		kN/m²

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru [–]
		x	z	x	z	x	z	
1		0.00	0.00	20.00	0.00	22.50	0.00	0.300
		55.00	10.00	100.00	10.00			

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

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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 =	30.38	[m]	Angles :	α_1 =	-11.33	[°]
	z =	39.29	[m]		α_2 =	43.03	[°]
Radius :	R =	40.07	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 95.8 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 97.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
22.39	0.00	24.95	-0.63	29.58	-0.90	36.23	-0.25	42.93	1.34
48.80	3.55	53.96	6.44	57.68	10.00				
The slip surface after optimization.									

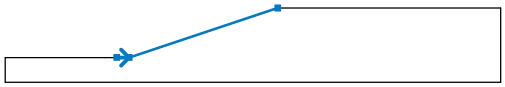
Slope stability verification (Sarma)
Combination 1
Utilization : 95.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 97.1 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 3)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		22.50	0.00	25.00	0.00	55.00	10.00

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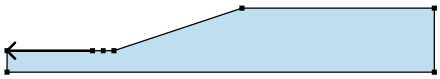
Assigning and surfaces

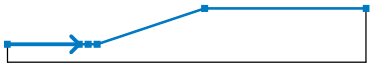
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		20.00	0.00	0.00	0.00	Whitby Mudstone
		0.00	-5.00	100.00	-5.00	
		100.00	10.00	55.00	10.00	
		25.00	0.00	22.50	0.00	

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	Magnitude q_2	Magnitude unit
1	No	No	strip	permanent	on terrain	x = 55.00	l = 45.00		0.00	10.00		kN/m²

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	20.00	0.00	22.50	0.00	0.300
		25.00	0.00	55.00	10.00	100.00	10.00	

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 =	31.74	[m]	Angles :	α_1 =	-10.38	[°]
	z =	36.78	[m]		α_2 =	44.26	[°]
Radius :	R =	37.39	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 101.8 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 104.0 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 3)

Polygonal slip surface

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Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
24.90	0.00	27.15	-0.55	30.79	-0.79	36.20	-0.32	43.06	1.26
49.12	3.58	54.06	6.45	57.68	10.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 101.4 %

Slope stability NOT ACCEPTABLE
Combination 2
Utilization : 103.6 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

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Slope stability analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Slope Assessment Whitby Mudstone 15m
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

Settings

United Kingdom - EN 1997

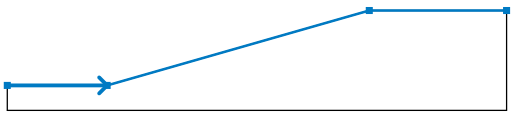
Stability analysis

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

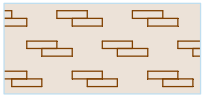
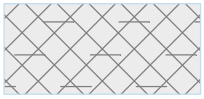
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	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	20.00	0.00	72.50	15.00
		100.00	15.00				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Topsoil / landscaping		24.00	0.00	17.00
2	Made Ground (Roade Cutting)		24.00	0.00	19.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
3	Alluvium		22.00	0.00	18.50
4	Glaciofluvial Deposits		33.00	0.00	19.00
5	Glacial Till		25.00	2.00	19.50
6	Whitby Mudstone		22.00	5.00	20.00
7	Marlstone Rock		30.00	5.00	21.00
8	Dyrham Formation		28.00	5.00	20.00
9	Class 1 Fill		36.00	0.00	20.50
10	Class 2 Fill		25.00	0.00	19.50
11	Class 6P Fill		38.00	0.00	21.00
12	Class 7A Fill		27.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Topsoil / landscaping		17.00		
2	Made Ground (Roade Cutting)		19.50		
3	Alluvium		18.50		

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No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
4	Glaciofluvial Deposits		19.00		
5	Glacial Till		19.50		
6	Whitby Mudstone		20.00		
7	Marlstone Rock		21.00		
8	Dyrham Formation		20.00		
9	Class 1 Fill		20.50		
10	Class 2 Fill		20.50		
11	Class 6P Fill		21.00		
12	Class 7A Fill		21.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 0.00 kPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 2.00 kPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 22.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill

