AG3080-19-AK82

APPLiED GEOLOGY

HIGHWAYS ENGLAND SUMMARY GEOTECHNICAL DESIGN REPORT FOR HOYLAND COMMON, BARNSLEY, M1 JUNCTION 36

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1.0 INTRODUCTION

1.1 Background and Purpose of Report

An area of land between the M1 motorway and Sheffield Road to the west of Hoyland Common near Barnsley (the site) is to be redeveloped by Newlands Developments (the Client). The proposals for the site comprised the reprofiling of the site to enable the construction of a single large distribution warehouse and other industrial units, with a new link road and associated infrastructure, parking, balancing pond and landscaping. The M1 motorway forms the western boundary of the site and Junction 36 is immediately adjacent to the north/northwestern tip of the site.

The proposed development is covered by planning application **Hoyland West Ref. 2020/0647.**

Applied Geology Limited has been appointed by Newlands Developments to undertake a Ground Investigation and provide professional geotechnical services to assist in the design of the proposed development. The following reports have been prepared and issued:

a) Desk Study Report Ref. AG3080-19-AJ70, dated January 2020;
b) Phase 1 Coal Mining Risk Assessment Ref. AG3080-19-AJ77, dated January 2020;
c) Ground Investigation Report (GIR) Ref. AG3080-19-AK21, dated June 2020.

The above referenced reports were included with the Planning Application. Highways England (HE), in its capacity as a consultee, noted that "*From the plans it appears that the development will require cut into the slope adjacent to our boundary with the potential to destabilise our earthworks".* HE therefore required Newlands Developments to appoint a Design Geotechnical Advisor to carry out a study of the impact of the proposed earthworks along the HE site boundary.

However, in addition to the above reports, Applied Geology had also been undertaking a Geotechnical Design Report (GDR), which has since been issued as report Ref. AG3080-19-AK36, dated August 2020. Discussions were therefore held with HE and it was agreed that Applied Geology would produce a summary design report for HE regarding the earthworks aspects of the GDR that are relevant to the HE assets.

This Summary GDR has been compiled to address the geotechnical aspects of the proposed development and to present the relevant geotechnical design elements, cross referencing relevant desk study information, factual data and ground conditions contained within the above referenced reports.

The geotechnical design works have been undertaken in accordance with relevant standards including BS5930, BS EN1997, Manual of Contract Documents for Highway Works, Specification for Highway Works [SHW]: Volume 1: 1998 [updated 2016] and EN16907-1: 2018 Earthworks. In addition to these documents, reference has also been made to BS6031:2019, BRE FB75 and the requirements of CD 622, albeit the proposed development does not constitute a HE project.

1.2 Summary of Proposed Earthworks

The site is divided into three main areas based on the proposed development but only Plots 1 and 3 border HE property.

The main central area (Plot 1 – also known as 'Hermes') is to comprise a large distribution warehouse measuring 375m by 75m and orientated NNW-SSE. There are associated lorry parking areas, a lorry wash, a lorry refuelling area, a staff car park surrounding the proposed building. The finished floor level is currently proposed at 144.5mOD and, therefore, significant earthworks will be required to create a level site area at this elevation.

The part of the site to the north of Tankersley Lane (Plot 3) is also to be prepared to create a level development platform for future light industrial use. It is understood that several small units are proposed in this area, however, development plans have not been finalised. The plateau level in this part of the site is currently proposed at 145.6mOD and will also involve some element of cut and fill.

The initial cut-fill profile was derived using maximum slope angles of 1v:3h and no retaining structures were intended to be used. A nominal off-set from the HE boundary fence line was also assumed to allow access for maintenance and toe/crest drainage.

The following details the proposed changes in ground level adjacent to the HE assets, from north to south:

Plot 3
Alongside the boundary with Junction 36 roundabout and the adjoining A road, the earthworks will result in an increase in ground level of generally between 0 and 2m. Alongside the motorway slip road and north of Tankersley Lane, up to 5m of fill is proposed. Here the motorway slip road is slightly higher than the site/at grade and then is in shallow cut towards the Tankersley Lane bridge.

Plot 1
From Tankersley Lane to approximately where the HV overhead powerlines cross the motorway, the proposed development will be in cut with cut slopes between <0.5m and 6m deep close to the HE boundary. However, the motorway is also in cutting along the same length. South of the overhead lines, the motorway is elevated above the site (on fill) and proposed site levels are also to increase by construction of engineered fill slopes up to 5.5m high close to the HE boundary.

1.3 Geotechnical Category

The proposed development as a whole has been categorised as both Geotechnical Category 2 and Category 3 as defined by British Standard EN 1997-1:2007 Eurocode 7 – Geotechnical Design. This is because it generally involves conventional types of geotechnical structures, earthworks and activities but some parts of the site will involve unusual/difficult ground conditions, high loading conditions associated with the placement of engineered fill and construction of buildings above significant thicknesses of uncontrolled opencast backfill. However, the earthworks adjacent to the HE asset are all considered to be Geotechnical Category 2.

2.0 INITIAL GEOTECHNICAL RISK REGISTER

A Geotechnical Risk Register was derived for the proposed development as part of the Desk Study and GIR process and is included in full in the GIR. The key geotechnical risks that are relevant to the earthworks close to the HE asset were identified as follows:

- Uncertain or variable thickness of Made Ground relating to the opencast backfilling;
- Slope stability, particularly if placing fill over untreated opencast backfill or forming cut slopes within Opencast Backfill;
- Unexpected or high groundwater conditions;
- Unsuitable soils for re-use as engineered fill;
- Difficult excavation of rock in areas of cut.

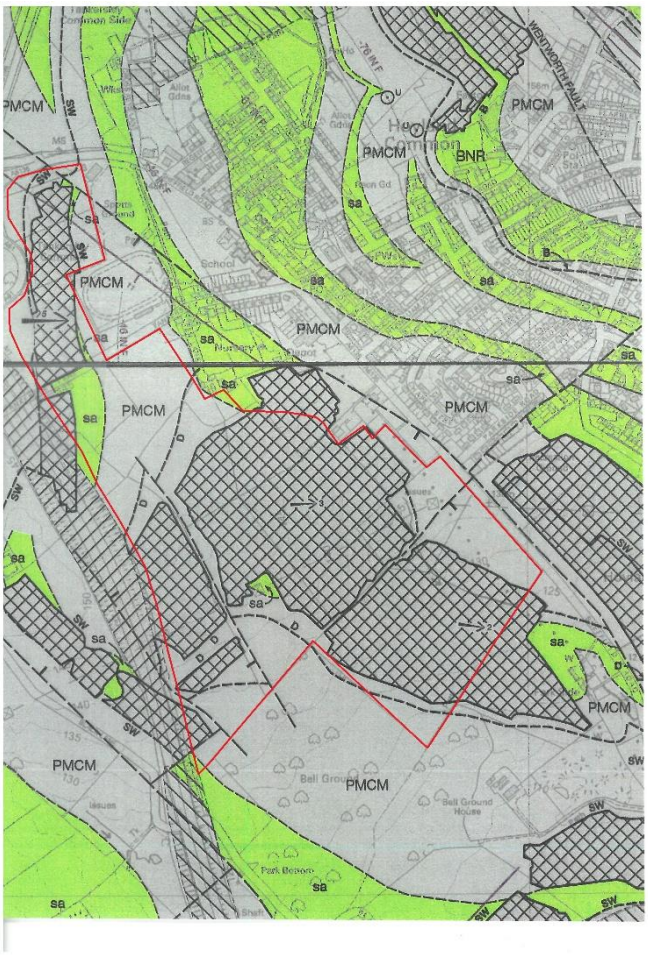
At GIR stage, a qualitative risk level was assigned to each geotechnical hazard/ risk, together with possible mitigation measures, some of which relate to work undertaken in the geotechnical design process. An updated geotechnical Risk Register was then undertaken following the geotechnical design stage and is reported in the GDR. The updated risk register relevant to the earthworks alongside the HE asset is discussed in Section 8.0 of this report.

3.0 DESK STUDY AND COAL MINING RISK ASSESSMENT SUMMARY

A Phase 1 Desk Study and Preliminary/Phase 1 Coal Mining Risk Assessment (CMRA) were carried out for the site by Applied Geology (Report Ref. AG3080-19-AJ70, Validated Issue 1 and Report Ref. AG3080-19-AJ77, Validated Issue 1), both dated January 2020. Reference should be made to both reports for full details, however, pertinent information relevant to the HE asset and site boundary are summarised below.

The site was agricultural land before opencast mining was undertaken in the mid to late 1940s with the site being restored to agricultural use by the early 1950s. Tankersley Lane was present by 1855 and the M1 motorway was constructed during the late 1960s.

The site is shown to be underlain by the Pennine Middle Coal Measures Formation, which typically comprises interbedded grey mudstone, siltstone and sandstone with numerous workable coal, ironstone and fireclay seams, which have been historically worked in the area. The stratum is shown to dip by between 2 and 5 degrees to the east. No natural Superficial Deposits are shown to be present on or in the vicinity of the site. Extracts from the BGS maps are shown below:



The site is within a Coal Mining Reporting Area, with much of the site within a Development High Risk Area. A Consultant's Coal Mining Report and relevant abandonment plans have been obtained and form part of the Coal Mining Risk Assessment Report.

Four separate opencast mines are present along sections of the site boundary with the HE asset (the western extents of the redline boundary). Either side of Tankersley Lane and the close to the extreme southwestern end of the HE site boundary, the Swallow Wood Coal Seam was opencast mined. Under the higher ground towards the centre-south the Dunsil Coal Seam (also known as the Harley Seam) was opencast mined. Several small faults are also shown on the BGS maps.

The coal seams generally dip to the east/southeast at shallow angles and therefore the depth of the opencast mines were at their shallowest at their eastern extents.

No recorded shaft are shown close to the boundary with the HE asset.

The BGS Maps also show the M1 motorway adjacent to the site to be located on Made or Worked Ground.

There are numerous records of past underground mining on and near the site, mostly relating to coal seams, but two relating to ironstone seams, between 23m

and 346m bgl. These were last worked between 1857 and 1972 and movements from these workings should have ceased.

No obvious potential sources of contamination were identified by the desk study in proximity to the HE asset. The Coal Authority abandonment plans indicated the opencast backfill materials to comprise natural overburden deposits including “clay, mudstone, sandstone and shale”.

Based on the findings of the Desk Study and Phase 1 CMRA a comprehensive ground investigation was designed with significant focus on determining the location, nature, depth and geotechnical properties of the opencast backfill materials.

4.0 GROUND INVESTIGATION SUMMARY

The Ground Investigation Report (GIR) was completed for the main site (Plots 1 - 3) and is referenced AG3080-19-AK21 dated June 2020, and includes the following:

- Factual data (including exploratory hole logs, exploratory hole location plan, in situ and laboratory test results, groundwater and ground gas monitoring);
- Interpreted ground conditions (including conjectured geological cross sections.
- Review and discussion on the geotechnical properties;
- Contamination Assessment;
- Updated Coal Mining Risk Assessment;
- Geotechnical risk register.

In the main site area (covering plots 1-3), beneath surface Topsoil, underlying Made Ground typically consisted of opencast backfill. This has been formed through reworking natural materials of the Pennine Middle Coal Measures Formation (PMCM), which has resulted in materials predominantly formed of gravelly clay including cobbles and rare boulders. Where natural in situ soils represented the PMCM were present in unworked areas or below opencast backfill, a weathered clay horizon was generally encountered at shallow depths, increasing to rock strength with depth. Shallow coal seams were encountered in some areas.

The Opencast Backfill included an initial cohesive ‘capping’ layer c. 1.0-1.5m thick was generally present in most areas of opencast backfill across the main site. Underlying materials were variable in the extreme with approximately a third to a quarter of all materials being granular, based on engineering descriptions.

Typical cohesive and granular descriptions can be represented respectively as ‘variably gravelly silty clay with occasional to frequent cobbles’ and ‘variably sandy variably clayey gravel with occasional to frequent cobbles’. Approximately one third of the materials were noted to contain cobbles and where present, they typically constituted approximately 10-20% of the soil volume. The presence of boulders was ‘rare’. From observations generally, an irregular loose macrofabric represented by ‘lumps’ of cohesive material is inferred. This appears to possibly be associated with small voids or looser material infill at depths above around 4 or 5m below existing levels.

Where the in situ PMCM were encountered near surface, there was an upper 1.0 – 1.5m thick weathered horizon of firm or stiff silty clay which soon became very stiff and friable with mudstone lithorelicts. Localised thin bands of rock strength siltstone or sandstone were sometimes present within this weathered horizon at shallow depths.

Rock strength strata were present below the upper weathered horizon and also below the Opencast Backfill materials, representing the floor of the former quarried areas. These generally comprised extremely weak to weak grey mudstone, siltstone and occasional sandstone interbeds with local coal seams.

In general, groundwater levels within the opencast backfill are considered highly variable. During the investigation work in Plot 3, the backfill materials were largely saturated and groundwater was present at shallow depths (around 1 -3m bgl). Fast inflows were recorded in some trial excavations. In Plot 1, however, the occurrence of groundwater was more localised and mainly towards the base, although occasionally higher level (1 – 4m bgl) inflows, were noted in the centre west near the HE boundary.

Generally, within the opencast backfill, a regime whereby groundwater locally perched on more cohesive fine-grained zones, which can be present at varying depths, is indicated. The levels are also inferred to be significantly responsive to weather and seasonal conditions. Generally higher levels in Plot 3 are likely to be related in part to the lack of existing land drainage.

Within the PMCM, a deeper groundwater regime is present at variable depths, sometimes under a low sub-artesian pressure head.

The geotechnical properties of the opencast backfill and PMCM, based on both laboratory and in situ testing, are covered in detail within the GIR. The main GDR discusses these properties and their variations and derived appropriate design parameters, which are summarised below.

It is emphasized that the Opencast Backfill material is extremely variable in all respects, comprising overburden likely excavated by dragline, roughly stockpiled and returned to the pit via loose tipping. It is unlikely there would have been any control on particle size or any effort made to compact the material. However, the backfill materials have been in-situ for around 70 years, hence self-weight settlement is expected to have completed.

Summary of Adopted Geotechnical Design Parameters

Material type		Unit Weight (kN/m^3)	Saturated Unit Weight (kN/m^3)	Effective Angle of Internal Friction (Degrees)	Undrained Shear Strength (kPa)	Unconfined Compressive Strength (MPa)	Poisson's Ratio	Effective Cohesion (kPa)	Deformation Modulus (MPa)	Permeability (ms^{-1})
Opencast Backfill	Dry (Upper 5m)	18	20	17 - 19	30 - 50	N/A	0.35	0*[7]	3.0-10.0*[8]	4.0×10^{-9} – 5.0×10^{-10}
	Dry (Lower)	18	20		50 - 100				5.0-12.5*[8]	
	Saturated	20	20		40 - 60				3.0-10.0*[8]	
Engineered Fill		20	20	24	75	N/A	0.35	0	10	5.0×10^{-10}
Pennine Middle Coal Measures	Clay (Upper 1.5m)	21	21	20	60	N/A	0.42	3	6	1.0×10^{-10}
	Clay (Lower)	21	21	22	135	N/A	0.42	3	13	
	Coal	13	13	25	N/A	2.5	0.40	5	250	1.0×10^{-8}
	Rock (Upper 4-8m)	23	23	30	N/A	1.0	0.25	5	100	5.0×10^{-10}
	Rock (Lower)	25	25	40	N/A	5.5	0.25	5	550	

5.0 CUTTING AND EMABNKMENT STABILITY

Cuttings will be made through both natural Coal Measures strata (soil and rock strength materials) and Made ground comprising opencast backfill materials. Embankment slopes will be constructed of site-derived engineered fill placed and compacted in accordance with the Earthworks Specification, which is included in full as Annex I of both this report and the main GDR report.

5.1 Methods of Analyses

Slope stability analyses were carried out using the GEO5 'Slope' package by Fine software with analyses using Design Approach 1 – reduction of actions and soil parameters and UK – EN1997 settings. Both undrained (short term) and drained (long term) analyses were undertaken.

The initial stage involved generic assessments assuming hypothetical well drained 5m high slopes formed in Engineered Fill and cut into natural soils to give a general indication of safe slope angles. Circular failure surfaces were considered, originating behind the slope crest and 'daylighting' near the toe, using Bishop method. Failure of underlying 'foundation' soils or slopes cut into Opencast backfill were not considered of value in this initial stage and hence were not included.

The detailed analysis stage, based on the ground investigation and proposed development slopes, involved the construction of various model profiles at locations shown on Drawings AG3080-19-07, Annex II. A number of these profiles were analysed in respect of slopes near the western site boundary close to the HE assets.

The model profiles have been created by overlaying the 3D CAD existing topographic survey with the proposed cut and fill levels ('Cut & Fill Contours' Winvic Dwg No 10986b) and importing to the GEO5 software. A variety of analyses methods, including Bishop and Morgenstern-price were undertaken in the detailed analysis stage.

Characteristic soil and rock material parameters used in the slope stability analyses are as set out in Section 3.0 above. Some sensitivity analyses were undertaken and included in the assessments in the main GDR report.

Groundwater is a key factor in slope stability and the groundwater regime and inherent variability resulted in the need to include a relatively large range of conditions in the stability analyses to reflect groundwater levels above those identified in investigations which might represent reasonable worst realistic case. This includes an allowance for the effects of working crest and toe drainage which is assumed to be implemented.

The GEO5 software output comprises a complete report for each analysis undertaken together with a drawing of the model that has been analysed. The GEO5 output reports, presented in Annex III, include full details of methodology, ground profile, soil parameters and resulting stability. Within the output reports, stability is expressed in terms of percentage 'utilization' of resisting forces, determined in accordance with EC 7, where less than 100% is deemed acceptable.

5.2 Generic Safe Gradients and Short Term (Temporary) Stability

The steepest long-term safe slope gradients for hypothetical slopes up to 5m high in a single material type including modelling a groundwater table at or just below the slope toe are assessed as follows:

- Engineered Fill: 1v:3.0h;
- Coal Measures – Clay 1v:2.75h;
- Coal Measures – Rock 1v:1.5h.

These generic safe gradients have been considered alongside the detailed analyses described in the following sections and in the assessment of appropriate design measures.

The analyses in short term (temporary) conditions are presented in the design note in Annex V of the main GDR report. These analyses conclude that the slopes are stable in the short-term condition where in close proximity to the HE assets. However, for the large embankment towards the southern tip of Plot 1, it will be essential that pore pressures are monitored and the rate of filling controlled to maintain short term stability of slopes.

5.3 Plot 1 'Hermes'

5.3.1 Ground Models

Cut slopes in the west

Cut slopes up to around 5.5m in height are required in northern and central parts of the western boundary with the motorway. The required gradients based on the cut/fill model are around 1v:3h at their steepest, slackening to the north and south. These slopes are represented by model sections E-E', F-F' and R-R'. Adjacent to the centre of the proposed building (E-E'), the majority of the slope will be cut into in situ PMCM strata comprising clay in the higher slope separated by a coal seam from rock strength materials in the lower slope. The adjacent motorway is in a cutting inferred to be within in situ PMCM and around 7m in depth. Southwards of this, gradually thickening opencast backfill is present, until at the southern end (F-F'), the entire slope will be cut within opencast backfill materials. However, the modelled slope angles here are much shallower at around 1v:8h. The critical section is represented by R-R', where significant thicknesses of opencast backfill are accompanied by a slope gradient of around 1v:3h.

Fill slopes in the south

Engineered embankment slopes up to about 6.5m high will be formed in the south of the plot. The cut/fill model shows these at gradients of 1v:3h and 1v:3.5h. On parts of the south western facing boundary adjacent to the motorway (which is constructed on a small embankment, the embankment will lie on an area of opencast backfill represented on section O-O'. Section P-P' is modelled through the apex between two slope boundaries, where again the embankment will rest on in situ PMCM strata.

5.3.2 Stability Summary

A summary of the stability analyses for each model section is provided below:

Summary of Stability Analyses – Plot 1 Slopes

Slope	Height (m)	Gradient	Stability (% Utilization)	Comment
Western cut – E-E'	5.5	1v:3h	76 - 83	Stability ACCEPTABLE
Western cut – F-F'	3.0	1v:8h	81 - 94	Stability ACCEPTABLE
Western cut – R-R'	5.4	1v:3h	112 - 116	Stability NOT ACCEPTABLE
Southern fill – O-O'	5.0	1v:3.5h	83 - 105	Stability MARGINAL/NOT ACCEPTABLE
Southern fill – P-P'	6.4	1v:3h	73 - 75	Stability ACCEPTABLE

The analyses on the western cut slopes have demonstrated that whilst the extremities, where either the steeper gradient is cut into natural materials (E-E') or much shallower gradients are cut within opencast backfill (F-F'), are acceptable, the areas between will not achieve an acceptable degree of stability

The southern embankment slope is indicated to be of acceptable stability along the junction between the south west and south east facing slopes, but is very marginal or unacceptable stability in the south west facing slope adjacent to the M1. Where the stability has been assessed as unacceptable, further specific design measures are required and these are evaluated below.

5.3.3 Specific Design Measures

Cut slopes in the west

The stability issues associated with the western cut slopes could be resolved by a combination of slackening the gradient and re-engineering the opencast backfill. These have been considered and ruled out as design options at this time because of potential ground disturbance in close proximity to the HE asset and the effects to the development platform. Retaining structures are therefore required in the design of this boundary slope. The extent of the boundary slope effected is indicated on Drawing No AG3080-19-12, Annex II. Further details are presented in a Design Note (Ref 'Western cut slope', Annex IV).

As the exposed strata in and the stability of the cut slope in this area will vary north to south, the retaining wall details will vary accordingly and a combination of retaining wall height and reduced slope angles will be required to suit the strata and slope geometry. Two of the many possible combinations have been modelled and the revised stability analyses are summarised below:

Summary of Stability Analyses – Section R-R' Re-designed cut slope options

Slope	Retained Height (m)	Gradient of remaining slope	Stability (% Utilization)	Comment
Western cut – R-R'	1.5	1v:4h	Global: 65-72 Upper slope: 88-94	Stability ACCEPTABLE
Western cut – R-R'	2.5	1v:5h	Global: 68-76 Upper slope: 72	Stability ACCEPTABLE

It is anticipated that specialist design & build subcontractors will be appointed by the Main Contractor to design suitable retaining structures, with Applied Geology undertaking global stability analyses of the revised slope profiles.

Fill slopes in the south

The southwestern facing embankment slope will require improvements to the immediately underlying embankment soils. Slopes should be constructed at a gradient of 1v:5h and re-engineering of the upper 1.0m thickness of opencast backfill is required in this area to achieve an acceptable degree of stability (as confirmed by further analyses). The approximate area of treatment is illustrated on Drawing No AG3080-19-12, Annex II. The revised stability analysis is summarised below:

Summary of Stability Analyses – Section O-O' Re-designed slope

Slope	Height (m)	Gradient	Stability (% Utilization)	Comment
Southern fill – O-O'	5.0	1v:5h	74-92	Stability ACCEPTABLE

Inclinometers are required in the fill embankment slope in the southwest to monitor lateral ground movements alongside settlements and pore pressure dissipation. The locations and details of the required instrumentation are provided on Drawing AG3080-19-13 in Annex II.

5.4 Plot 3

Two sections (A-A' and B-B') were created and analysed in detail for the purposes of assessing the likely magnitude and variations in settlements that could affect the future buildings. At the western end of this plot, embankment fill slopes are to be constructed of engineered fill and will almost entirely be placed on in situ Coal Measures strata. At Section A-A' the engineered fill embankment is only around 2m in height and at Section B-B' up to 3.5m of engineered fill will be placed to create the slopes. Slope angles of 1v:3h are proposed in the engineered fill at these locations and the stability assessments are covered by the generic stability assessment described above. The analyses included modelling of shallow groundwater, which is indicated to be present in this area. Owing to the relatively modest height of these embankments and the favourable degree of stability, instrumentation is not considered necessary.

6.0 DRAINAGE AND GROUNDWATER

Significant groundwater ingress is expected in some excavations and temporary drainage/control measures are necessary during the earthworks.

Dependent on the time of year, standing surface water may be present causing construction difficulties in the low-lying southern apex of Plot 1. Also, some shallow occurrences of groundwater are expected in the centre-west towards the boundary with the M1 cutting, which could impact to an extent on the cut slope required in this area.

In general, sump pumping should be sufficient to maintain excavations towards the western site boundary sufficiently dry during construction.

Permanent drainage measures (to be designed by others) will include both toe and crest drains for the slopes.

7.0 UPDATED GEOTECHNICAL RISK REGISTER

The Geotechnical Risk Register based on the initial version presented in the GIR, has been updated in light of the assessments/design in the GDR and is included in an annex to the GDR.

In respect of the earthworks and the potential impacts on the HE asset, appropriate design has been put forward to mitigate these risks. Where initial slope angles were deemed to be unsuitable slope angles have been reduced, some re-engineering of opencast backfill materials has been specified and/or some small retaining structures have been specified.

Retaining structures are to be designed in detail by the Contractor's specialist subcontractor.

For the larger embankment towards the southwestern corner of the site, slope and settlement monitoring will be undertaken and the data used to monitor stability.

The updated Coal Mining Risk Assessment concludes that the there is no evidence that the site has been affected by underground mining at shallow depths and that the development should not require a programme of drilling and grouting. Subsidence from deep coal mining of several seams should have ceased. Subsidence due to self-weight settlement of the opencast backfill (in place for c.70 years) should also have ceased by now.

Should any evidence of former bell pits or mine shafts be encountered during the course of the works, Site Personnel will immediately inform Applied Geology Limited. The area should be cordoned off and work will cease in the vicinity. Applied Geology Limited will attend site (if not already present) to inspect the area, consult with the Coal Authority and, if appropriate, subsequently agree suitable remedial measures.

8.0 GEOTECHNICAL FEEDBACK REPORT

Applied Geology has been appointed to oversee the earthworks operations and, on completion of the infrastructure works, will complete a Geotechnical Feedback Report (GFR) for the whole site. The GFR will include details of the earthworks undertaken, slope monitoring results and any design changes (including global stability checks on specialist contractor designed retaining wall slopes) and will be undertaken in general accordance with CD622.

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GENERAL NOTES

A) The assessment made in this report is based on the site terrain and ground conditions revealed by the various field investigations undertaken and also any other relevant data for the site including previous site investigation reports (if available) and desk study data. There may be special conditions appertaining to the site, however, which have not been revealed by the investigation and which have not, therefore, been taken into account in the report. The assessment may be subject to amendment in the light of additional information becoming available. It must be recognised that many of the Environmental Searches obtained during the course of the desk study are often lengthy. Applied Geology have, where appropriate and in the interests of simplicity, only reproduced the summary of the searches within the report. A full copy of all the search data is held at the Applied Geology office and is available for inspection if required.

B) Where any data supplied by the Client or other external source, including that from previous site investigations, has been used it has been assumed that the information is correct. No responsibility can be accepted by Applied Geology for inaccuracies within this data.

C) Whilst the report may express an opinion on possible configurations of strata between or beyond the exploratory locations, or on the possible presence of features based on either visual, verbal or published evidence this is for guidance only and no liability can be accepted for the accuracy.

D) Comments on groundwater (and landfill gas) conditions are based on observations made during the course of the present and past investigations or with reference to published data unless otherwise stated. It should be noted, however, that groundwater (and landfill gas) levels vary due to seasonal (or atmospheric conditions) or other effects.

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F) This report is prepared and written in the context of the proposals stated in the introduction to the report and should not be used in a differing context. Furthermore, new information, improved practices and legislation may necessitate an alteration to the report in whole or in part after its submission. Therefore with any change in circumstances or after the expiry of one year from the date of the report, the report should be referred to Applied Geology for re-assessment and if necessary, re-appraisal.

G) The survey was conducted and this report was prepared for the sole internal use and reliance of the Client. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Applied Geology. If an unauthorised third party comes into possession of this report they rely on it at their peril and Applied Geology owes them no duty of care and skill.

H) Ground conditions should be monitored during the construction of the works and the recommendations of the report re-evaluated in the light of this data by the supervising geotechnical or geo-environmental engineers.

I) Unless specifically stated, the investigation has not taken into account the possible effects of mineral extraction.

J) The economic viability of the proposals referred to in the report, or of the solutions put forward to any problems encountered, depends on very many factors in addition to geotechnical considerations and hence its evaluation is outside the scope of this report.

K) Applied Geology operates as a Consultancy and does not operate it's own laboratory for soil testing, this work being sub contracted to known and respected, generally UKAS accredited, laboratories. Applied Geology can therefore not be held responsible for the testing carried out.

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ANNEX
I

EARTHWORKS SPECIFICATION

A1 General

A1.1 The classification of soils is to be made with respect to the general requirements given in the Manual of Contract Documents for Highway Works, Specification for Highway Works [SHW]: Volume 1: 1998 [updated 2016] for use as Earthworks Material and EN16907-1: 2018 Earthworks. In addition to these documents, reference has also been made to BS6031:2019, BRE FB75 Building on Fill: Geotechnical Aspects, 3rd Edition and Trenter & Charles (1996).

A1.2 It should be noted and clear reference made to the fact that the engineering performance of an earthworks material can be greatly influenced by the moisture content at the time of assessment and excavation/placement and compaction. With variation in the moisture content, the end performance of a material can be both improved and reduced, and consideration should be given to the management of the moisture as a key element of any earthworks control.

A1.3 The majority of fill to be placed needs to support future buildings or to form significant embankments where settlement needs to be minimised. Therefore, the engineered fill needs to meet the requirements for 'Fill to Structure' – specifically Class 7A or Class 6N materials. It may be feasible in some small areas of the site for Class 1 or Class 2 General Fill or some Class 4 Fill to Landscaped Areas to be placed, however, at this stage of the design all fill should meet the requirement of this Specification. Some Class 6C starter layer materials are also required to replace existing low points in the site and water courses that are to be covered with Engineered Fill.

