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Approved Designer for:

MACCAFERRI

Green Terramesh Reinforced Earth Slope

Coed Darcy

Location Address:	Coed Darcy
Date:	21.11.19
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1.0 Introduction

1.1 Brief

Maccaferri Ltd. requested that Geoman Ltd. carry out a design for a Green Terramesh (GTM) reinforced earth slope as an element of the permanent works at the proposed residential development at Heritage Gate, Coed Darcy.

1.2 Scope

This design covers the proposed Green Terramesh reinforced earth slope retaining the gardens of Plots 1 to 8, as shown on the indicative plan on Geoman Ltd. drawing number SK19-6042-01B. The limits of this element design are the reinforced soil zone, which extends from the front face of the base course of units back to the rear of the Green Terramesh reinforcement tails, and up to the underside of the surface vertically above the rear of the uppermost reinforcement tails.

The most onerous cross-sections have been considered as follows:

- Section 1-1: A Green Terramesh slope with a maximum retained height of 5.58m. There is assumed to be a maximum 1V:3H crest slope connecting into a 1V:12H garden and a maximum 1V:12H toe slope. An RC retaining wall, approximately 2.3m retained height, is located to a minimum distance of 3m from the front face of the upper unit, on the crest of the GTM reinforced slope. This RC retaining wall is wholly outside Geoman's scope of works and details are to be confirmed by others. Refer to Section 1-1 on drawing SK19-6042-01B.
- Section 2-2: A Green Terramesh slope with a maximum retained height of 5.837m. There is assumed to be a maximum 1V:5H crest slope connecting into a 1V:12H garden and a maximum 1V:12H toe slope. Refer to Section 2-2 on drawing SK19-6042-01B.

For the above sections:

- Temporary excavations have the potential to collapse rapidly and without warning. This solution is for the permanent works only and is issued on the basis that a safe system of works is provided for construction. The Principal Contractor/ Green Terramesh installer must produce a method statement and risk assessment for the works to be approved by the Client's Consulting Engineer. Stability of the excavated face in the short term is outside our scope and is to be designed by the Temporary Works Contractor.
- All slope geometry, setting out and required offsets are to be confirmed by the Principal Contractor prior to construction. The Principal Contractor must also confirm the locations of all services prior to construction and ensure that none will be affected by the Green Terramesh and its installation.
- A maximum live load of 10kN/m² was assumed to act on the ground on the retained side of the GTM. Please advise if a more onerous surcharge should be considered.
- Some settlement will occur after construction, depending on the compaction and condition of the backfill placed. Settlement should be monitored, and the placement of any surface finishes delayed until it has ceased.
- It has been assumed that any fence placed at the crest of the GTM will be a maximum of 1.8m high, and placed in minimum 1.0m long, 0.3m diameter sleeves behind the GTM. Please advise us of any additional



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wind/impact loads to be considered and we will revise the design. Pedestrian and vehicle barrier requirements are to be determined by others.

- Green Terramesh to abut with separate retaining wall at both ends. End details and levels to be determined by Principal Contractor/Client's Consulting Engineer prior to construction. Foundation level of separate retaining walls which abut to proposed Green Terramesh should be checked on site prior to construction commencing. Principal Contractor must ensure that the excavation for the reinforced slope does not destabilize the separate retaining walls.
- Stability of the separate retaining wall (designed by others) at the crest of the Green Terramesh (a minimum distance of 3m from the front face) is outside the scope of this design and must be checked by others. We advise the underlying fill is monitored and the reinforced concrete foundation for the wall is not installed until post construction settlement of the underlying fill has ceased. We would recommend preloading the area to limit any future settlement.

It is assumed that the building foundations on the retained side will be taken down to such a level so as to ensure that no loads are transferred to the Green Terramesh and reinforced backfill. **The building foundations must not rely on the flexible Green Terramesh system for support (including lateral support) and are outside the scope of this design.**

Any solution outside this scope is not covered by this design and Geoman Ltd. should be informed so that a new design can be advised as necessary. Site drainage is outside the scope of this design.

1.3 Relevant Parties

- Maccaferri Ltd. is the material supplier and our client.
- Waterstone Homes is Maccaferri's Client and the Project Client.
- Jehu Group is the Principal Contractor.
- Roberts Limbrick is the Client's Consulting Engineer.
- Maccaferri is to install the wall.

The above parties should all read and check this design document before proceeding. **Please advise us before proceeding with construction if there are any errors in the scope.**

1.4 Information

This design package is based on the information provided to Geoman Ltd. as follows:

- Roberts Limbrick drawings:
 - Sketch Site Layout, drawing no. PH2-SCH03 N & M
- Spring drawing 'Retaining Wall Plan' drawing no. 2000/00/503
- Pentan Architects drawing:
 - Site Location Plan, drawing no. 3713/PA/001
 - Existing Site Survey, drawing no. 3713/PA/002
 - Proposed Site Plan, drawing no. 3713/PA/005A
 - Proposed Floor Plans & Elevations, drawing no. 3713/PA/010 A
 - Proposed Site Sections, drawing no. 3713/PA/011 A
 - Indicative Street Scene, drawing no. 3713/PA/012 A
- Jehu dwg '9117-PH2-SCH03P Preliminary Site Plan



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- Maccaferri Design Brief 10.09.19
- Intégral Géotechnique
 - Ref:12494/PB (July '19)
 - Supplemental Foundation Assessment, Ref:12481/GNS (June '19)
 - IG Review of reports and gas membrane confirmation, Ref: 12446/HP (May'19)
- Earth Science Partnership 'Phase two coal mining Risk Assessment' Report Ref: ESP.7103h.3169
- URS 'BP Llandarcy Refinery, Factual Report, Area 1 Site Investigation' Ref:44382624/1395 (Jun'06)
- Iesisstructure drawings:
 - SE1649-ISS-XX-XX-SK-S-5020
 - SE1649-ISS-XX-XX-SK-S-5021
 - SE1649-ISS-XX-XX-SK-S-5022
 - SE1649-ISS-XX-XX-SK-S-5023
- General email correspondence (copies retained by Geoman Ltd.)

Geoman Ltd keep a record of all email correspondence.

2.0 Design

2.1 Ground Conditions/Design Parameters

The Scheme Engineer and Principal Contractor must ensure that all parameters used comply with those found on site. Any variance in these must be reported to Geoman Ltd. immediately so that the implications can be assessed.

URS 'BP Llandarcy Refinery, Factual Report, Area 1 Site Investigation' Ref:44382624/1395 (Jun'06) includes boreholes and trial pits excavated at the site. The boreholes & trial pits generally indicate that superficial deposits recorded as Made Ground, Alluvium and Glacial drift are overlying bedrock described as SANDSTONE. It has been assumed that Glacial drift, described as silty SAND&GRAVEL/ sandy CLAY or bedrock will be present at formation level of the proposed Green Terramesh. A minimum effective angle of internal friction of 30 degrees was assumed for the Drift Deposits, based on typical parameters for such Glacial materials in the area.

No in-situ or laboratory testing was carried out on samples of the material present on site. We would recommend that Shear box and Plasticity tests are carried out on recovered sample of the Drift Deposits presents at the proposed location of the GTM slope in order to confirm the assumed parameters.

The URS 'BP Llandarcy Refinery, Factual Report, Area 1 Site Investigation' Ref:44382624/1395 (Jun'06) indicates significant depths of MADE GROUND in boreholes MSMW203 to 207. The Principal Contractor/Client's Consulting Engineer must confirm that the location of these boreholes is not in the proximity of the proposed Green Terramesh, and that no made ground is present at or below formation level.

The retained material has been assumed to be MADE GROUND, in the form of soft-firm gravelly CLAY or loose silty GRAVEL. Where levels are to be raised, it is assumed that Class 1 or 2C general upfill will be used. The upfill must be benched into the in situ soils and compacted in layers. It must be confirmed to possess a minimum effective angle of internal friction of 27 degrees, such as through plasticity or shear box testing.



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The soil parameters assumed in the design are therefore based on the above as follows:

Material	Description	Unit Weight (kN/m ³)	Assumed Effective Angle of Internal Friction	Cohesion (kN/m ²)
Foundation	Original, undisturbed medium dense silty SAND&GRAVEL / firm-stiff sandy CLAY	19.0	30°	0
	Bedrock (Sandstone)	20.0	35°	0
Retained	MADE GROUND and Class 1/2C Upfill	19.0	27°	0

The Principal Contractor and/or a Geotechnical Engineer must confirm the localised suitability of the material at formation level of the reinforced earth slope. It must be ensured that original medium dense silty SAND&GRAVEL/ firm-stiff sandy CLAY or bedrock, with a minimum allowable bearing capacity of 200kPa, is present prior to construction. Where any soft/ low strength ($c_u < 100\text{kPa}$), loose or unsuitable material (such as **made ground**, peat or alluvium) is present at or below formation level, it must be removed and replaced with compacted Class 6F2 granular fill.

Plate bearing tests should be carried out at formation level to confirm the allowable bearing capacity prior to construction. Plate Bearing tests should be carried out to comply with BS1377-9 Incremental load test to CI4.1.6.4.2. The plate should be loaded to at least 500kPa.

2.2 Imported Granular Fill to reinforced earth zone

The reinforced backfill for the Green Terramesh must be imported granular fill which complies with, and is placed and compacted in accordance with, Class 6I/J fill in accordance with the MCHW Specification for Highway Works, Series 600.

The Contractor is responsible for the selection of this material to ensure compliance with the geotechnical characteristics specified in SHW Series 600 'Earthworks', as shown on the relevant drawings and in the design documents/calculations.

Quality control testing should follow the principles set out in HA 44/91 and under responsibility of the Principal Contractor and Principal Designer.

The soil parameters assumed for the Class 6I fill used in the design calculations are as follows:

Description	Use	Unit Weight (kN/m ³)	Angle of Shearing Resistance	Cohesion (kN/m ²)	Porewater pressure coefficient (ru)
Class 6I/J Fill	Reinforced fill	19.0	35°	0	0

2.3 Surcharge Loads

A maximum live load of 10kN/m^2 was assumed to act on the ground on the retained side of the slope of the proposed reinforced slope in the permanent condition. Please advise if a more onerous surcharge should be considered.

Additional indicative analyses were conducted to consider a maximum applied loading from the proposed RC walls at the crest of the slope of 61kN/m^2 over a length of 10m. It was assumed that the RC walls will be kept a minimum of 3m from the front face of the uppermost units.



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2.4 Crest/ Toe Slopes

Refer to Geoman Ltd. drawing number SK19-6042-01B. The presence of any toe slopes should be confirmed prior to construction.

2.5 Ground Water

The highest groundwater strike was recorded in MSMW61 at 2.5m depth. We have assumed that the reinforced and retained material will be maintained in a fully drained condition. Site drainage is outside the scope of the design.

For analysis purposes, we have considered a Porewater Pressure Coefficient (R_u) of 0.1 for the foundation materials. The Client's Consulting Engineer must review this assumption and advise if a more onerous condition should be considered.

2.6 Drainage

A minimum 150mm diameter perforated PVC drainage pipe is to be placed at the rear of the reinforced slope, with a fall to a suitable outlet (as per Geoman Ltd. drawing number SK19-6042-01B). The drain is to be connected to the outlet prior to construction of the slope to a height greater than 1.52m (2 units). The pipe is to be fully jettable and regularly maintained.

Should any water ingress be observed in the cut, this should be taken to the heel drain of the GTM slope by means of a localised chimney drain or drainage geocomposite.