Unit weight : γ = 21.00 kN/m^3
Stress-state : effective

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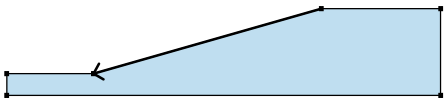
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Class 7A Fill
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		72.50	15.00	20.00	0.00	Whitby Mudstone
		0.00	0.00	0.00	-5.00	
		100.00	-5.00	100.00	15.00	

Surcharge

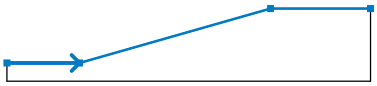
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F	q_2	unit
1	strip	permanent	on terrain	x = 72.50	l = 27.50		0.00	10.00		kN/m2

Surcharges

No.	Name
1	Surcharge

Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m] x	z	x	z	x	z	Coeff. Ru [–]
1		0.00	0.00	20.00	0.00	72.50	15.00	0.300
		100.00	15.00					

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 =	31.34	[m]	Angles :	α_1 =	-9.36	[°]
	z =	68.90	[m]		α_2 =	39.48	[°]
Radius :	R =	69.83	[m]				
The slip surface after optimization.							

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Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 96.5 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 98.6 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 1)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
19.98	0.00	26.20	-1.06	35.57	-0.71	44.56	0.67	53.32	2.87
61.67	5.88	69.71	10.01	75.49	15.00				
The slip surface after optimization.									

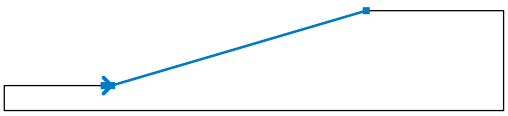
Slope stability verification (Sarma)
Combination 1
Utilization : 96.6 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 98.4 %

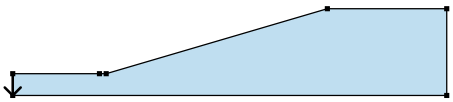
Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		20.00	0.00	21.50	0.00	72.50	15.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	0.00	0.00	-5.00	Whitby Mudstone
		100.00	-5.00	100.00	15.00	
		72.50	15.00	21.50	0.00	
		20.00	0.00			

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	q_2	unit
1	No	No	strip	permanent	on terrain	x = 72.50	l = 27.50		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

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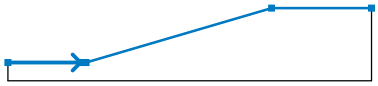
Water

Water type : Coefficient Ru

No.	Interface Ru location	Coordinates of interface Ru points [m]						Coeff. Ru
		x	z	x	z	x	z	[–]
1		0.00	0.00	20.00	0.00	21.50	0.00	0.300
		72.50	15.00	100.00	15.00			

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 =	31.84	[m]	Angles :	α_1 =	-8.67	[°]
	z =	67.73	[m]		α_2 =	39.68	[°]
Radius :	R =	68.51	[m]				
The slip surface after optimization.							

Slope stability verification (Morgenstern-Price)
Combination 1
Utilization : 98.8 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 101.1 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

Analysis 2 (stage 2)

Polygonal slip surface

Coordinates of slip surface points [m]									
x	z	x	z	x	z	x	z	x	z
21.31	0.00	26.43	-0.93	35.19	-0.77	44.62	0.64	53.43	2.87
61.82	5.88	69.83	10.01	75.49	15.00				
The slip surface after optimization.									