A1.4 Fills should not be placed in a frozen condition, but may be used, if acceptable, when thawed. Materials shall not be lain on any surface which is frozen or covered with ice or standing water. No fill shall be placed when the temperature is $0^{O}C$ or less.

A1.5 The materials and workmanship specification for the earthworks should be based on the requirements given in the SHW Series 600-800 documents, unless otherwise amended by this Specification. The Earthworks Contractor should supply information as to the acceptability of all materials incorporated in the works, methods of construction of the works and monitoring of the works in order to satisfy the requirements of this Specification. The Earthworks Contractor should construct the works and undertake all necessary testing in accordance with the Specification.

A1.6 All work shall comply with the relevant British Standards, Specification for Highway Works Series 600 and other relevant guidance documents and as amended, clarified and defined by this Specification. Where any conflict occurs between the Specification for Highways Works series 600 and this Specification, the requirements defined herein shall take precedence

A2 Acceptance Criteria

A2.1 <u>Sub-formation level - Base of fill (excluding areas being ground improved):</u>

In situ material to achieve:

i. 3% CBR

ii. No less than 50kPa Undrained shear strength (if cohesive)

A2.2 Engineered Fill

The cohesive earthworks material shall comply with Class 7A material and meet the following criteria:

Each layer:

i. No less than 5% CBR
ii. No less than 75kPa Undrained shear strength
iii. Moisture content within appropriate range according to material type (see Figures A1.1 to A1.3);
iv. Dry density within appropriate range according to material type (see Figures A1.1 to A1.3);
v. Maximum 5% air voids

For Class 7A Engineered Fill placed in embankment areas the following criteria shall also apply:

vi. Minimum effective angle of friction of 24 degrees.

The granular earthworks material shall comply with Class 6N material and meet the following criteria:

Each layer:

i. No less than 10% CBR;
ii. Minimum 95% compaction (based on vibrating hammer tests);
iii. Moisture content within the range optimum to optimum + 2%, unless otherwise agreed by the Geotechnical Engineer.

For Class 6N Engineered Fill placed in embankment areas the following criteria shall also apply:

iv. Minimum effective angle of friction of 30 degrees.

After each 1m of Engineered Fill has been placed and at finished fill level, the fill will also need to achieve:

- Less than 4mm settlement at working load (taken as 150 kN/m^2) measured by BS1377 incremental plate load test (600mm plate).

A2.3 Base of Cut/At Grade Layer (excluding areas being ground improved)

For Plot 1 external areas, the in situ material is to achieve:

i. 3% CBR
ii. No less than 50kPa Undrained shear strength (if cohesive)

For all of Plots 2 & 3 and below the main Hermes building footprint + 5m, the in situ material is to achieve:

i. 5% CBR
ii. No less than 75kPa Undrained shear strength (if cohesive)
iii. Less than 4mm settlement at working load (taken as 150 kN/m^2) measured by BS1377 incremental plate load test (600mm plate).

A3 Cut Area Considerations

A3.1 Prior to the cut exercise being undertaken, the site will need to be stripped of any recent vegetation, topsoil and any ponded water removed.

A3.2 The base of the cut areas should be inspected for the presence of any soft, loose, or compressible deposits which, if present, should be removed. The exposed subgrade level should be proof rolled and tested to ensure the above criteria have been met. Any rectification measures, following testing failures, should be proposed in writing by the earthworks contractor and submitted to the Geotechnical Engineer.

A3.3 Significant variation in materials will be encountered and cut materials need to be segregated based on their geological nature/origin and compliance testing out per material type. All areas being cut should be supervised by an appropriately qualified and experienced person to ensure appropriate segregation of materials and removal of unsuitable materials.

A3.4 Perched water may be present at varying depths within opencast backfill materials and groundwater may be encountered from within backfill and natural strata in some areas of cut. Temporary dewatering of excavations will be required in places and temporary and permanent slope crest and toe drainage will be required. All water should be controlled to avoid softening of the materials and the sub-formation and be appropriately disposed of.

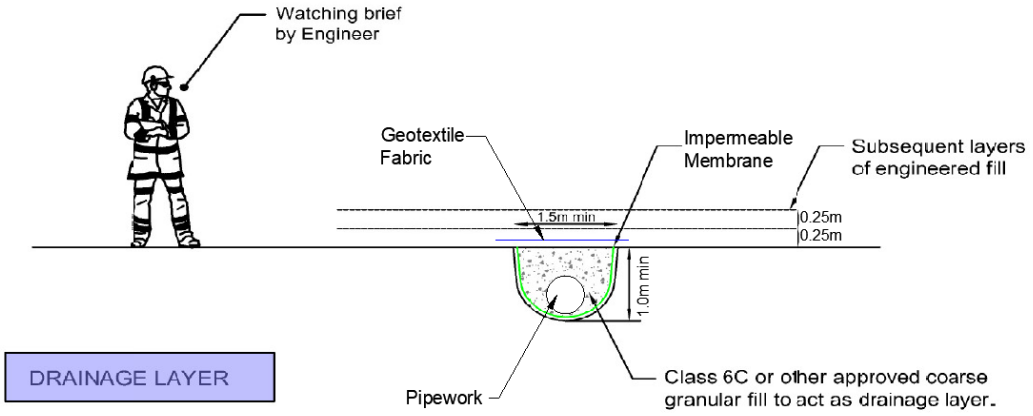
A4 Fill Area Considerations

A4.1 Prior to the fill exercise being undertaken, the site will need to be stripped of any recent vegetation, topsoil and any ponded water removed. Then areas of proposed fill should be inspected for the presence of any soft, loose, or compressible deposits which, if present, should be removed. The exposed subgrade level should be proof rolled and tested to ensure a minimum 3% CBR and 50kN/m^2 undrained shear strength prior to commencement of the infill operation. Any rectification measures, following testing failures, should be proposed in writing by the earthworks contractor and submitted to the Geotechnical Engineer.

A4.2 Areas of former hedge lines located within the site to be visually inspected and where areas of obvious desiccation and/or remnant tree roots are observed materials to be excavated and deemed unsuitable (unless suitably modified and screened).

A4.3 For Plot 2, a drainage trench should be installed along the existing line of the water course and along the low points of the site from this water course back to the position of the spring line shown on OS maps – see Dwg AG3080-19-14. Subject to the drainage design, further existing surface water drains in the areas to the northwest of this point may also need to be incorporated. This trench should comprise a 1m deep trench of minimum 1.5m width with an impermeable liner to prevent infiltration. The trench infill should comprise Class 6C or other approved coarse granular fill (placed to a method specification) to act as a drainage layer, possibly with suitably robust but flexible plastic pipework within. A geotextile layer needs to be placed above the Class 6C granular material to prevent mixing of the overlying Engineered Fill. This drainage layer will need to be connected to the permanent surface water drainage system near the site boundary. Details of how

this will be achieved will be specified by RPS. An indicative sketch is included below for illustration purposes.



A4.4 Within sloped areas of the site the sub-formation layer should be suitably benched in to ensure the placed fill is keyed into the existing slope/faces. Generally, benching should be formed at a 1:1 slope and benches to be no taller than 0.5m (2 x layer thickness). Bench heights may need to be reduced if layer thickness is reduced (i.e smaller compaction plant).

A4.5 Material requiring end-product compaction shall be deposited in layers not exceeding 250 mm uncompacted thickness.

A4.6 For the large embankments where significant thicknesses of fill are to be placed, the Contractor shall raise site levels in a regular pattern completing each layer over the whole embankment area before commencing the next layer. The rate of fill shall be carefully monitored taking account of pore pressures generated in the underlying soils. As far as reasonably practicable, each layer shall comprise similar source materials to try to reduce the likelihood of different rates of settlements occurring during surcharging for areas of similar fill thickness.

A5 Material Selection

A5.1 Cut materials will comprise Opencast Backfill Made Ground and variable Coal Measures strata, including rock and some coal seams. Should any unanticipated strata be encountered, and for all imported fills, it is recommended that any new material type be clearly identified by an appropriately qualified Geotechnical Engineer, who is fully conversant with the ground conditions beneath the site and the requirements of the Earthworks Specification and be stockpiled separately. The Contractor will be responsible for providing all necessary certification to the written satisfaction of the regulatory bodies and the Client prior to any material to be used as Engineered Fill being imported to the site.

A5.2 For the purposes of this specification, a change in source will be defined by the following:

- Change in the visual appearance of the material.

- Change in the engineering properties of the material, such as Maximum Dry Density, Particle Density etc.
- Change in the particle size distribution of the material based on the grading envelope defined by the SHW.
- Change in the geological composition of the material.

A5.3 The information included within Appendix 1/5 details the minimum testing frequencies required per source. Source approval and placement and compaction requirements for each material type are detailed in the following sections. It is important that all test locations (NGR) and levels (in mOD) are recorded with a reasonable degree of accuracy to demonstrate compliance with the requirements for the different end uses in different areas of the site. Simple grid square references and layer numbers will not be acceptable.

A5.4 It is envisaged that the majority of soils derived from the excavated arisings will grade as Class 2A 'Wet Cohesive' and Class 2C 'Stoney Cohesive' with lesser amounts of Class 2B 'dry Cohesive' general fills. Conditioning or modification is anticipated to be required for some materials to achieve Class 7A compliance, the details of which are to be determined by the Earthworks Contractor using information from the site investigation and trial pads.

A5.5 The upper weathered mudstone is has shown to be plastic with very variable degrees of plasticity and hence moisture control will be critical to material behaviour. Less weathered mudstone/siltstone and areas of the Opencast backfill at any depth will include fragments of rock materials that through handling and compaction is anticipated to break down potentially to create Class 2 grade material. The compaction plant adopted should take into account the requirement to break down weak material and the requirement to seal layers prevent moisture ingress.

A5.6 Less weathered Coal Measures strata and larger cobbles and boulders within the Opencast backfill will include rock strength material that will probably require crushing and screening to produce materials to be used as Engineered Fill (Class 6N envisaged). However, the less weathered Coal Measures strata can still contain lower strengths materials (between layers of competent rock) that could be broken down as described in A5.5 above.

A6 Unacceptable Materials

A6.1 Unacceptable material Class U shall be materials as defined below and shall not be used in the Permanent Works where the material does not comply with the permitted constituents and material properties of Table 6/1 and Appendix 6/1 for acceptable material. The following unacceptable materials may be generated from the cut operation:

- Class U1: Wet fill material – material falling outside specified moisture content limits must be stockpiled and have moisture content modified e.g. by air drying or, if appropriate, by addition of lime/cement to make suitable.
- Class U1: Dry fill material – material falling outside specified moisture content limits must be stockpiled and have moisture content modified e.g. by addition of water to make suitable.
- Class U1: Oversize material – cobbles >75mm, boulders and excavated

rock.
- Class U2: Coal, carbonaceous mudstone with a calorific value >2MJ/kg.

A6.2 Where materials are determined Class U1 they should be processed (where possible) to achieve acceptance, otherwise the contractor shall make all necessary arrangements for their safe handling and appropriate disposal.

A6.3 Coal or material with high calorific value is to be separated and sold or disposed off-site (Earthworks Contractor to comply with Coal Authority requirements).

A6.4 Material shall not be placed within 500mm, or other distance specified by RPS, of concrete, cement-bound materials, cementitious materials or stabilised capping if this is to be used for the permanent works, if when tested in accordance with TRL 447 either:

- The water-soluble sulphate (WS) content exceeds 1.5g/l (asSO_4);
- The total potential sulphate (TPS) content exceeds 0.6% (as SO_4); or
- The pH value is <5.5 when tested in accordance with BS1377-3.

A6.5 Potentially contaminated materials are not envisaged, however, procedures for dealing with such if encountered are included in the Geotechnical Design Report.

A7 Source Approval Testing

A7.1 Some source approval testing has been undertaken as part of the site investigation; however, due to the quantity of proposed cut, additional approval testing will need to be undertaken, as per the frequency given in Appendix 1/5. The grading requirements shall be as per Table 6/1 and Table 6/2 of the SHW.

A7.2 Acceptance envelopes have been developed for the geological materials and these are included at the end of this Specification. The results of the Contractor's classification testing shall be compared to these acceptance envelopes and, if deemed appropriate by the Geotechnical Engineer, the envelopes will be revised to suit the more recent results or, if materially different, a new acceptance envelope will be defined for any new source.

A7.3 The moisture content limits shall be sufficient to achieve a <5% Air Voids when determined by laboratory analysis in accordance with BS 1377-4:1990: Method 3.5/3.6/3.7 using the 4.5kg rammer or vibrating hammer (as appropriate to the grading) and to meet the dry density values included in the acceptance envelopes. Due to the variable nature of materials, regular checks should be made on the material prior to placement to ensure that the moisture content is within the acceptability limits as defined for the appropriate material type. In this regard, the use of on-site moisture content testing is advised and moisture content result must be provided to the Geotechnical Engineer within 24 hours of sampling. Should on-site testing be employed, regular calibration with laboratory determined moisture contents must be undertaken with methods agreed with the Geotechnical Engineer.

A7.4 The Contractor shall employ a full-time resident on site testing technician responsible for undertaking the appropriate sampling and on-site testing. Additional technicians shall be provided as the quantity of sampling and testing dictates.

A7.5 Each classification test result shall include the following information in respect of the sample details:

- Geological material type (as per acceptance envelopes);
- Brief description of material;
- Unique sample reference number;
- Date of sampling;
- Location of sample (x,y,z co-ordinates).

Additionally, all information required by the appropriate British Standard test procedure is to be provided.

A7.6 The selection of the appropriate range of moisture contents has largely been determined on the basis of the testing completed during the ground investigation. It is recognised that once the main earthworks program begins, additional test data will become available, which will allow a review of the target range of acceptable moisture contents and classification testing frequencies by the Geotechnical Engineer.

A8 Compaction Trial Pads

A8.1 Prior to commencing the bulk earthworks, trial pads shall be undertaken for each geological type material as agreed with the Geotechnical Engineer to confirm the material suitable for use as Class 7A material. The trial pads will also be used to determine that the proposed layer thickness and number of passes meet the appropriate stiffness as measured by in-situ plate bearing tests. The determination of the in-situ dry density shall be taken from BS 1377-9: 1990, with an appropriate method selected from this standard, however, the Nuclear Density Meter is not to be used during the test pad trials unless undertaken alongside sand replacement tests as part of the calibration process. In situ hand shear vane tests and in situ CBR tests will also be undertaken to confirm compliance.

A8.2 The plate bearing tests shall be undertaken in-accordance with the details presented in Appendix 1/5.

A8.3 The trial pads should be undertaken in accordance with the following procedure:

1. A trial area measuring approximately 20m x 20m should be adopted for each material being tested with suitable adjacent areas for manoeuvre of plant.
2. The formation layer should be rolled and validated in accordance with the Specification (50kPa undrained shear strength and 3% CBR).
3. Place a 250mm thick layer of Class 7A material, re survey and compact, as per Table 6/4 for Class 2A/2C (initially).
4. Undertake shear vanes and resurvey compacted layer.
5. Place Second 250mm layer of Class 7A material.
6. Obtain representative samples for laboratory testing to include natural moisture content, particle size distribution, 4.5kg compaction testing, particle density and Atterberg limits.
7. Compact as per layer 1.
8. Carry out in-situ density testing by sand replacement testing at 4No locations.
9. Undertake shear vanes and resurvey compacted layer
10. Repeat steps to place layers 3 and 4.

11. Carry out 600mm diameter plate testing at two locations on layer 4, measure settlements at working load and derive CBR results.
12. Repeat above steps with additional compactive effort (heavier roller or increased number of passes).
13. Should the Contractor wish to vary the above, a written procedure must be submitted to the Geotechnical Engineer at least 5 working days in advance for approval.

A8.4 The appropriate compaction method will be that which meets the end product specification without causing deterioration of the fill.

A8.5 Some adjustment of compaction methods can be expected as the project proceeds in response to variations in material types and/or moisture content.

A9 Placement and Compaction

A9.1 Subject to the acceptability of the material for inclusion in the permanent works, the adopted method of placing the materials should be based upon the guidance given in the SHW Table 6/1 (appropriate method for material class) and Table 6/4 (type and size of roller, no of passes etc.).

A9.2 During the earthworks phase, accurate records should be kept and provided for inspection to ensure that the appropriate method of compaction has been followed. Included with this information should be records of measurement of the moisture content of the material, prior to placement, showing that the material was within the acceptability limits as determined during the source approval or recording the modification undertaken. The frequency of the testing for the moisture content should be at least daily (for each material type).

A9.3 The Earthworks Contractor shall provide a dedicated Field-Testing Technician full-time resident on site for the duration of the earthworks programme which, wherever possible, shall be the same person. The testing technician shall be equipped with all in situ testing equipment necessary to undertake any of the in-situ testing required by this Specification. Copies of field test sheets shall be provided to the Geotechnical Engineer at the end of each working day. Certified results for in situ tests shall be provided to the Geotechnical Engineer within 48 hours of completing the tests. Certified laboratory test results for classification tests shall be provided within 5 working days of sampling.

A9.4 The Earthworks Contractor shall provide test certification that the fill compacted to end product requirements meets a field dry density and air voids content, complying with the relevant material acceptance envelopes.

A9.5 Field dry density shall be measured in accordance with BS1377: Part 9. If nuclear density methods are utilised these should be confirmed with the engineer following suitable on-site calibration for each geological material type and should be supplemented with sand replacement tests after each set of 25 tests.

A9.6 Once the trial pads have suitably demonstrated appropriate methodology, the subsequent layers of fill placed will be tested to confirm the required end product and settlement performance criteria have been achieved. The frequency of such testing shall be as specified in Appendix 1/5, unless otherwise instructed by the Geotechnical Engineer.

A9.7 Each in situ validation test result shall include the following information in respect of the material details:

- Geological material type (as per acceptance envelopes);
- Brief description of material;
- Unique validation test reference number;
- Date of test;
- Location of test (x,y,z co-ordinates).

Additionally, all information required by the appropriate British Standard test procedure is to be provided.

A10 Validation Reporting

A10.1 The Contractor shall provide a validation report on completion on the earthworks for inclusion in the Geotechnical Engineer's Geotechnical Feedback Report.

A10.2 The Contractor's report shall describe the extent of all excavations and filling at the Site and include the results of all laboratory and in situ testing undertaken as part of the works. Copies of all laboratory testing results undertaken shall be included and plans shall be provided indicating the location and extent of all excavations and filling undertaken and all validation test locations. The report shall include the following:

- A brief factual description of the earthworks undertaken, including a description of the site operations, technical specifications of compaction plant used, details of material processing and modification undertaken, time of year and weather conditions encountered and a summary of materials encountered and used as Engineered Fill;
- Daily weather record detailing temperature ranges and precipitation;
- All laboratory classification test records and calibration results;
- All in situ validation test records;
- Details of all ground improvement undertaken and associated validation testing;
- Results of all settlement and slope stability monitoring undertaken (as specified in the GDR);
- Plans showing the surveyed locations of all sampling and in situ testing carried out, the location of any temporary or permanent surface and groundwater drainage features left in place at the end of the earthworks, detailed positions of the opencast highwall and all slope and settlement monitoring instrumentation;
- An as-constructed topographic survey of the finished earthworks levels giving northings, eastings (to NGR) and reduced level (in mOD) to an accuracy of 0.01m across the whole site;
- The completed Materials Management Plan Verification Report including an as-built record of the earthworks undertaken including identification of the various material types placed on site;

- Volume of unsuitable material (if any) removed from the Site together with associated laboratory testing results, waste classification and waste transfer notes, including proof of disposal;
- Volume of material imported to Site (if any) together with all supporting geotechnical and contamination laboratory testing results;
- Copies of all relevant correspondence, licences, permits and/or agreement with Regulators including Local Authority, Environment Agency, Coal Authority.

A10.3 Laboratory and in situ test data shall be provided in AGS electronic format and the Contractor's Validation report shall be provided in pdf format with drawings also provided in AutoCAD dwg format.

APPENDIX 1/5

TESTING REQUIREMENTS AND PLATE LOAD TEST METHODOLOGY

Routine Classification Tests

Test/Property	Frequency of test
Site-won Cohesive Fills – per source	
Organic Content (Loss on Ignition)	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Full BRE SD1 suite (TRL method)	1 per 10,000m³
Calorific Value	1 per 10,000m³
Moisture Content	1 per 1,000m³
Atterberg Limits	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Grading Analysis	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
4.5kg rammer compaction tests	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Particle Density	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Effective stress parameters (Embankment Fill only)	3 per source then 1 per source per 25,000m³
Site-generated Granular Fills – per material class	
Organic Content (Loss on Ignition)	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Full BRE SD1 suite (TRL method)	1 per 10,000 m³
Moisture content	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Grading Analysis	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Vibrating hammer compaction tests	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Particle Density	1 per 1000m³ to 10,000m³ then 1 per 10,000m³
Los Angeles Coefficient - Clause 635	3 per source then 1 per source per 25,000m³
Effective stress parameters (Embankment Fill only)	3 per source then 1 per source per 25,000m³

Notes:

1. Testing frequency to be reviewed as further test results become available.
2. On site moisture content testing assumed with laboratory calibrated equipment.
3. The classification and acceptability criteria for earthworks materials are indicated in Table 6/1 of the Specification for Highway Works. Table 6/1 indicates the required tests and acceptability limits.
4. The classification of earthworks materials into their various classes shall be carried out by the Contractor prior to, and at the point of, excavation for materials to be won from within the Site, and at the point of source for imported materials. Preliminary classification has been carried out during site investigation works and material acceptance envelopes developed.
5. The Contractor shall be responsible for carrying out the testing scheduled in accordance with the requirements of Table 6/1 of the Specification and this Appendix.
6. The Contractor shall seek approval from the Geotechnical Engineer for the proposed testing laboratory.

Validation Tests

Test/Property	Frequency of test	Compliance Criteria
Sub-formation – In-situ Materials at base of Fill – all site		
CBR Assessment using 300mm diameter plate load test	1 per 25m x 25m grid	Min 3%
In situ shear strength by hand vane	Set of 3 on a 25m x 25m grid	Min 50 kN/m^2
Sub-formation – In-situ Materials at base of Cut – external areas Plot 1 and road only		
CBR Assessment using 300mm diameter plate load test	1 per 25m x 25m grid 1 per 25m linear metres on road	Min 3%
In situ shear strength by hand vane	Set of 3 on a 25m x 25m grid 1 per 25m linear metres on road	Min 50 kN/m^2
Fill material – assume all Class 7A – all site		
CBR Assessment using mexe-probe (set of 3) or BS1377 method	1 set per layer on a 25m x 25m grid	Min 5%
In situ shear strength by hand vane (set of 3)	1 set per layer on a 25m x 25m grid	Min 75 kN/m^2
In situ Density *[1]	1 per layer on a 25m x 25m grid	See compliance envelopes
Air voids	Alongside in situ density	<5%
Incremental 600mm diameter plate load test	1 per 50m x 50m grid after each 1m lift and at final level	<4mm settlement at working load (all locations)
At base of cut below Hermes Building		
Incremental 600mm diameter plate load test	1 per 50m x 50m grid	No criteria – results to confirm settlement assessment

Notes:

1. Field dry density may be made using a nuclear density gauge only if appropriately site calibrated before commencement and subsequently using sand replacement test alongside every 25 NDG tests. A calibration must be done per source material.

600mm Diameter Incremental Plate Bearing Test Methodology

The area of the test shall be compacted in advance using the same techniques and plant which are to be used through the duration of the contract.

- The test shall utilise a 600mm diameter plate;
- The plate shall be bedded upon a hand prepared level surface with any undulations infilled with clean dry sand;
- The working load for the test shall be 150kPa and the load shall be applied such that the plate imposes a uniform pressure for each stage;
- The plant shall be subjected to a bedding cycle of load to 15kPa to minimise the influence of initial bedding settlement;
- The test loading shall be measured using a calibrated load cell with a range consistent with the defined maximum test load;
- The settlement of the plate shall be measured using a minimum of three dial gauges accurate to +/- 0.05mm spread equally around the circumference of the plate;
- The test loading shall be applied to the plate in the increments shown in the table below. The load shall be kept constant throughout each incremental measurement period. All the load stages shall be applied irrespective of the settlement results obtained.

Loading Stages	**Applied Load (% Working Load)**	**Applied Load (kPa)**	**Cycle**
Stage 1	0	0	Bedding Cycle
Stage 2	10	15	
Stage 3	0	0	2 x Test Cycles (8 Stages per test)
Stage 4	20	30	
Stage 5	40	60	
Stage 6	60	90	
Stage 7	80	120	
Stage 8	100	150	
Stage 9	150	225	
Stage 10	0	0	
Repeat stages 3 to 10			

Following each application of an increment of load, the load shall be maintained at the specified value and the settlement measured at the following intervals: -

- 30 seconds,
- 1 minute
- 2 minutes
- 4 minutes
- 8 minutes
- 16 minutes.

OR until the rate of settlement is less than 0.02mm per minute

The test results (load applied, time, settlement for each of the dial gauges and average settlement) shall be provided to the Geotechnical Engineer in tabular format at the end of the test. Additionally, the ambient temperature throughout the test period shall be measured.

APPENDIX 6/1

EARTHWORKS CLASSIFICATION AND ACCEPTABILITY CRITERIA

TABLE 6/1: (02/16) Acceptable Earthworks Materials: Classification and Compaction Requirements

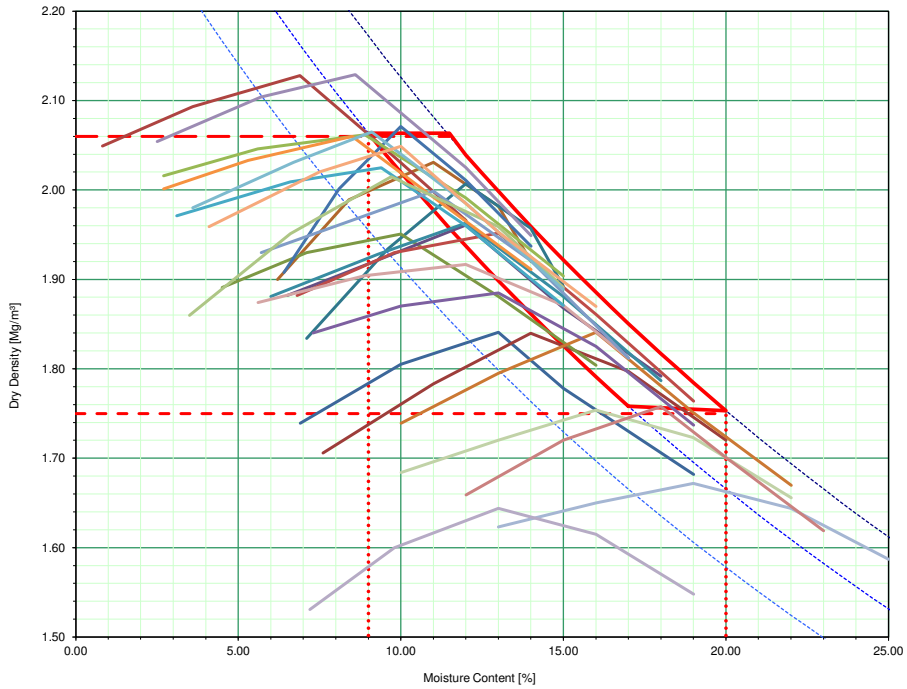
Class				General Material Description	Typical Use	Permitted Constituents (All Subject to Requirements of Clause 601 and contract specific Appendix 6/1)	Material Properties Required for Acceptability (In Addition to Requirements on Use of Fill Materials in Clause 601 and Testing in Clause 631)				Compaction Requirements in Clause 612	Class		
							Property (See Exceptions in Previous Column)	Defined and Tested in Accordance with:	Acceptable Limits Within: Lower	Acceptable Limits Within: Upper				
SELECTED 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.	(i) grading	BS 1377: Part 2	Tab 6/2	Tab 6/2	End product: less than 5% air voids and 95% of maximum dry density of BS1377: Part 4 (vibrating rammer).	6	N	-
							(ii) uniformity coefficient	See notes	10	-				
							(iii) Los Angeles coefficient	Clause 635	-	40				
							(iv) effective angle of internal friction (ϕ')	Clause 636	30	-				
							(v) mc	BS 1377: Part 2 See notes	TBC after compaction testing					
	7	A	–	Selected cohesive material	Fill to Structures	Any material, or combination of materials, other than material designated as Class 3 in the Contract.	(i) grading	BS 1377: Part 2	Tab 6/2	Tab 6/2	End product: less than 5% air voids and 100% of maximum dry density of BS1377: Part 4 (2.5kg rammer) – see acceptance envelopes	7	A	–
							(ii) mc	BS 1377: Part 2 See notes	See acceptance envelopes	See acceptance envelopes				
							(iii) liquid limit	BS 1377: Part 2	-	45				
							(iv) plasticity index	BS 1377: Part 2	-	25				
							(v) organic content	BS 1377: Part 3	-	2				
							(vi) calorific value (MJ/kg)		-	2				
							(vii) effective angle of internal friction (ϕ')	Clause 636	24	-				

Notes

1) Where in the Acceptable Limits column reference is made to App 6/1, only those properties having limits ascribed to them in contract specific Appendix 6/1 shall apply. Where contract specific Appendix 6/1 gives limits for other properties not listed in this Table such limits shall also apply.
2) The moisture content shall be determined on the material passing the 37.5mm BS sieve. Where BS 1377: Part 2 is specified for mc, this shall mean BS 1377: Part 2 where the material is a soil or BS EN 1097-5 where the material is required to conform to a harmonised European Standard.
3) Uniformity coefficient is defined as the ratio of the particle diameters: D_{60} to D_{10} on the particle size distribution where: D_{60} - particle diameter at which 60% of the soil weight is finer D_{10} - particle diameter at which 10% of the soil weight is finer.