3.0 Analysis

- Methods of Analysis: BSEN1997-1:2004 – Eurocode 7 and BS8006-1:2010
- Factors of Safety: According to BSEN1997-1:2004 – Eurocode 7 and BS8006-1:2010

MacStars W (Rel. 4.0) analysis files MS19-6042-01 to -04 are included in the attached Appendix. As shown by all of the Factors of Safety for the worst Load Combinations being in excess of 1.00, the requirements of BSEN1997-1:2004 and BS8006-1:2010 were satisfied for all analyses. The following table is a summary of the analysis results:

Section	Analysis	In accordance with:	Minimum Factors of Safety		
1-1	MS19-6042-01	Eurocode 7 EN 1997-1	Global Stability Check	DA1/1 1.352	DA1/2 1.103
1-1	MS19-6042-02	BS 8006-1:2010		A	B
			Sliding Check	3.232	2.149
			Overturning Check	6.527	4.102
			Bearing Capacity	1.108	1.719
				A	B
2-2	MS19-6042-04	BS 8006-1:2010	Internal Stability	1.589	1.330
			Global Stability Check	DA1/1 1.301	DA1/2 1.044
				A	B
			Sliding Check	2.373	1.560
			Overturning Check	6.171	3.848
2-2	MS19-6042-04	BS 8006-1:2010	Bearing Capacity	1.143	1.767
				A	B
			Internal Stability	1.363	1.307



3.1 Check with RC wall loading

Additional indicative analyses were conducted to consider a maximum applied loading from the proposed RC walls at the crest of the slope of 61kN/m² over a length of 10m. It was assumed that the RC walls will be kept a minimum of 3m from the front face of the uppermost units.

3.1.1 Method of Analysis – INTERNAL & GLOBAL

- Methods of Analysis: BSEN1997-1:2004 - Eurocode 7
- Factors of Safety: According to BSEN1997-1:2004 - Eurocode 7&BS 8006-1:2010

Global stability analysis was carried out for design section 1-1 using MacStars W (Rel. 4.0). Analysis results show that the required FoS of 1.00 was achieved for each section (see checks MS19-6042-05&06 in the Appendix).

3.2 Fence Wind load check

We have been advised that a 1.8m high fence (designed by others) is to be placed at the crest of the GTM. The fence posts are to be fully concreted into minimum 1.0m long, 300mm diameter sleeves infilled with concrete at 1.8m centres. We have derived a wind pressure of 0.99kPa as per BS EN1991-1-4.

Wind Pressure BS EN1991-1-4	Fence Height	Distance between posts	Wind Load on the fence posts
0.99 kN/m ²	1.8m	1.8m	0.99kN/m ² * 1.8m*1.8m = 3.2kN

Effective vertical stress $\sigma_v' = z * \gamma'$	Nº of straps per post	Strap dimension (wide x length)	Phi' ϕ'	Pull out resistance $\sigma_v' * \tan(\phi') * A_{\text{strap}} * n_{\text{straps}}$
0.5m x 19kN/m ³	2	0.08m x L	35 degrees	

Assuming the Paraweb straps will be placed 0.5m up from the base of the void former, we have calculated the strap will need to be **3m long** to avoid pullout. Please advise us if a higher wind load than assumed is to be considered.

4.0 Summary

This design proposal and associated drawing have been produced using the methodology detailed above. However, it should be noted that the design proposal has been generated from information provided to Geoman Ltd, which has not been independently verified and may contain assumptions and inaccuracies regarding geotechnical, hydraulic and other parameters.

If any discrepancy is noted between the site conditions and the design assumptions (regarding water levels, soil conditions, proposed loadings etc.), the Principal Contractor must contact Geoman Ltd. immediately to facilitate a review of the design.

Geoman Ltd did not undertake to supervise the construction of the structure, and therefore cannot comment on the standard of workmanship. The main issues to consider are adequate compaction of the foundation soils and imported fill, and adequate drainage.

Geoman Ltd accordingly does not accept responsibility for the accuracy or completeness of information or assumptions from which the design proposal has been produced.



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The material supplier can provide typical health & safety hazards to consider when approaching this work. Designer's hazards include falling from height and the stability of excavated cuttings.

5.0 Construction Supervision Requirements

The following construction supervision requirements should be adhered to by the project team (Principal Contractor and Client's Consulting Engineer). If any issues arise on site which differ from what has been assumed in this design, Geoman Ltd. should be contacted immediately so the possible consequences can be assessed.

1. The Principal Contractor and/or a Geotechnical Engineer must confirm that original medium dense silty SAND&GRAVEL / firm-stiff sandy CLAY or bedrock, with a minimum allowable bearing capacity of 200kPa, is present at formation level prior to construction. Where any soft/ low strength ($c_u < 100\text{kPa}$), loose or unsuitable material (such as **made ground**, peat or alluvium) is present at or below formation level, it must be removed and replaced with compacted Class 6F2 granular fill.
2. Plate bearing tests should be carried out at formation level to confirm the allowable bearing capacity prior to construction. Plate Bearing tests should be carried out to comply with BS1377-9 Incremental load test to CI4.1.6.4.2. The plate should be loaded to at least 500kPa.
3. The reinforced backfill for the Green Terramesh must be imported granular fill which complies with, and is placed and compacted in accordance with, Class 6I/J fill in accordance with the MCHW Specification for Highway Works, Series 600. Quality control testing should follow the principles set out in HA 44/91 and be under the responsibility of the Principal Contractor.
4. Should any water ingress be observed in the cut, this should be taken to the heel drain of the GTM slope by means of a localised chimney drain or drainage geocomposite.
5. The slope construction should be carried out in accordance with the manufacturer's installation guidelines by an installer experienced with reinforced earth systems.
6. It should be ensured that the face does not rotate during compaction of each course. SHW advice (CI. 622) concerning restriction of compaction plant within 2.0m of the front face shall be followed. If face movement should occur, the next course shall be set back as necessary to ensure that overall face batter remains at or below 67 degrees.

Within 2 m of the face, the maximum compaction plant shall be:

- Vibratory roller: 1,300kg/m and a total mass of 1,000kg
 - Vibrating plate compactor not greater than 1,000kg
 - Vibro-tamper not exceeding 75kg.
7. Seeded topsoil should be placed in the face to promote rapid vegetation growth. It should be ensured that the front face does not dry out in the first few months by watering as necessary. The front face should be kept moist.
 8. Particular attention must be taken over the quality and condition of the topsoil placed behind the unit facing, and the pre-seeding/planting of this. The use of good quality topsoil is essential to promote rapid vegetation. Irrigation of the surface maybe required if dry weather conditions occur.
 9. The Principal Contractor must accept it will be their responsibility to ensure successful vegetation achieved by careful construction, inclusion of suitable topsoil on face, appropriate planting and irrigation



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if this becomes necessary. Should, three months after completing construction, no significant vegetation be visible we recommend that the face of the Green Terramesh slope is hydro seeded.

6.0 Maintenance Requirements

Maintenance requirements for the Green Terramesh slope are as follows:

- The slope should be routinely inspected once a month for the 6 months following construction. After six months, the GTM slope should be checked annually for signs of any faults, vandalism or movement. The batter of the slope should be checked to ensure it remains within the allowed tolerances in accordance with BS EN 14475:2006.
- The ground above and below the GTM should also be inspected for signs of any movement.
- It should be ensured that the front face does not dry out by watering as necessary. The front face should be kept moist.

These requirements should be included in the maintenance regime for the site/development.

7.0 CDM Regulations

Geoman is not the Principal Designer, but has considered the risks associated with this element of the works that affect or are affected by the design. “**Designers**” are responsible for fulfilling their obligations as defined in the Construction (Design & Management) Regulations 2015.

Geoman Ltd., as designers, understand that under the Regulations its duties are generally to;

- Ensure that the client for the project is aware of the duties and responsibilities that they have.
- So far as is reasonably practicable, taking due account of other relevant design considerations, avoid foreseeable risks to the health and safety of any persons carrying out, liable to be affected by such or maintaining the permanent fixtures and fittings of construction work.

In discharging this duty, the designer shall:

- Eliminate hazards that may give rise to risks
- Reduce risks from any remaining hazards and in doing so give collective measures priority over individual measures.

The designer shall also:

- Take all reasonable steps to provide with the design sufficient information about aspects of the design of the structure or its construction or maintenance as will adequately assist clients, other designers and contractors to comply with their duties under the Regulations.

In respect of this particular project, Geoman hereby draws to the attention of the Principal Designer and Principal Contractor that they have specific duties under CDM 2015.

The ‘Principal Contractor’ must be responsible for and fulfil all the contractor’s obligations.

However, since the **Principal Designer** has designated the chosen location and dimensions of the structures on this site, the **Principal Designer** has, in this respect, acted as a ‘designer’ under CDM 2015. The **Principal Designer** is therefore responsible for fulfilling all the obligations that this entails.



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The scope of Geoman, as element 'designer', to minimise design risks is therefore limited by those elements of the design pre-determined by the **Principal Designer**. The significant design risks shown in Section 7.1 remain and must therefore be addressed by the **Principal Designer** and **Principal Contractor**.

7.1 SIGNIFICANT DESIGN RISKS REMAINING:

RISK	SUGGESTED REMEDIATION
01 Slope stability compromised and/or excessive settlement due to in situ soils not complying with design assumptions.	The Principal Contractor and/or a Geotechnical Engineer must confirm that original medium dense silty SAND&GRAVEL / firm-stiff sandy CLAY or bedrock, with a minimum allowable bearing capacity of 200kPa, is present at formation level prior to construction. Where any soft/ low strength ($c_u < 100\text{kPa}$), loose or unsuitable material (such as made ground , peat or alluvium) is present at or below formation level, it must be removed and replaced with compacted Class 6F2 granular fill. The Principal contractor must inspect the proposed formation level of the reinforced slope and ensure that no soft/loose MADE GROUND is present at or below formation level of the proposed Green Terramesh.
02 Use of unsuitable fill material in the reinforced earth zone causing excessive movement/failure of the Green Terramesh.	The reinforced backfill for the Green Terramesh must be imported granular fill which complies with, and is placed and compacted in accordance with, Class 6I/J fill in accordance with the MCHW Specification for Highway Works, Series 600. Quality control testing should follow the principles set out in HA 44/91 and under responsibility of the Principal Contractor and Principal Designer.
03 Wind/impact loads on fences affecting the slope stability.	We have been advised that a 1.8m high fence (designed by others) is to be placed at the crest of the GTM. The fence posts are to be fully concreted into minimum 1.0m long, 300mm diameter sleeves infilled with concrete and with a 3m long Paraweb strap. The fence designer must ensure that the base design is adequate, as any rotational failure of the fence posts will adversely affect the appearance of the upper GTM units.
04 Instability of the temporary cut slope.	Temporary excavations have the potential to collapse rapidly and without warning. This reinforced slope solution is for the permanent works only and is on the basis that a safe system of works is provided for construction. Principal Contractor to provide method statement for the works to satisfy the Principal Designer. Geoman Ltd. is not responsible for temporary stability or design of any temporary works.
05 Serviceability failure of the Green Terramesh slope during/immediately following construction	The slope construction should be carried out in accordance with the manufacturer's installation guidelines. It should be ensured that the face does not rotate during compaction of each course. SHW advice (Cl. 622) concerning restriction of compaction plant within 2m of the front face shall be followed. If face movement should occur, the next course shall be set back as necessary to ensure that overall face batter remains at or below 67 degrees.
06 Erosion of the GTM face due to failure to establish vegetation on the slope	Seeded topsoil should be placed in the face to promote rapid vegetation growth. It should be ensured that the front face does not dry out in the first few months by watering as necessary. The Principal Contractor must accept it will be their responsibility to ensure successful vegetation establishment achieved by careful construction, inclusion of suitable topsoil on face, appropriate planting and irrigation if this becomes necessary.