Slope stability verification (Sarma)
Combination 1
Utilization : 98.8 %

Slope stability ACCEPTABLE
Combination 2
Utilization : 100.9 %

Slope stability NOT ACCEPTABLE
Optimized slip surface for : Combination 2

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Settlement analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Setlement Assessment 2m Alluvium & 3m Land Raise
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

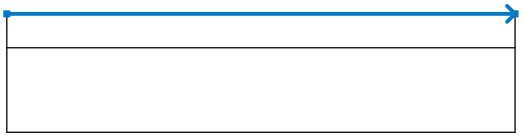
Settings

United Kingdom - EN 1997

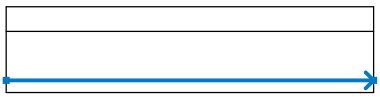
Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	20.00	30.00	20.00		
2		0.00	18.00	30.00	18.00		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	14.00	30.00	14.00		

Soil parameters

Topsoil / landscaping

Unit weight : γ = 17.00 kN/m^3
Oedometric modulus : E_{oed} = 2.00 MPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium

Unit weight : γ = 18.50 kN/m^3

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Oedometric modulus : E_{oed} = 3.50 MPa
Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits
Unit weight : γ = 19.00 kN/m^3
Oedometric modulus : E_{oed} = 10.00 MPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till
Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone
Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 11.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation
Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 10.00 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill
Unit weight : γ = 20.50 kN/m^3
Oedometric modulus : E_{oed} = 15.00 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill
Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.50 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 40.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

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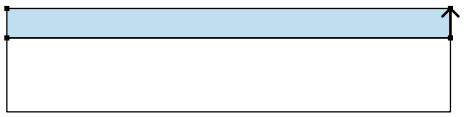
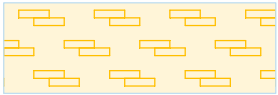
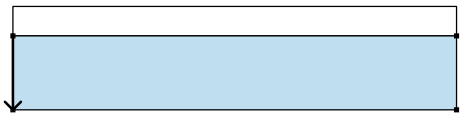
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	18.00	30.00	20.00	Alluvium
		0.00	20.00	0.00	18.00	
2		0.00	18.00	0.00	13.00	Whitby Mudstone
		30.00	13.00	30.00	18.00	

Surcharge

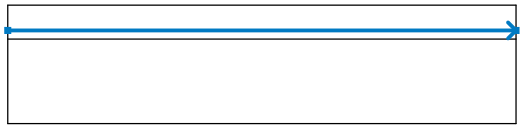
No.	Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	strip	on terrain	x = 0.00	l = 30.00			10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	18.50	30.00	18.50		

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

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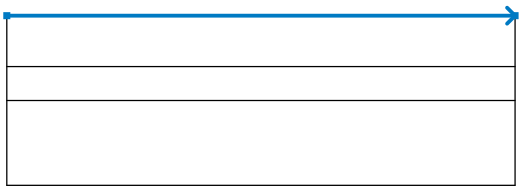
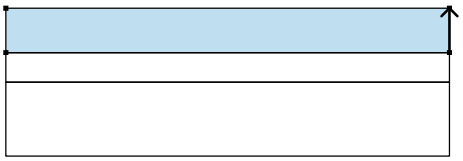
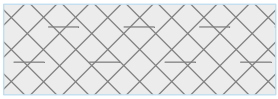
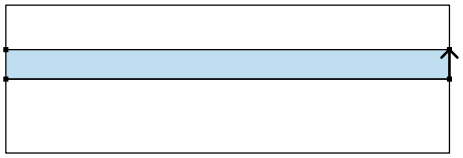
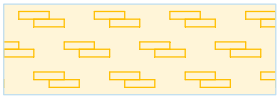
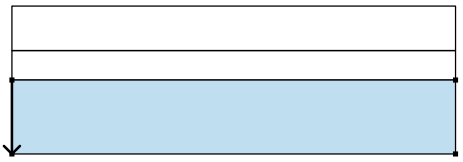
Input data (Stage of construction 2)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	23.00	30.00	23.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	20.00	30.00	23.00	Class 2 Fill
		0.00	23.00	0.00	20.00	
2		30.00	18.00	30.00	20.00	Alluvium
		0.00	20.00	0.00	18.00	
3		0.00	18.00	0.00	13.00	Whitby Mudstone
		30.00	13.00	30.00	18.00	