FIGURES – EARTHWORKS ACCEPTANCE ENVELOPES

Moisture Content/Dry Density Assessment - Cohesive Opencast Backfill Materials



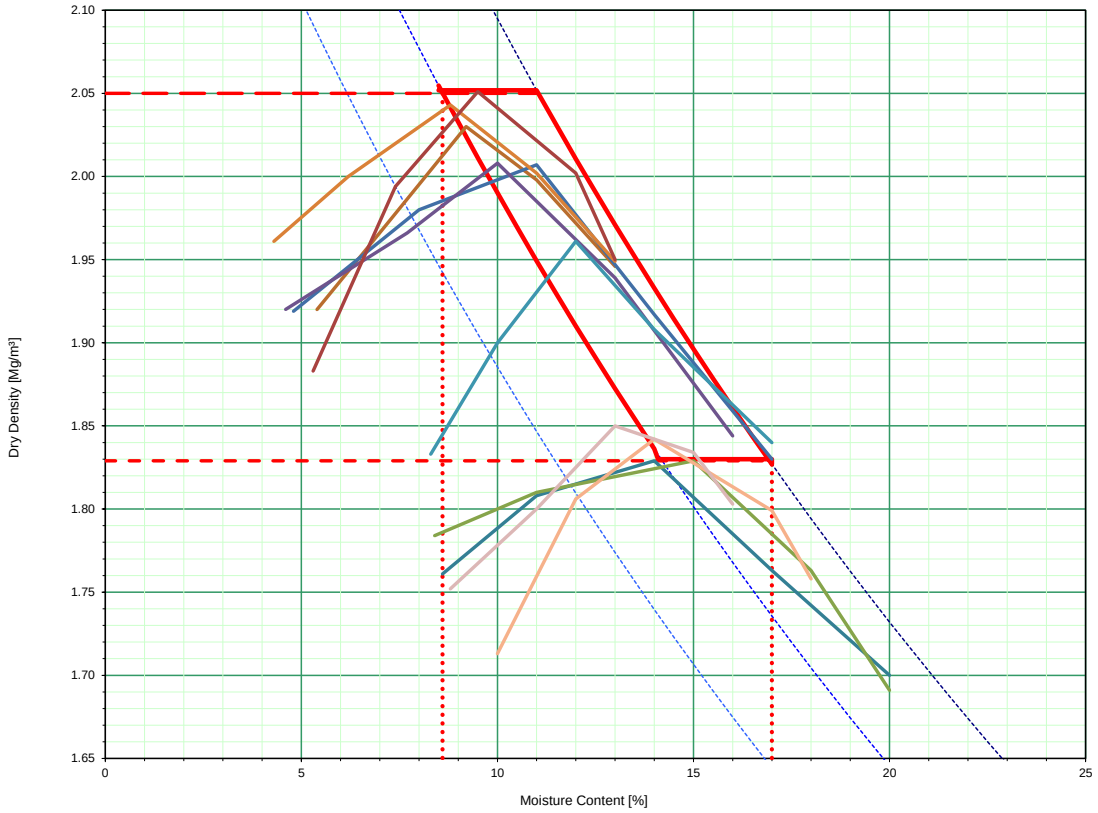
Maximum Dry Density = 2.06Mg/m³	Maximum Moisture Content = 20%
Minimum Dry Density = 1.75Mg/m³	Minimum Moisture Content = 9%

Particle Density = 2.70 Mg/m³ ;0% Air Voids	5% Air Voids	10% Air Voids
Maximum Dry Density	Minimum Dry Density	Lower Moisture Limit
Upper Moisture Limit	Nominal Acceptance Envelope	TP1002 - 3 m 4.5kg
TP1004 - 3 m 4.5kg	TP1007 - 0.6 m 4.5kg	TP1009 - 2 m 4.5kg
TP1012 - 1.6 m 4.5kg	TP1027 - 2.5 m 4.5kg	TP1029 - 3 m 4.5kg
TP1033 - 2 m 4.5kg	TP1033 - 2 m 2.5kg	TP1033 - 3.5 m 4.5kg
TP1036 - 3 m 4.5kg	TP1040 - 1 m 4.5kg	TP1042 - 3 m 4.5kg
TP1043 - 4 m 4.5kg	TP1043 - 4 m 2.5kg	TP1045 - 2.5 m 4.5kg
TP1045 - 2.5 m 2.5kg	TP1048 - 1.5 m 4.5kg	TP1054 - 2.5 m 4.5kg
TP1055 - 3 m 4.5kg	TP1056 - 0.5 m 4.5kg	TP1063 - 2 m 4.5kg
TP1064 - 3 m 4.5kg	TP1069 - 2.5 m 4.5kg	TP1086 - 1.5 m 4.5kg

Client:	Newlands Developments
Project:	Hoyland Common, Barnsley, M1 Junction 36
Project No.:	AG3080-19
Figure No.:	A1.1

APPLiED GEOLOGY

Moisture Content/Dry Density Assessment - Pennine Middle Coal Measures - Weathered Rock



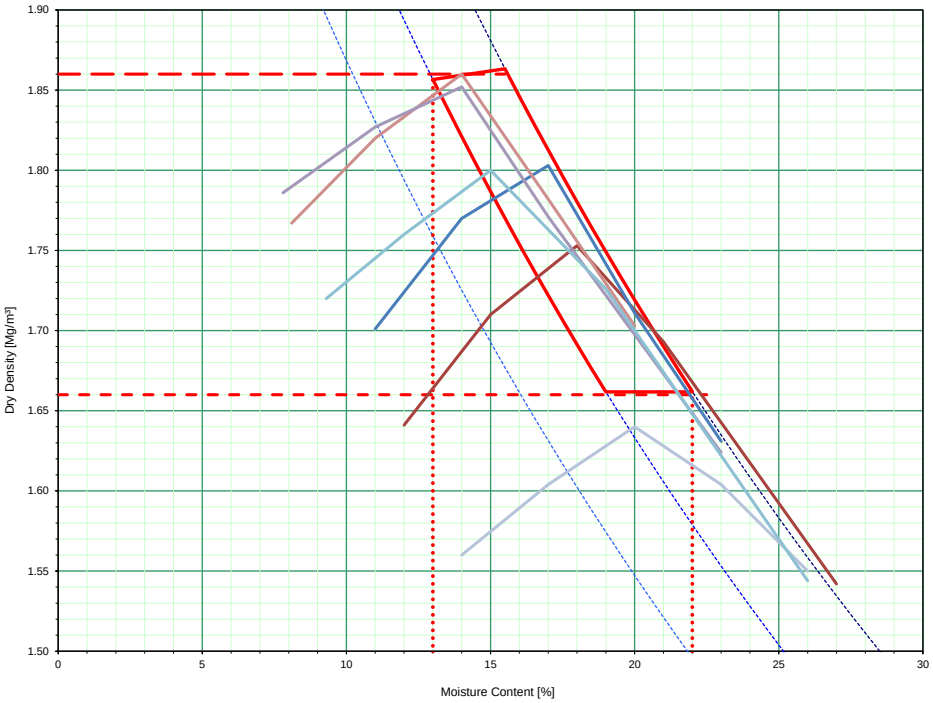
Maximum Dry Density = 2.05Mg/m³	Maximum Moisture Content = 17%
Minimum Dry Density = 1.83Mg/m³	Minimum Moisture Content = 9%

Particle Density = 2.65 Mg/m³ ;0% Air Voids
5% Air Voids
10% Air Voids
Maximum Dry Density
Minimum Dry Density
Lower Moisture Limit
Upper Moisture Limit
Nominal Acceptance Envelope
TP1003 - 2.5 m 4.5kg
TP1015 - 1.2 m 4.5kg
TP1017 - 2 m 4.5kg
TP1022 - 0.9 m 4.5kg
TP1024 - 1 m 4.5kg
TP1030 - 2.5 m 2.5kg
TP1030 - 2.5 m 4.5kg
TP1032 - 2 m 2.5kg
TP1032 - 2 m 4.5kg
TP1049 - 3 m 4.5kg

Client:	Newlands Developments
Project:	Hoyland Common, Barnsley, M1 Junction 36
Project No.:	AG3080-19
Figure No.:	A1.2

APPLiED GEOLOGY

Moisture Content/Dry Density Assessment - Pennine Middle Coal Measures - Clay



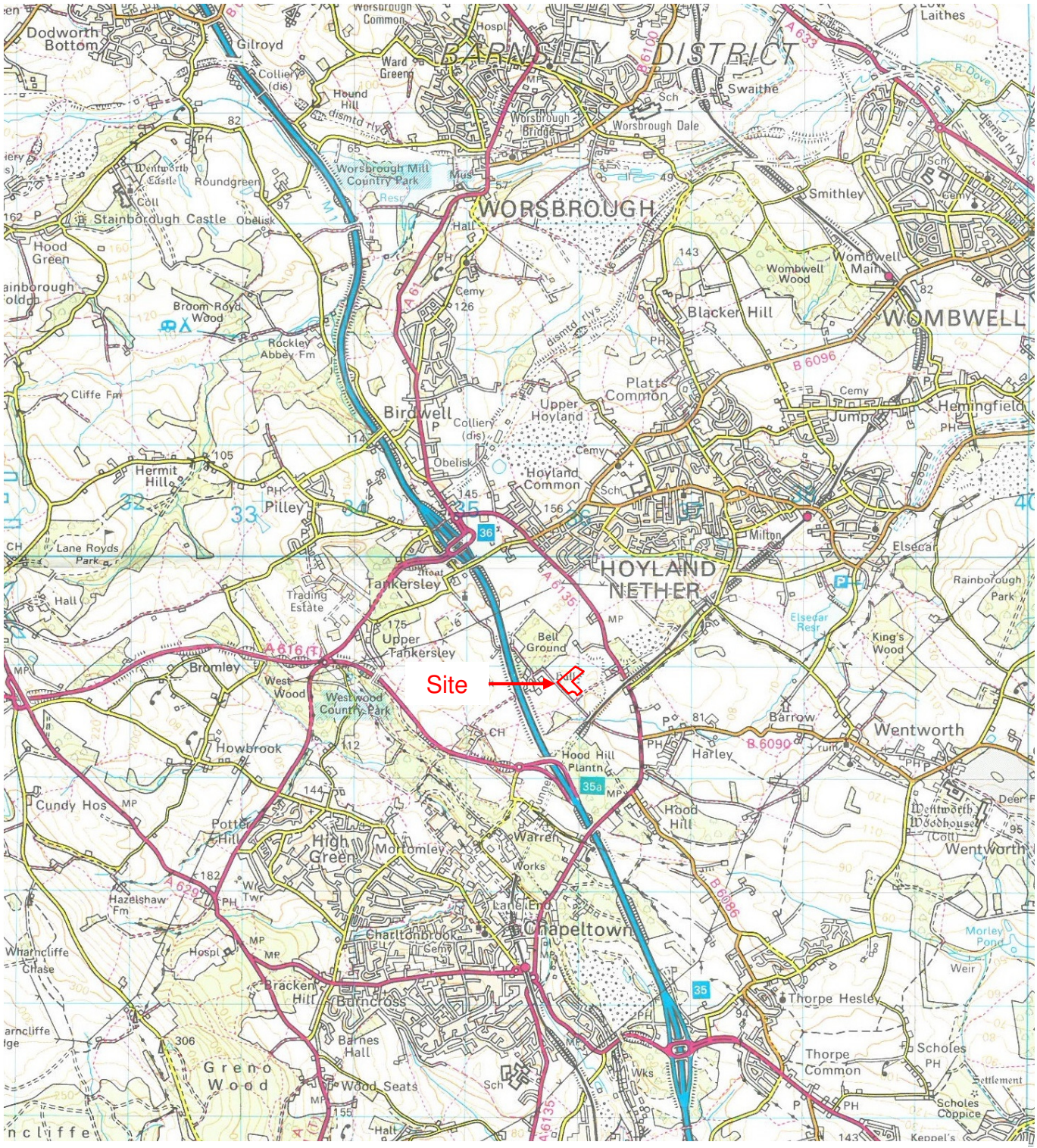
Maximum Dry Density = 1.86Mg/m³	Maximum Moisture Content = 22%
Minimum Dry Density = 1.66Mg/m³	Minimum Moisture Content = 13%

Particle Density = 2.62 Mg/m³ ;0% Air Voids
5% Air Voids
10% Air Voids
Minimum Dry Density
Maximum Dry Density
Lower Moisture Limit
Upper Moisture Limit
Nominal Acceptance Envelope
TP1018 - 1 m 4.5kg
TP1032 - 0.5 m 4.5kg
TP1032 - 0.5 m 2.5kg
TP1049 - 1.5 m 4.5kg
TP1201 - 0.5 m 4.5kg
TP1202 - 0.5 m 4.5kg

Client:	Newlands Developments
Project:	Hoyland Common, Barnsley, M1 Junction 36
Project No.:	AG3080-19
Figure No.:	A1.3

APPLIED GEOLOGY

ANNEX
II



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APPLiED GEOLOGY

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Client: newlands developments

Project: HOYLAND COMMON, BARNSLEY
M1 JUNCTION 36 - BALANCING POND

Drawn By:	Checked By:	Paper Size:
JS	FD	A4

Scale:	Date:	NGR:
NTS	27.03.2020	435932 398848

Drawing No:	Revision:
AG3080-19-01A	0

Title: SITE LOCATION PLAN

Areas Schedule

Plot No.	Warehouse GIA sqft	Warehouse GIA sqm	Offices GIA sqft	Offices GIA sqm	**Total GIA sqft**	Total GIA sqm	Cars Parking	HGV Parking	Docks
1	298700	27750	40594	3771	**339821**	31571	650	595	163
2	480000	44593	44800	4162	**524800**	48755	380	133	64
Total	778700	72343	85394	7933	**864621**	80326	1030	728	227

Note: total Area figure for plot 1 includes VMU / gatehouse areas (as area schedule on Site Plan)

net site area
4.92ha

net site area
18.00ha

APPLICATION RED LINE AREA

net site area
10.47ha

Overhead Electricity Cables
No Building Zone hatched Blue

Revision:

P1	first issue	29mar2019	PL
P2	Unit 2 scheme added	09dec2019	PL
P3	Unit 2 layout updated	10dec2019	PL
P4	layout updated	16dec2019	PL
P5	new road design, redline adjusted	29jan2020	PL
P6	residential site access proposal indicated	29jan2020	PL
P7	small commercial site layouts added	31jan2020	PL
P8	areas table corrected	03feb2020	PL
P9	updated following comments	03feb2020	PL
P10	net site areas noted	03feb2020	PL
P11	plot 2 changed to 2 units	12feb2020	RM
P12	road updated, ponds added	24feb2020	PL
P13	plot 2 amended to single unit	25mar2020	RM
P14	new RPS road design update	13apr2020	PL
P15	balancing pond, road and red line amended	15apr2020	RM
P16	Minor update to road	20apr2020	JM
P17	roundabout and Plot 2 access update	28apr2020	PL
P18	net site plot areas adjusted and shown	07may2020	PL
P19	plateau contours updated	19may2020	PL
P20	further earthworks update	20may2020	PL
P21	redline and road update	21may2020	PL
P22	acoustic fence, generator added, areas update	29may2020	PL
P23	acoustic barrier extent updated	04jun2020	PL
P24	Area Table corrected	10jun2020	PL
P25	Plot 5 access added	15jun2020	PL

0 50m 100m SCALE 1:2500

N

Hoyland Common
Barnsley M1, J36

newlands developments

pHp Architects
www.peter-haddon.com

Masterplan

Drawing Status:	Preliminary
CAD Reference:	4400-001
Drawn:	PL
Date:	feb2020
Scale @A1:	1/2500

Project No:	Drawing No:	Rev:
4400	001	P25

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KEY:

- Extent of Open Cast Site as shown on Coal Authority Abandonment Plans
- Interpreted Extent of Open Cast Site Based on Trial Trench Findings and Coal Authority Abandonment Plans
- TP1001 — Trial Pit
- TT2001 — Trial Trench
- RS3001 — Rotary (sonic) Borehole
- RC4001 — Dynamic / Sample and Rotary Cored Borehole
- CPT5001 — Cone Penetration Test
- DCS6001 — Driven Continuous Sampling Borehole
- A — A — Section Line (Geological Cross Section and GEO5 Analysis) - refer to drawing AG3080-19-08
- C — C — Section Line (Geological Cross Section only) - refer to drawing AG3080-19-08
- R — R — Section Line (GEO5 Analysis only)

Drawing based on stafsurv, drawing No:10663-T dated 06/11/2019 and pHp Architects, drawing 029 Revision P4 dated 19th December 2019.

Rev	Notes	Date	By
2	Section lines 'R', 'S' and 'T' added	30.07.2020	AP
1	Section line 'L' extended	07.07.2020	FD

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M1 JUNCTION 36

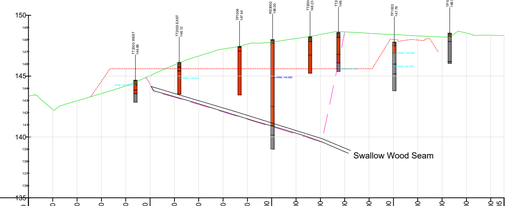
Title:
EXPLORATORY HOLE LOCATION PLAN
WITH OPENCAST MINE EXTENTS &
GEOLOGICAL SECTION LINES

Drawn By:	Checked By:	Paper Size:
FD	SD	A1

Scale:	Date:
1:2500	19.05.2020

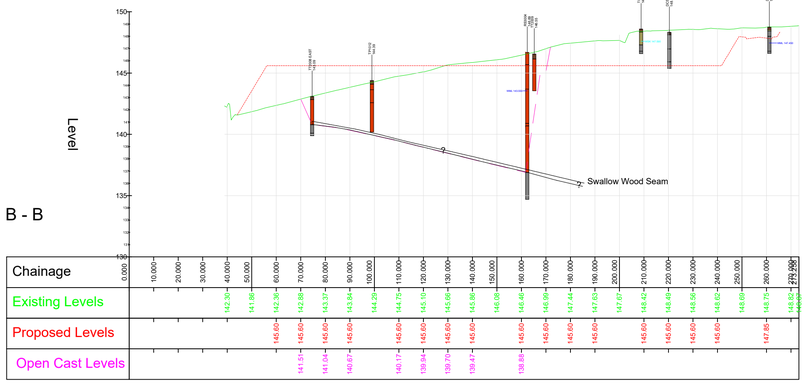
Drawing No:	Revision:
AG3080-19-07	2

A - A



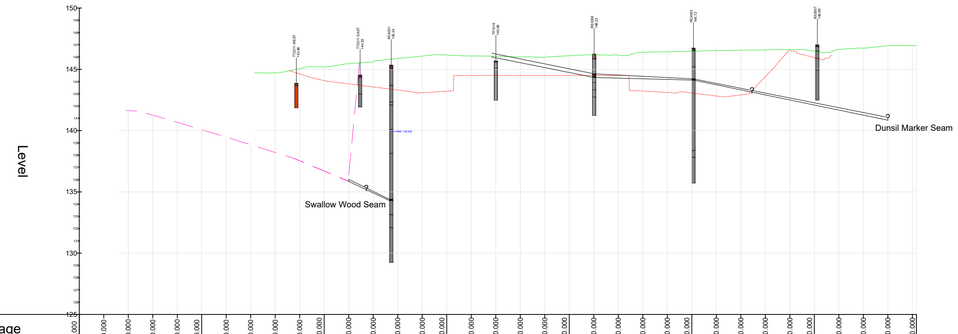
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Existing Levels	143.69	142.25	142.07	143.05	144.15	145.01	145.05	146.05	147.23	147.64	147.79	148.03	148.42	148.63	148.51	148.42	148.32	148.22	148.04	148.36	148.69
Proposed Levels				144.99	145.00		145.00	145.00	145.00	145.00		145.00	145.00	145.00	145.00		147.96				
Open Cast Levels							145.91	145.85	144.69	144.39		143.21	142.69								

B - B



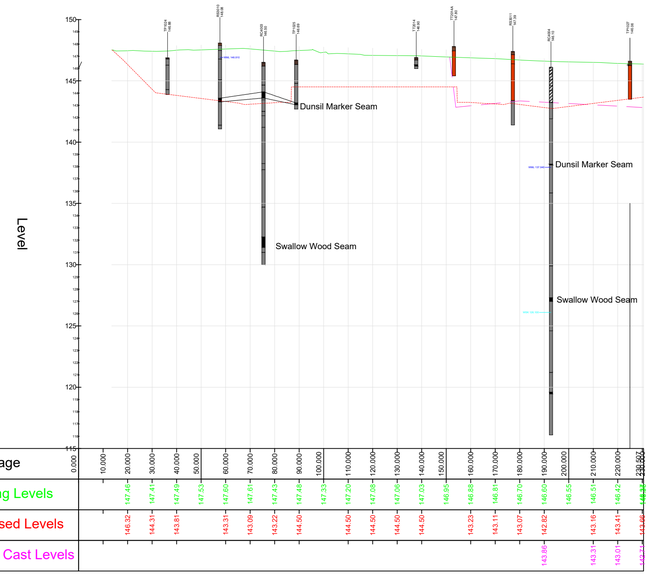
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Existing Levels					142.29	141.86	142.39	142.89	143.37	143.94	144.29	144.71	145.10	145.58	145.86	146.08	146.46	146.99	147.44	147.63	147.82	148.43	148.49	148.54	148.62	148.68	148.75	148.82
Proposed Levels							145.60	145.60	145.60	145.60		145.60	145.60	145.60	145.60		145.60	145.60	145.60	145.60		145.60	145.60	145.60	145.60		147.85	
Open Cast Levels							141.51	141.04	140.87			140.17	139.84	139.70	139.47		138.88											

C - C



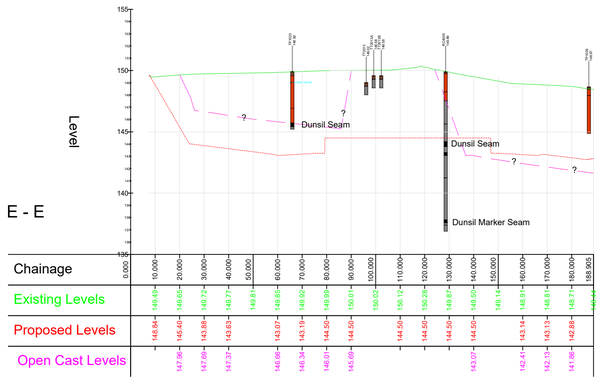
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Existing Levels										144.77	145.06	145.20	145.40	145.62	145.59	145.38	146.08	146.16		146.09	146.07	146.01	145.98	146.10	146.20	146.14	146.39	146.43	146.47	146.53	146.56	146.59	146.63	146.72	146.80	146.92
Proposed Levels											144.62			143.85	143.58	143.33	143.08			144.50	144.50	144.50		144.50		144.50	144.50	143.23	143.11			142.82	142.91	144.40	146.52	
Open Cast Levels		141.60	141.26	140.68			139.47	138.84	139.21																										

D - D



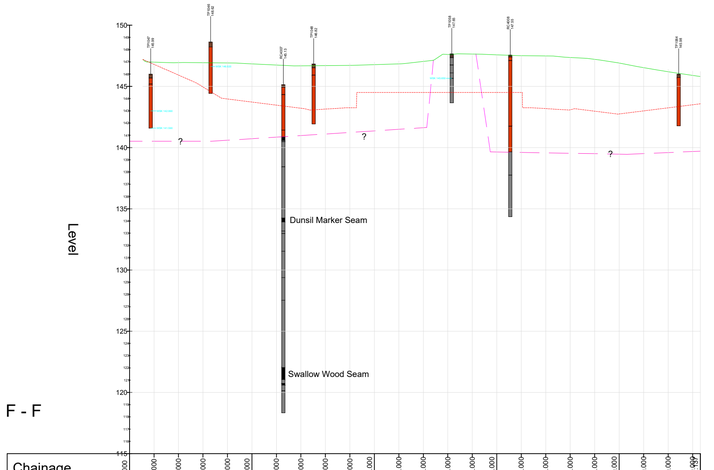
Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	238.000
Existing Levels		147.46	147.41	147.49	147.53		147.60	147.61	147.45	147.49	147.33	147.20	147.08	147.09	147.03	146.95	146.88	146.91	146.70	146.66	146.55	146.51	146.42	146.32	146.33
Proposed Levels		146.32	144.31	143.81			143.31	143.09	143.22	144.50		144.50	144.50	144.50	144.50		143.23	143.11	143.07	142.82		143.18	143.41	143.66	
Open Cast Levels																				143.86		143.31	143.01	142.77	

E - E



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	188.905
Existing Levels		149.49	149.65	149.72	149.77	149.81	149.85	149.92	149.92	149.99	150.01	150.02	150.17	150.29	149.97	149.90	149.14	148.91	148.81	148.77	148.90
Proposed Levels		148.94	145.40	143.88	143.63		143.07	143.19	144.50	144.50		144.50	144.50	144.50	144.50		143.07		143.14	143.13	142.88	
Open Cast Levels			147.99	147.89	147.31		146.69	146.34	146.01	145.69								142.41	143.14	141.99			

F - F



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	238.000
Existing Levels		146.98	146.84	146.93	146.91	146.84	146.74	146.89	146.70	146.72	146.78	146.84	147.03	147.60	147.64	147.57	147.50	147.45	147.30	147.21	146.90	146.53	146.19	145.89	145.90
Proposed Levels		146.79	145.92	144.95	143.97		143.46	143.21	143.14	143.25		144.50	144.50	144.50	144.50		144.50	143.18	143.09	142.97		142.99	143.24	143.46	
Open Cast Levels		143.00	142.71	142.42	142.29		142.03	141.95	141.77	141.84		141.48	141.62				141.09	140.89	140.86	140.48		139.97	139.84	139.71	

Key:

- Topsoil
- Topsoil/ Made Ground
- Made Ground
- Made Ground- Opcast Backfill
- Coal Seams
- Pennine Middle Coal Measures Formation
- CPT Locations

- HIGHEST MONITORED WATER LEVEL
- WATER STRIKE
- EXISTING GROUND PROFILE
- PROPOSED DESIGN 4400-001-P12-3d
- BASE OF INFERRED OPEN CAST PROFILE

APPLiED GEOLOGY

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Client: newlands developments

Project: HOYLAND COMMON, BARNSLEY
M1 JUNCTION 36

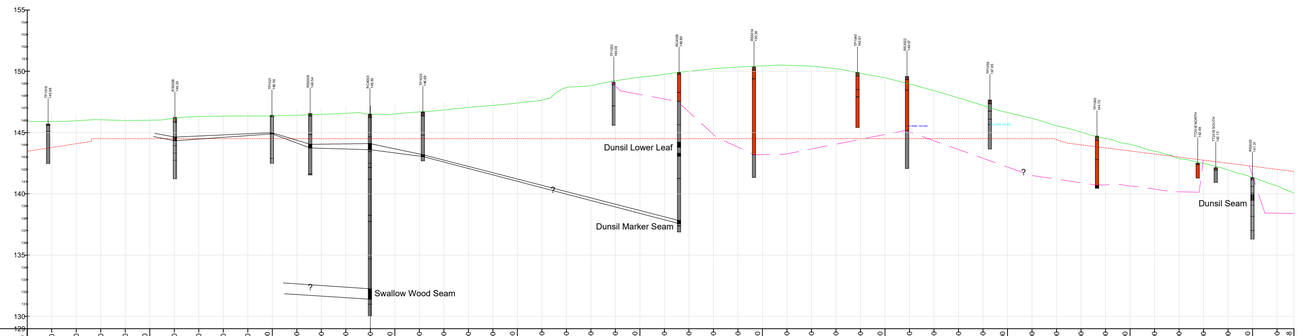
Title: GEOLOGICAL CROSS SECTIONS-
SHEET 2 OF 4

Drawn By:	Checked By:	Paper Size:
SB	FC	A1

Scale:	Date:
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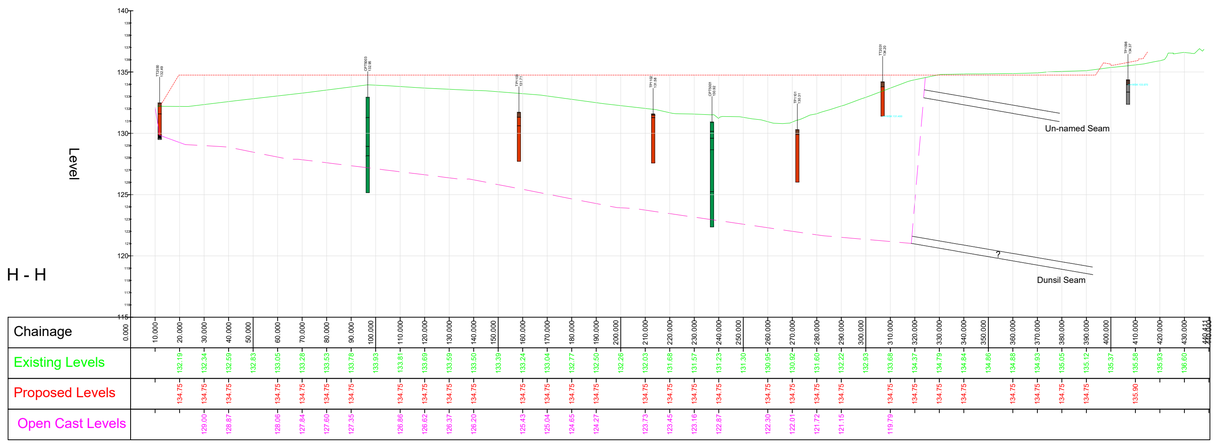
Drawing No:	Revision:
AG3080-19-08 Sheet 2 of 4	A