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		Should, three months after completing construction, no significant vegetation be visible we recommend that the face of the Green Terramesh slope is hydro seeded.
07	Incorrect construction geometry	All slope geometry, setting out and required offsets are to be confirmed by the Principal Contractor and Principal Designer prior to construction. The Principal Contractor and Principal Designer must also confirm the locations of all services prior to construction and ensure that none will be affected by the reinforced earth slope and its installation.
08	Stability of building foundations/ Piling works affecting GTM	Proposed building foundations (designed by others) at the rear of the GTM are assumed to be placed to such a level so as to ensure that no loads are transferred to the GTM slope or reinforced backfill. The building foundations must not rely on the flexible GTM for support (including lateral support), and are outside the scope of this design. Please advise us if a piling rig is to be used on the retained side of the Green Terramesh reinforced slope, as well as its required minimum offset and maximum operational surcharge. If the surcharge on the retained side of the reinforced slope is to exceed 10kN/m² and/ or a piling rig is to be used following construction of the Green Terramesh, the Principal Designer must inform Geoman Ltd. prior to construction to allow this design to be reviewed. <u>Any piling rigs operating on the retained side of the GTM must be kept the maximum possible distance from the reinforced slope, and must always operate on the far side of the proposed piles from the GTM. The piling rig must be kept outside a 10m exclusion zone from the top of the GTM.</u>
09	Stability of the separate retaining walls (which abut the GTM, and at the toe of the GTM)	-Green Terramesh to abut with separate retaining wall at both ends. End details and levels to be determined by Principal Contractor/Client's Consulting Engineer prior to construction. Foundation level of separate retaining walls which abut proposed Green Terramesh should be checked on site prior to construction commencing. Principal contractor must ensure that the excavation for the reinforced slope does not destabilize the separate retaining walls. -Stability of the separate retaining wall (designed by others) at the toe of the Green Terramesh (a minimum distance of 4.5m from the front face) is outside the scope of this design and must be checked by others.
10	Proposed RC Wall at the rear of the Green Terramesh affecting stability or causing movement at the face	Stability of the separate retaining wall (designed by others) at the crest of the Green Terramesh (a minimum distance of 3m from the front face) is outside the scope of this design and must be checked by others. We advise the underlying fill is monitored and the reinforced concrete foundation for the wall is not installed until post construction settlement of the underlying fill has ceased. We would recommend preloading the area to limit any future settlement. Additional indicative analyses were conducted to consider a maximum applied loading from the proposed RC walls at the crest of the slope of 61kN/m² over a length of 10m. It was assumed that the RC walls will be kept a minimum of 3m from the front face of the uppermost units.



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Green Terramesh Reinforced Earth Slope	Coed Darcy	19-6042	21.11.19	B

8.0 Designer Risk Assessment

CONSTRUCTION OF GREEN TERRAMESH

NOTICE OF HAZARD IDENTIFICATION (GENERIC DESIGNER RISK ASSESSMENT)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Working at heights >2m	Falling	H	Wear Harness OR provide access scaffold	Contractor
C/M	Working at heights	Falling	M	Wear Harness OR provide access scaffold	Contractor
C	Cutting mesh, lacing, etc.	Personal Injury	M	Use of suitable PPE (safety goggles, gloves, etc.)	Contractor
C	Placing backfill	Personal Injury	M	Use mini excavator to place stone fill where practicable	Contractor
C	Excavation of embankment prior to installation of wall	Embankment Slip - Personal Injury	H	Excavation of embankment to a safe angle of repose for the short term.	Contractor
M	Steep retaining structures > 2m in height	Falling/Personal Injury	H	Provision of permanent fence/ barrier at crest of retaining structure	Client

Category: C = Construction, M = Maintenance/Use, D = Demolition

NOTICE OF HAZARD IDENTIFICATION (SPECIFIC DESIGNER RISK ASSESSMENT)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Excavation into existing material to foundation level	Bank slip / Personal injury	H	Excavation of ground to a safe angle of repose for the short term and/ or foundation excavation & construction of lower courses carried out in short lengths. Use of granular backfill.	Principal Contractor / Wall Installer
C	Excavation into existing material to foundation level	Striking existing services/ Personal injury	M	Principal Designer to provide details of all existing services in the vicinity of the wall to Contractor. Use of Cable Avoidance Tools (CAT scanners).	Principal Designer / Principal Contractor / Wall Installer
C	Excavation into existing material to foundation level	Striking live cables/ electrocution	M	Principal Designer to provide details of all existing electrical services in the vicinity of the wall to Contractor. Electrical services to be relocated where risk is unacceptable. Use of Cable Avoidance Tools (CAT scanners).	Principal Designer / Principal Contractor / Wall Installer
C	General Installation of Green Terramesh	Personal Injury	M	Adhere to Supplier Installation Guidelines.	Contractor

Category: C = Construction, M = Maintenance/Use, D = Demolition



Geoman Ltd.	Project:	Ref:	Date:	Rev:
Green Terramesh Reinforced Earth Slope	Coed Darcy	19-6042	21.11.19	B

9.0 Appendices

- Geoman Ltd. drawing number SK19-6042-01B
- MacStars analyses files MS19-6042-01 to -06

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
Officine Maccaferri S.p.A. - Via Kennedy 10 - 40069 Zola Predosa (Bologna)
Tel. 051.6436000 - Fax 051.236507

Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 1-1

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-01A - RC wall

Date.....: 11/18/2019

Checks according to: Eurocode 7 EN 1997-1
 Eurocode 7 EN 1997-1

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SOIL PROPERTIES

Soil: CLASS 6I	Description:	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30
Soil: FOUNDATION	Description: Firm-stiff CLAY or medium-dense SAND	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	30.00
Ru value.....		0.10
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30
Soil: RETAINED	Description: MADE GROUND or Class 1/2C Upfill	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	27.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30
Soil: ROCK	Description: weathered SANDSTONE	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.03	16.56	22.87	16.72	23.21	16.76
24.41	16.80	26.30	16.80				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.87	11.87	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.41	11.88	26.30	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 5.00 Height.....= 4.56
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate..= 12.00
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76
 Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 5.00

Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 61KPA

Description :

Class : Variable unfavourable

 Magnitude.....[kN/m²]...= 61.00 Inclination angle.....[°]...= 0.00

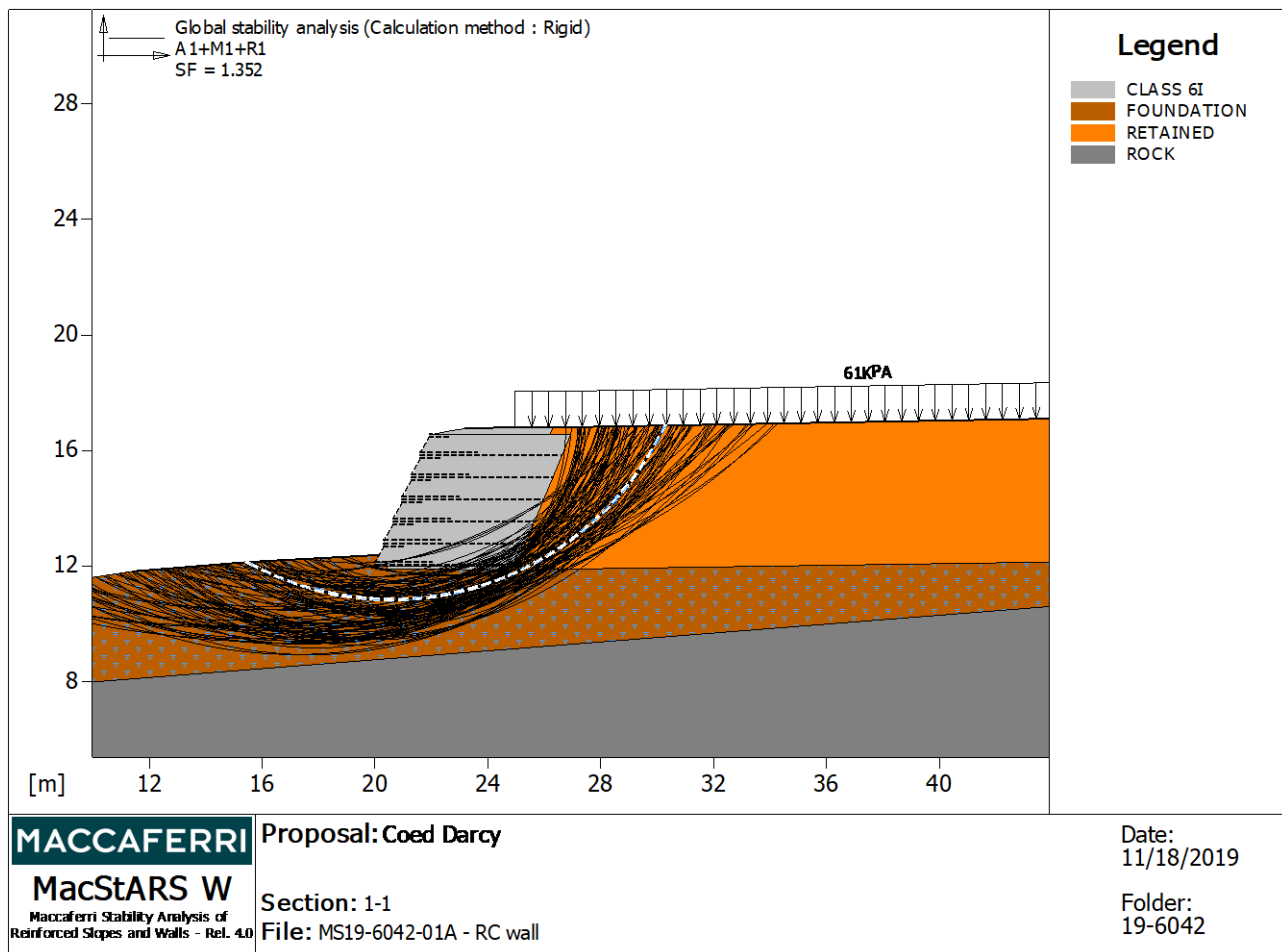
Abscissa.....[m]...: from = 24.96 To = 50.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m].....	50.00
Plastic extension ratio	:	0.00
Elastic extension coefficient	[m ³ /kN].....	1.10e-04
Reinforcement Stiffness	[kN/m].....	556.00
Minimum anchorage length	[m].....	0.15
Breakage Safety Factor (gravel)	:	1.54
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (silty sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sandy clay)	:	1.52
Pull-out Safety Factor	:	1.00
Interaction factor reinforcement/reinforcement	:	0.16
Pullout coefficient reinforcement-gravel	:	0.90
Pullout coefficient reinforcement-sand	:	0.90
Pullout coefficient reinforcement-silt	:	0.70
Pullout coefficient reinforcement-clay	:	0.40

CHECKS RESULTS



Global Stability Check :

Multiplier combination : A1+M1+R1

Reinforcements active Forces according to Rigid Method

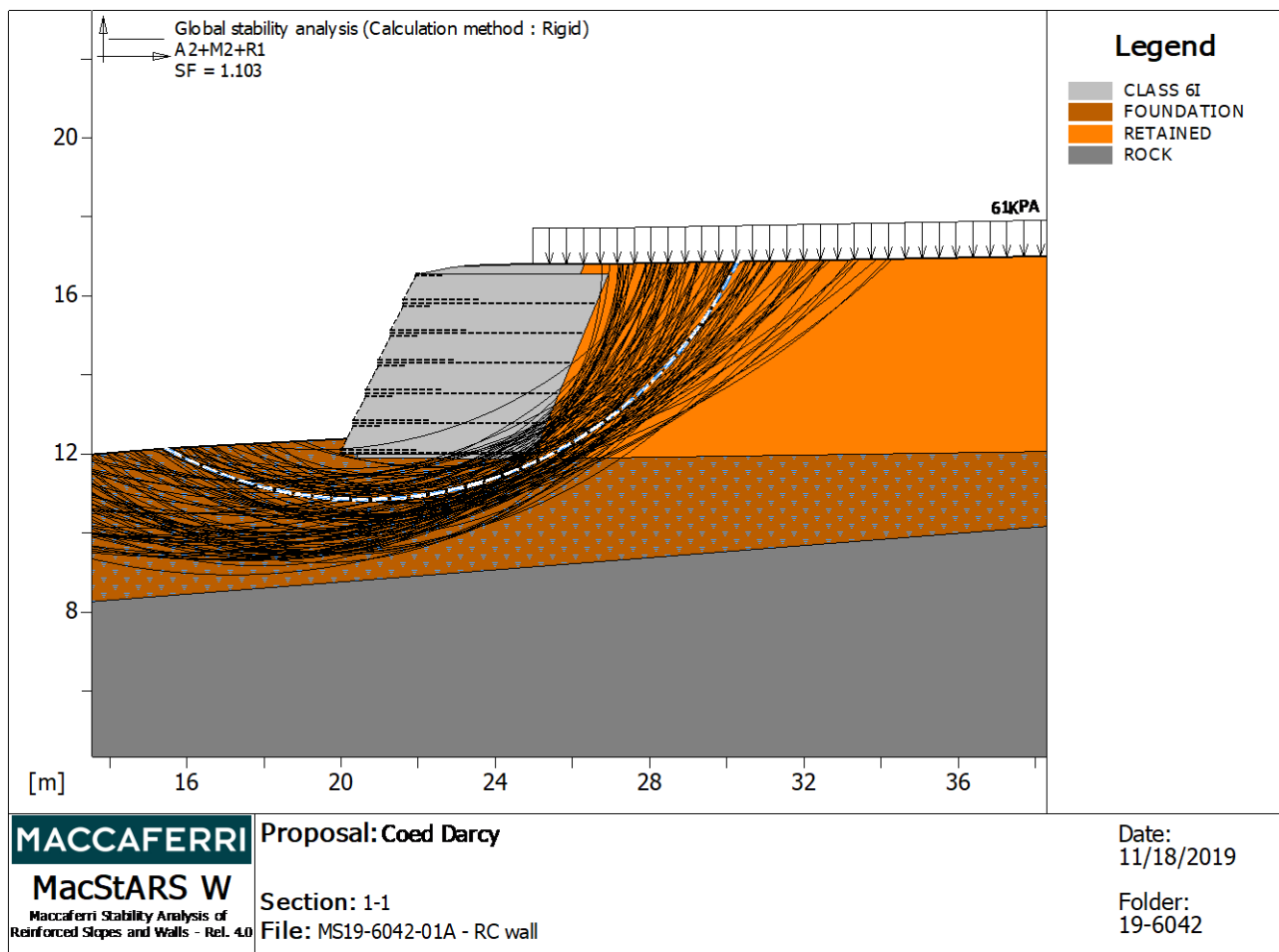
Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.352