Surcharge

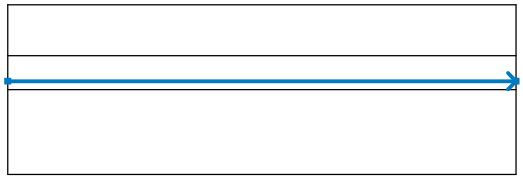
No.	Surcharge		Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
	new	change		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	No	No	strip	on terrain	x = 0.00	l = 30.00			10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	18.50	30.00	18.50		

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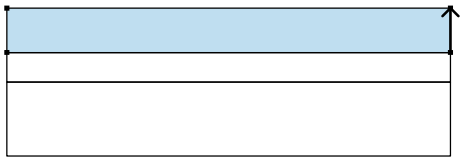
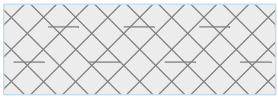
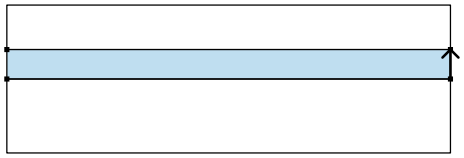
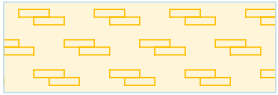
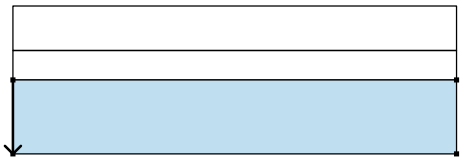
Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 51.9 mm
Maximum depth of influence zone = 5.50 m

Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	20.00	30.00	23.00	Class 2 Fill
		0.00	23.00	0.00	20.00	
2		30.00	18.00	30.00	20.00	Alluvium
		0.00	20.00	0.00	18.00	
3		0.00	18.00	0.00	13.00	Whitby Mudstone
		30.00	13.00	30.00	18.00	

Surcharge

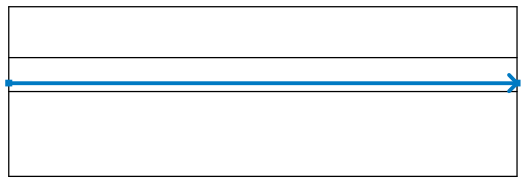
No.	Surcharge		Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
	new	change		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	Yes		strip	on terrain	x = 0.00	l = 30.00			50.00		kN/m^2

Surcharges

No.	Name
1	Building

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	18.50	30.00	18.50		

Results (Stage of construction 3)

Results

Analysis has not been performed.

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Settlement analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Settlement Assessment Screening bund 14m height BHG018
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

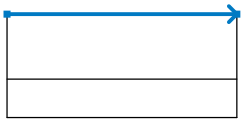
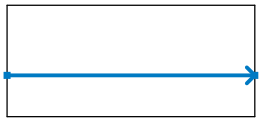
Settings

United Kingdom - EN 1997

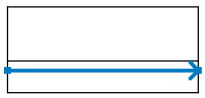
Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	20.00	30.00	20.00		
2		0.00	11.50	30.00	11.50		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	10.00	30.00	10.00		

Soil parameters

Topsoil / landscaping (2)

Unit weight : γ = 17.00 kN/m^3
Oedometric modulus : E_{oed} = 2.00 MPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting) (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium (2)

Unit weight : γ = 18.50 kN/m^3
Oedometric modulus : E_{oed} = 3.50 MPa
Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits (2)

Unit weight : γ = 19.00 kN/m^3

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Oedometric modulus : E_{oed} = 18.00 MPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till (2)
Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone (2)
Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock (2)
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 11.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation (2)
Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 10.00 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

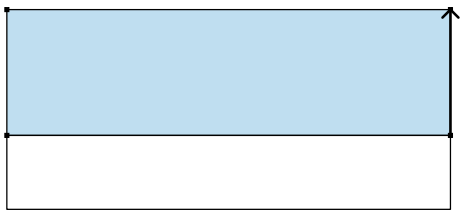
Class 1 Fill (2)
Unit weight : γ = 20.50 kN/m^3
Oedometric modulus : E_{oed} = 15.00 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill (2)
Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.50 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill (2)
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 40.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill (2)
Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	11.50	30.00	20.00	Glaciofluvial Deposits (2)
		0.00	20.00	0.00	11.50	