G - G



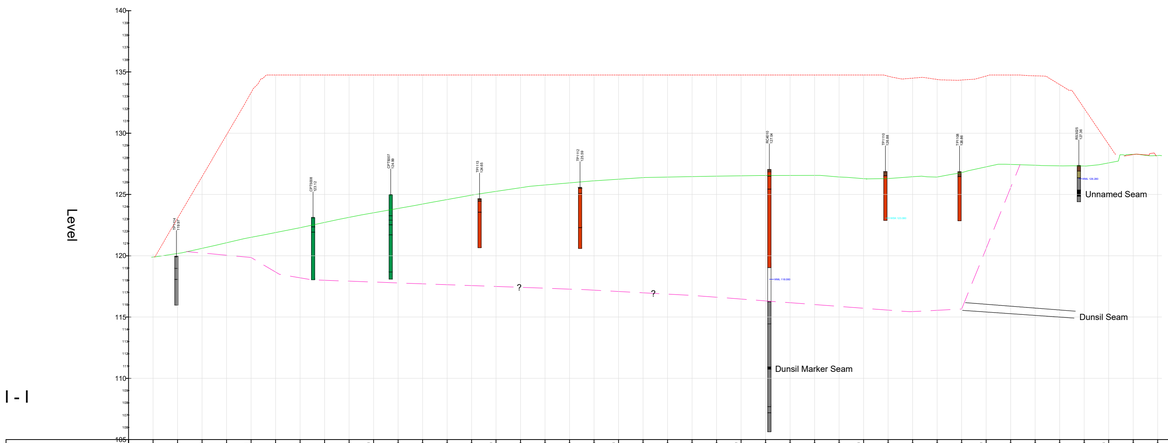
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Existing Levels	145.60	145.91	145.97	146.04	145.98	146.01	146.15	146.31	146.34	146.35	146.36	146.42	146.49	146.57	146.51	146.52	146.69	146.85	147.05	147.22	147.41	147.65	148.68	148.85	149.22	149.52	149.75	150.09	150.20	150.35	150.44	150.69	150.90	151.42	151.24	151.84	152.19	151.93	151.65	151.96	152.47	151.95	141.34	140.64	140.23
Proposed Levels		143.78	144.09	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	145.87	145.34	144.69	144.04	143.49	143.24	142.98	142.75	142.97	142.19	141.93	141.69	142.71	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	144.50	143.25	143.00	142.75	142.50	143.00
Open Cast Levels																												145.87	145.34	144.69	144.04	143.49	143.24	142.98	142.75																						138.42	138.42	

H - H



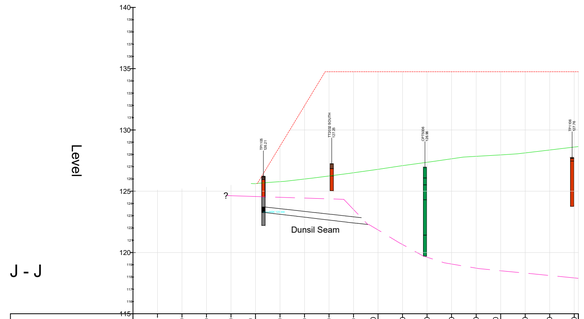
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Existing Levels		132.19	132.34	132.59	132.83	133.04	133.20	133.53	133.77	133.93	133.97	133.81	133.83	133.95	133.93	133.95	133.35	133.24	133.04	132.77	132.56	132.28	132.03	131.84	131.57	131.23	131.30	130.95	130.92	131.69	132.22	132.93	133.65	134.37	134.73	134.84	134.86	134.85	134.93	135.05	135.12	135.37	135.58	135.97	136.05	136.11	136.16	136.21	136.26	136.31	136.36	136.41	136.46	136.51	136.56	136.61
Proposed Levels		134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	135.90	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75
Open Cast Levels			125.05	128.87			128.06	127.84	127.69	127.35		126.86	126.62	126.37	126.20			125.43	125.04	124.65	124.27		123.73	123.45	123.18	122.87		122.30	122.01	121.72	121.15		119.79																													

I - I



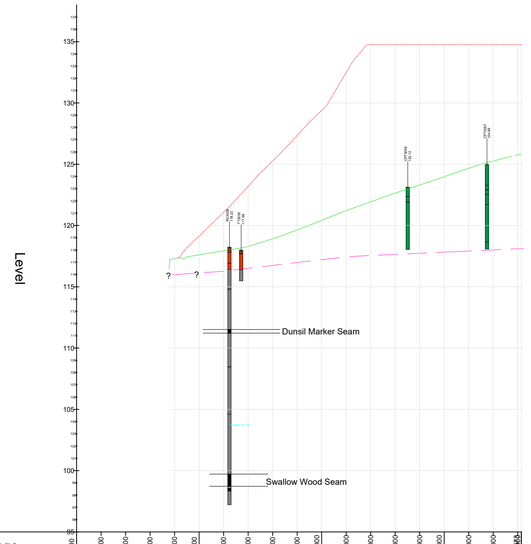
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Existing Levels		119.89	120.18	120.00	121.06	121.50	121.89	122.29	122.72	123.13	123.50	123.86	124.22	124.58	124.95	125.29	125.56	125.78	125.95	126.12	125.25	126.38	126.42	126.46	126.50	126.52	126.55	126.56	126.55	126.56	126.42	126.29	126.31	126.45	126.42	126.78	127.26	127.45	127.39	127.33	127.32	127.58	128.27	128.18	128.27	128.36	128.45	128.54	128.63	128.72	128.81	128.90	128.99	129.08	129.17	129.26
Proposed Levels		123.05	126.46	129.86	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	128.25	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75
Open Cast Levels										119.16	119.14	118.69	118.85	118.69	118.62			118.34	118.22	118.11	117.96		117.09	117.42	117.23	117.06		116.76	116.69	116.46	116.31		116.69	115.86	115.66	115.69																												

J - J



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000
Existing Levels						125.62	125.77	125.99	126.24	126.50	126.78	127.09	127.34	127.64	127.84	127.97	128.16	128.36	128.63
Proposed Levels							128.69	131.98	134.75	134.75		134.75	134.75	134.75	134.75		134.75	134.75	134.75
Open Cast Levels												122.16	121.98	121.89	121.72		121.16	120.89	120.99

K - K



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	181.868
Existing Levels					117.29	117.60	117.89	118.26	118.62	119.64	120.41	121.21	121.93	122.65	123.30	123.98	124.67	125.30	125.77
Proposed Levels							121.07	123.20	125.26	127.35		132.48	134.75	134.75	134.75		134.75	134.75	134.75
Open Cast Levels															119.42		119.53	119.60	119.70

Key:

- Topsoil
- Topsoil/ Made Ground
- Made Ground
- Made Ground- Opencast Backfill
- Coal Seams
- Pennine Middle Coal Measures Formation
- CPT Locations
- HIGHEST MONITORED WATER LEVEL
- WATER STRIKE
- EXISTING GROUND PROFILE
- PROPOSED DESIGN 4400-001-P12-3d
- BASE OF INFERRED OPEN CAST PROFILE

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Title:
GEOLOGICAL CROSS SECTIONS-
SHEET 3 OF 4

Drawn By:	Checked By:	Paper Size:
SB	FC	A1

Scale: Horizontal 1:1250
Vertical 1:250

Date: 29.05.2020

Drawing No: AG3080-19-08 Sheet 3 of 4

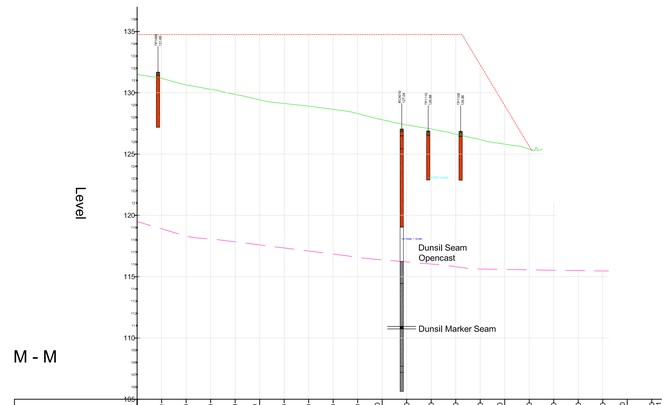
Revision: A

L - L



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Existing Levels	140.00	139.95	139.40	138.85	138.30	137.75	137.25	136.70	136.07	135.32	134.82	134.30	134.11	133.77	132.76	132.02	132.27	132.39	132.15	132.01	131.72	131.41	131.00	130.61	130.15	129.81	129.49	129.26	129.03	128.61	128.10	127.66	127.20	126.83	126.62	126.34	126.04	125.64	125.36	124.89					
Proposed Levels		138.61	139.82	140.02	139.35		134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.75	134.74	131.40	128.05						
Open Cast Levels		130.05	130.04	129.44	128.85		127.06	127.07	126.47	125.85		124.37	127.98	127.29	126.52		125.08	124.33	123.61	123.02		122.14	121.32	121.07	120.44		119.35	119.02	118.74	118.58		118.31	118.17	118.02	117.86		117.28	117.22	117.05	116.90			116.65	116.34	116.44	

M - M



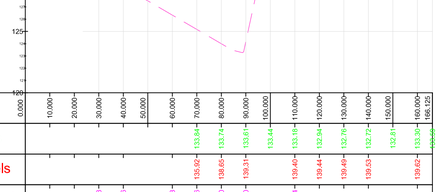
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Existing Levels	134.00	131.19	130.64	130.26	129.87	129.42	129.13	128.91	128.60	128.30	127.80	127.36	127.04	126.62	126.19	125.86							
Proposed Levels		134.75	134.75	134.75	134.75		134.75	134.75	134.75	134.75		134.75	134.75	134.75	132.28		125.60	125.55	125.45	125.41			
Open Cast Levels		118.9	118.31	118.07	117.84		117.34	117.10	116.86	116.58		116.20	116.03	115.82	115.62		125.58	125.55	125.45	125.41			

N - N



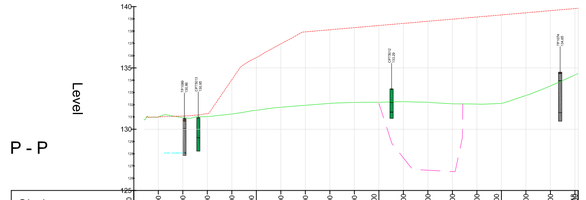
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Existing Levels	142.00	145.49	145.02	145.39	145.99		146.12	146.25	146.31	146.39	146.66	146.75	146.86	147.21	147.50	147.85	148.05	148.04	148.02	149.03	149.25	148.44	148.27	147.99	147.69	147.39	147.10	146.97	146.69	146.37	146.14	145.91	145.54	145.20	144.84	144.60	144.41	144.22	144.03	143.78	143.57	143.37	143.01	142.89	143.30	143.04	142.72	142.41	142.22	142.10	142.00	141.93	142.10	142.07	142.04	142.04	142.18	142.04
Proposed Levels		145.49	145.02	145.39	145.00		144.02	143.78	143.54	143.39		143.21	144.55	144.55	144.50		144.55	144.50	144.50	144.50	143.25		143.13	142.96	142.74	142.58		142.40	142.58		147.39		147.33	147.26	146.97	146.69	146.37	146.14		144.55	144.50	144.89	144.68	144.41		143.97	143.84	143.61	143.37		143.30	143.04	142.72	142.41	142.22		142.10	141.76	141.68	141.68	141.83		142.10	141.74	141.68	141.83	
Open Cast Levels	142.13	142.09	142.02	141.91	145.00		141.71	141.71	141.71	141.72		141.72	141.71	141.71	141.71		141.20	143.25				140.69	140.69	140.53	140.46		140.36	143.46	143.22	143.69	140.11	143.93	139.79	144.17		144.55	144.55	144.89	138.48	138.09	144.68	137.63		138.74	138.38	144.22	135.93	143.61	143.37	135.56		134.65	143.04	142.66	133.86	142.42	133.39	142.18		132.53	141.76	132.14	141.74	131.82	141.68	131.47	141.83	

O - O



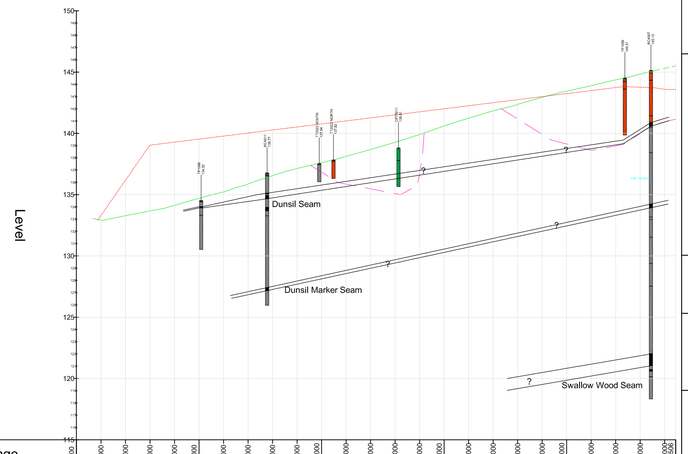
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Existing Levels	129.68	128.69	128.33	125.18	135.92	133.84	138.65	133.74	124.09	153.61	139.33	133.44	133.19	132.94	132.70	132.72	148.00	132.91	133.30	139.62	139.62
Proposed Levels																							
Open Cast Levels																							

P - P



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	181.000
Existing Levels	131.00	131.04	131.03	131.25	131.54	131.79	131.95	132.10	132.18	132.20	132.24	132.10	132.08	132.02	132.11	132.75	133.54	134.47	134.47	134.47
Proposed Levels	131.00	131.07	131.29	134.04		136.97	137.94	138.11	138.29		138.63	138.81	138.98	139.15		139.50	139.67	139.84		
Open Cast Levels																				

Q - Q



Chainage	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	90.000	100.000	110.000	120.000	130.000	140.000	150.000	160.000	170.000	180.000	190.000	200.000	210.000	220.000	230.000	240.000	250.000	260.000	270.000	280.000	290.000	300.000	310.000	320.000	330.000	340.000	350.000	360.000	370.000	380.000	390.000	400.000	410.000	420.000	430.000	440.000	450.000	460.000	470.000	480.000	490.000	500.000	510.000	520.000	530.000	540.000	541.000
Existing Levels	133.30	136.17	139.03	139.28	134.69	135.22	135.86	140.02	140.27	140.52	137.10	137.60	138.12	141.02	141.26	139.27	141.51	141.76	140.60	142.25	141.83	142.26	142.52	142.75	143.00	143.45	143.89	144.13	144.37	144.63	144.88	145.14	145.39	145.63	145.88	146.12	146.37	146.61	146.86	147.10	147.35	147.59	147.84	148.08	148.33	148.57	148.82	149.06	149.31	149.55	149.80	150.04	150.29	150.53	150.78	150.82
Proposed Levels														137.24	141.26	137.29	141.51	141.76	137.32	142.25	141.83	142.26	142.52	142.75	143.00	138.31	143.89	140.14	143.74	140.49	144.63	140.69	145.14	140.70	145.63	140.73	146.12	140.77	146.61	140.81	147.10	140.85	147.59	140.89	148.08	140.93	148.57	140.97	149.06	141.01	149.55	141.05	150.04	141.09	150.53	141.13	150.82
Open Cast Levels																																																															

Key:

- Topsoil
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- Coal Seams
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- HIGHEST MONITORED WATER LEVEL
- WATER STRIKE
- EXISTING GROUND PROFILE
- PROPOSED DESIGN 4400-001-P12-3d
- BASE OF INFERRED OPEN CAST PROFILE

APPLiED GEOLOGY

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email: admin@appliedgeology.co.uk

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M1 JUNCTION 36

Title:
GEOLOGICAL CROSS SECTIONS-
SHEET 4 OF 4

Drawn By:	Checked By:	Paper Size:
SB	FC	A1

Scale: Horizontal 1:1250, Vertical 1:250

Date: 29.05.2020

Drawing No: AG3080-19-08 Sheet 4 of 4

Revision: A

1:2500

PLATEAU

Opencast backfill materials to be removed to 4.5m below plateau level and to full depth where cut is less than 2m.

Stepped excavation to treat highwall (refer to Figure 6.4 for detail)

Stepped excavation to treat highwall

Excavate and re-engineer Made Ground to a depth of 1m below underside of capping

Excavate and re-engineer Made Ground to a depth of 1m below existing ground level in areas of fill and to a depth of 1m below capping in areas of cut.

Stepped excavation to treat highwall

Retaining wall solution to be adopted in this area.

Stepped excavation to treat highwall

Design Option 1: Engineered fill embankment slope gradient of 1v:4h with a half depth shear key.

Design Option 2: Engineered fill embankment slope gradient of 1v:5h with Made Ground excavated and re-engineered to a depth of 1m below existing ground level.

Over excavation required to remove and re-engineer all opencast backfill beneath building footprint +5m

Excavate and re-engineer Made Ground to a depth of 4.5m below plateau level.

Excavate ridge/ promontory of nautral Coal Measures strata in between Opencasts and replace with engineered fill

Remove thin layer of Made Ground down to natural strata prior to placement of engineered fill.

Excavate and re-engineer Made Ground to a depth of 1m below existing ground level

1m over dig and re-engineer of Made Ground beneath slope

PLATEAU 134.55m

60m

1:1250

Area requiring over excavation of opencast backfill materials where encountered in pond slope and replacement with engineered fill.

398900N

398800N

BLACK LANE

116.1m

435800E

435900E

436000E

436100E

KEY:

- Extent of Open Cast Site as shown on Coal Authority Abandonment Plans
- Interpreted Extent of Open Cast Site Based on Trial Trench Findings and Coal Authority Abandonment Plans
- TP1001 Trial Pit
- TT2001 Trial Trench
- RS3001 Rotary (sonic) Borehole
- RC4001 Dynamic / Sample and Rotary Cored Borehole
- CPT5001 Cone Penetration Test
- DCS6001 Driven Continuous Sampling Borehole
- Extent of Cut/ Fill taken from stafsurv, drawing No:10986b dated 03/06/2020.

Drawing based on stafsurv, drawing No:10986b dated 03/06/2020.

Rev	Notes	Date	By
1	Balancing Pond site added & minor amendments to text	03.08.2020	FC

APPLiED GEOLOGY

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Abbey Park
Stareton
Kenilworth
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Tel: 02476 511822
Fax: 02476 697682
email: admin@appliedgeology.co.uk

Client: newlands developments

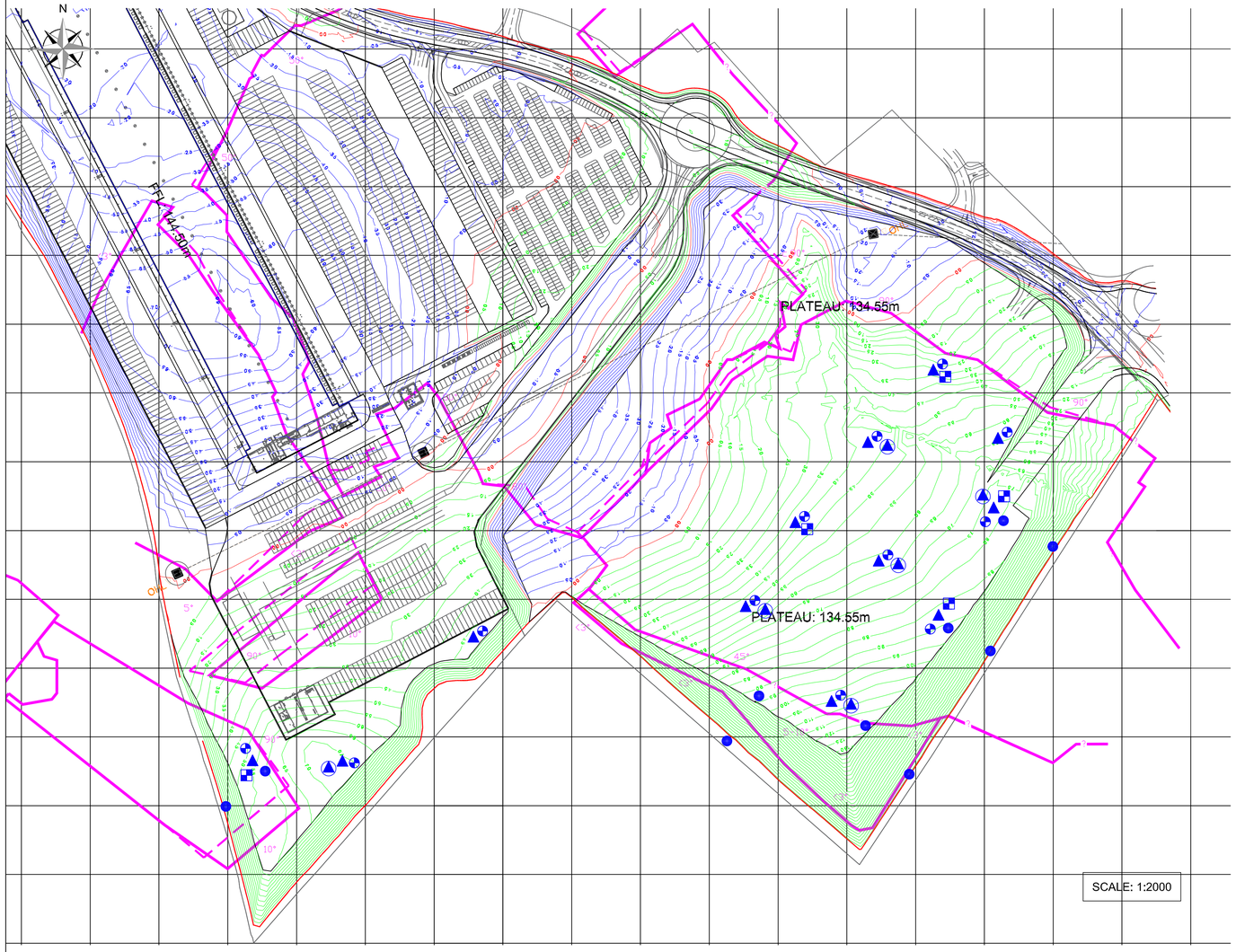
Project: HOYLAND COMMON, BARNSLEY
M1 JUNCTION 36

Title: AREAS REQUIRING OVER-EXCAVATION AND RE-ENGINEERING

Drawn By:	Checked By:	Paper Size:
FD	SD	A1

Scale:	Date:
AS SHOWN	15.06.2020

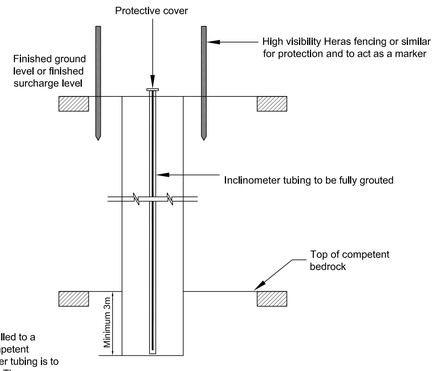
Drawing No:	Revision:
AG3080-19-12	1



KEY:

- Vibrating Wire Piezometer
- Rod-Plate Settlement Gauge (at original ground level)
- Rod-Plate Settlement Gauge (at top of engineered fill)
- Magnet Extensometer
- Inclinometer

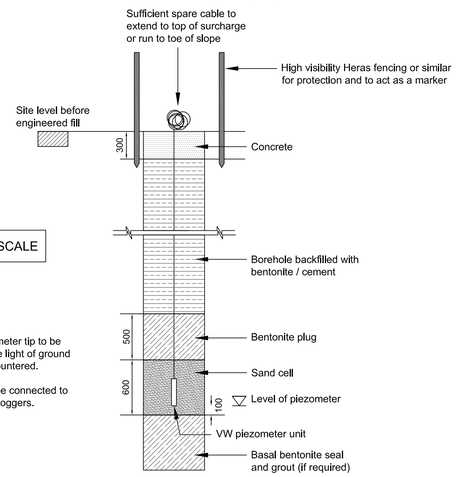
INCLINOMETER (I)



The borehole is to be drilled to a minimum of 3m into competent bedrock. The inclinometer tubing is to be fully grouted in place. The instrument is to be carefully protected and, if required, extended during placement of the surcharge.

NOT TO SCALE

VIBRATING WIRE PIEZOMETER (VWP)

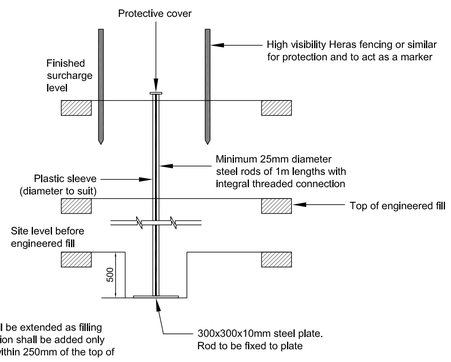


NOT TO SCALE

Depth of piezometer tip to be confirmed in the light of ground conditions encountered.

VWP cable to be connected to individual data loggers.

ROD & PLATE SETTLEMENT GAUGE (RPSG)



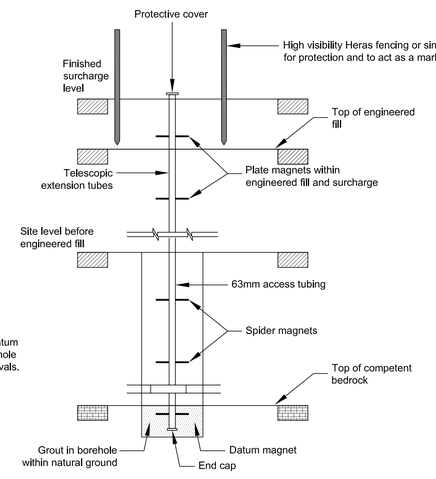
NOT TO SCALE

The rod and sleeve shall be extended as filling processes. Each extension shall be added only when the level of fill is within 250mm of the top of the previous section.

Levels are to be taken on each tube immediately before and after installation and extension. Some RPSGs to be placed just below original level, others to be placed on top of engineered fill.

Lateral spacing between Rod-Plate Gauges to be no greater than 1-2m.

MAGNET EXTENSOMETER (ME)



NOT TO SCALE

Where required the borehole is to be drilled to a minimum penetation of 1m into competent Coal Measure strata. A datum magnet is to be installed within the grouted section of borehole at the base. Magnet locations to be nominally at 2.0m intervals. Magnet depths are to be recorded during installation. The instrument is to be carefully protected and extended during the filling operations.

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Client: newlands developments

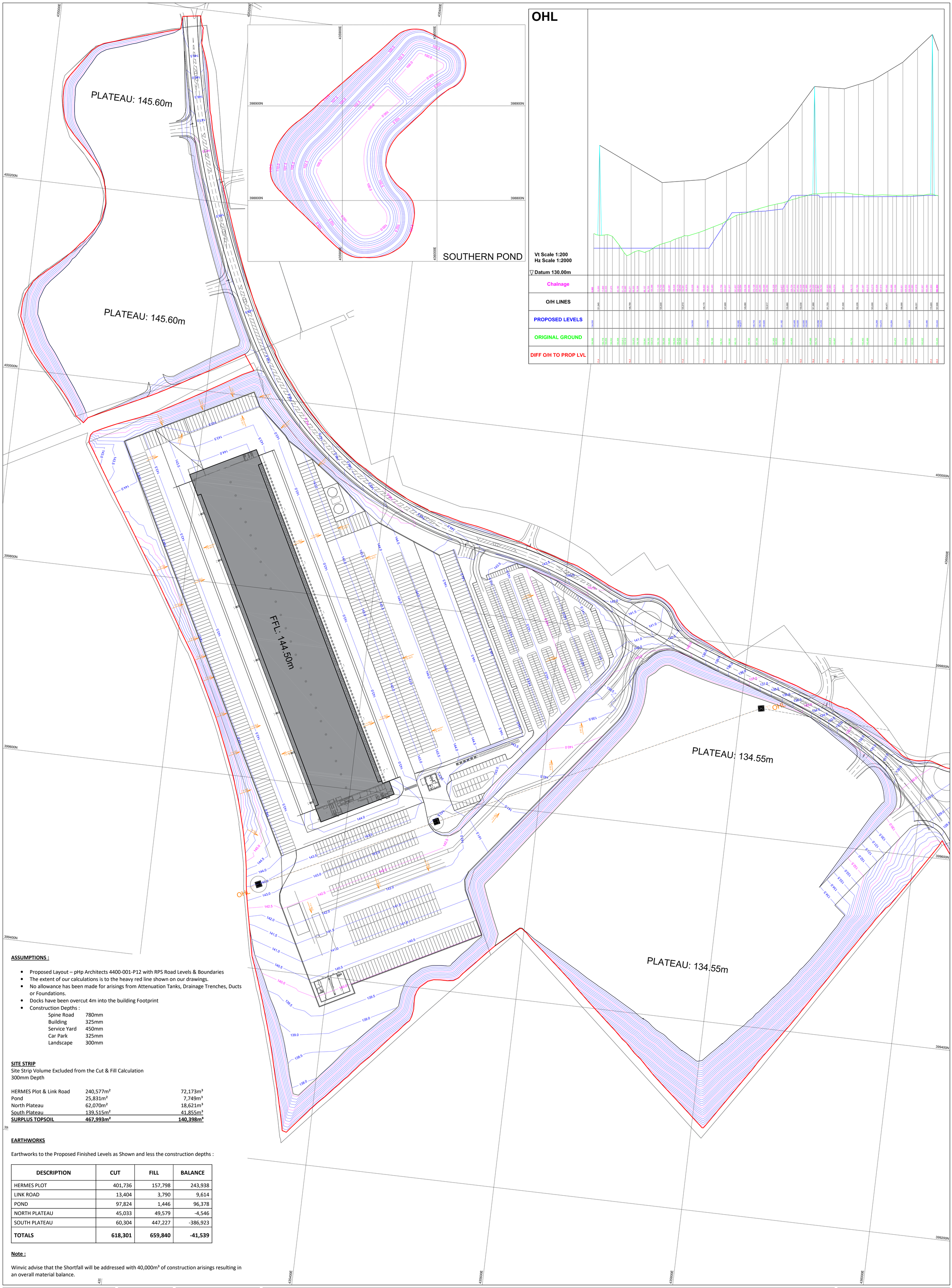
Project: HOYLAND COMMON, BARNSLEY
M1 JUNCTION 36

Title: PROPOSED INSTRUMENTATION LOCATIONS

Drawn By:	Checked By:	Paper Size:
FD	SD	A1

Scale:	Date:
AS SHOWN	20.06.2020

Drawing No:	Revision:
AG3080-19-13	0



OHL

Vt Scale 1:200
Hz Scale 1:2000

▽ Datum 130.00m

Chainage	0.000 … 582.846
O/H LINES	55.945 … 567.446
PROPOSED LEVELS	144.650 … 144.444
ORIGINAL GROUND	145.066 … 134.550
DIFF O/H TO PROP LVL	17.4 … 24.5

ASSUMPTIONS :

- Proposed Layout – pHp Architects 4400-001-P12 with RPS Road Levels & Boundaries
- The extent of our calculations is to the heavy red line shown on our drawings.
- No allowance has been made for arisings from Attenuation Tanks, Drainage Trenches, Ducts or Foundations.
- Docks have been overcut 4m into the building Footprint
- Construction Depths :

Spine Road	780mm
Building	325mm
Service Yard	450mm
Car Park	325mm
Landscape	300mm

SITE STRIP

Site Strip Volume Excluded from the Cut & Fill Calculation
300mm Depth

HERMES Plot & Link Road	240,577m²	72,173m³
Pond	25,831m²	7,749m³
North Plateau	62,070m²	18,621m³
South Plateau	139,515m²	41,855m³
SURPLUS TOPSOIL	**467,993m²**	**140,398m³**

EARTHWORKS

Earthworks to the Proposed Finished Levels as Shown and less the construction depths :

DESCRIPTION	CUT	FILL	BALANCE
HERMES PLOT	401,736	157,798	243,938
LINK ROAD	13,404	3,790	9,614
POND	97,824	1,446	96,378
NORTH PLATEAU	45,033	49,579	-4,546
SOUTH PLATEAU	60,304	447,227	-386,923
TOTALS	**618,301**	**659,840**	**-41,539**

Note :

Winvic advise that the Shortfall will be addressed with 40,000m³ of construction arisings resulting in an overall material balance.