Surfaces searching range

Starting range, abscises [m]		Arrival range, abscises [m]	
First point	Second point	First point	Second point
5.00	19.00	21.00	40.00
Number of starting point on the starting segment.....:		100	
Total number of trial surfaces.....:		1000	
Minimum base length of slices.....[m].....:		0.50	
Superior limit search angle.....[°].....:		0.00	
Inferior limit search angle.....[°].....:		0.00	

Multiplier	Class
1.50	Variable unfavourable
1.00	Angle of shearing resistance (Tan phi)
1.00	Effective cohesion
1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability



Global Stability Check :

Multiplier combination : A2+M2+R1

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor : 1.103

Surfaces searching range

Starting range, abscises [m]

Arrival range, abscises [m]

First point	Second point	First point	Second point
5.00	19.00	21.00	40.00

Number of starting point on the starting segment.....: 100

Total number of trial surfaces: 1000

Minimum base length of slices [m]: 0.50

Superior limit search angle [°]: 0.00

Inferior limit search angle.....[°].....: 0.00

Multiplier

Class

1.30	Variable unfavourable
1.25	Angle of shearing resistance (Tan phi)
1.25	Effective cohesion
1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
Officine Maccaferri S.p.A. - Via Kennedy 10 - 40069 Zola Predosa (Bologna)
Tel. 051.6436000 - Fax 051.236507

Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 1-1

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-02A

Date.....: 11/18/2019

Checks according to: BS 8006-1:2010
 Wall - Cat. 2 (medium)

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SOIL PROPERTIES
Soil: CLASS 6I

Description:

Cohesion Class.....	: Soil material factor c'	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Soil material factor $\tan(\phi)$	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Mass of the reinforced soil body	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: FOUNDATION

Description: Firm-stiff CLAY or medium-dense SAND

Cohesion Class.....	: Soil material factor c'	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Soil material factor $\tan(\phi)$	
Friction Angle.....	[°].	30.00
Ru value.....		0.10
Weight Class.....	: Foundation soil	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: RETAINED

Description: MADE GROUND or Class 1/2C Upfill

Cohesion Class.....	: Soil material factor c'	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Soil material factor $\tan(\phi)$	
Friction Angle.....	[°].	27.00
Ru value.....		0.00
Weight Class.....	: Earth pressure (mass of the backfill) behind the structure	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: ROCK

Description: weathered SANDSTONE

Cohesion Class.....	: Soil material factor c'	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Soil material factor $\tan(\phi)$	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Foundation soil	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.58	17.85	22.87	17.85	23.21	18.53
24.10	18.90	27.22	18.90				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.87	11.87	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.87	11.87	26.54	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

Stratum: UPFILL

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
26.54	16.80	27.22	18.90	28.43	18.90	31.36	18.90
50.00	19.13						

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 4.20 Height.....= 6.08
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate.....= 12.00
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76
 Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 4.20
 Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 10 KPA

Description :

Class : Traffic load on reinforced soil block

Magnitude.....[kN/m²]...= 10.00 Inclination angle.....[°]...= 0.00

Abscissa.....[m]...: from = 24.50 To = 26.50

Distributed Loads : 10KPA

Description :

Class : Traffic load behind reinforced soil block

Magnitude.....[kN/m²]...= 10.00 Inclination angle.....[°]...= 0.00

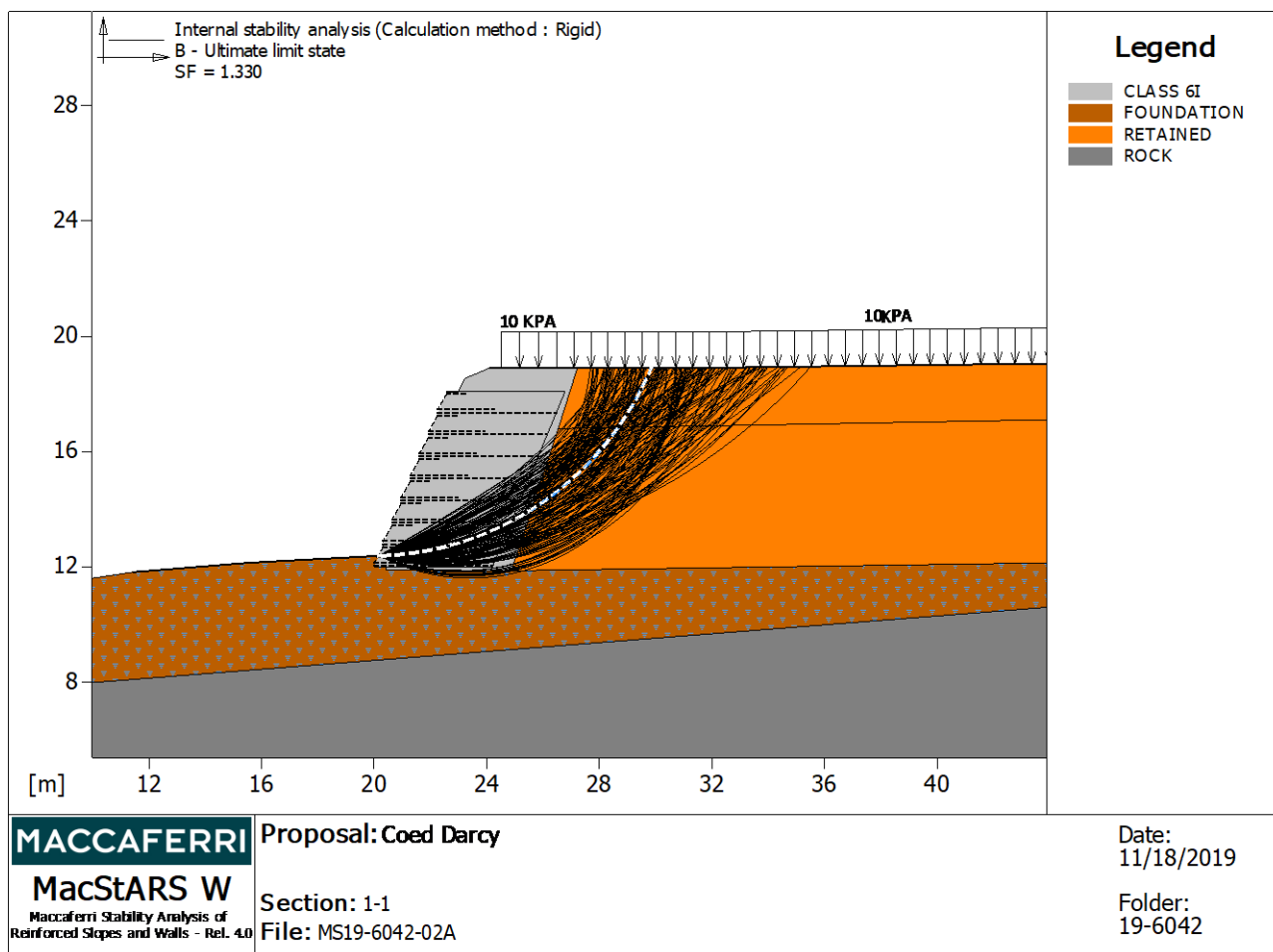
Abscissa.....[m]...: from = 26.50 To = 50.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m].....	50.00
Plastic extension ratio		0.00
Elastic extension coefficient	[m³/kN].....	1.10e-04
Reinforcement Stiffness	[kN/m].....	556.00
Minimum anchorage length	[m].....	0.15
Breakage Safety Factor (gravel)		1.54
Pull-out Safety Factor		1.00
Breakage Safety Factor (sand)		1.52
Pull-out Safety Factor		1.00
Breakage Safety Factor (silty sand)		1.52
Pull-out Safety Factor		1.00
Breakage Safety Factor (sandy clay)		1.52
Pull-out Safety Factor		1.00
Interaction factor reinforcement/reinforcement		0.16
Pullout coefficient reinforcement-gravel		0.90
Pullout coefficient reinforcement-sand		0.90
Pullout coefficient reinforcement-silt		0.70
Pullout coefficient reinforcement-clay		0.40

CHECKS RESULTS



Internal Stability :

Multiplier combination : B - Ultimate limit state

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.330

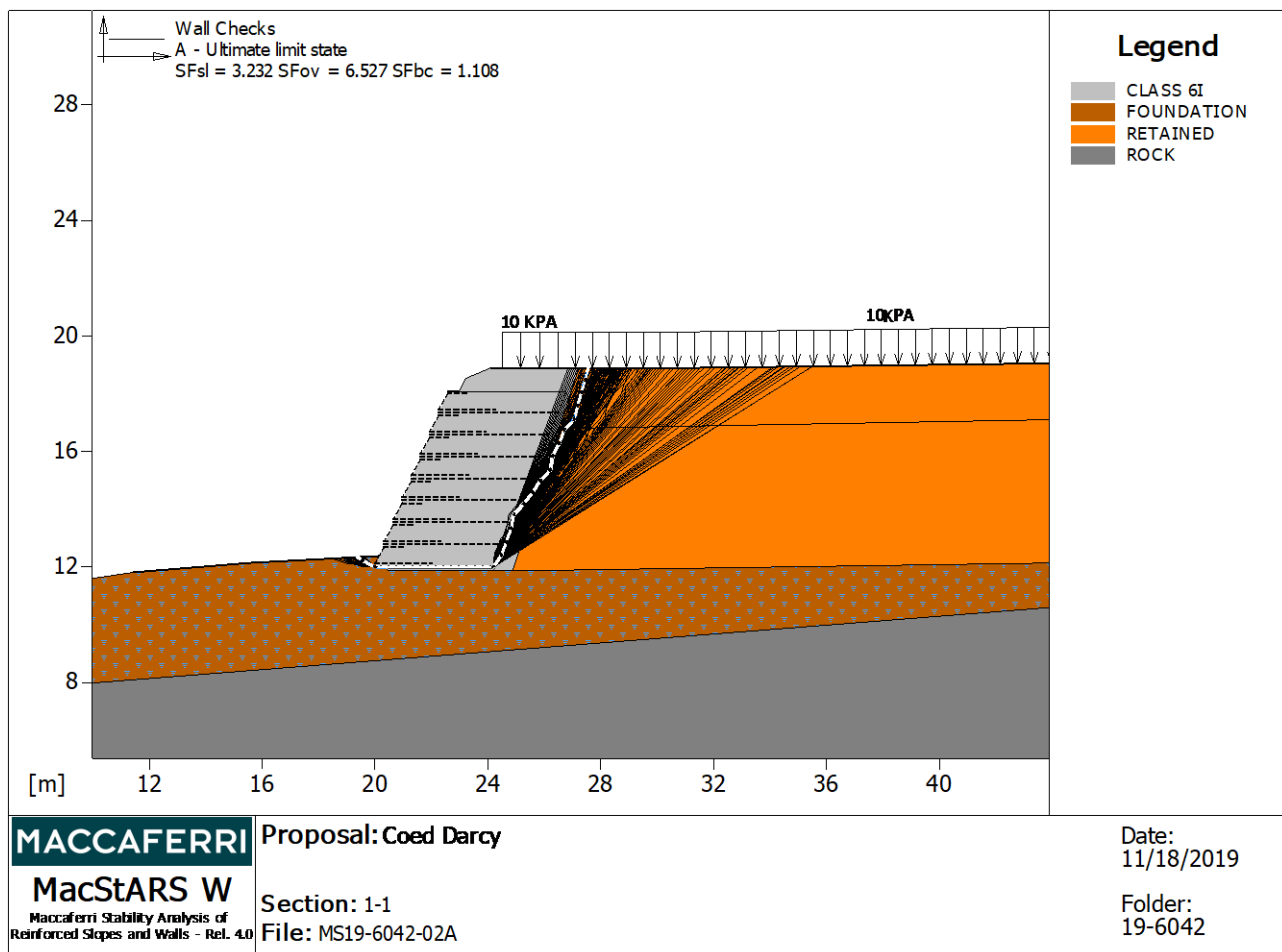
Surfaces searching range
Arrival range, abscises [m]
Block GTM First point 23.00 Second point 40.00
Number of starting point on the starting segment.....: 1
Total number of trial surfaces.....: 1000
Minimum base length of slices.....[m].....: 0.50
Superior limit search angle.....[°].....: 0.00
Inferior limit search angle.....[°].....: 0.00