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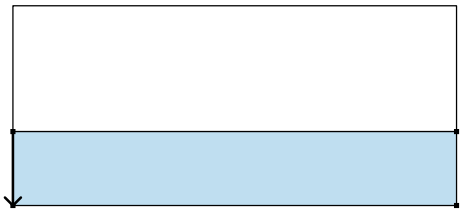
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		0.00	11.50	0.00	6.50	Whitby Mudstone (2)
		30.00	6.50	30.00	11.50	

Surcharge

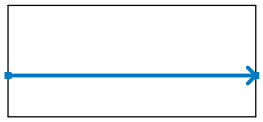
No.	Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	strip	on terrain	x = 0.00	l = 30.00			10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	11.50	30.00	11.50		

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

Results (Stage of construction 1)

Results

Analysis of geostatic stress was successfully completed

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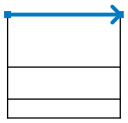
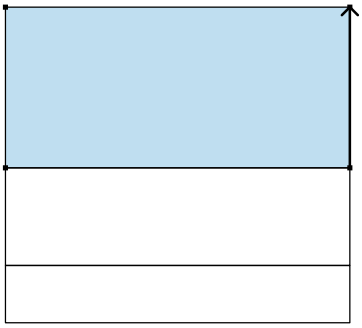
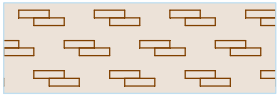
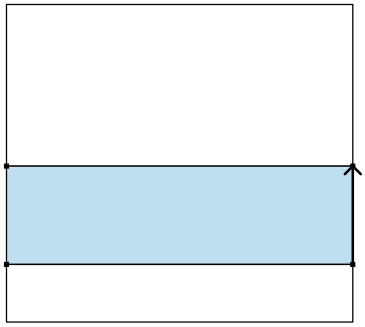
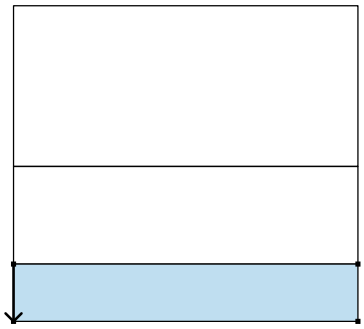
Input data (Stage of construction 2)

Embankment interface

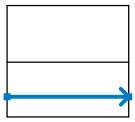
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	34.00	30.00	34.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	20.00	30.00	34.00	Topsoil / landscaping (2)
		0.00	34.00	0.00	20.00	
2		30.00	11.50	30.00	20.00	Glaciofluvial Deposits (2)
		0.00	20.00	0.00	11.50	
3		0.00	11.50	0.00	6.50	Whitby Mudstone (2)
		30.00	6.50	30.00	11.50	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	11.50	30.00	11.50		

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Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 131.8 mm
Maximum depth of influence zone = 9.50 m

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Settlement analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Settlement Assessment Screening bund Rathvilly Farm
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

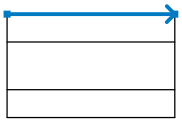
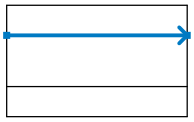
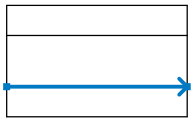
Settings

United Kingdom - EN 1997

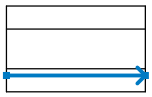
Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	25.00	30.00	25.00		
2		0.00	20.00	30.00	20.00		
3		0.00	11.50	30.00	11.50		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	10.00	30.00	10.00		

Soil parameters

Topsoil / landscaping (2)

Unit weight : γ = 17.00 kN/m^3
Oedometric modulus : E_{oed} = 2.00 MPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting) (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium (2)

Unit weight : γ = 18.50 kN/m^3
Oedometric modulus : E_{oed} = 3.50 MPa

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Saturated unit weight : γ_{sat} = 18.50 kN/m^3