SITE
HOYLAND COMMON
BARNSLEY. M1 J36

SCALE
1:1250 @ A0

DATE
03-06-2020

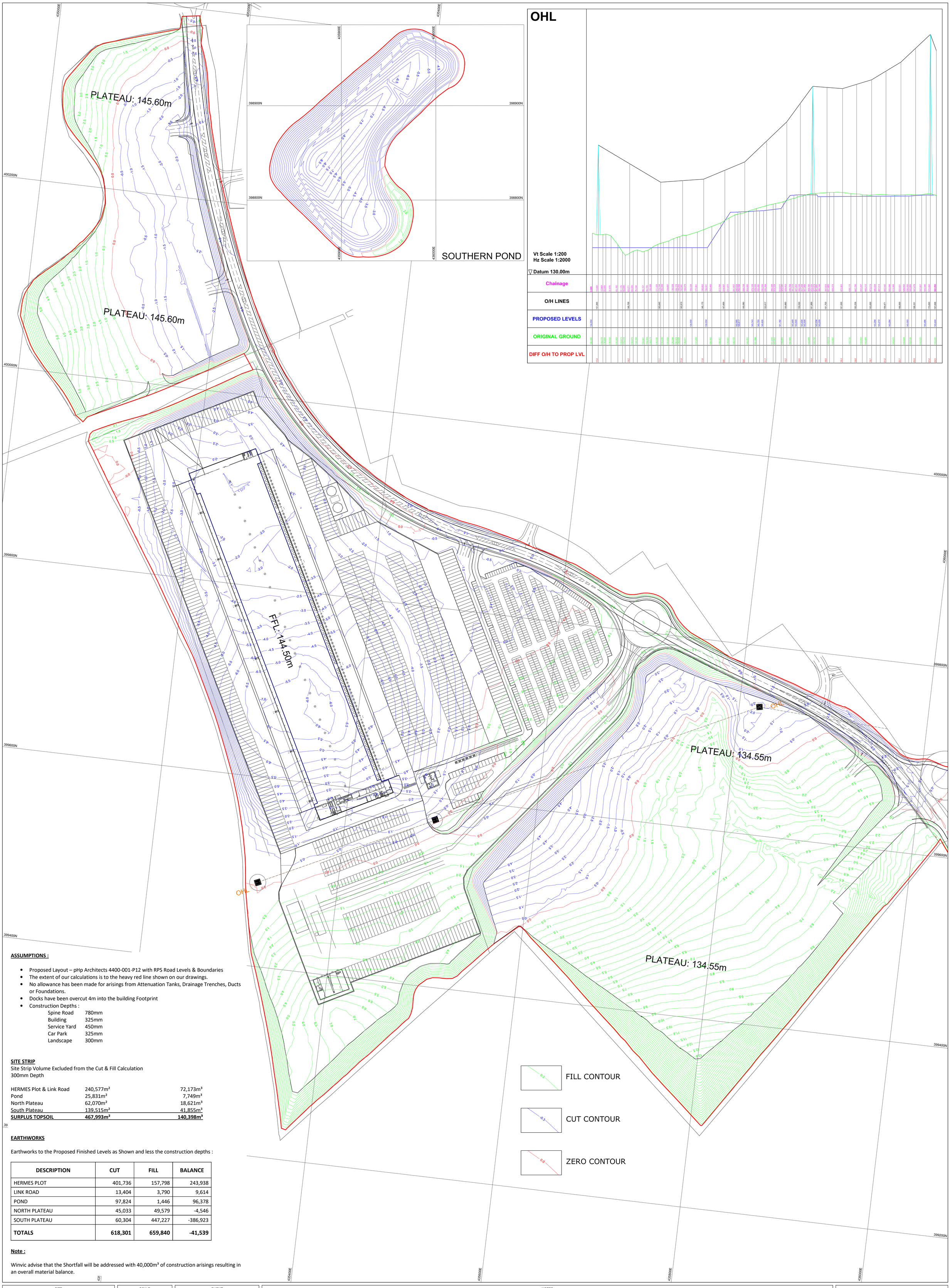
PROJECT
PROPOSED FINISHED LEVELS
LAYOUT : pHp Architects : 4400-001-P12

DRAWING No.
10986a

CLIENT
winvic Construction Limited
Brampton House
19 Tenter Road
Moulton Park
Northampton
NN3 6PZ
Tel 01604 678960
Fax 01604 671021
email mail@winvic.co.uk

NOTES

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ASSUMPTIONS :

- Proposed Layout – pHp Architects 4400-001-P12 with RPS Road Levels & Boundaries
- The extent of our calculations is to the heavy red line shown on our drawings.
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SITE
HOYLAND COMMON
BARNSLEY. M1 J36

SCALE
1:1250 @ A0

DATE
03-06-2020

PROJECT
CUT & FILL CONTOURS
LAYOUT : pHp Architects : 4400-001-P12

DRAWING No.
10986b

CLIENT
winvic Construction Limited
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ANNEX
III

Slope stability analysis

Input data

Project

Task : Section E-E' Slope Stability
Author : Fiona Connor / Adam Perks
Date : 15/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

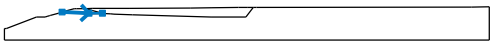
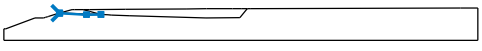
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

Permanent design situation

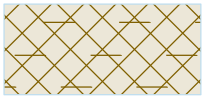
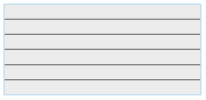
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

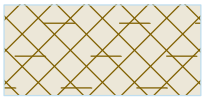
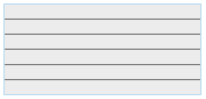
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-30.00	-0.70	-29.20	-0.70	-16.30	4.15
		-12.50	4.15	-11.72	4.42	-10.73	4.76
		-10.27	4.93	-6.76	5.92	-5.57	6.26
		-5.26	6.35	0.00	7.85	0.95	7.76
		4.84	7.81	7.66	7.86	23.53	7.99
		50.05	8.12	59.11	8.18	70.53	8.28
		74.60	8.29	76.95	8.29	78.26	8.29
		170.78	8.53	178.33	8.55		
2		4.84	7.81	12.14	5.84	12.67	5.70
		15.71	5.52	17.08	5.44	25.04	5.11
		58.79	4.19	73.72	4.25	76.95	8.29
3		-5.26	6.35	6.35	5.84	12.14	5.84
4		-5.57	6.26	-5.55	6.26	6.34	5.63
		12.67	5.70				

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[SIGMA-X Ltd. | +44 (0)203 603 1442 | info@sigma-x.net| http://www.sigma-x.net]

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		15.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 15.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Engineered Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective

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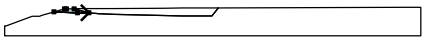
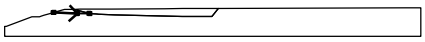
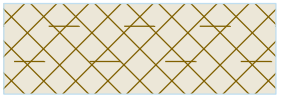
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Coal Measures CLAY
Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

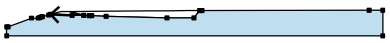
Coal Measures Siltstone / Mudstone / Sandstone
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

COAL
Unit weight : γ = 13.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		6.35	5.84	12.14	5.84	Coal Measures CLAY
		4.84	7.81	0.95	7.76	
		0.00	7.85	-5.26	6.35	
2		-5.55	6.26	6.34	5.63	COAL
		12.67	5.70	12.14	5.84	
		6.35	5.84	-5.26	6.35	
		-5.57	6.26			
3		12.14	5.84	12.67	5.70	Made Ground - Opencast Backfill
		15.71	5.52	17.08	5.44	
		25.04	5.11	58.79	4.19	
		73.72	4.25	76.95	8.29	
		74.60	8.29	70.53	8.28	
		59.11	8.18	50.05	8.12	
		23.53	7.99	7.66	7.86	
		4.84	7.81			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		6.34	5.63	-5.55	6.26	Coal Measures Siltstone / Mudstone / Sandstone
		-5.57	6.26	-6.76	5.92	
		-10.27	4.93	-10.73	4.76	
		-11.72	4.42	-12.50	4.15	
		-16.30	4.15	-29.20	-0.70	
		-30.00	-0.70	-30.00	-5.70	
		178.33	-5.70	178.33	8.55	
		170.78	8.53	78.26	8.29	
		76.95	8.29	73.72	4.25	
		58.79	4.19	25.04	5.11	
		17.08	5.44	15.71	5.52	
		12.67	5.70			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	-1.85	-5.51	6.29	6.97	5.58
		12.56	5.69	16.43	5.51	36.27	4.90
		60.39	4.19	73.73	4.34	170.78	4.19
		178.33	4.18				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

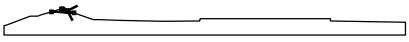
Design situation : permanent

Input data (Stage of construction 2)

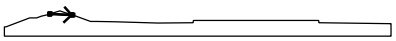
Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		0.00	7.85	0.45	7.81	2.99	6.97
		6.35	5.84	8.33	5.12	16.41	2.32
		19.85	2.23	29.58	1.99	52.74	1.39
		71.64	1.54	71.77	2.79	139.35	2.79
		139.47	1.54	178.33	1.03		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		6.35	5.84	2.99	6.97	Coal Measures CLAY
		0.45	7.81	0.00	7.85	
		-5.26	6.35			

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
2		-5.55	6.26	6.34	5.63	COAL
		6.91	5.64	6.35	5.84	
		-5.26	6.35	-5.57	6.26	
3		6.34	5.63	-5.55	6.26	Coal Measures Siltstone / Mudstone / Sandstone
		-5.57	6.26	-6.76	5.92	
		-10.27	4.93	-10.73	4.76	
		-11.72	4.42	-12.50	4.15	
		-16.30	4.15	-29.20	-0.70	
		-30.00	-0.70	-30.00	-5.70	
		178.33	-5.70	178.33	1.03	
		139.47	1.54	139.35	2.79	
		71.77	2.79	71.64	1.54	
		52.74	1.39	29.58	1.99	
		19.85	2.23	16.41	2.32	
		8.33	5.12	6.91	5.64	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		-30.00	-1.85	-5.42	6.28	6.97	5.58
		16.40	2.07	28.46	1.53	54.87	1.03
		72.07	1.28	103.23	1.18	166.62	0.89
		178.33	0.59				

Tensile crack

Tensile crack not input.

Earthquake

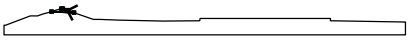
Earthquake not included.

Settings of the stage of construction

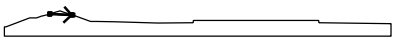
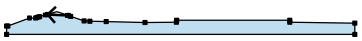
Design situation : permanent

Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		6.35	5.84	2.99	6.97	Coal Measures CLAY
		0.45	7.81	0.00	7.85	
		-5.26	6.35			

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
2		-5.55	6.26	6.34	5.63	COAL
		6.91	5.64	6.35	5.84	
		-5.26	6.35	-5.57	6.26	
3		6.34	5.63	-5.55	6.26	Coal Measures Siltstone / Mudstone / Sandstone
		-5.57	6.26	-6.76	5.92	
		-10.27	4.93	-10.73	4.76	
		-11.72	4.42	-12.50	4.15	
		-16.30	4.15	-29.20	-0.70	
		-30.00	-0.70	-30.00	-5.70	
		178.33	-5.70	178.33	1.03	
		139.47	1.54	139.35	2.79	
		71.77	2.79	71.64	1.54	
		52.74	1.39	29.58	1.99	
		19.85	2.23	16.41	2.32	
		8.33	5.12	6.91	5.64	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		-30.00	-1.85	-5.42	6.28	6.97	5.58
		16.40	2.07	28.46	1.53	54.87	1.03
		72.07	1.28	103.23	1.18	166.62	0.89
		178.33	0.59				

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 =	11.68	[m]	Angles :	α_1 =	-57.89	[°]
	z =	15.21	[m]		α_2 =	21.75	[°]
Radius :	R =	13.89	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (all methods)
Combination 1

Bishop : Utilization = 77.2 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 83.3 % **ACCEPTABLE**
Spencer : Utilization = 76.3 % **ACCEPTABLE**

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Janbu : Utilization = 76.2 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 76.6 % **ACCEPTABLE**

Combination 2

Bishop : Utilization = 74.3 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 79.9 % **ACCEPTABLE**
Spencer : Utilization = 73.9 % **ACCEPTABLE**
Janbu : Utilization = 74.1 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 74.1 % **ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section F-F' Slope Stability
Author : Adam Perks
Date : 15/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

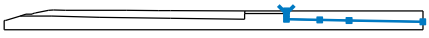
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

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		-30.00	0.70	-29.20	0.70	-19.87	3.69
		-16.30	4.85	-12.50	4.85	-11.72	5.12
		-10.73	5.46	-10.27	5.63	-1.95	7.19
		1.00	7.44	8.64	7.14	23.94	7.25
		47.17	7.16	67.24	6.97	74.60	6.96
		121.29	6.89	147.41	6.86	233.14	6.74
2		-19.87	3.69	0.00	3.58	30.14	2.71
		74.60	2.18	121.17	1.63	121.25	5.16
		121.29	6.89				
3		147.41	6.86	147.42	5.16	147.45	1.65
		168.33	1.21	186.71	0.78	233.14	-0.06
4		121.25	5.16	147.42	5.16		

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Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		15.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : $\gamma = 18.00$ kN/m^3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 15.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.00$ kN/m^3

Engineered Fill

Unit weight : $\gamma = 20.50$ kN/m^3
Stress-state : effective

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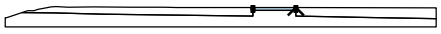
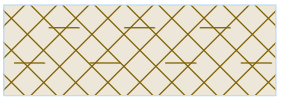
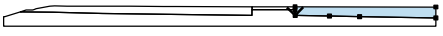
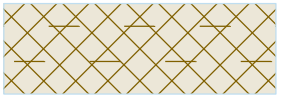
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

Coal Measures CLAY
Unit weight : γ = 20.50 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

Coal Measures Siltstone / Mudstone / Sandstone
Unit weight : γ = 21.00 kN/m3
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/m3

COAL
Unit weight : γ = 13.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		147.42	5.16	147.41	6.86	Coal Measures CLAY
		121.29	6.89	121.25	5.16	
2		0.00	3.58	30.14	2.71	Made Ground - Opencast Backfill
		74.60	2.18	121.17	1.63	
		121.25	5.16	121.29	6.89	
		74.60	6.96	67.24	6.97	
		47.17	7.16	23.94	7.25	
		8.64	7.14	1.00	7.44	
		-1.95	7.19	-10.27	5.63	
		-10.73	5.46	-11.72	5.12	
		-12.50	4.85	-16.30	4.85	
		-19.87	3.69			
3		147.42	5.16	147.45	1.65	Made Ground - Opencast Backfill
		168.33	1.21	186.71	0.78	
		233.14	-0.06	233.14	6.74	
		147.41	6.86			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		121.25	5.16	121.17	1.63	Coal Measures Siltstone / Mudstone / Sandstone
		74.60	2.18	30.14	2.71	
		0.00	3.58	-19.87	3.69	
		-29.20	0.70	-30.00	0.70	
		-30.00	-5.06	233.14	-5.06	
		233.14	-0.06	186.71	0.78	
		168.33	1.21	147.45	1.65	
		147.42	5.16			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	5.71	-11.46	5.34	8.15	4.95
		33.22	5.00	62.65	4.95	74.60	4.95
		233.14	4.95				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Input data (Stage of construction 2)

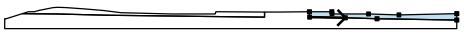
Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		5.47	7.27	16.15	6.56	27.23	5.58
		37.58	4.33	66.99	3.59	89.01	3.61
		92.57	3.55	92.82	4.80	129.53	4.71
		160.41	4.80	160.53	3.60	181.79	3.47
		199.51	3.03	233.14	3.76		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	3.58	30.14	2.71	Made Ground - Opencast Backfill
		74.60	2.18	121.17	1.63	
		121.24	4.73	92.82	4.80	
		92.57	3.55	89.01	3.61	
		66.99	3.59	37.58	4.33	
		27.23	5.58	16.15	6.56	
		5.67	7.26	1.00	7.44	
		-1.95	7.19	-10.27	5.63	
		-10.73	5.46	-11.72	5.12	
		-12.50	4.85	-16.30	4.85	
		-19.87	3.69			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		147.45	1.65	168.33	1.21	Made Ground - Opencast Backfill
		186.71	0.78	233.14	-0.06	
		233.14	3.76	199.51	3.03	
		181.79	3.47	160.53	3.60	
		160.41	4.80	147.42	4.76	
3		121.17	1.63	74.60	2.18	Coal Measures Siltstone / Mudstone / Sandstone
		30.14	2.71	0.00	3.58	
		-19.87	3.69	-29.20	0.70	
		-30.00	0.70	-30.00	-5.06	
		233.14	-5.06	233.14	-0.06	
		186.71	0.78	168.33	1.21	
		147.45	1.65	147.42	4.76	
		129.53	4.71	121.24	4.73	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	5.71	-11.46	5.34	8.15	4.95
		33.22	5.00	62.65	4.95	74.60	4.95
		233.14	4.95				

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

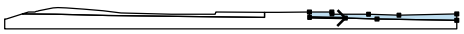
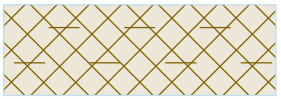
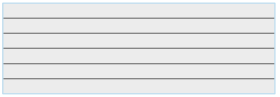
Design situation : permanent

Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	3.58	30.14	2.71	Made Ground - Opencast Backfill
		74.60	2.18	121.17	1.63	
		121.24	4.73	92.82	4.80	
		92.57	3.55	89.01	3.61	
		66.99	3.59	37.58	4.33	
		27.23	5.58	16.15	6.56	
		5.67	7.26	1.00	7.44	
		-1.95	7.19	-10.27	5.63	
		-10.73	5.46	-11.72	5.12	
		-12.50	4.85	-16.30	4.85	
		-19.87	3.69			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		147.45	1.65	168.33	1.21	Made Ground - Opencast Backfill
		186.71	0.78	233.14	-0.06	
		233.14	3.76	199.51	3.03	
		181.79	3.47	160.53	3.60	
		160.41	4.80	147.42	4.76	
3		121.17	1.63	74.60	2.18	Coal Measures Siltstone / Mudstone / Sandstone
		30.14	2.71	0.00	3.58	
		-19.87	3.69	-29.20	0.70	
		-30.00	0.70	-30.00	-5.06	
		233.14	-5.06	233.14	-0.06	
		186.71	0.78	168.33	1.21	
		147.45	1.65	147.42	4.76	
		129.53	4.71	121.24	4.73	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	-0.38	-10.40	5.34	31.64	4.59
		37.73	3.84	39.24	4.13	54.93	3.67
		70.44	3.47	92.33	3.40	199.65	2.87
		233.14	3.01				

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 =	33.50	[m]	Angles :	α_1 =	-53.38	[°]
	z =	9.67	[m]		α_2 =	40.05	[°]
Radius :	R =	6.99	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (all methods)

Combination 1

Bishop : Utilization = 81.6 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 94.1 % **ACCEPTABLE**
Spencer : Utilization = 81.4 % **ACCEPTABLE**
Janbu : Utilization = 81.4 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 81.4 % **ACCEPTABLE**

Combination 2

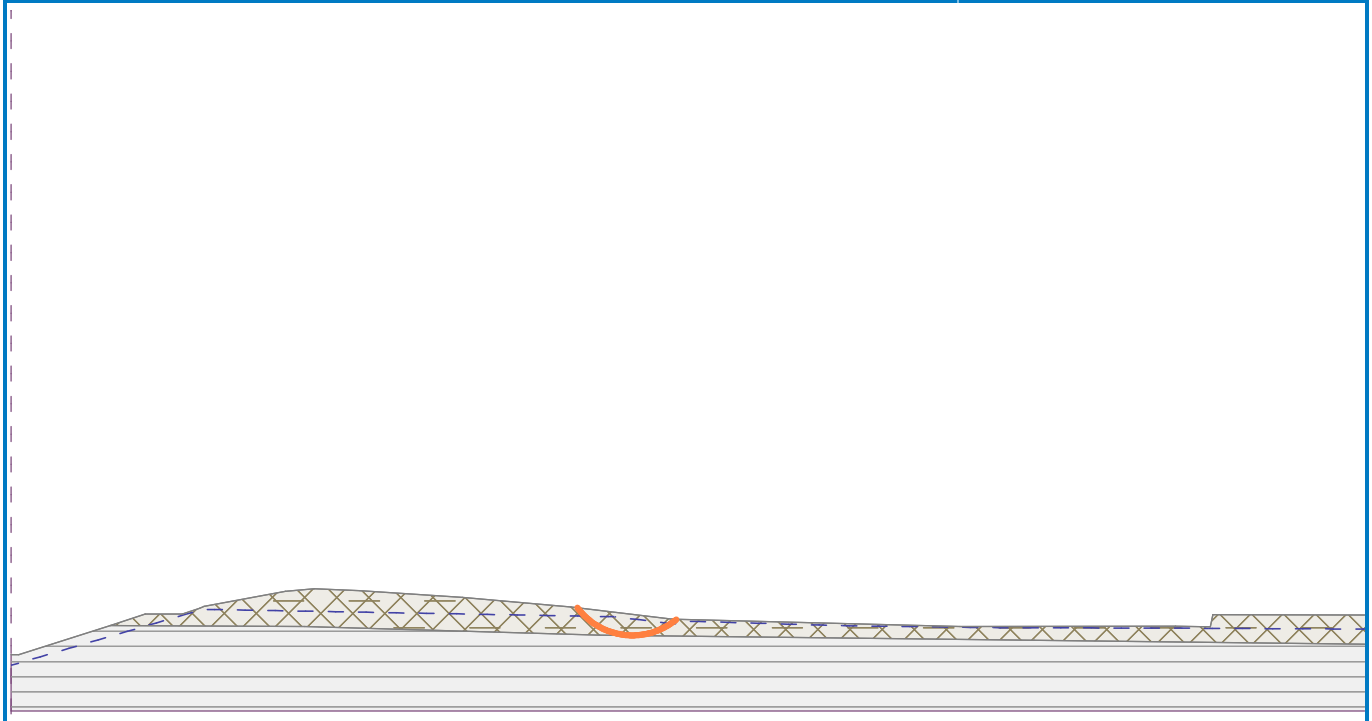
Bishop : Utilization = 64.1 % **ACCEPTABLE**

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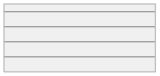
Fellenius / Petterson :	Utilization = 73.5 %	**ACCEPTABLE**
Spencer :	Utilization = 64.1 %	**ACCEPTABLE**
Janbu :	Utilization = 64.1 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 64.1 %	**ACCEPTABLE**

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Name :	Stage - analysis : 3 - 1



 Made Ground - Opencast Backfill

 Coal Measures Siltstone / Mudstone / Sandstone

Analysis of the slip surface without optimization.

Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 81.6 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 94.1 %	**ACCEPTABLE**
Spencer :	Utilization = 81.4 %	**ACCEPTABLE**
Janbu :	Utilization = 81.4 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 81.4 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 64.1 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 73.5 %	**ACCEPTABLE**
Spencer :	Utilization = 64.1 %	**ACCEPTABLE**
Janbu :	Utilization = 64.1 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 64.1 %	**ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section R-R' Slope Stability - Plot 1 Western Margin with M1
Author : Adam Perks
Date : 12/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

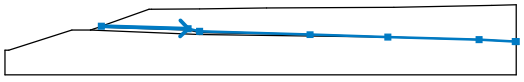
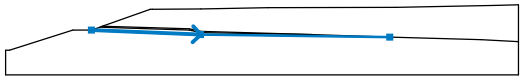
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

Permanent design situation

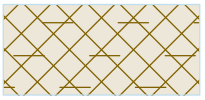
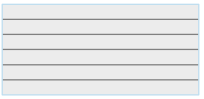
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

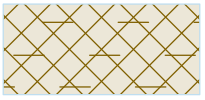
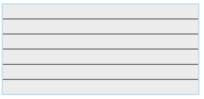
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-30.00	141.00	-29.20	141.00	-16.30	145.15
		-12.50	145.15	-11.72	145.42	-10.73	145.76
		-10.27	145.93	-0.50	149.40	0.00	149.40
		9.80	149.44	23.50	149.68	49.60	149.80
		69.60	150.20	74.60	150.30		
2		-10.27	145.93	7.50	145.40	9.80	144.89
		32.41	144.20	48.35	143.72	67.00	143.16
		74.39	142.79	74.60	142.78		
3		-10.73	145.76	7.50	145.15	9.80	144.64
		32.41	144.20				
4		-12.50	145.15	9.80	144.24	48.35	143.72

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Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		19.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 19.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m^3

Engineered Fill

Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °

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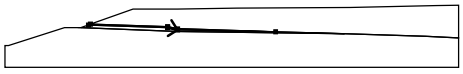
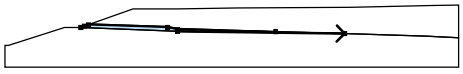
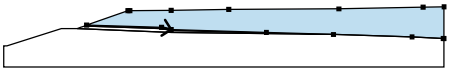
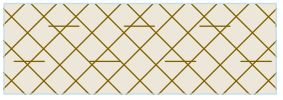
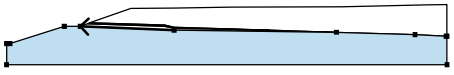
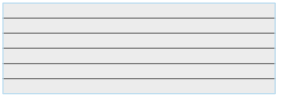
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Coal Measures CLAY
Unit weight : γ = 20.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Coal Measures Siltstone / Mudstone / Sandstone
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

COAL
Unit weight : γ = 13.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		7.50	145.15	9.80	144.64	COAL
		32.41	144.20	9.80	144.89	
		7.50	145.40	-10.27	145.93	
		-10.73	145.76			
2		9.80	144.24	48.35	143.72	Coal Measures CLAY
		32.41	144.20	9.80	144.64	
		7.50	145.15	-10.73	145.76	
		-11.72	145.42	-12.50	145.15	
3		7.50	145.40	9.80	144.89	Made Ground - Opencast Backfill
		32.41	144.20	48.35	143.72	
		67.00	143.16	74.39	142.79	
		74.60	142.78	74.60	150.30	
		69.60	150.20	49.60	149.80	
		23.50	149.68	9.80	149.44	
		0.00	149.40	-0.50	149.40	
		-10.27	145.93			
4		9.80	144.24	-12.50	145.15	Coal Measures Siltstone / Mudstone / Sandstone
		-16.30	145.15	-29.20	141.00	
		-30.00	141.00	-30.00	136.00	
		74.60	136.00	74.60	142.78	
		74.39	142.79	67.00	143.16	
		48.35	143.72			

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Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.80	146.15	74.60	144.13		

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

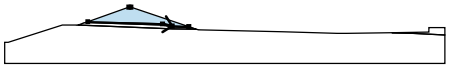
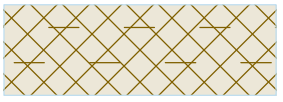
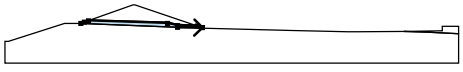
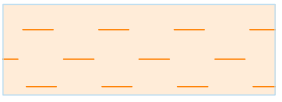
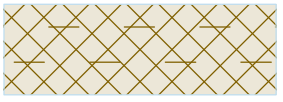
Design situation : permanent

Input data (Stage of construction 2)

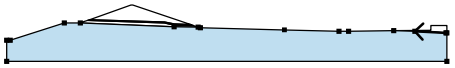
Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		-0.50	149.40	0.00	149.40	16.00	144.00
		36.00	143.50	49.00	143.18	51.25	143.18
		70.80	143.42	70.80	144.50	74.60	144.50

Assigning and surfaces

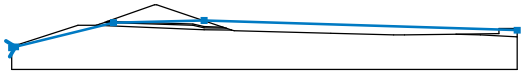
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		7.50	145.40	9.80	144.89	Made Ground - Opencast Backfill
		13.72	144.77	0.00	149.40	
		-0.50	149.40	-10.27	145.93	
2		7.50	145.15	9.80	144.64	COAL
		14.37	144.55	13.72	144.77	
		9.80	144.89	7.50	145.40	
		-10.27	145.93	-10.73	145.76	
3		9.80	144.24	15.52	144.16	Coal Measures CLAY
		14.37	144.55	9.80	144.64	
		7.50	145.15	-10.73	145.76	
		-11.72	145.42	-12.50	145.15	
4		67.00	143.16	74.39	142.79	Made Ground - Opencast Backfill
		74.60	142.78	74.60	144.50	
		70.80	144.50	70.80	143.42	
		61.96	143.31			

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
5		74.39	142.79	67.00	143.16	Coal Measures Siltstone / Mudstone / Sandstone
		61.96	143.31	51.25	143.18	
		49.00	143.18	36.00	143.50	
		16.00	144.00	15.52	144.16	
		9.80	144.24	-12.50	145.15	
		-16.30	145.15	-29.20	141.00	
		-30.00	141.00	-30.00	136.00	
		74.60	136.00	74.60	142.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.80	146.15	74.60	144.13		

Tensile crack

Tensile crack not input.