Block : GTM
Linear Composites - ParaGrid - 50

Y	Tb breakage	Tp pullout	Td design	Tb/Td 1/Fmax	Tp/Td
[m]	[kN/m]	[kN/m]	[kN/m]		
0.760	50.0	61.3	32.9	1.52	1.86

Multiplier 1.00 Class Traffic load behind reinforced soil block

0.00	Traffic load on reinforced soil block
1.00	Soil material factor $\tan(\phi)$
1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.00	Danger level of the work



Wall Checks :

Multiplier combination : A - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 579.45

Active force.....[kN/m] : 137.92

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 3.232

Restoring moment.....[kN*m/m] : 3064.90

Overturning moment.....[kN*m/m] : 469.60

Overturning class.....: Overturning

Overturning safety factor.....: 6.527

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 300.00

Active pressure.....[kN/m²] : 200.53

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 1.108

Equivalent bearing area.....[m] : 4.20

Eccentricity of normal force.....[m] : -0.98

Lever arm of overturning force.....[m] : 3.40

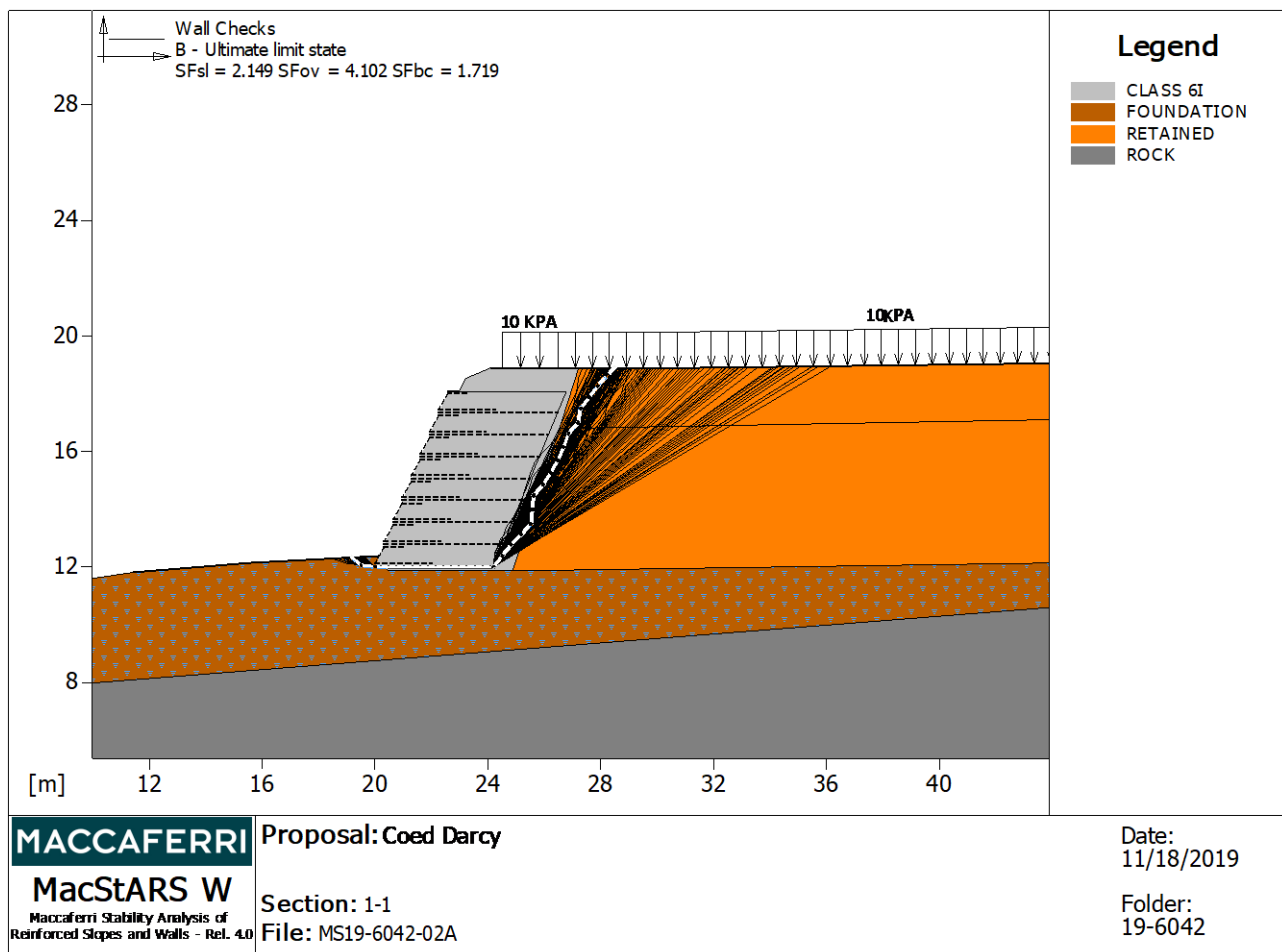
Normal force on the base.....[kN] : 842.23

Outer edge stress.....[kN/m²] : -614.58

Inner edge stress.....[kN/m²] : 1367.56

Multiplier	Class
1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning



Wall Checks :

Multiplier combination : B - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 373.69

Active force.....[kN/m] : 133.76

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 2.149

Restoring moment.....[kN*m/m] : 1942.60

Overturning moment.....[kN*m/m] : 473.62

Overturning class.....: Overturning

Overturning safety factor.....: 4.102

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 300.00

Active pressure.....[kN/m²] : 129.30

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 1.719

Equivalent bearing area.....[m] : 4.20

Eccentricity of normal force.....[m] : -0.61

Lever arm of overturning force.....[m] : 3.54

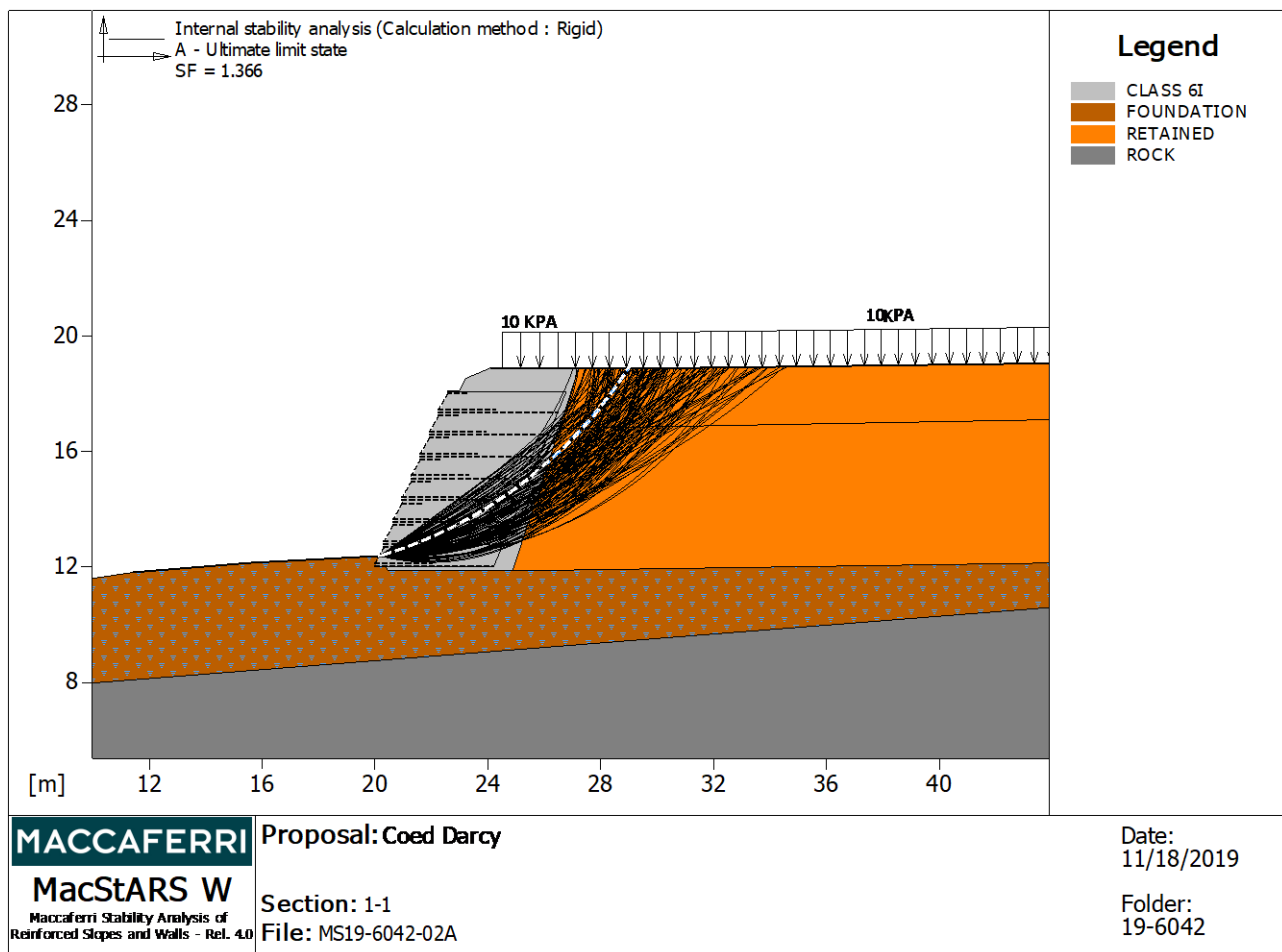
Normal force on the base.....[kN] : 543.08

Outer edge stress.....[kN/m²] : -38.88

Inner edge stress.....[kN/m²] : 402.14

Multiplier	Class
1.50	Traffic load behind reinforced soil block
0.00	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning



Internal Stability :

Multiplier combination : A - Ultimate limit state

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.366

Surfaces searching range
Arrival range, abscises [m]
Block GTM First point 23.00 Second point 40.00

Number of starting point on the starting segment.....: 1
Total number of trial surfaces.....: 1000
Minimum base length of slices.....[m].....: 0.50
Superior limit search angle.....[°].....: 0.00
Inferior limit search angle.....[°].....: 0.00