Glaciofluvial Deposits (2)

Unit weight : γ = 19.00 kN/m^3
Oedometric modulus : E_{oed} = 18.00 MPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone (2)

Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 11.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation (2)

Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 10.00 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill (2)

Unit weight : γ = 20.50 kN/m^3
Oedometric modulus : E_{oed} = 15.00 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.50 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 6P Fill (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 40.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Made Ground Rathvilly Farm pit

Unit weight : γ = 18.00 kN/m^3
Oedometric modulus : E_{oed} = 6.00 MPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

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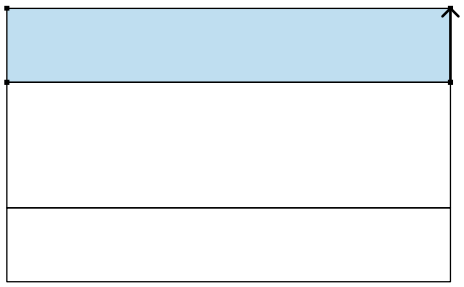
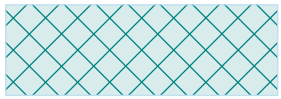
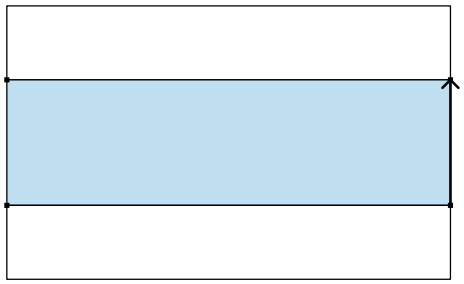
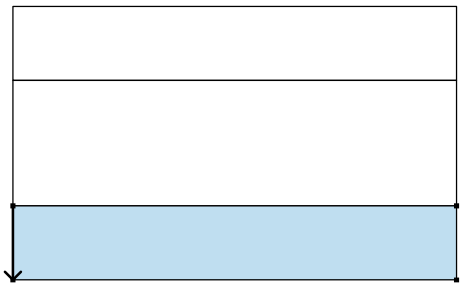
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	20.00	30.00	25.00	Made Ground Rathvilly Farm pit
		0.00	25.00	0.00	20.00	
2		30.00	11.50	30.00	20.00	Glaciofluvial Deposits (2)
		0.00	20.00	0.00	11.50	
3		0.00	11.50	0.00	6.50	Whitby Mudstone (2)
		30.00	6.50	30.00	11.50	

Surcharge

No.	Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	strip	on terrain	x = 0.00	l = 30.00			10.00		kN/m^2

Surcharges

No.	Name
1	Surcharge

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	12.00	30.00	12.00		

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact

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Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

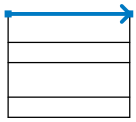
Results (Stage of construction 1)

Results

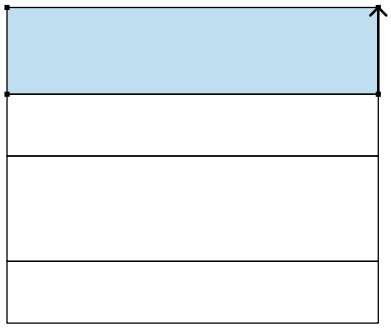
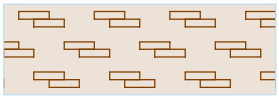
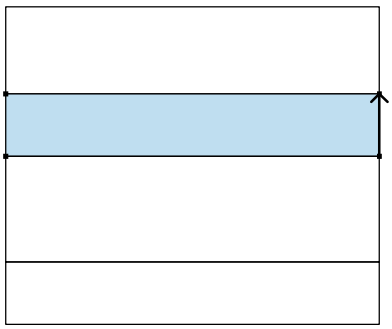
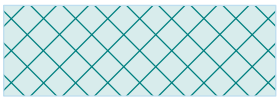
Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	32.00	30.00	32.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	25.00	30.00	32.00	Topsoil / landscaping (2) 
		0.00	32.00	0.00	25.00	
2		30.00	20.00	30.00	25.00	Made Ground Rathvilly Farm pit 
		0.00	25.00	0.00	20.00	