Earthquake

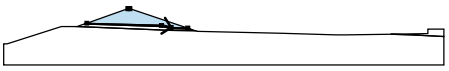
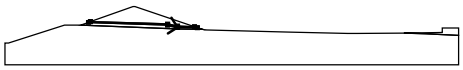
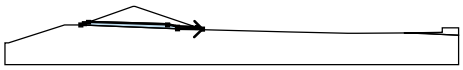
Earthquake not included.

Settings of the stage of construction

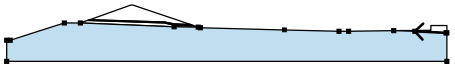
Design situation : permanent

Input data (Stage of construction 3)

Assigning and surfaces

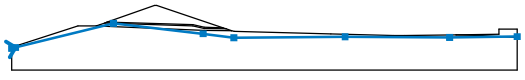
No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		7.50	145.40	9.80	144.89	Made Ground - Opencast Backfill
		13.72	144.77	0.00	149.40	
		-0.50	149.40	-10.27	145.93	
2		7.50	145.15	9.80	144.64	COAL
		14.37	144.55	13.72	144.77	
		9.80	144.89	7.50	145.40	
		-10.27	145.93	-10.73	145.76	
3		9.80	144.24	15.52	144.16	Coal Measures CLAY
		14.37	144.55	9.80	144.64	
		7.50	145.15	-10.73	145.76	
		-11.72	145.42	-12.50	145.15	
4		67.00	143.16	74.39	142.79	Made Ground - Opencast Backfill
		74.60	142.78	74.60	144.50	
		70.80	144.50	70.80	143.42	
		61.96	143.31			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
5		74.39	142.79	67.00	143.16	Coal Measures Siltstone / Mudstone / Sandstone
		61.96	143.31	51.25	143.18	
		49.00	143.18	36.00	143.50	
		16.00	144.00	15.52	144.16	
		9.80	144.24	-12.50	145.15	
		-16.30	145.15	-29.20	141.00	
		-30.00	141.00	-30.00	136.00	
		74.60	136.00	74.60	142.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.58	143.52	15.97	142.69	38.98	142.89
		60.59	142.75	74.60	142.94		

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 =	10.13	[m]	Angles :	α_1 =	-42.42	[°]
	z =	161.03	[m]		α_2 =	6.54	[°]
Radius :	R =	15.75	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (all methods)

Combination 1

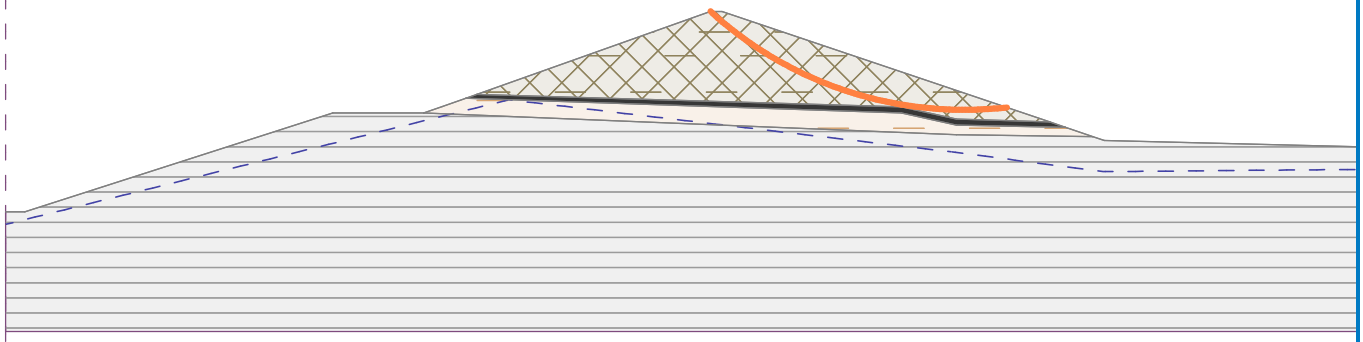
Bishop : Utilization = 96.9 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 101.0 % **NOT ACCEPTABLE**
Spencer : Utilization = 96.9 % **ACCEPTABLE**
Janbu : Utilization = 96.9 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 96.9 % **ACCEPTABLE**

Combination 2

Bishop : Utilization = 111.8 % **NOT ACCEPTABLE**
Fellenius / Petterson : Utilization = 116.4 % **NOT ACCEPTABLE**
Spencer : Utilization = 111.8 % **NOT ACCEPTABLE**
Janbu : Utilization = 111.8 % **NOT ACCEPTABLE**
Morgenstern-Price : Utilization = 111.8 % **NOT ACCEPTABLE**

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Name : **Stage - analysis : 3 - 1**



Made Ground - Opencast Backfill

COAL

Coal Measures CLAY

Coal Measures Siltstone / Mudstone / Sandstone

Analysis of the slip surface without optimization.

Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 96.9 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 101.0 %	**NOT ACCEPTABLE**
Spencer :	Utilization = 96.9 %	**ACCEPTABLE**
Janbu :	Utilization = 96.9 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 96.9 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 111.8 %	**NOT ACCEPTABLE**
Fellenius / Petterson :	Utilization = 116.4 %	**NOT ACCEPTABLE**
Spencer :	Utilization = 111.8 %	**NOT ACCEPTABLE**
Janbu :	Utilization = 111.8 %	**NOT ACCEPTABLE**
Morgenstern-Price :	Utilization = 111.8 %	**NOT ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section R-R' Slope Stability
Description : 1.5m high retaining structure + 1v:4h slope above
Customer : Newlands Developments
Author : Adam Perks
Date : 12/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

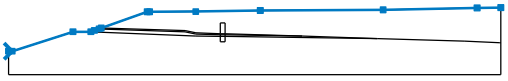
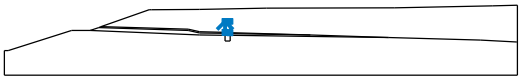
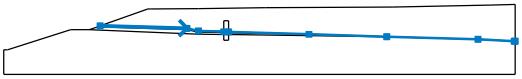
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

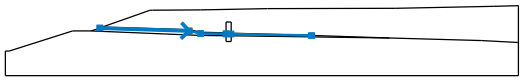
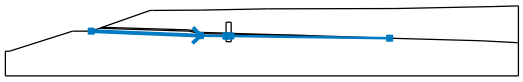
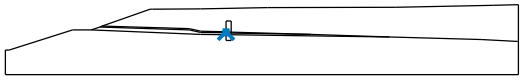
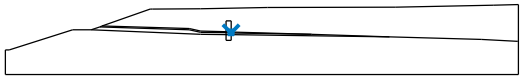
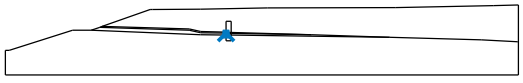
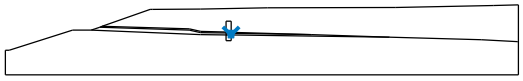
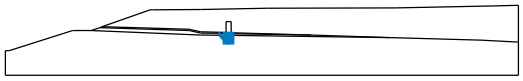
Permanent design situation

		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		-30.00	141.00	-29.20	141.00	-16.30	145.15
		-12.50	145.15	-11.72	145.42	-10.73	145.76
		-10.27	145.93	-0.50	149.40	0.00	149.40
		9.80	149.44	23.50	149.68	49.60	149.80
		69.60	150.20	74.60	150.30		
2		15.00	144.73	15.00	147.00	16.00	147.00
		16.00	144.70				
3		-10.27	145.93	7.50	145.40	9.80	144.89
		15.00	144.73	16.00	144.70	32.41	144.20
		48.35	143.72	67.00	143.16	74.39	142.79
		74.60	142.78				

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No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-10.73	145.76	7.50	145.15	9.80	144.64
		15.00	144.54	16.00	144.52	32.41	144.20
5		-12.50	145.15	9.80	144.24	15.00	144.17
		15.00	144.16	16.00	144.16	48.35	143.72
6		15.00	144.54	15.00	144.73		
7		16.00	144.70	16.00	144.52		
8		15.00	144.17	15.00	144.54		
9		16.00	144.52	16.00	144.16		
10		15.00	144.16	15.00	143.00	16.00	143.00
		16.00	144.16				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		19.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		

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No.	Name	Pattern	γ_{sat} [kN/m3]	γ_s [kN/m3]	n [–]
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : $\gamma = 18.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 19.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.00$ kN/m3

Engineered Fill

Unit weight : $\gamma = 20.50$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 24.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.50$ kN/m3

Coal Measures CLAY

Unit weight : $\gamma = 20.50$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 20.00$ °
Cohesion of soil : $c_{ef} = 3.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.50$ kN/m3

Coal Measures Siltstone / Mudstone / Sandstone

Unit weight : $\gamma = 21.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 30.00$ °
Cohesion of soil : $c_{ef} = 5.00$ kPa
Saturated unit weight : $\gamma_{sat} = 21.00$ kN/m3

COAL

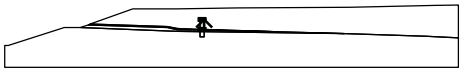
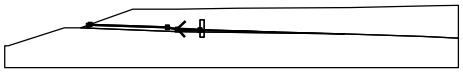
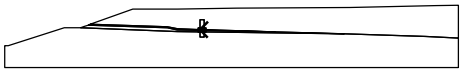
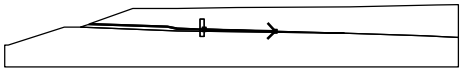
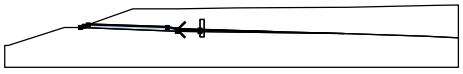
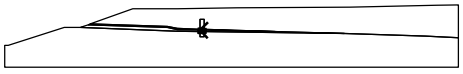
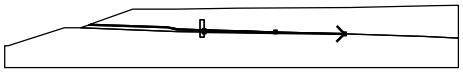
Unit weight : $\gamma = 13.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 25.00$ °
Cohesion of soil : $c_{ef} = 5.00$ kPa
Saturated unit weight : $\gamma_{sat} = 13.00$ kN/m3

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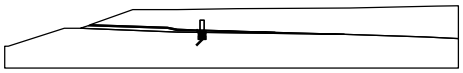
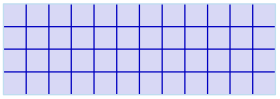
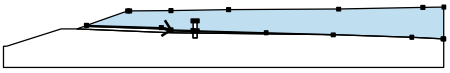
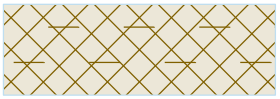
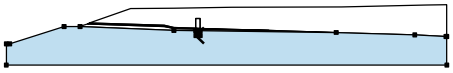
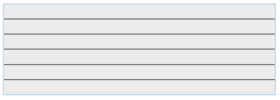
Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Gravity retaining wall		25.00

Assigning and surfaces

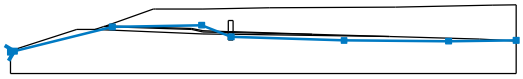
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		16.00	144.70	16.00	147.00	Gravity retaining wall
		15.00	147.00	15.00	144.73	
2		15.00	144.73	9.80	144.89	COAL
		7.50	145.40	-10.27	145.93	
		-10.73	145.76	7.50	145.15	
		9.80	144.64	15.00	144.54	
3		16.00	144.70	15.00	144.73	Gravity retaining wall
		15.00	144.54	16.00	144.52	
4		16.00	144.52	32.41	144.20	COAL
		16.00	144.70			
5		15.00	144.54	9.80	144.64	Coal Measures CLAY
		7.50	145.15	-10.73	145.76	
		-11.72	145.42	-12.50	145.15	
		9.80	144.24	15.00	144.17	
6		16.00	144.52	15.00	144.54	Gravity retaining wall
		15.00	144.17	15.00	144.16	
		16.00	144.16			
7		16.00	144.16	48.35	143.72	Coal Measures CLAY
		32.41	144.20	16.00	144.52	

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
8		15.00	143.00	16.00	143.00	Gravity retaining wall
		16.00	144.16	15.00	144.16	
9		7.50	145.40	9.80	144.89	Made Ground - Opencast Backfill
		15.00	144.73	15.00	147.00	
		16.00	147.00	16.00	144.70	
		32.41	144.20	48.35	143.72	
		67.00	143.16	74.39	142.79	
		74.60	142.78	74.60	150.30	
		69.60	150.20	49.60	149.80	
		23.50	149.68	9.80	149.44	
		0.00	149.40	-0.50	149.40	
		-10.27	145.93			
10		16.00	143.00	15.00	143.00	Coal Measures Siltstone / Mudstone / Sandstone
		15.00	144.16	15.00	144.17	
		9.80	144.24	-12.50	145.15	
		-16.30	145.15	-29.20	141.00	
		-30.00	141.00	-30.00	136.00	
		74.60	136.00	74.60	142.78	
		74.39	142.79	67.00	143.16	
		48.35	143.72	16.00	144.16	

Water

Water type : GWT

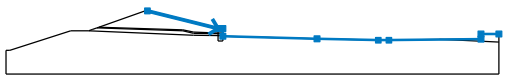
No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	15.63	143.67	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

Input data (Stage of construction 2)

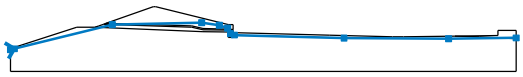
Earth cut

No.	Cut location	Coordinates of cut points [m] x	z	x	z	x	z
1		0.00	149.40	15.00	145.65	16.00	145.65
		16.00	144.00	36.00	143.50	49.00	143.18
		51.25	143.18	70.80	143.42	70.80	144.50
		74.60	144.50				

Water

Water type : GWT

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No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	13.17	145.53	14.90	144.97
		15.46	143.82	16.27	143.52	38.98	142.89
		60.59	142.75	74.60	142.94		

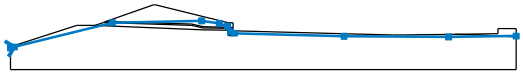
Settings of the stage of construction

Design situation : permanent

Input data (Stage of construction 3)

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	13.17	145.53	14.90	144.97
		15.46	143.82	16.27	143.52	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

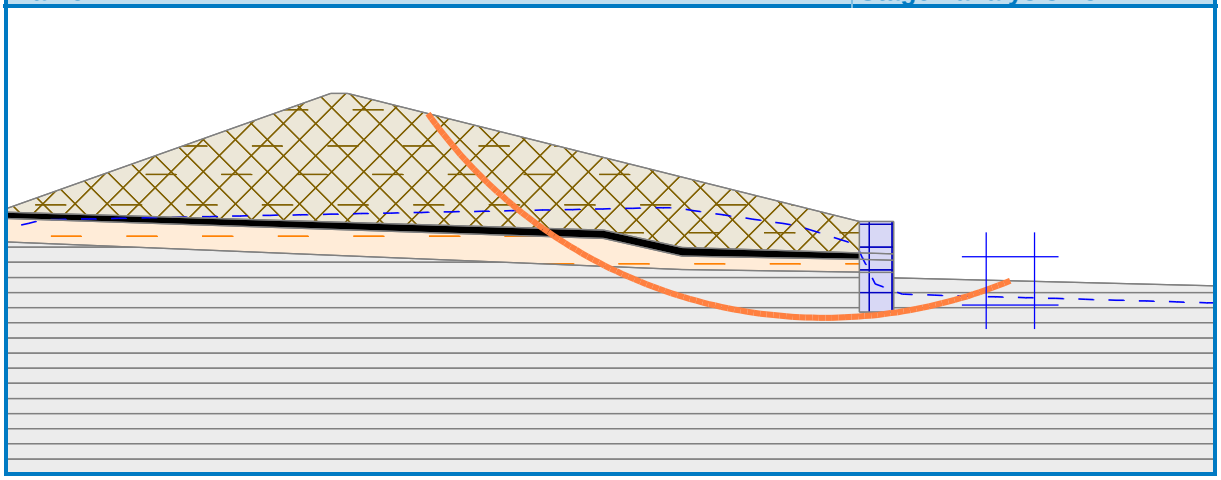
Results (Stage of construction 3) – Global Stability of Wall Check

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	13.96	[m]	Angles :	α_1 =	-54.52	[°]
	z =	157.09	[m]		α_2 =	22.49	[°]
Radius :	R =	14.26	[m]				
Slip surface first determined via optimization with Bishop then without optimization with all methods.							

Name :	Stage - analysis : 3 - 1



Slope stability verification (all methods)
Combination 1
Bishop : Utilization = 66.2 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 71.5 % **ACCEPTABLE**

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Spencer : Utilization = 64.9 % **ACCEPTABLE**
Janbu : Utilization = 64.9 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 64.9 % **ACCEPTABLE**

Combination 2
Bishop : Utilization = 65.3 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 69.7 % **ACCEPTABLE**
Spencer : Utilization = 64.4 % **ACCEPTABLE**
Janbu : Utilization = 64.4 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 64.4 % **ACCEPTABLE**

Input data (Stage of construction 4)

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	13.17	145.53	14.90	144.97
		15.46	143.82	16.27	143.52	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

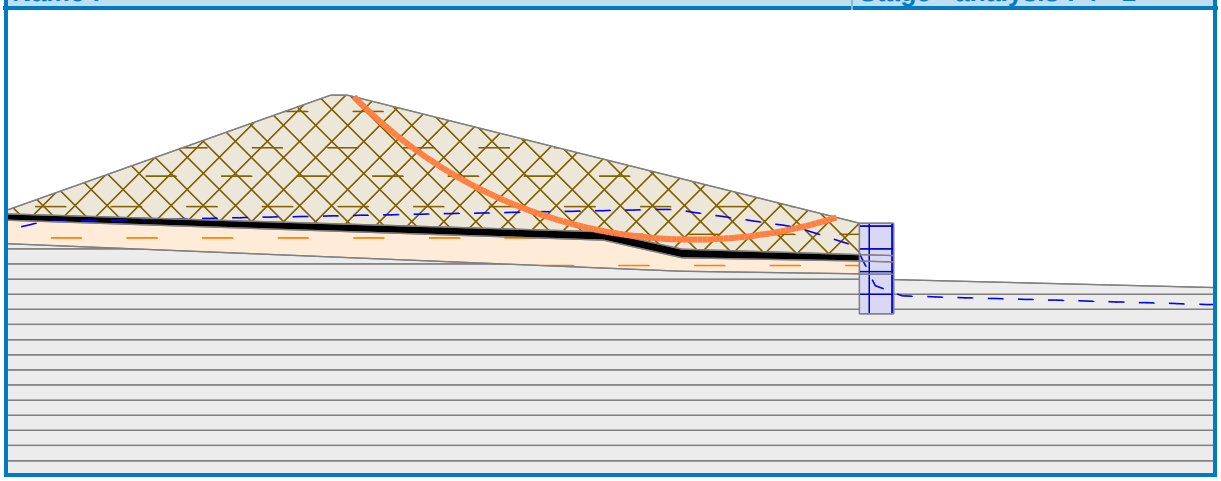
Results (Stage of construction 4) –Stability of Upper Slope Check

Analysis 1 (stage 4)

Circular slip surface

Slip surface parameters							
Center :	x =	10.12	[m]	Angles :	α_1 =	-45.68	[°]
	z =	159.05	[m]		α_2 =	17.61	[°]
Radius :	R =	13.88	[m]				
Slip surface first determined via optimization with Bishop then without optimization with all methods.							

Name :	Stage - analysis : 4 - 1



Slope stability verification (all methods)
Combination 1
Bishop : Utilization = 82.6 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 87.9 % **ACCEPTABLE**
Spencer : Utilization = 82.6 % **ACCEPTABLE**

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Janbu : Utilization = 82.6 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 82.6 % **ACCEPTABLE**

Combination 2
Bishop : Utilization = 88.3 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 94.0 % **ACCEPTABLE**
Spencer : Utilization = 88.4 % **ACCEPTABLE**
Janbu : Utilization = 88.4 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 88.4 % **ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section R-R' Slope Stability
Description : 2.5m high retaining structure + 1v:5h slope above
Customer : Newlands Developments
Author : Adam Perks
Date : 12/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

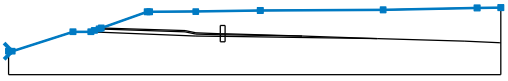
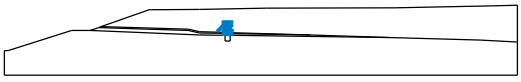
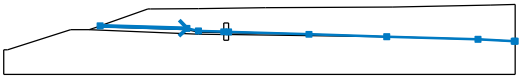
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

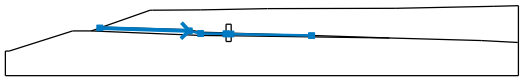
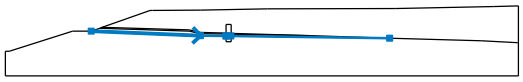
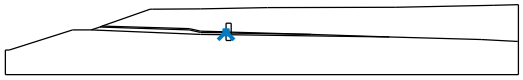
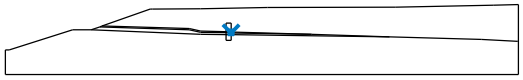
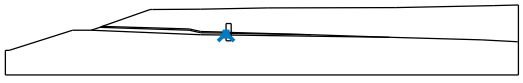
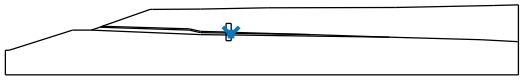
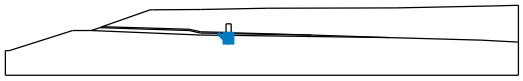
Permanent design situation

		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		-30.00	141.00	-29.20	141.00	-16.30	145.15
		-12.50	145.15	-11.72	145.42	-10.73	145.76
		-10.27	145.93	-0.50	149.40	0.00	149.40
		9.80	149.44	23.50	149.68	49.60	149.80
		69.60	150.20	74.60	150.30		
2		15.00	144.73	15.00	146.50	16.00	146.50
		16.00	144.70				
3		-10.27	145.93	7.50	145.40	9.80	144.89
		15.00	144.73	16.00	144.70	32.41	144.20
		48.35	143.72	67.00	143.16	74.39	142.79
		74.60	142.78				

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No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-10.73	145.76	7.50	145.15	9.80	144.64
		15.00	144.54	16.00	144.52	32.41	144.20
5		-12.50	145.15	9.80	144.24	15.00	144.17
		15.00	144.16	16.00	144.16	48.35	143.72
6		15.00	144.54	15.00	144.73		
7		16.00	144.70	16.00	144.52		
8		15.00	144.17	15.00	144.54		
9		16.00	144.52	16.00	144.16		
10		15.00	144.16	15.00	143.00	16.00	143.00
		16.00	144.16				

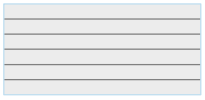
Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		19.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		

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No.	Name	Pattern	γ_{sat} [kN/m3]	γ_s [kN/m3]	n [–]
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : $\gamma = 18.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 19.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.00$ kN/m3

Engineered Fill

Unit weight : $\gamma = 20.50$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 24.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.50$ kN/m3

Coal Measures CLAY

Unit weight : $\gamma = 20.50$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 20.00$ °
Cohesion of soil : $c_{ef} = 3.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.50$ kN/m3

Coal Measures Siltstone / Mudstone / Sandstone

Unit weight : $\gamma = 21.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 30.00$ °
Cohesion of soil : $c_{ef} = 5.00$ kPa
Saturated unit weight : $\gamma_{sat} = 21.00$ kN/m3

COAL

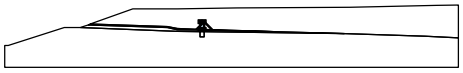
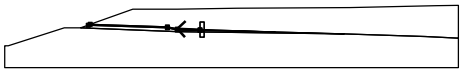
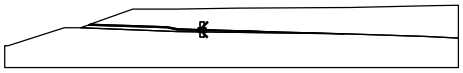
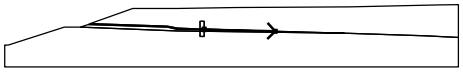
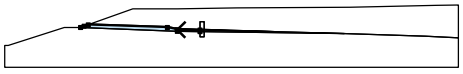
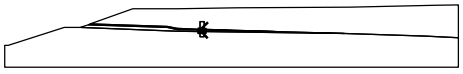
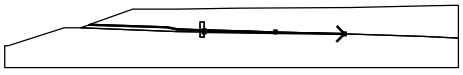
Unit weight : $\gamma = 13.00$ kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 25.00$ °
Cohesion of soil : $c_{ef} = 5.00$ kPa
Saturated unit weight : $\gamma_{sat} = 13.00$ kN/m3

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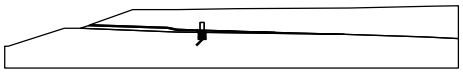
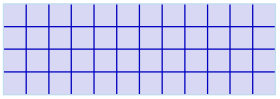
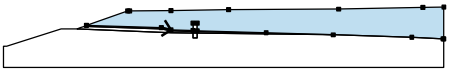
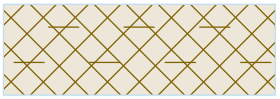
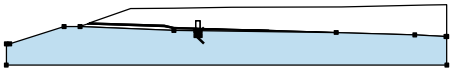
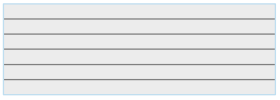
Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Gravity retianing wall		25.00

Assigning and surfaces

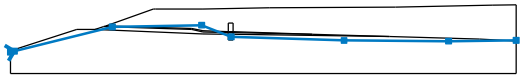
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		16.00	144.70	16.00	146.50	Gravity retianing wall
		15.00	146.50	15.00	144.73	
2		15.00	144.73	9.80	144.89	COAL
		7.50	145.40	-10.27	145.93	
		-10.73	145.76	7.50	145.15	
		9.80	144.64	15.00	144.54	
3		16.00	144.70	15.00	144.73	Gravity retianing wall
		15.00	144.54	16.00	144.52	
4		16.00	144.52	32.41	144.20	COAL
		16.00	144.70			
5		15.00	144.54	9.80	144.64	Coal Measures CLAY
		7.50	145.15	-10.73	145.76	
		-11.72	145.42	-12.50	145.15	
		9.80	144.24	15.00	144.17	
6		16.00	144.52	15.00	144.54	Gravity retianing wall
		15.00	144.17	15.00	144.16	
		16.00	144.16			
7		16.00	144.16	48.35	143.72	Coal Measures CLAY
		32.41	144.20	16.00	144.52	

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
8		15.00	143.00	16.00	143.00	Gravity retianing wall
		16.00	144.16	15.00	144.16	
9		7.50	145.40	9.80	144.89	Made Ground - Opencast Backfill
		15.00	144.73	15.00	146.50	
		16.00	146.50	16.00	144.70	
		32.41	144.20	48.35	143.72	
		67.00	143.16	74.39	142.79	
		74.60	142.78	74.60	150.30	
		69.60	150.20	49.60	149.80	
		23.50	149.68	9.80	149.44	
		0.00	149.40	-0.50	149.40	
		-10.27	145.93			
10		16.00	143.00	15.00	143.00	Coal Measures Siltstone / Mudstone / Sandstone
		15.00	144.16	15.00	144.17	
		9.80	144.24	-12.50	145.15	
		-16.30	145.15	-29.20	141.00	
		-30.00	141.00	-30.00	136.00	
		74.60	136.00	74.60	142.78	
		74.39	142.79	67.00	143.16	
		48.35	143.72	16.00	144.16	

Water

Water type : GWT

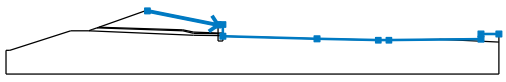
No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	15.63	143.67	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

Input data (Stage of construction 2)

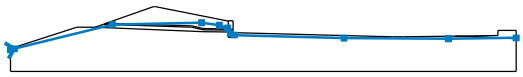
Earth cut

No.	Cut location	Coordinates of cut points [m] x	z	x	z	x	z
1		0.00	149.40	15.00	146.40	15.00	146.50
		16.00	146.50	16.00	144.00	36.00	143.50
		49.00	143.18	51.25	143.18	70.80	143.42
		70.80	144.50	74.60	144.50		

Water

Water type : GWT

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No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		9.52	146.06	13.17	145.53	14.90	144.97
		15.46	143.82	16.27	143.52	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

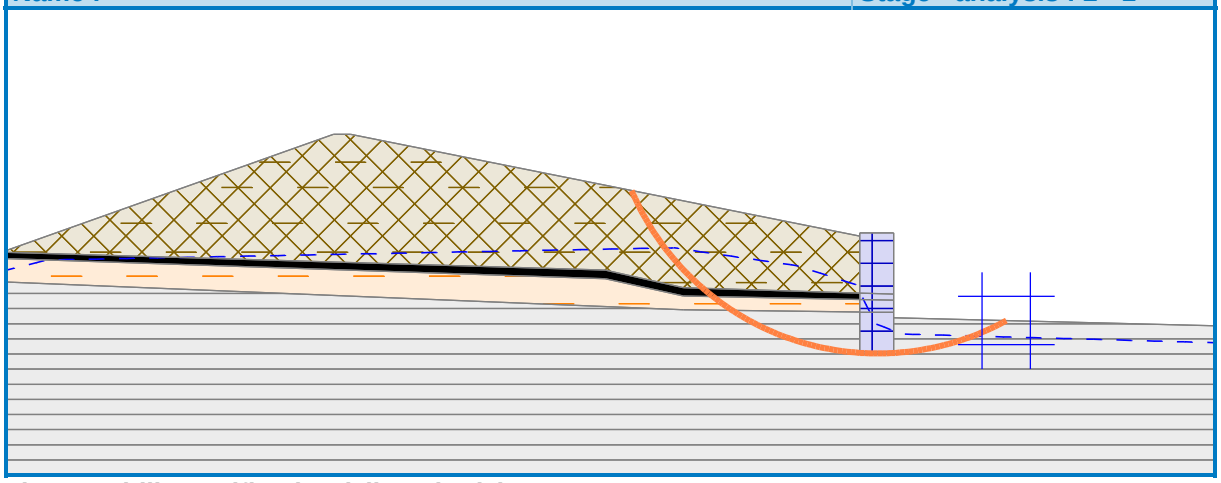
Results (Stage of construction 2) – Global Stability of Wall Check

Analysis 1 (stage 2)

Circular slip surface

Slip surface parameters							
Center :	x =	15.53	[m]	Angles :	α_1 =	-66.95	[°]
	z =	150.83	[m]		α_2 =	28.69	[°]
Radius :	R =	7.88	[m]				
Slip surface first determined via optimization with Bishop then without optimization with all methods.							