Block : GTM
Linear Composites - ParaGrid - 50

Y	Tb breakage	Tp pullout	Td design	Tb/Td 1/Fmax	Tp/Td
[m]	[kN/m]	[kN/m]	[kN/m]		
0.760	50.0	22.5	17.3	2.89	1.30
0.760	50.0	12.0	9.2	5.43	1.30
1.520	50.0	83.6	32.9	1.52	2.54
2.280	50.0	68.1	32.9	1.52	2.07

Multiplier Class

1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block
1.00	Soil material factor $\tan(\phi)$
1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.00	Danger level of the work

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
Officine Maccaferri S.p.A. - Via Kennedy 10 - 40069 Zola Predosa (Bologna)
Tel. 051.6436000 - Fax 051.236507

Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 2-2

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-03A

Date.....: 11/18/2019

Checks according to: Eurocode 7 EN 1997-1
 Eurocode 7 EN 1997-1

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SOIL PROPERTIES

Soil: CLASS 6I	Description:	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].....	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].....	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].....	19.00
Bulk unit weight - below GWT.....	[kN/m ³].....	19.00
Elastic Modulus.....	[kN/m ²].....	0.00
Poisson's ratio.....		0.30
Soil: FOUNDATION	Description: Firm-stiff CLAY or medium-dense SAND	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].....	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].....	30.00
Ru value.....		0.10
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].....	20.00
Bulk unit weight - below GWT.....	[kN/m ³].....	20.00
Elastic Modulus.....	[kN/m ²].....	0.00
Poisson's ratio.....		0.30
Soil: RETAINED	Description: MADE GROUND or Class 1/2C Upfill	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].....	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].....	27.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].....	19.00
Bulk unit weight - below GWT.....	[kN/m ³].....	19.00
Elastic Modulus.....	[kN/m ²].....	0.00
Poisson's ratio.....		0.30
Soil: ROCK	Description: weathered SANDSTONE	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].....	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].....	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].....	20.00
Bulk unit weight - below GWT.....	[kN/m ³].....	20.00
Elastic Modulus.....	[kN/m ²].....	0.00
Poisson's ratio.....		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.58	17.85	22.94	18.01	23.41	18.17
24.34	18.50	27.11	18.65				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.41	11.88	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.41	11.88	26.30	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

Stratum: UPFILL

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
26.30	16.80	27.11	18.65	28.43	18.65	31.36	18.65
50.00	19.13						

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 4.20 Height.....= 6.84
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate.....= 11.68
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76

Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 4.20
 Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 10KPA

Description :

Class : Variable unfavourable

Magnitude.....[kN/m²]...= 10.00 Inclination angle.....[°]...= 0.00

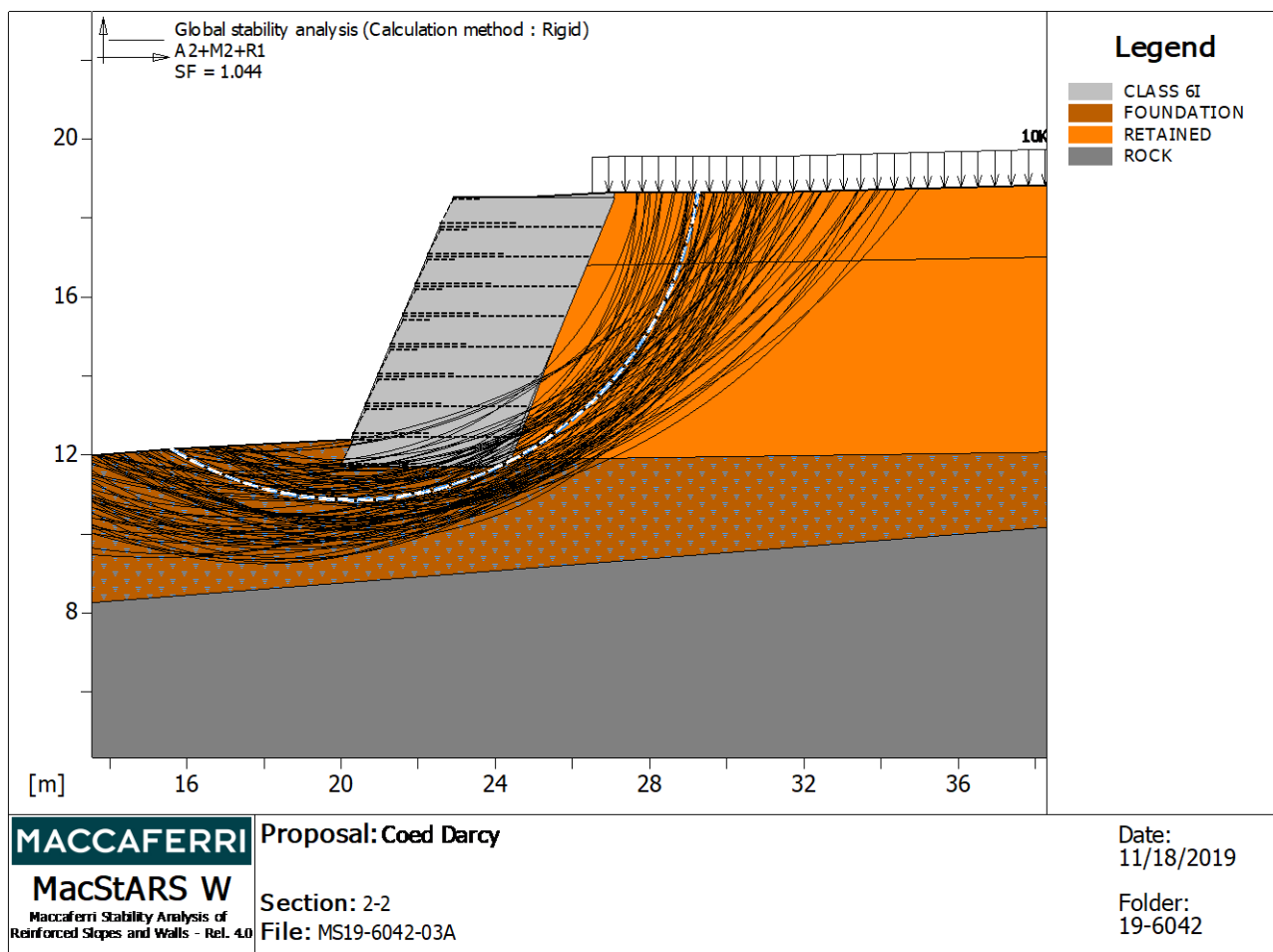
Abscissa.....[m]...: from = 26.50 To = 50.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m] :	50.00
Plastic extension ratio	:	0.00
Elastic extension coefficient.....	[m³/kN] :	1.10e-04
Reinforcement Stiffness.....	[kN/m] :	556.00
Minimum anchorage length.....	[m] :	0.15
Breakage Safety Factor (gravel).....	:	1.54
Pull-out Safety Factor.....	:	1.00
Breakage Safety Factor (sand).....	:	1.52
Pull-out Safety Factor.....	:	1.00
Breakage Safety Factor (silty sand).....	:	1.52
Pull-out Safety Factor.....	:	1.00
Breakage Safety Factor (sandy clay).....	:	1.52
Pull-out Safety Factor.....	:	1.00
Interaction factor reinforcement/reinforcement.....	:	0.16
Pullout coefficient reinforcement-gravel.....	:	0.90
Pullout coefficient reinforcement-sand.....	:	0.90
Pullout coefficient reinforcement-silt.....	:	0.70
Pullout coefficient reinforcement-clay.....	:	0.40

CHECKS RESULTS



Global Stability Check :

Multiplier combination : A2+M2+R1

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.044

Surfaces searching range

Starting range, abscises [m]		Arrival range, abscises [m]	
First point	Second point	First point	Second point
5.00	19.00	21.00	40.00

Number of starting point on the starting segment.....: 100

Total number of trial surfaces.....: 1000

Minimum base length of slices.....[m].....: 0.50

Superior limit search angle.....[°].....: 0.00

Inferior limit search angle.....[°].....: 0.00

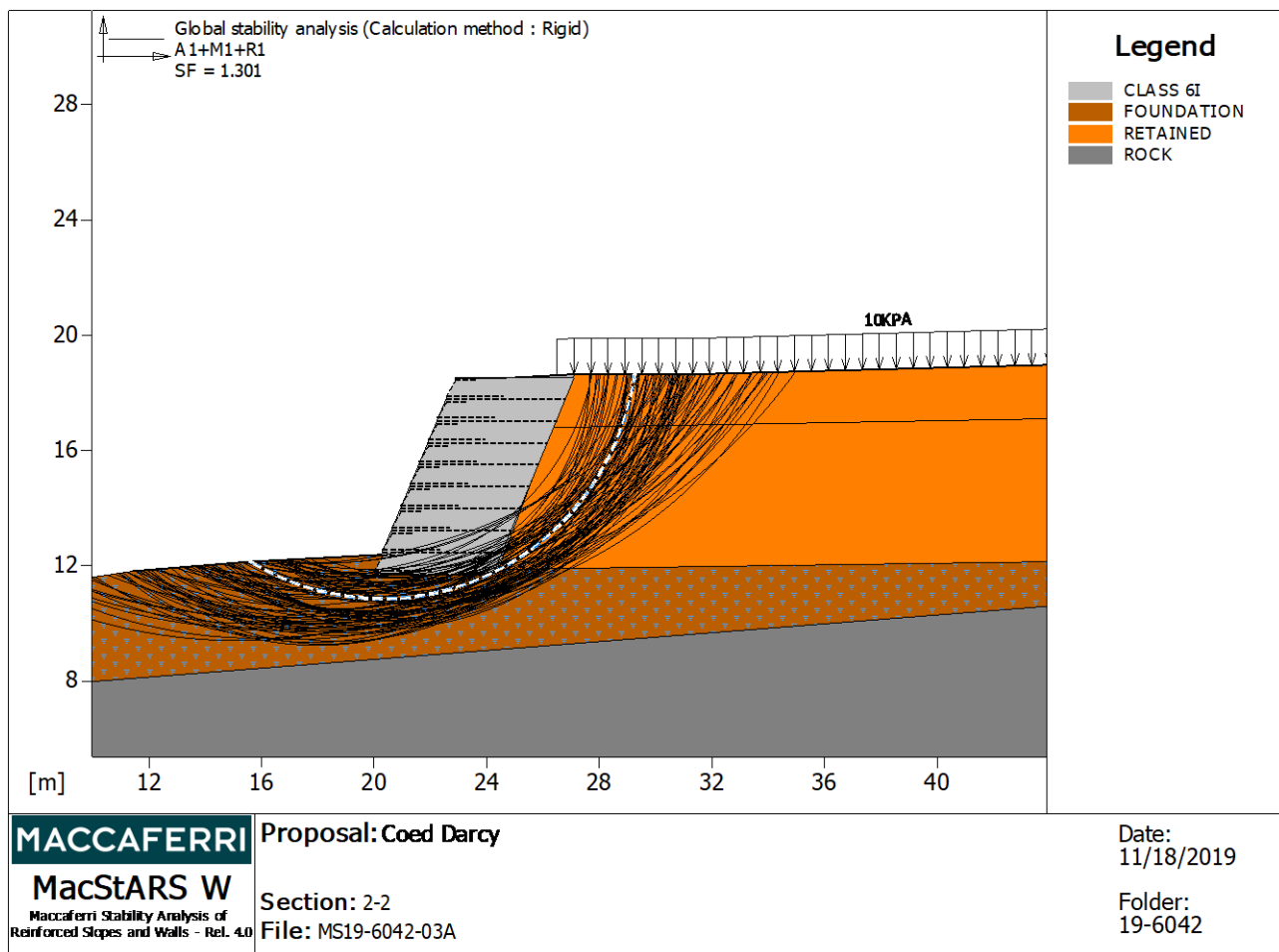
Block : GTM

Linear Composites - ParaGrid - 50

Y	Tb	Tp	Td	Tb/Td	Tp/Td
[m]	breakage	pullout	design	1/Fmax	
0.000	50.0	11.1	11.1	4.50	1.00

Multiplier	Class
1.30	Variable unfavourable

1.25	Angle of shearing resistance (Tan phi)
1.25	Effective cohesion
1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability



Global Stability Check :

Multiplier combination : A1+M1+R1

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.301

Surfaces searching range

Starting range, abscises [m]		Arrival range, abscises [m]	
First point	Second point	First point	Second point
5.00	19.00	21.00	40.00
Number of starting point on the starting segment.....:		100	
Total number of trial surfaces.....:		1000	
Minimum base length of slices.....[m]:		0.50	
Superior limit search angle.....[°]:		0.00	
Inferior limit search angle.....[°]:		0.00	

Block : GTM

Linear Composites - ParaGrid - 50

Y	Tb	Tp	Td	Tb/Td	Tp/Td
[m]	breakage	pullout	design	1/Fmax	
0.000	50.0	11.1	11.1	4.50	1.00

Multiplier	Class
1.50	Variable unfavourable
1.00	Angle of shearing resistance (Tan phi)
1.00	Effective cohesion

1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
Officine Maccaferri S.p.A. - Via Kennedy 10 - 40069 Zola Predosa (Bologna)
Tel. 051.6436000 - Fax 051.236507

Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 2-2

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-04A

Date.....: 11/18/2019

Checks according to: BS 8006-1:2010
 Wall - Cat. 2 (medium)

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SOIL PROPERTIES
Soil: CLASS 6I

Description:

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	35.00
Ru value		0.00
Weight Class	: Mass of the reinforced soil body	
Bulk unit weight - above GWT	[kN/m ³]	19.00
Bulk unit weight - below GWT	[kN/m ³]	19.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: FOUNDATION

Description: Firm-stiff CLAY or medium-dense SAND

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	30.00
Ru value		0.10
Weight Class	: Foundation soil	
Bulk unit weight - above GWT	[kN/m ³]	20.00
Bulk unit weight - below GWT	[kN/m ³]	20.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: RETAINED

Description: MADE GROUND or Class 1/2C Upfill

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	27.00
Ru value		0.00
Weight Class	: Earth pressure (mass of the backfill) behind the structure	
Bulk unit weight - above GWT	[kN/m ³]	19.00
Bulk unit weight - below GWT	[kN/m ³]	19.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: ROCK

Description: weathered SANDSTONE

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	35.00
Ru value		0.00
Weight Class	: Foundation soil	
Bulk unit weight - above GWT	[kN/m ³]	20.00
Bulk unit weight - below GWT	[kN/m ³]	20.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.58	17.85	22.94	18.01	23.41	18.17
24.34	18.50	27.11	18.65				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.41	11.88	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.41	11.88	26.30	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

Stratum: UPFILL

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
26.30	16.80	27.11	18.65	28.43	18.65	31.36	18.65
50.00	19.13						

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 4.20 Height.....= 6.84
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate.....= 11.68
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76

Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 4.20
 Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 10 KPA

Description :

Class : Traffic load on reinforced soil block

Magnitude.....[kN/m²]...= 10.00 Inclination angle.....[°]...= 0.00

Abscissa.....[m]...: from = 24.50 To = 26.50

Distributed Loads : 10KPA

Description :

Class : Traffic load behind reinforced soil block

Magnitude.....[kN/m²]...= 10.00 Inclination angle.....[°]...= 0.00

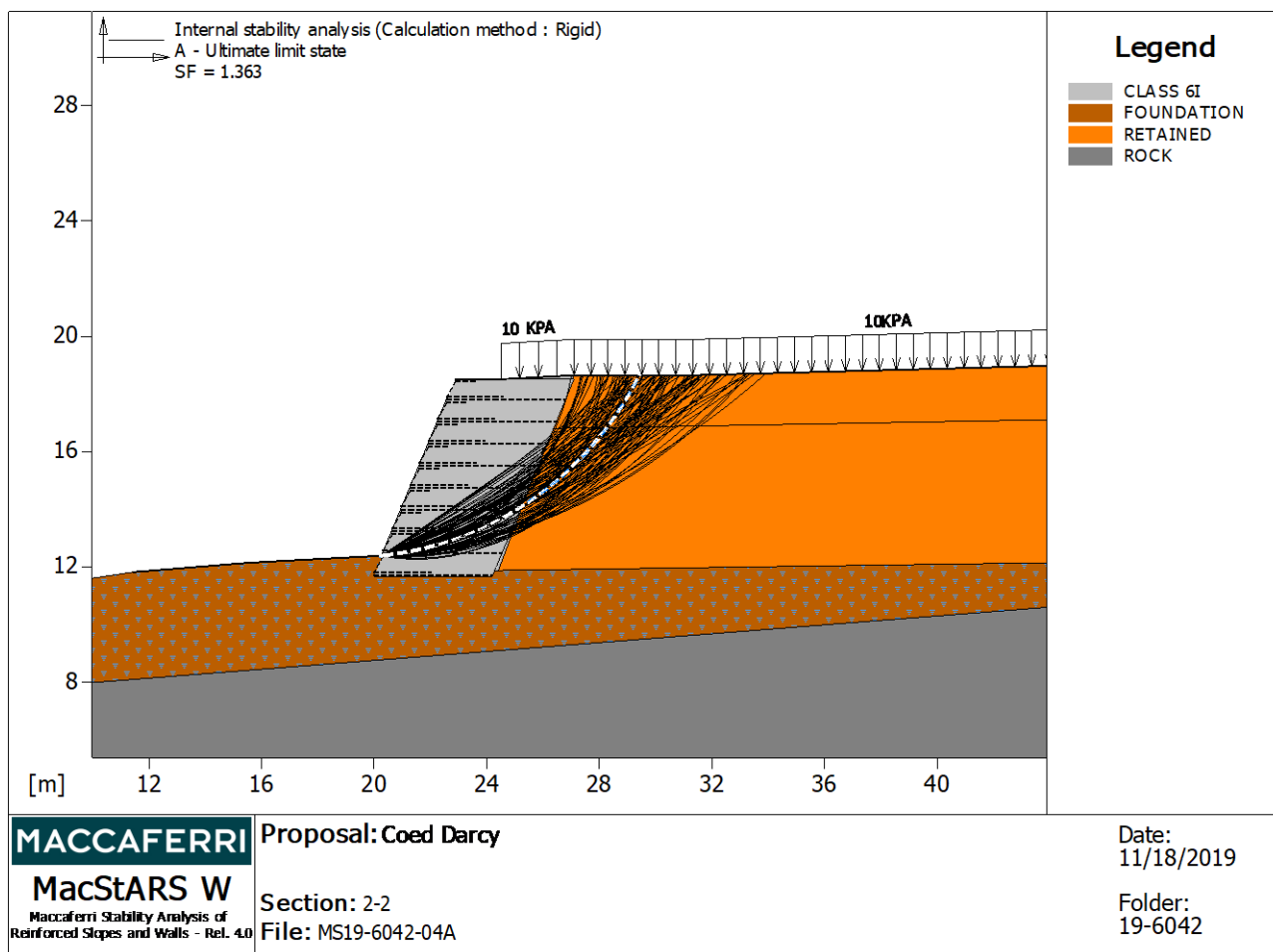
Abscissa.....[m]...: from = 26.50 To = 50.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m] :	50.00
Plastic extension ratio	:	0.00
Elastic extension coefficient	[m³/kN] :	1.10e-04
Reinforcement Stiffness	[kN/m] :	556.00
Minimum anchorage length	[m] :	0.15
Breakage Safety Factor (gravel)	:	1.54
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (silty sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sandy clay)	:	1.52
Pull-out Safety Factor	:	1.00
Interaction factor reinforcement/reinforcement	:	0.16
Pullout coefficient reinforcement-gravel	:	0.90
Pullout coefficient reinforcement-sand	:	0.90
Pullout coefficient reinforcement-silt	:	0.70
Pullout coefficient reinforcement-clay	:	0.40

CHECKS RESULTS



Internal Stability :

Multiplier combination : A - Ultimate limit state

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

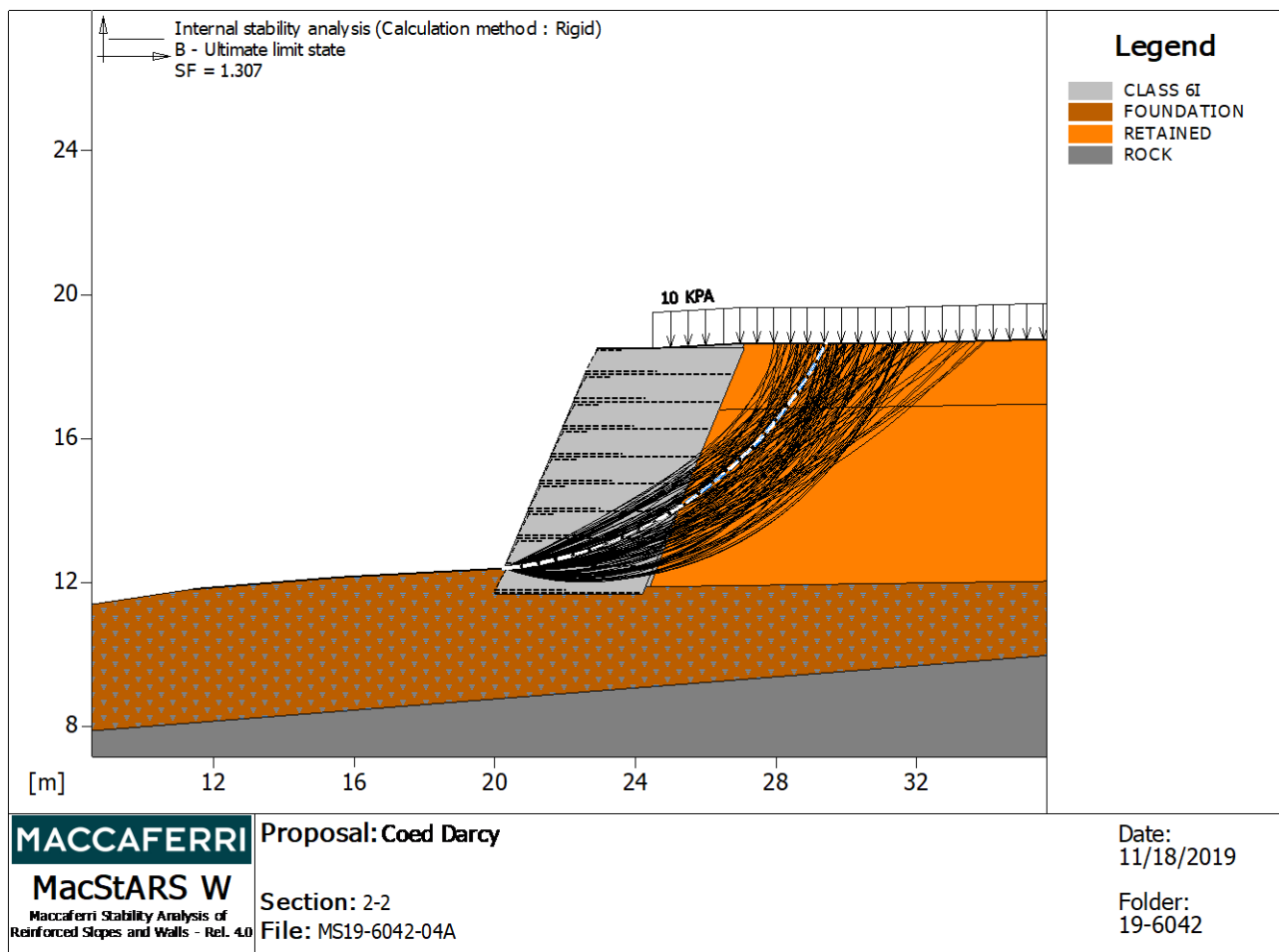
Evaluated Safety Factor.....: 1.363

Surfaces searching range
Arrival range, abscises [m]
Block GTM First point 23.00 Second point 40.00
Number of starting point on the starting segment.....: 1
Total number of trial surfaces.....: 1000
Minimum base length of slices.....[m].....: 0.50
Superior limit search angle.....[°].....: 0.00
Inferior limit search angle.....[°].....: 0.00