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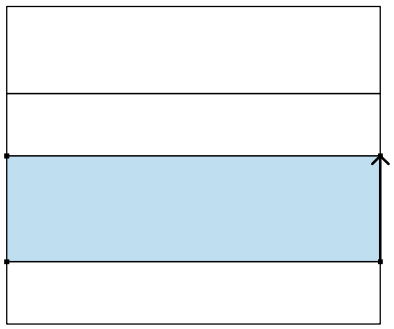
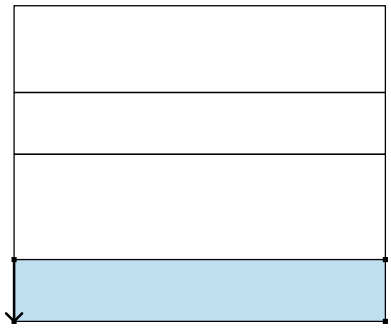
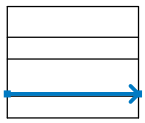
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
3		30.00	11.50	30.00	20.00	Glaciofluvial Deposits (2)
		0.00	20.00	0.00	11.50	
4		0.00	11.50	0.00	6.50	Whitby Mudstone (2)
		30.00	6.50	30.00	11.50	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	12.00	30.00	12.00		

Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 149.7 mm
Maximum depth of influence zone = 14.00 m

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Settlement analysis

Input data

Project

Task : Rail Central, Milton Malsor
Part : Conceptual GDR
Description : Settlement Assessment 7m Class 7A fill
Customer : Ashfield Land
Author : RB
Date : 05/09/2017
Project ID : C151171

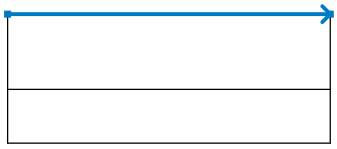
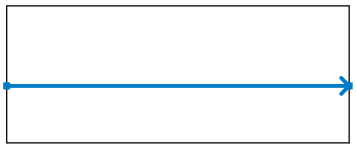
Settings

United Kingdom - EN 1997

Settlement

Analysis method : Analysis using oedometric modulus
Restriction of influence zone : by percentage of Sigma,Or
Coeff. of restriction of influence zone : 10.0 [%]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	20.00	30.00	20.00		
2		0.00	13.00	30.00	13.00		

Incompressible subsoil

No.	Location of incompress.subsoil	Coordinates of points of incompress.subsoil [m]					
		x	z	x	z	x	z
1		0.00	17.50	30.00	17.50		

Soil parameters

Topsoil / landscaping (2)

Unit weight : γ = 17.00 kN/m^3
Oedometric modulus : E_{oed} = 2.00 MPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

Made Ground (Roade Cutting) (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 5.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Alluvium (2)

Unit weight : γ = 18.50 kN/m^3
Oedometric modulus : E_{oed} = 3.50 MPa
Saturated unit weight : γ_{sat} = 18.50 kN/m^3

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Glaciofluvial Deposits (2)

Unit weight : γ = 19.00 kN/m^3
Oedometric modulus : E_{oed} = 18.00 MPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Glacial Till (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.00 MPa
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

Whitby Mudstone (2)

Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Marlstone Rock (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 11.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Dyrham Formation (2)

Unit weight : γ = 20.00 kN/m^3
Oedometric modulus : E_{oed} = 10.00 MPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Class 1 Fill (2)

Unit weight : γ = 20.50 kN/m^3
Oedometric modulus : E_{oed} = 15.00 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Class 2 Fill (2)

Unit weight : γ = 19.50 kN/m^3
Oedometric modulus : E_{oed} = 8.50 MPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

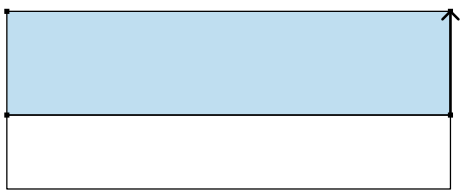
Class 6P Fill (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 40.00 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Class 7A Fill (2)