Name :	Stage - analysis : 2 - 1



Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 67.0 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 75.6 %	**ACCEPTABLE**
Spencer :	Utilization = 65.5 %	**ACCEPTABLE**
Janbu :	Utilization = 65.6 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 65.6 %	**ACCEPTABLE**

Combination 2

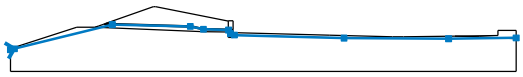
Bishop :	Utilization = 68.4 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 75.8 %	**ACCEPTABLE**
Spencer :	Utilization = 67.4 %	**ACCEPTABLE**
Janbu :	Utilization = 67.5 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 67.5 %	**ACCEPTABLE**

Input data (Stage of construction 3)

Water

Water type : GWT

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No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-30.00	140.48	-29.20	140.68	-8.94	145.70
		7.18	145.31	9.89	144.73	15.09	144.56
		15.46	143.82	16.27	143.52	38.98	142.89
		60.59	142.75	74.60	142.94		

Settings of the stage of construction

Design situation : permanent

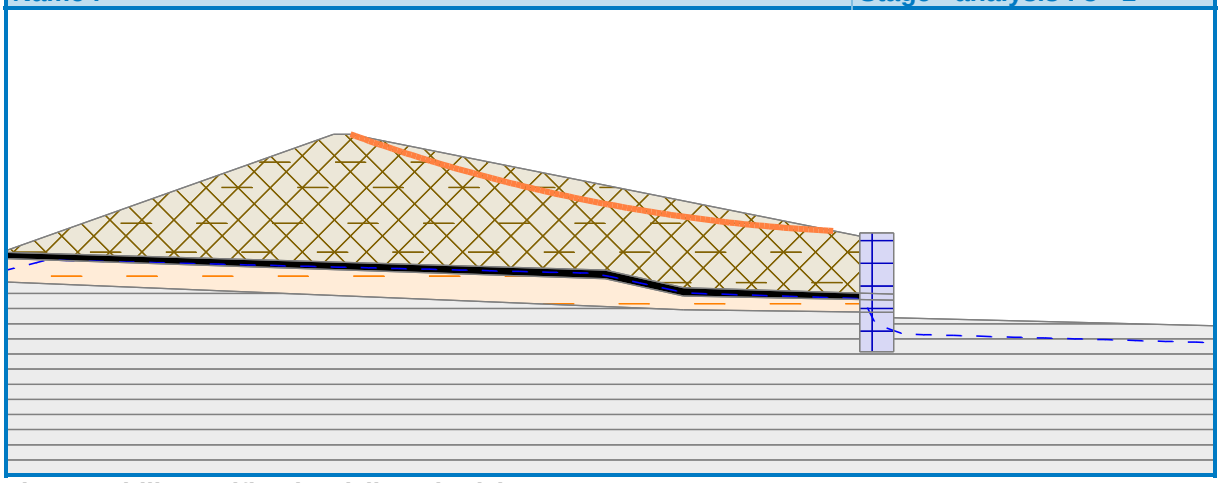
Results (Stage of construction 3) –Stability of Upper Slope Check

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	16.61	[m]	Angles :	α_1 =	-19.82	[°]
	z =	195.48	[m]		α_2 =	-2.80	[°]
Radius :	R =	48.98	[m]				
Slip surface first determined via optimization with Bishop then without optimization with all methods.							

Name :	Stage - analysis : 3 - 1



Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 57.7 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 57.9 %	**ACCEPTABLE**
Spencer :	Utilization = 57.7 %	**ACCEPTABLE**
Janbu :	Utilization = 57.7 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 57.7 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 71.9 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 72.3 %	**ACCEPTABLE**
Spencer :	Utilization = 71.9 %	**ACCEPTABLE**
Janbu :	Utilization = 71.9 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 71.9 %	**ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section O-O' Slopes
Author : Fiona Connor
Date : 15/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

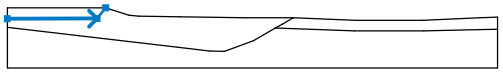
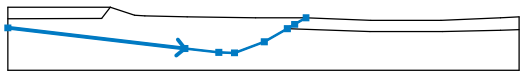
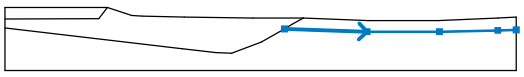
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

Permanent design situation

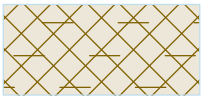
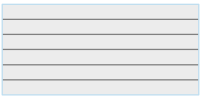
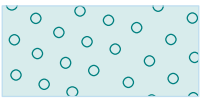
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

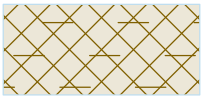
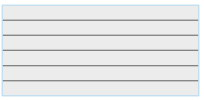
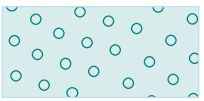
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	9.93	27.13	10.00	29.67	13.25
2		0.00	13.25	29.67	13.25	36.67	11.00
		39.67	10.77	51.88	10.50	71.73	10.27
		86.33	10.25	105.10	9.50	125.39	9.49
		142.67	10.25	148.00	10.48		
3		0.00	7.32	51.30	1.34	61.10	0.21
		65.60	0.07	74.23	3.27	80.88	7.11
		83.03	8.34	86.33	10.25		
4		80.88	7.11	104.79	6.29	125.73	6.29
		142.67	6.66	148.00	6.78		

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Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		19.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00
6	M1 construction		38.50	0.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		
6	M1 construction		21.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 19.00 °

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Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m3

Engineered Fill
Unit weight : γ = 20.50 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

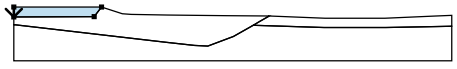
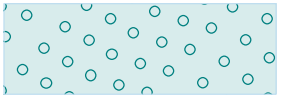
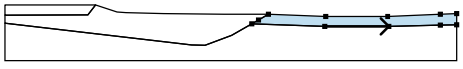
Coal Measures CLAY
Unit weight : γ = 20.50 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

Coal Measures Siltstone / Mudstone / Sandstone
Unit weight : γ = 21.00 kN/m3
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/m3

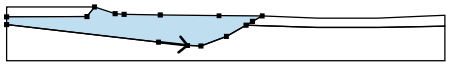
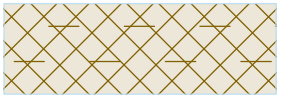
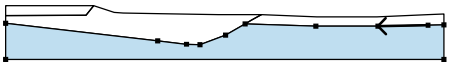
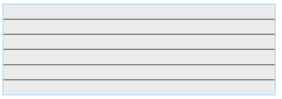
COAL
Unit weight : γ = 13.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m3

M1 construction
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.50 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	13.25	0.00	9.93	M1 construction
		27.13	10.00	29.67	13.25	
2		104.79	6.29	125.73	6.29	Coal Measures CLAY
		142.67	6.66	148.00	6.78	
		148.00	10.48	142.67	10.25	
		125.39	9.49	105.10	9.50	
		86.33	10.25	83.03	8.34	
		80.88	7.11			

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
3		51.30	1.34	61.10	0.21	Made Ground - Opencast Backfill
		65.60	0.07	74.23	3.27	
		80.88	7.11	83.03	8.34	
		86.33	10.25	71.73	10.27	
		51.88	10.50	39.67	10.77	
		36.67	11.00	29.67	13.25	
		27.13	10.00	0.00	9.93	
		0.00	7.32			
4		142.67	6.66	125.73	6.29	Coal Measures Siltstone / Mudstone / Sandstone
		104.79	6.29	80.88	7.11	
		74.23	3.27	65.60	0.07	
		61.10	0.21	51.30	1.34	
		0.00	7.32	0.00	-4.93	
		148.00	-4.93	148.00	6.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	4.55	90.29	5.30	131.92	5.07
		142.67	5.30	148.00	5.41		

Tensile crack

Tensile crack not input.

Earthquake

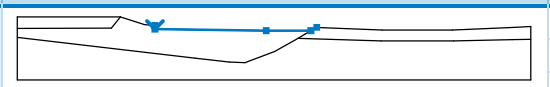
Earthquake not included.

Settings of the stage of construction

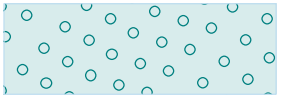
Design situation : permanent

Input data (Stage of construction 2)

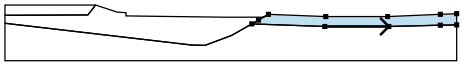
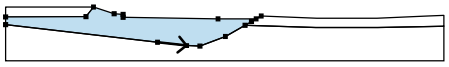
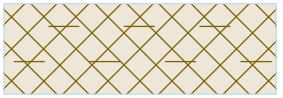
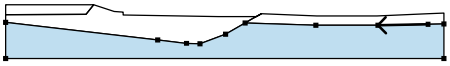
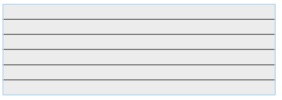
Earth cut

No.	Cut location	Coordinates of cut points [m]					
		x	z	x	z	x	z
1		39.67	10.77	39.67	9.77	71.73	9.27
		84.61	9.26	86.33	10.25		

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		27.13	10.00	29.67	13.25	M1 construction
		0.00	13.25	0.00	9.93	

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No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		104.79	6.29	125.73	6.29	Coal Measures CLAY
		142.67	6.66	148.00	6.78	
		148.00	10.48	142.67	10.25	
		125.39	9.49	105.10	9.50	
		86.33	10.25	83.03	8.34	
		80.88	7.11			
3		51.30	1.34	61.10	0.21	Made Ground - Opencast Backfill
		65.60	0.07	74.23	3.27	
		80.88	7.11	83.03	8.34	
		86.33	10.25	84.61	9.26	
		71.73	9.27	39.67	9.77	
		39.67	10.77	36.67	11.00	
		29.67	13.25	27.13	10.00	
		0.00	9.93	0.00	7.32	
4		142.67	6.66	125.73	6.29	Coal Measures Siltstone / Mudstone / Sandstone
		104.79	6.29	80.88	7.11	
		74.23	3.27	65.60	0.07	
		61.10	0.21	51.30	1.34	
		0.00	7.32	0.00	-4.93	
		148.00	-4.93	148.00	6.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	4.55	90.29	5.30	131.92	5.07
		142.67	5.30	148.00	5.41		

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

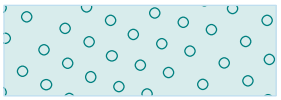
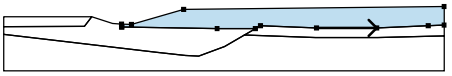
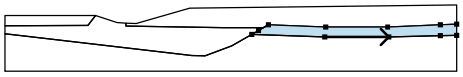
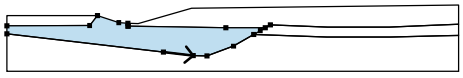
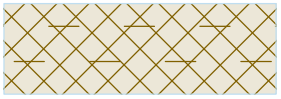
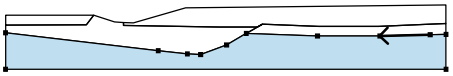
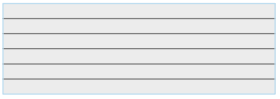
Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		39.67	10.77	42.98	10.70	60.52	15.70
		148.00	16.70				

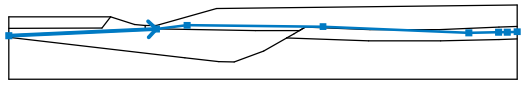
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Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		27.13	10.00	29.67	13.25	M1 construction
		0.00	13.25	0.00	9.93	
2		105.10	9.50	125.39	9.49	Engineered Fill
		142.67	10.25	148.00	10.48	
		148.00	16.70	60.52	15.70	
		42.98	10.70	39.67	10.77	
		39.67	9.77	39.72	9.77	
		71.73	9.27	84.61	9.26	
		86.33	10.25			
3		104.79	6.29	125.73	6.29	Coal Measures CLAY
		142.67	6.66	148.00	6.78	
		148.00	10.48	142.67	10.25	
		125.39	9.49	105.10	9.50	
		86.33	10.25	83.03	8.34	
		80.88	7.11			
4		51.30	1.34	61.10	0.21	Made Ground - Opencast Backfill
		65.60	0.07	74.23	3.27	
		80.88	7.11	83.03	8.34	
		86.33	10.25	84.61	9.26	
		71.73	9.27	39.72	9.77	
		39.67	9.77	39.67	10.77	
		36.67	11.00	29.67	13.25	
		27.13	10.00	0.00	9.93	
		0.00	7.32			
5		142.67	6.66	125.73	6.29	Coal Measures Siltstone / Mudstone / Sandstone
		104.79	6.29	80.88	7.11	
		74.23	3.27	65.60	0.07	
		61.10	0.21	51.30	1.34	
		0.00	7.32	0.00	-4.93	
		148.00	-4.93	148.00	6.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	7.75	42.96	9.71	51.89	10.78
		91.47	10.40	133.94	8.62	142.56	8.76
		145.10	8.76	148.00	8.91		

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 =	48.65	[m]	Angles :	α_1 =	-48.42	[°]
	z =	20.19	[m]		α_2 =	71.39	[°]
Radius :	R =	14.02	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (all methods)

Combination 1

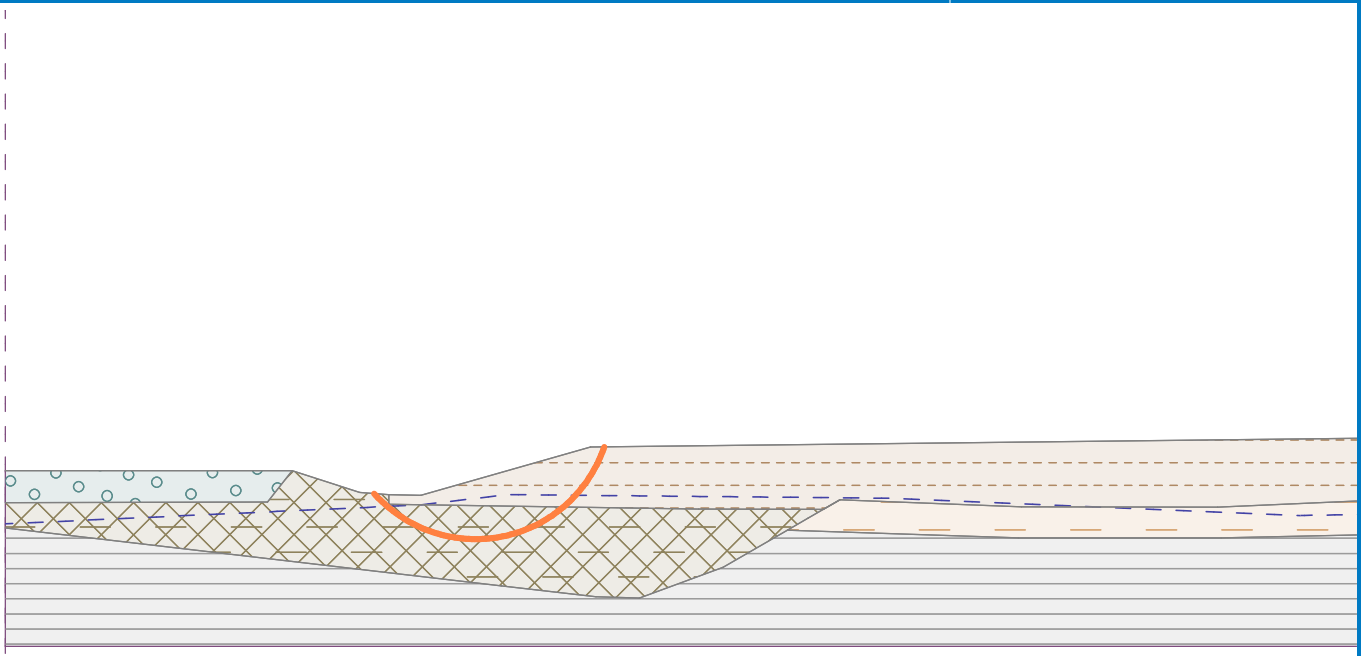
Bishop : Utilization = 83.1 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 105.2 % **NOT ACCEPTABLE**
Spencer : Utilization = 83.0 % **ACCEPTABLE**
Janbu : Utilization = 82.8 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 82.8 % **ACCEPTABLE**

Combination 2

Bishop : Utilization = 76.1 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 96.0 % **ACCEPTABLE**
Spencer : Utilization = 76.4 % **ACCEPTABLE**
Janbu : Utilization = 76.2 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 76.2 % **ACCEPTABLE**

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Name :	Stage - analysis : 3 - 1

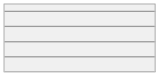



M1 construction


Engineered Fill


Coal Measures CLAY


Made Ground - Opencast Backfill


Coal Measures Siltstone / Mudstone / Sandstone

Analysis of the slip surface without optimization.

Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 83.1 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 105.2 %	**NOT ACCEPTABLE**
Spencer :	Utilization = 83.0 %	**ACCEPTABLE**
Janbu :	Utilization = 82.8 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 82.8 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 76.1 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 96.0 %	**ACCEPTABLE**
Spencer :	Utilization = 76.4 %	**ACCEPTABLE**
Janbu :	Utilization = 76.2 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 76.2 %	**ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section O-O' Slope Stability
Description : Slope at 1v:5h with 1m deep re-engineering of backfill beneath
Customer : Newlands Developments
Author : Adam Perks
Date : 15/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

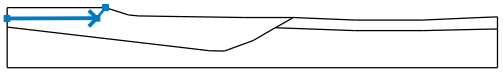
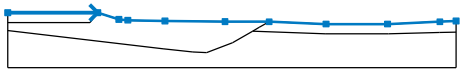
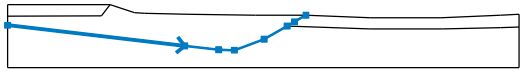
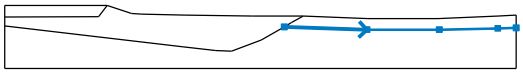
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

Permanent design situation

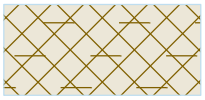
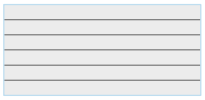
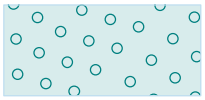
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

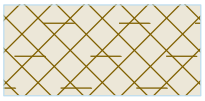
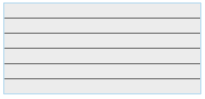
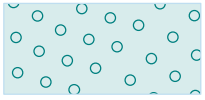
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	9.93	27.13	10.00	29.67	13.25
2		0.00	13.25	29.67	13.25	36.67	11.00
		39.67	10.77	51.88	10.50	71.73	10.27
		86.33	10.25	105.10	9.50	125.39	9.49
		142.67	10.25	148.00	10.48		
3		0.00	7.32	51.30	1.34	61.10	0.21
		65.60	0.07	74.23	3.27	80.88	7.11
		83.03	8.34	86.33	10.25		
4		80.88	7.11	104.79	6.29	125.73	6.29
		142.67	6.66	148.00	6.78		

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Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		19.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00
6	M1 construction		38.50	0.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		
6	M1 construction		21.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : γ = 18.00 kN/m^3

Stress-state : effective

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Angle of internal friction : φ_{ef} = 19.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.00 kN/m3

Engineered Fill
Unit weight : γ = 20.50 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 24.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

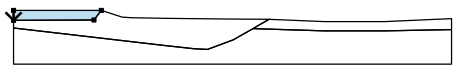
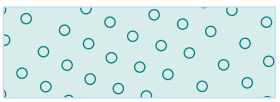
Coal Measures CLAY
Unit weight : γ = 20.50 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 20.00 °
Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m3

Coal Measures Siltstone / Mudstone / Sandstone
Unit weight : γ = 21.00 kN/m3
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/m3

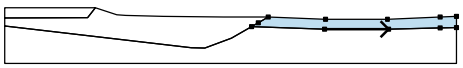
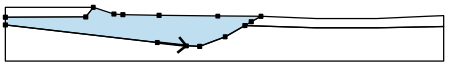
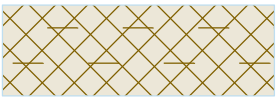
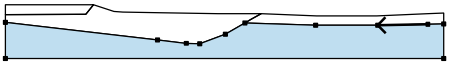
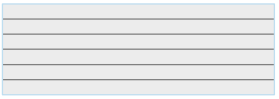
COAL
Unit weight : γ = 13.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m3

M1 construction
Unit weight : γ = 21.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.50 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Assigning and surfaces

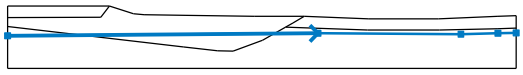
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		0.00	13.25	0.00	9.93	M1 construction
		27.13	10.00	29.67	13.25	

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No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
2		104.79	6.29	125.73	6.29	Coal Measures CLAY
		142.67	6.66	148.00	6.78	
		148.00	10.48	142.67	10.25	
		125.39	9.49	105.10	9.50	
		86.33	10.25	83.03	8.34	
		80.88	7.11			
3		51.30	1.34	61.10	0.21	Made Ground - Opencast Backfill
		65.60	0.07	74.23	3.27	
		80.88	7.11	83.03	8.34	
		86.33	10.25	71.73	10.27	
		51.88	10.50	39.67	10.77	
		36.67	11.00	29.67	13.25	
		27.13	10.00	0.00	9.93	
		0.00	7.32			
4		142.67	6.66	125.73	6.29	Coal Measures Siltstone / Mudstone / Sandstone
		104.79	6.29	80.88	7.11	
		74.23	3.27	65.60	0.07	
		61.10	0.21	51.30	1.34	
		0.00	7.32	0.00	-4.93	
		148.00	-4.93	148.00	6.78	

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	4.55	90.29	5.30	131.92	5.07
		142.67	5.30	148.00	5.41		

Settings of the stage of construction

Design situation : permanent

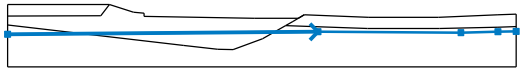
Input data (Stage of construction 2)

Earth cut

No.	Cut location	Coordinates of cut points [m] x	z	x	z	x	z
1		39.67	10.77	39.67	9.77	71.73	9.27
		84.61	9.26	86.33	10.25		

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	4.55	90.29	5.30	131.92	5.07
		142.67	5.30	148.00	5.41		

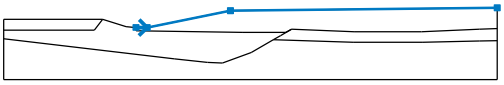
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Settings of the stage of construction

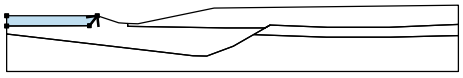
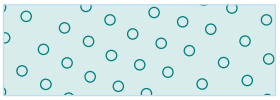
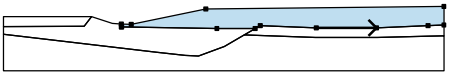
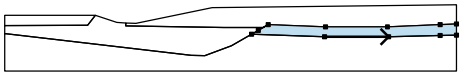
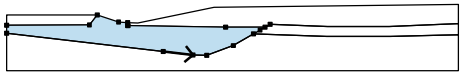
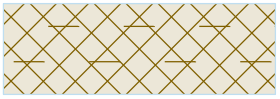
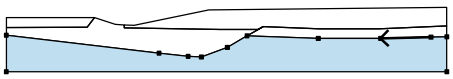
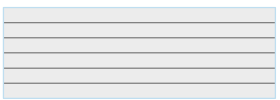
Design situation : permanent

Input data (Stage of construction 3)

Embankment interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		39.67	10.77	42.98	10.70	68.00	15.79
		148.00	16.70				

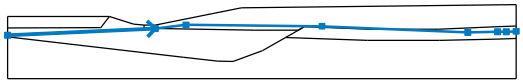
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		27.13	10.00	29.67	13.25	M1 construction
		0.00	13.25	0.00	9.93	
2		105.10	9.50	125.39	9.49	Engineered Fill
		142.67	10.25	148.00	10.48	
		148.00	16.70	68.00	15.79	
		42.98	10.70	39.67	10.77	
		39.67	9.77	39.72	9.77	
		71.73	9.27	84.61	9.26	
		86.33	10.25			
3		104.79	6.29	125.73	6.29	Coal Measures CLAY
		142.67	6.66	148.00	6.78	
		148.00	10.48	142.67	10.25	
		125.39	9.49	105.10	9.50	
		86.33	10.25	83.03	8.34	
		80.88	7.11			
4		51.30	1.34	61.10	0.21	Made Ground - Opencast Backfill
		65.60	0.07	74.23	3.27	
		80.88	7.11	83.03	8.34	
		86.33	10.25	84.61	9.26	
		71.73	9.27	39.72	9.77	
		39.67	9.77	39.67	10.77	
		36.67	11.00	29.67	13.25	
		27.13	10.00	0.00	9.93	
		0.00	7.32			
5		142.67	6.66	125.73	6.29	Coal Measures Siltstone / Mudstone / Sandstone
		104.79	6.29	80.88	7.11	
		74.23	3.27	65.60	0.07	
		61.10	0.21	51.30	1.34	
		0.00	7.32	0.00	-4.93	
		148.00	-4.93	148.00	6.78	

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Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	7.75	42.96	9.71	51.89	10.78
		91.47	10.40	133.94	8.62	142.56	8.76
		145.10	8.76	148.00	8.91		

Settings of the stage of construction

Design situation : permanent

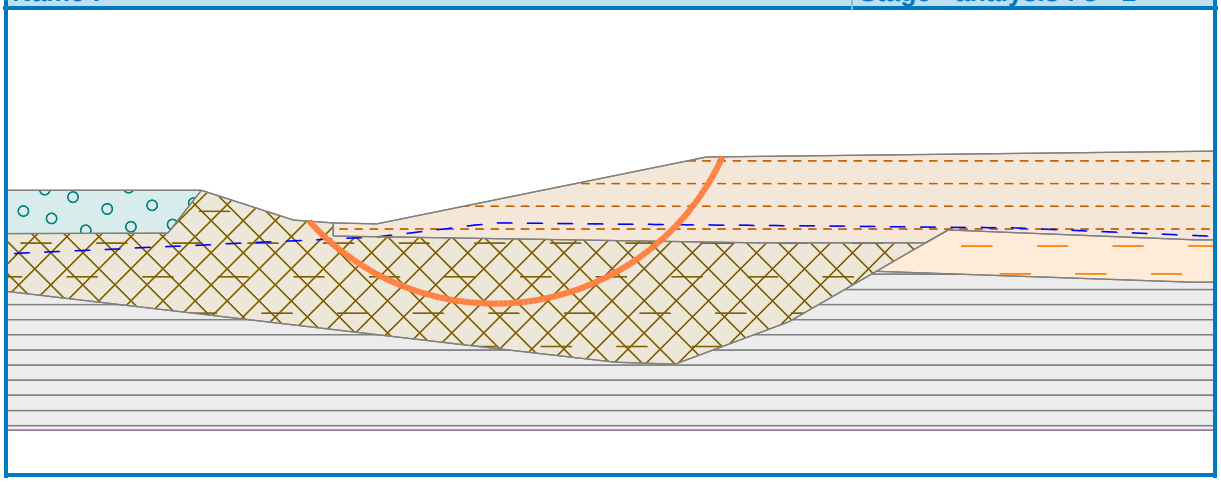
Results (Stage of construction 3)

Analysis 1 (stage 3)

Circular slip surface

Slip surface parameters							
Center :	x =	51.93	[m]	Angles :	α_1 =	-47.90	[°]
	z =	23.62	[m]		α_2 =	65.65	[°]
Radius :	R =	18.96	[m]				
Slip surface first determined via optimization with Bishop then without optimization with all methods.							

Name :	Stage - analysis : 3 - 1



Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 74.3 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 91.8 %	**ACCEPTABLE**
Spencer :	Utilization = 74.3 %	**ACCEPTABLE**
Janbu :	Utilization = 74.1 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 74.1 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 63.7 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 78.4 %	**ACCEPTABLE**
Spencer :	Utilization = 63.9 %	**ACCEPTABLE**
Janbu :	Utilization = 63.7 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 63.7 %	**ACCEPTABLE**

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Slope stability analysis

Input data

Project

Task : Section P-P' Slope Stability
Author : Fiona Connor
Date : 15/06/2020
Project ID : Hoyland Common, Barnsley
Project number : AG3080-19

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

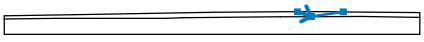
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)

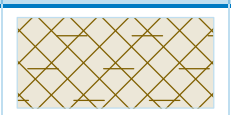
Permanent design situation

		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	[–]

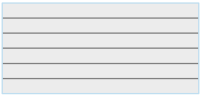
Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.11	26.56	0.55	68.52	1.24
		96.31	1.42	105.76	1.49	111.36	1.41
		136.44	1.10				
2		96.31	1.42	100.81	-0.08	111.36	1.41
3		0.00	-1.00	16.54	-0.78	31.11	-0.72
		52.96	-0.78	58.36	-0.50	90.76	-0.22
		100.81	-0.18	116.86	-0.16	136.44	-0.47

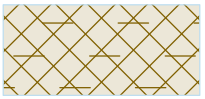
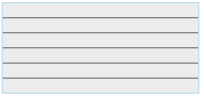
Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Made Ground - Opencast Backfill		15.00	0.00	18.00
2	Engineered Fill		24.00	0.00	20.50

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No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
3	Coal Measures CLAY		20.00	3.00	20.50
4	Coal Measures Siltstone / Mudstone / Sandstone		30.00	5.00	21.00
5	COAL		25.00	5.00	13.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Made Ground - Opencast Backfill		20.00		
2	Engineered Fill		20.50		
3	Coal Measures CLAY		20.50		
4	Coal Measures Siltstone / Mudstone / Sandstone		21.00		
5	COAL		13.00		

Soil parameters

Made Ground - Opencast Backfill

Unit weight : $\gamma = 18.00$ kN/m^3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 15.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.00$ kN/m^3

Engineered Fill

Unit weight : $\gamma = 20.50$ kN/m^3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 24.00$ °
Cohesion of soil : $c_{ef} = 0.00$ kPa
Saturated unit weight : $\gamma_{sat} = 20.50$ kN/m^3

Coal Measures CLAY

Unit weight : $\gamma = 20.50$ kN/m^3
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 20.00$ °

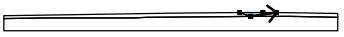
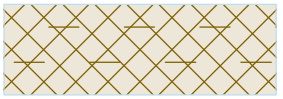
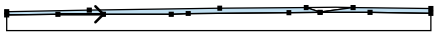
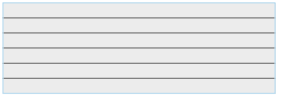
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Cohesion of soil : c_{ef} = 3.00 kPa
Saturated unit weight : γ_{sat} = 20.50 kN/m^3

Coal Measures Siltstone / Mudstone / Sandstone
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

COAL
Unit weight : γ = 13.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 25.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 13.00 kN/m^3

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		100.81	-0.08	111.36	1.41	Made Ground - Opencast Backfill
		105.76	1.49	96.31	1.42	
2		16.54	-0.78	31.11	-0.72	Coal Measures CLAY
		52.96	-0.78	58.36	-0.50	
		90.76	-0.22	100.81	-0.18	
		116.86	-0.16	136.44	-0.47	
		136.44	1.10	111.36	1.41	
		100.81	-0.08	96.31	1.42	
		68.52	1.24	26.56	0.55	
		0.00	0.11	0.00	-1.00	
3		116.86	-0.16	100.81	-0.18	Coal Measures Siltstone / Mudstone / Sandstone
		90.76	-0.22	58.36	-0.50	
		52.96	-0.78	31.11	-0.72	
		16.54	-0.78	0.00	-1.00	
		0.00	-6.00	136.44	-6.00	
		136.44	-0.47			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-1.64	16.67	-1.51	44.22	-1.55
		101.52	-1.53	136.44	-1.53		

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

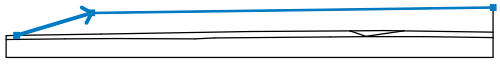
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Settings of the stage of construction

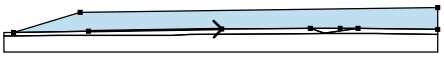
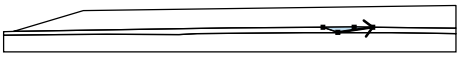
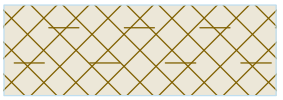
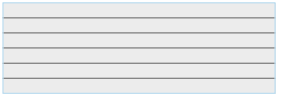
Design situation : permanent

Input data (Stage of construction 2)

Embankment interface

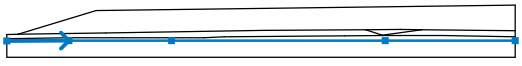
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		3.01	0.16	24.01	6.50	136.44	8.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		26.56	0.55	68.52	1.24	Engineered Fill
		96.31	1.42	105.76	1.49	
		111.36	1.41	136.44	1.10	
		136.44	8.00	24.01	6.50	
		3.01	0.16			
2		100.81	-0.08	111.36	1.41	Made Ground - Opencast Backfill
		105.76	1.49	96.31	1.42	
3		16.54	-0.78	31.11	-0.72	Coal Measures CLAY
		52.96	-0.78	58.36	-0.50	
		90.76	-0.22	100.81	-0.18	
		116.86	-0.16	136.44	-0.47	
		136.44	1.10	111.36	1.41	
		100.81	-0.08	96.31	1.42	
		68.52	1.24	26.56	0.55	
		3.01	0.16	0.00	0.11	
		0.00	-1.00			
4		116.86	-0.16	100.81	-0.18	Coal Measures Siltstone / Mudstone / Sandstone
		90.76	-0.22	58.36	-0.50	
		52.96	-0.78	31.11	-0.72	
		16.54	-0.78	0.00	-1.00	
		0.00	-6.00	136.44	-6.00	
		136.44	-0.47			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-1.64	16.67	-1.51	44.22	-1.55
		101.52	-1.53	136.44	-1.53		

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

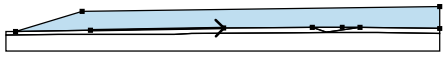
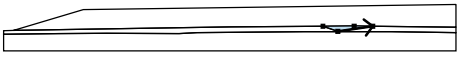
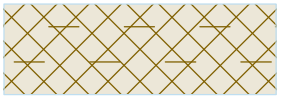
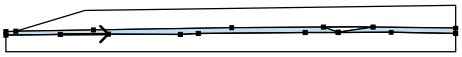
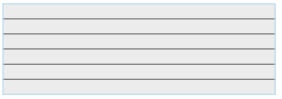
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Settings of the stage of construction

Design situation : permanent

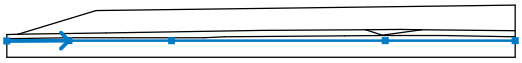
Input data (Stage of construction 3)

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		26.56	0.55	68.52	1.24	Engineered Fill
		96.31	1.42	105.76	1.49	
		111.36	1.41	136.44	1.10	
		136.44	8.00	24.01	6.50	
		3.01	0.16			
2		100.81	-0.08	111.36	1.41	Made Ground - Opencast Backfill
		105.76	1.49	96.31	1.42	
3		16.54	-0.78	31.11	-0.72	Coal Measures CLAY
		52.96	-0.78	58.36	-0.50	
		90.76	-0.22	100.81	-0.18	
		116.86	-0.16	136.44	-0.47	
		136.44	1.10	111.36	1.41	
		100.81	-0.08	96.31	1.42	
		68.52	1.24	26.56	0.55	
		3.01	0.16	0.00	0.11	
		0.00	-1.00			
4		116.86	-0.16	100.81	-0.18	Coal Measures Siltstone / Mudstone / Sandstone
		90.76	-0.22	58.36	-0.50	
		52.96	-0.78	31.11	-0.72	
		16.54	-0.78	0.00	-1.00	
		0.00	-6.00	136.44	-6.00	
		136.44	-0.47			

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m] x	z	x	z	x	z
1		0.00	-1.64	16.67	-1.51	44.22	-1.55
		101.52	-1.53	136.44	-1.53		

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

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Slip surface parameters							
Center :	x =	6.20	[m]	Angles :	α_1 =	-7.06	[°]
	z =	37.17	[m]		α_2 =	34.85	[°]
Radius :	R =	37.31	[m]				
Analysis of the slip surface without optimization.							

Slope stability verification (all methods)

Combination 1

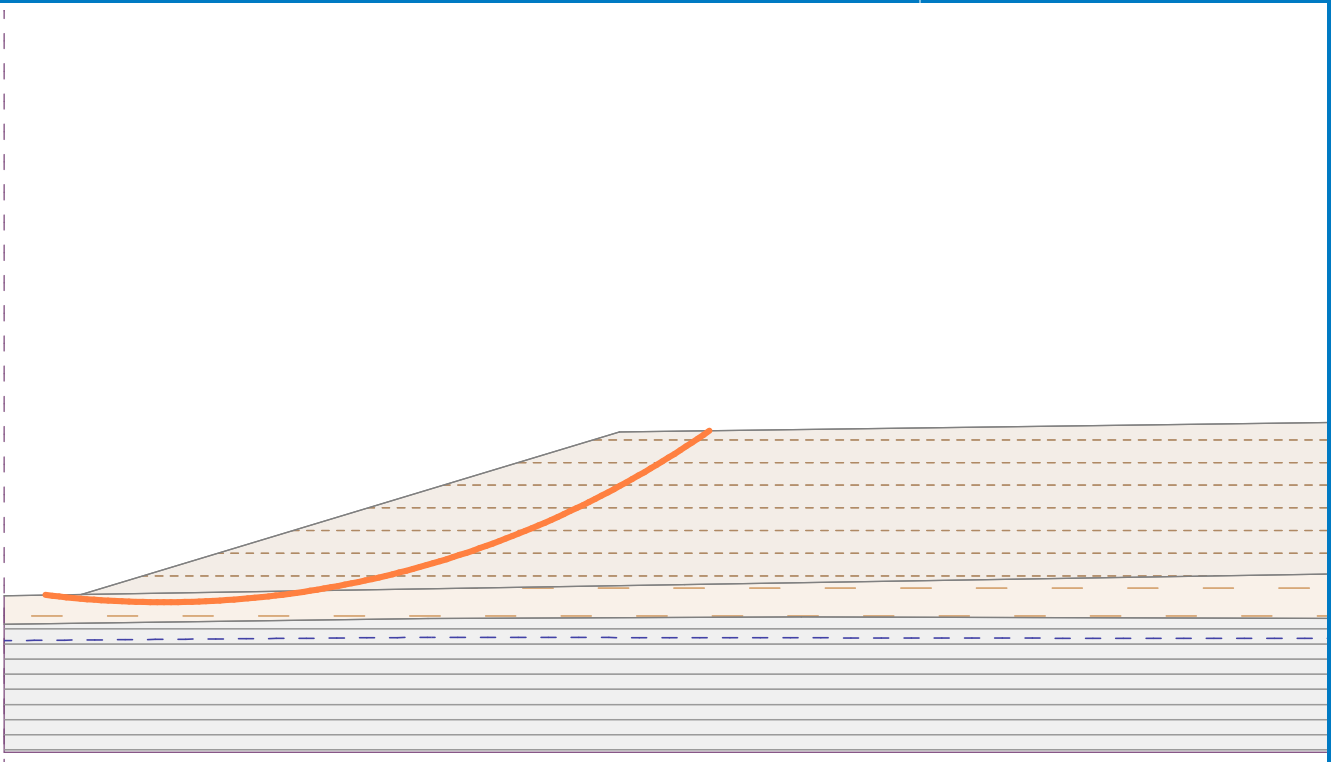
Bishop : Utilization = 61.7 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 63.6 % **ACCEPTABLE**
Spencer : Utilization = 61.9 % **ACCEPTABLE**
Janbu : Utilization = 61.9 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 61.9 % **ACCEPTABLE**

Combination 2

Bishop : Utilization = 72.7 % **ACCEPTABLE**
Fellenius / Petterson : Utilization = 74.9 % **ACCEPTABLE**
Spencer : Utilization = 72.9 % **ACCEPTABLE**
Janbu : Utilization = 72.9 % **ACCEPTABLE**
Morgenstern-Price : Utilization = 73.0 % **ACCEPTABLE**

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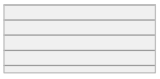
Name :	Stage - analysis : 3 - 1




Engineered Fill


Made Ground - Opencast Backfill


Coal Measures CLAY


Coal Measures Siltstone / Mudstone / Sandstone

Analysis of the slip surface without optimization.

Slope stability verification (all methods)

Combination 1

Bishop :	Utilization = 61.7 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 63.6 %	**ACCEPTABLE**
Spencer :	Utilization = 61.9 %	**ACCEPTABLE**
Janbu :	Utilization = 61.9 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 61.9 %	**ACCEPTABLE**

Combination 2

Bishop :	Utilization = 72.7 %	**ACCEPTABLE**
Fellenius / Petterson :	Utilization = 74.9 %	**ACCEPTABLE**
Spencer :	Utilization = 72.9 %	**ACCEPTABLE**
Janbu :	Utilization = 72.9 %	**ACCEPTABLE**
Morgenstern-Price :	Utilization = 73.0 %	**ACCEPTABLE**

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ANNEX
IV

Summary of relevant soil parameters from Applied Geology GIR

- Uncorrected plasticity index ranged from 18% to 38% with an average of 24%;
- Liquid limits ranged from 36% to 65%;
- Plastic limits ranged from 18% to 26%;
- Moisture contents ranged from 8% to 28%;
- Fines content ranged from 22% to 88%;
- SPT N ranged from 4 to 26 with average around 12 (ignoring high values due to likely obstructions);
- No UT100s were recovered – QUDs on undisturbed weathered coal measures clay gave shear strengths of 40 and 52 kN/m^2 on two samples.

AG Small Shear Box Test

- Undertaken on recompacted weathered coal measures clay at optimum mc and using 2.5kg rammer. Confining pressures of 50, 100 & 200 kN/m^2 used;
- $Ø'_p$ was 24.5^o based on straight line (some cohesion indicated);
- $Ø'_r$ was 19.5^o based on straight line (some cohesion indicated).

AG CPT results

The interpreted friction angle values displayed on the CPT plots are based on the Kulhawy and Mayne (1990) method, which is intended for use with granular soils. This method is also sensitive to larger grain size particles (such as coarse gravel and cobble sized coal measure rock fragments present in the Opencast Backfill), which increase tip resistance and artificially raise friction angle. The granular material in the Opencast Backfill is considered to be present as discrete pockets and 'lumps', which are not contiguous and are chaotically distributed. Hence the CPT interpreted values, that are often >30°, are not considered to represent the materials as a whole and little reliance is drawn from these values.

Other Sources and Publications

In the process of determining the design friction angle for the Made Ground-Opencast Backfill a series of published works and sources were reviewed to provide context. Whilst none of the materials in the published sources can be a direct analogue to the materials on this site, their properties have provided a useful framework.

No.	Source / Publication	Range of friction angle values	Notes / Description
1	BS8002:2015	For PI = 24%, Ø'cv is c. 25° For PI = 38%, Ø'cv is c. 22.5°	Gives values for Ø'cv based on plasticity - values for natural undisturbed clays.
2	BRE: FB75 Building on Fill	For a cohesive fill, Ø'cv is stated as being between 20° and 30° (Table 5).	p44 suggests for non-engineered fills Ø'cv is appropriate. For a granular fill, Ø'cv is stated as being close to the angle of repose.
3	Clarke, BG: Engineering Properties of Glacial Tills, 2018	15° to 40° overall and generally in range 15° to 30° for the relevant range of PI.	From Fig 16.
4	Sorenson & Okkels: Correlation between drained shear strength and plasticity index of undisturbed overconsolidated clays, 2013	Suggests Ø'nc lower bound = 20° to 25° for PI in range 20-40%.	Values are for normally consolidated reconstituted clays. A similar range is also quoted for over consolidated clays. The values are valid for soils with <80% fines. Also states that a 'mobilised' angle of shearing resistance, which is lower than estimated peak values, may be applicable.
5	Stard & Eid, Slope stability analyses in stiff fissured clays, 1997	Quotes various residual friction angles as follows: Lias Clay failures – 14.5°; Carsington Dam failure – 12°; London Clay failures – 14.2°.	Reports differences between 'fully softened' friction angle and residual friction angle is in the range 4 – 8° for the relevant range of liquid limits (40-60%).
6	R K Taylor, Composition and engineering properties of British colliery discards, NCBs, 1983	<u>Triaxial & shear box</u> Coarse discards: Ø' in the range 22.5-38.5°; Fine discards: 19-50° but with outliers: 16°, 53° & 60°; Tailings: 19-43° with outliers of 16° and 46°. <u>Section 4.9 'shear strengths at large deformations (failures)':</u> Coarse discard material at Aberfan - Ø'p of 39.5° dropped to 17.5-18.5° for failed slope; Littleton Tip - Ø'r of 20.5°; Askern Colliery shear tests (0-400kN/m^2 pressures) Ø'r: 18-22°; Other values of Ø'r are quoted as 26.6°, 18.3° & 26.6°.	In summary, Ø'r ranged from 9° to 37° with an average of 17.5° for UK discards based on 31 tests.

Discussion

Up to approximately one quarter of the materials are predominantly granular and many of the clay 'lumps' and pockets encountered were of firm through to stiff consistency suggesting that peak or near peak values of friction angle may be valid locally. It is also likely that some of the materials have experienced greater strain and softening and residual strength parameters are more appropriate. When assessing an averaged global design value for the Opencast Backfill peak values of friction angle of say >20° are not considered appropriate due to the disturbance to the original soil structure and the likelihood that a significant proportion of the clays would be strain and / or water softened to some degree. Fully residual values are considered to be too conservative given the expected beneficial effects of the granular proportion and firm to stiff, peak or near peak, clays.

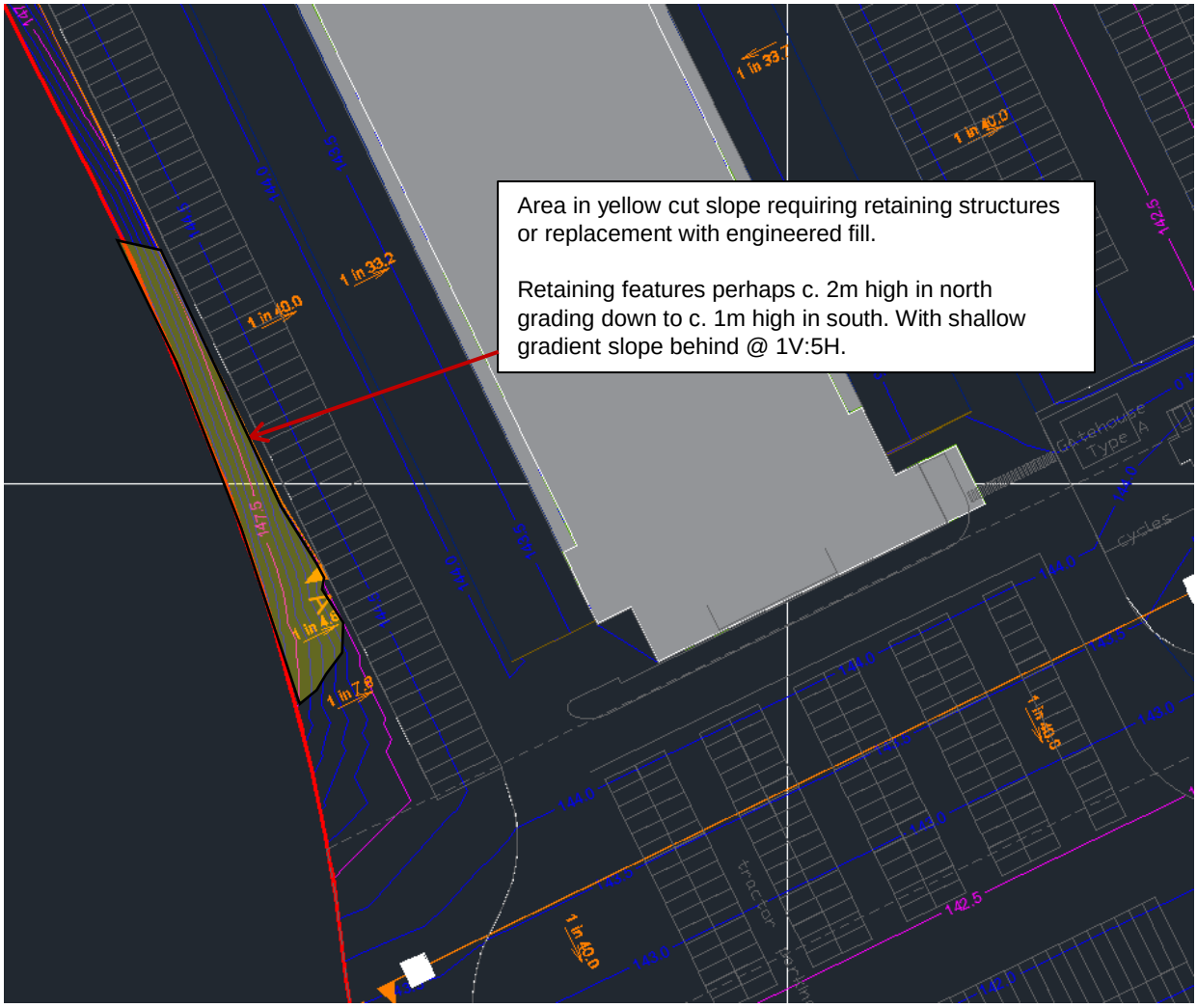
In conclusion, from study of the laboratory tested properties of the Made Ground-Opencast Backfill, together with context from published values for other similar (but not identical) Made Ground fills, 'mobilised' or strain softened friction angles are considered most appropriate. Such values are considered to fall within the range of >15° and <20°. Hence, a design value of 19° has been chosen with 17° also considered as part of sensitivity checks.

Plot	Section Line	Post cut/fill slope geometry and geology	Undrained Stability (% optimisation)
Plot 1	E-E'	16m long slope at 5.5m high at a gradient of 1v:3h. Upper slope is Coal Measures clay and lower slope is rock.	Shallow slip in clay – 6.8% (Cu: 60) Deeper slip through rock – 6.1% (Ci: 300)
	F-F'	35m long slope at 3m high at a total gradient of 1v:11.5h. Slip circle analysed consists of 'mini slope' at slightly steeper gradient near foot of slope comprising 7.5m long slope 0.9m high at a gradient of 1v:8h. whole slope comprises Opencast Backfill overlying Coal Measures rock.	13.2% (Cu: 30, 50, 40)
	O-O'	17.5m long slope at 5m high at a gradient of 1v:3.5h. Slope is an engineered fill embankment on top of Opencast Backfill with top 1m re-engineered.	64.8% (Cu: 30, 50, 40)
	P-P'	21m long slope at 6.5m high at a gradient of 1v:3.2h. Slope is an engineered fill embankment on to natural Coal Measures clay then rock.	19.8%
	Q-Q'	22m long slope at 6.5m high at a gradient of 1v:3.4h. Slope is an engineered fill embankment on to natural Coal Measures clay then rock.	24.7%
	R-R'	15.5m long cut slope at 5.25m high at a gradient of 1v:3h. c. ¾ of slope is formed of cut Opencast Backfill with the bottom c. ¼ made up of a coal seam and CM clay then rock. Long term slope at 1v:3h gradient is not stable and retaining wall or re-engineering required.	28.0% (Cu: 30, 50, 40)
Plot 1 / Plot 2 Boundary	T-T'	23m long slope at 5.7m high at a gradient of 1v:4h. Slope crest is Engineered Fill and rest of slope is cut Opencast Backfill on top of further backfill materials. No surcharge as east of slope toe is the no build zone of Plot 2.	63.5% (Cu: 30, 50, 40)
Plot 2	J-J'	27m long slope at 9m high at a gradient of 1v:3h. Engineered embankment with underlying Opencast Backfill removed and re-engineered. Surcharge mound on top of embankment, surcharge 6m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 46.1% (Cu: 30, 50, 40) After addition of surcharge – 84.7% (Cu: 30, 50, 40)
	K-K'	80m long slope at 13m high at a gradient of 1v:4.5h. Engineered embankment with underlying Opencast Backfill removed and re-engineered. Surcharge mound on top of embankment, surcharge 6.7m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 43.1% (Cu: 30, 50, 40) 67.8% (Cu: 40, 70, 50) After addition of surcharge – 103.9% (Cu: 30, 50, 40) 86.3% (Cu: 40, 70, 50)
	L-L'	Design Option 1 – 1v:5h slope and 1m re-engineer Opencast beneath slope: Engineered fill embankment on Opencast Backfill. 28m long slope at 9.5m high. Surcharge mound on top of embankment, surcharge 7m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 70.8% (Cu: 30, 50, 40) 58.9% (Cu: 40, 70, 50) After addition of surcharge – 102.8% (Cu: 30, 50, 40) 85.9% (Cu: 40, 70, 50)
		Design Option 2 – 1v:4h slope and half depth shear key: Engineered fill embankment on Opencast Backfill. 38m long slope at 9.5m high. Engineered fill embankment over half depth shear key and then Opencast Backfill. Surcharge mound on top of embankment, surcharge 7m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 84.5% (Cu: 30, 50, 40) 68.6% (Cu: 40, 70, 50) After addition of surcharge – 112.8% (Cu: 30, 50, 40) 92.7% (Cu: 40, 70, 50)

Plot	Section Line	Post cut/fill slope geometry and geology	Undrained Stability (% optimisation)
Plot 2 continued	M-M'	40m long slope at 7m high at a gradient of 1v:h. Engineered embankment with underlying Opencast Backfill removed and re-engineered. Surcharge mound on top of embankment, surcharge 7.6m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 60.7% (Cu: 30, 50, 40) 53.5% (Cu: 40, 70, 50) After addition of surcharge – 110.5% (Cu: 30, 50, 40) 91.4% (Cu: 40, 70, 50)
	S-S'	Design Option 1 – 1v:5h slope and 1m re-engineer Opencast beneath slope: Engineered fill embankment on Opencast Backfill. 46m long slope at 9.2m high. Surcharge mound on top of embankment, surcharge 7.6m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 75.6% (Cu: 30, 50, 40) 62.3% (Cu: 40, 70, 50) After addition of surcharge – 105.3% (Cu: 30, 50, 40) 88.4% (Cu: 40, 70, 50)
		Design Option 2 – 1v:4h slope and half depth shear key: Engineered fill embankment on Opencast Backfill. 36.8m long slope at 9.2m high. Engineered fill embankment over half depth shear key and then Opencast Backfill. Surcharge mound on top of embankment, surcharge 7.6m high 3m from embankment crest at 1v:2.5h gradient.	Before addition of surcharge – 83.2% (Cu: 30, 50, 40) 68.8% (Cu: 40, 70, 50) After addition of surcharge – 111.7% (Cu: 30, 50, 40) 93.1% (Cu: 40, 70, 50)
Pond	North Slope	Upper slope: 19m long slope at 6.3m high at gradient of 1v:3h. Upper slope comprises cut Opencast Backfill which has been removed and re-engineered in first 6-10m laterally of slope face. Lower slope at 1v:4h in rock.	30.6% (Cu: 30, 50, 40)
	East Slope	23m long slope at 5.5m high at gradient of 1v:4h. Slope comprises cut Opencast Backfill which has been removed and re-engineered in first 5-17m laterally of slope face. Rock present beneath slope.	20.6% (Cu: 30, 50, 40)
	West Slope	Upper slope: 25m long slope at 6.5m high at gradient of 1v:3.6h. Upper slope comprises cut Opencast Backfill which has been removed and re-engineered in first 5-10m laterally of slope face. Lower slope at 1v:6.75h in rock.	17.7% (Cu: 30, 50, 40)

Notes:

All slopes stable in short term condition. Values of utilisation of >100% for SE embankment slope in Plot 2 are based on worst case undrained shear strength parameters for the Opencast Backfill as per the values noted above. When allowing for some improvement of these parameters (as shown) utilisation falls below 100%. Pore pressures will need to be monitored and rate of filling controlled to maintain short term stability of slopes, in particular with the SE embankment slope of Plot 2.



Approximate co-ordinates for northern extent of area: 435249.316, 3996563962

Approximate co-ordinates for southern extent of area: 435285.603, 399569.566

Approximately 95m long section from northwest to southeast.