Unit weight : γ = 21.00 kN/m^3
Oedometric modulus : E_{oed} = 12.50 MPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.00	13.00	30.00	20.00	Whitby Mudstone (2)
		0.00	20.00	0.00	13.00	

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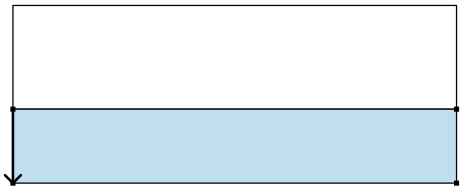
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
2		0.00	13.00	0.00	8.00	Whitby Mudstone (2)
		30.00	8.00	30.00	13.00	

Water

Water type : No water

Holes layout

Layout and refinement of holes : standard

Horizontal layout

Layout pattern : exact
Add holes : by number of sections
Number of sections : 20

Vertical refinement

No.	From depth [m]	Refinement [m]
1	0.00	0.10
2	2.00	0.30
3	5.00	0.50
4	10.00	2.00
5	30.00	10.00

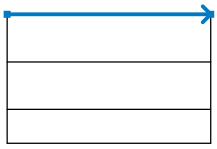
Results (Stage of construction 1)

Results

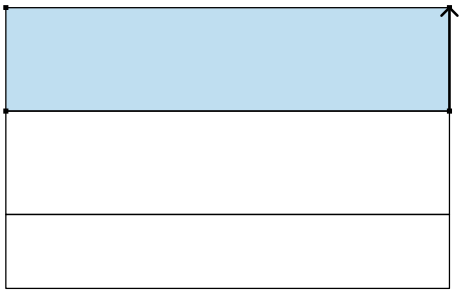
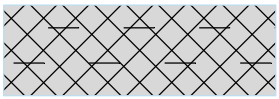
Analysis of geostatic stress was successfully completed

Input data (Stage of construction 2)

Embankment interface

No.	Interface location	Coordinates of interface points [m] x	z	x	z	x	z
1		0.00	27.00	30.00	27.00		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		30.00	20.00	30.00	27.00	Class 7A Fill (2)
		0.00	27.00	0.00	20.00	

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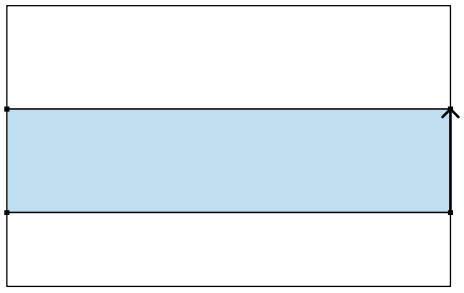
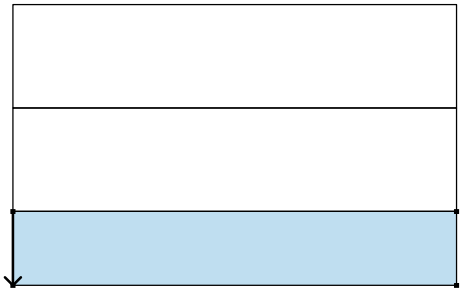
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		30.00	13.00	30.00	20.00	Whitby Mudstone (2)
		0.00	20.00	0.00	13.00	
3		0.00	13.00	0.00	8.00	Whitby Mudstone (2)
		30.00	8.00	30.00	13.00	

Surcharge

No.	Surcharge		Type	Location	Origin	Length	Width	Distance from axes	Magnitude		
	new	change		z [m]	x [m]	l [m]	b [m]	y [m]	q, q_1, f, F	q_2	unit
1	Yes		strip	on terrain	x = 0.00	l = 30.00			10.00		kN/m^2

Surcharges

No.	Name
1	surcharge

Water

Water type : No water

Results (Stage of construction 2)

Results

Analysis performed, method Analysis using oedometric modulus
Maximum settlement = 31.3 mm
Maximum depth of influence zone = 2.30 m

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