Block : GTM
Linear Composites - ParaGrid - 50

Y	Tb breakage	Tp pullout	Td design	Tb/Td 1/Fmax	Tp/Td
[m]	[kN/m]	[kN/m]	[kN/m]		
0.760	50.0	14.0	10.8	4.63	1.30
0.760	50.0	1.6	1.2	41.67	1.33
1.520	50.0	117.9	32.9	1.52	3.58

Multiplier	Class
1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block
1.00	Soil material factor $\tan(\phi)$
1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.00	Danger level of the work



Internal Stability :

Multiplier combination : B - Ultimate limit state

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.307

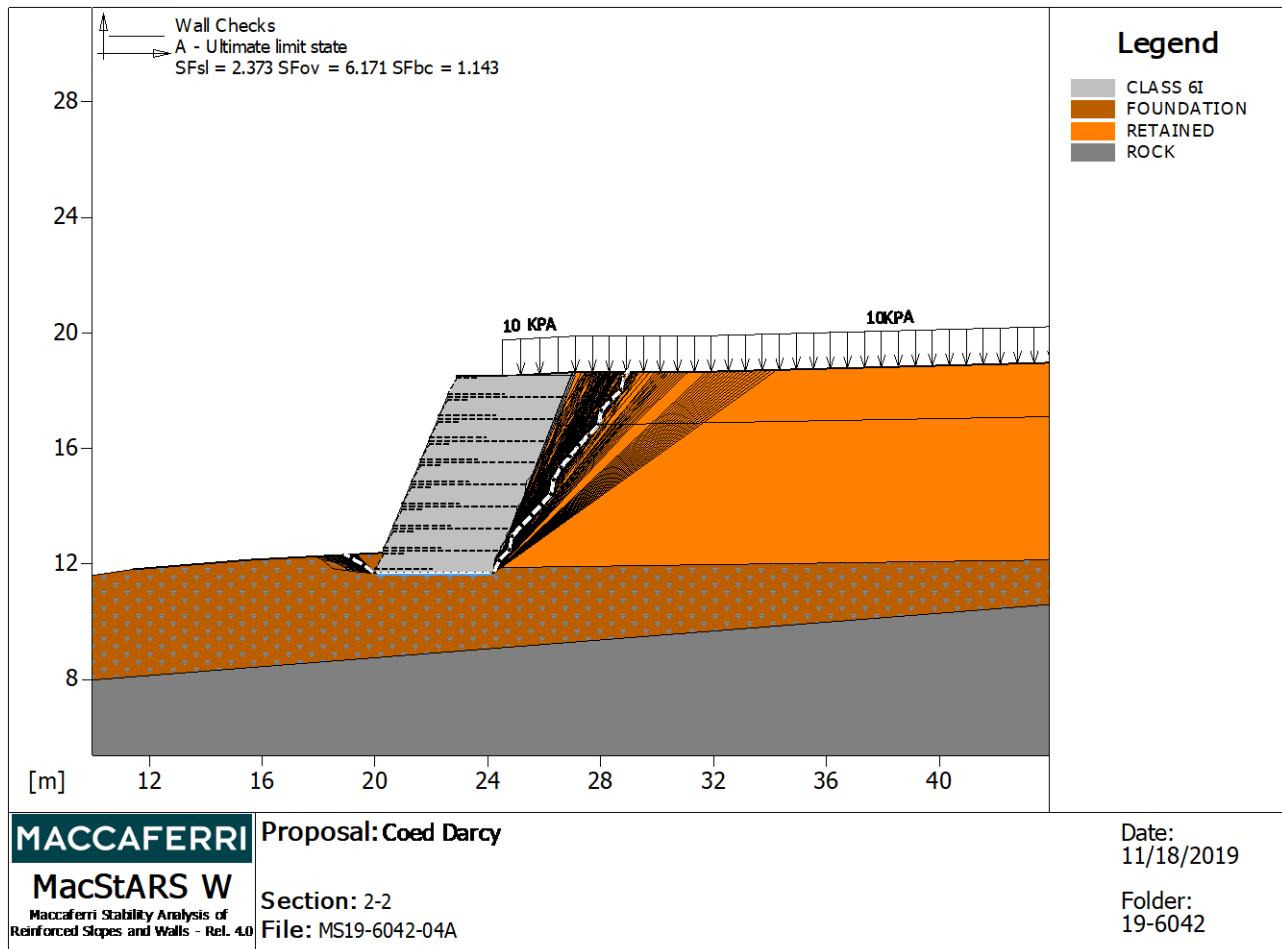
Surfaces searching range
Arrival range, abscises [m]
Block GTM First point 23.00 Second point 40.00
Number of starting point on the starting segment.....: 1
Total number of trial surfaces.....: 1000
Minimum base length of slices.....[m].....: 0.50
Superior limit search angle.....[°].....: 0.00
Inferior limit search angle.....[°].....: 0.00

Block : GTM
Linear Composites - ParaGrid - 50

Y	Tb breakage	Tp pullout	Td design	Tb/Td 1/Fmax	Tp/Td
[m]	[kN/m]	[kN/m]	[kN/m]		
0.760	50.0	9.3	7.2	6.94	1.29
0.760	50.0	1.1	0.8	62.50	1.38
1.520	50.0	76.7	32.9	1.52	2.33

Multiplier 1.00 Class Traffic load behind reinforced soil block

0.00	Traffic load on reinforced soil block
1.00	Soil material factor $\tan(\phi)$
1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.00	Danger level of the work



Wall Checks :

Multiplier combination : A - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 471.64

Active force.....[kN/m] : 152.88

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 2.373

Restoring moment.....[kN*m/m] : 3019.20

Overturning moment.....[kN*m/m] : 489.29

Overturning class.....: Overturning

Overturning safety factor.....: 6.171

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 300.00

Active pressure.....[kN/m²] : 194.50

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 1.143

Equivalent bearing area.....[m] : 4.20

Eccentricity of normal force.....[m] : -1.00

Lever arm of overturning force.....[m] : 3.20

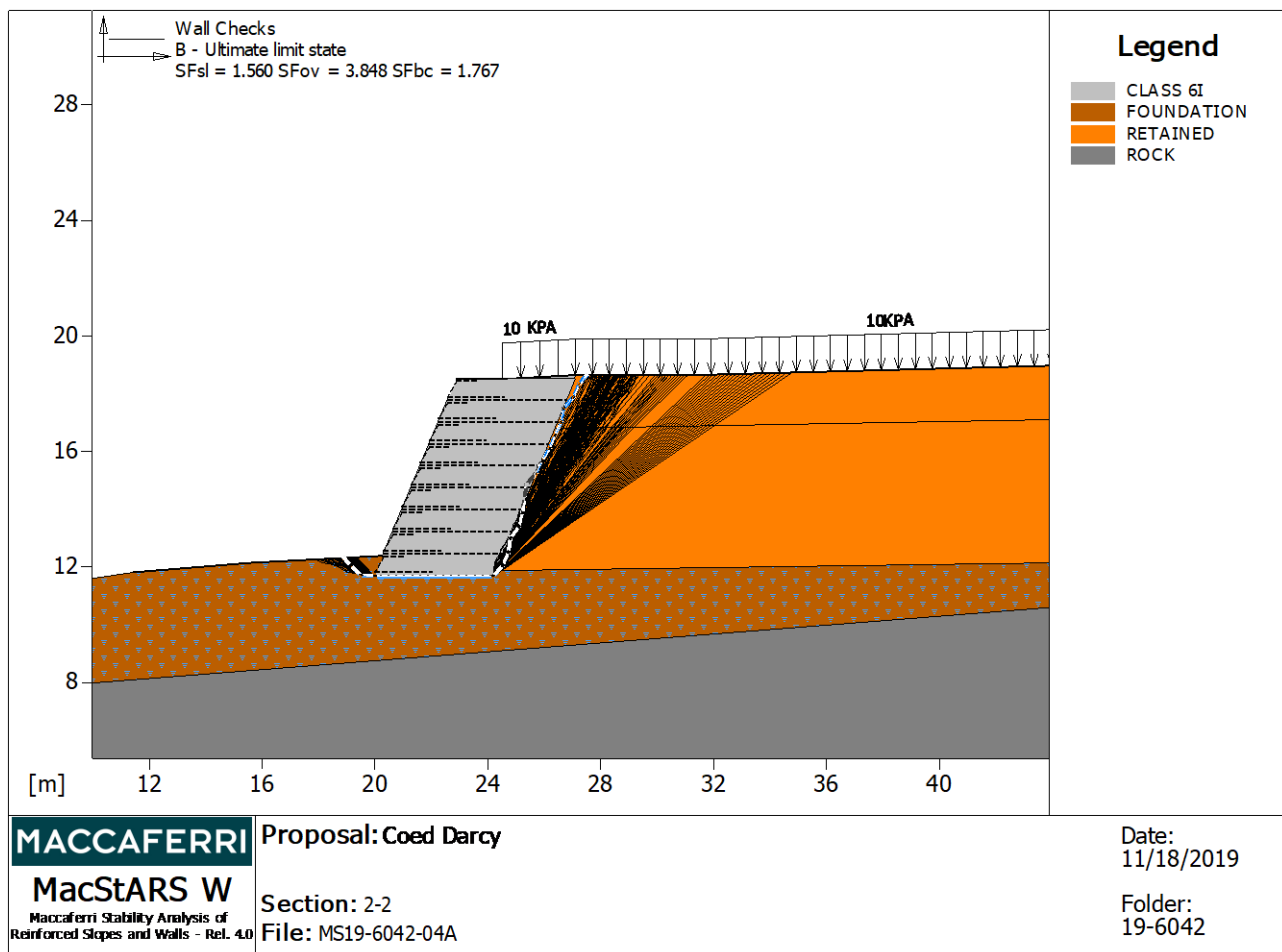
Normal force on the base.....[kN] : 816.91

Outer edge stress.....[kN/m²] : -633.74

Inner edge stress.....[kN/m²] : 1374.33

Multiplier	Class
1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning



Wall Checks :

Multiplier combination : B - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 305.00

Active force.....[kN/m] : 150.42

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 1.560

Restoring moment.....[kN*m/m] : 1923.60

Overturning moment.....[kN*m/m] : 499.85

Overturning class.....: Overturning

Overturning safety factor.....: 3.848

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 300.00

Active pressure.....[kN/m²] : 125.78

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 1.767

Equivalent bearing area.....[m] : 4.20

Eccentricity of normal force.....[m] : -0.60

Lever arm of overturning force.....[m] : 3.32

Normal force on the base.....[kN] : 528.28

Outer edge stress.....[kN/m²] : -32.73

Inner edge stress.....[kN/m²] : 383.78

Multiplier	Class
1.50	Traffic load behind reinforced soil block
0.00	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
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Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 1-1

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-01A - RC wall

Date.....: 11/18/2019

Checks according to: Eurocode 7 EN 1997-1
 Eurocode 7 EN 1997-1

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SOIL PROPERTIES

Soil: CLASS 6I	Description:	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: FOUNDATION	Description: Firm-stiff CLAY or medium-dense SAND	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	30.00
Ru value.....		0.10
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: RETAINED	Description: MADE GROUND or Class 1/2C Upfill	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	27.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	19.00
Bulk unit weight - below GWT.....	[kN/m ³].	19.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

Soil: ROCK	Description: weathered SANDSTONE	
Cohesion Class.....	: Effective cohesion	
Cohesion.....	[kN/m ²].	0.00
Friction Angle Class.....	: Angle of shearing resistance (Tan phi)	
Friction Angle.....	[°].	35.00
Ru value.....		0.00
Weight Class.....	: Weight density	
Bulk unit weight - above GWT.....	[kN/m ³].	20.00
Bulk unit weight - below GWT.....	[kN/m ³].	20.00
Elastic Modulus.....	[kN/m ²].	0.00
Poisson's ratio.....		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.03	16.56	22.87	16.72	23.21	16.76
24.41	16.80	26.30	16.80				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.87	11.87	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.41	11.88	26.30	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 5.00 Height.....= 4.56
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate..= 12.00
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76
 Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 5.00

Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 61KPA

Description :

Class : Variable unfavourable

 Magnitude.....[kN/m²]...= 61.00 Inclination angle.....[°]...= 0.00

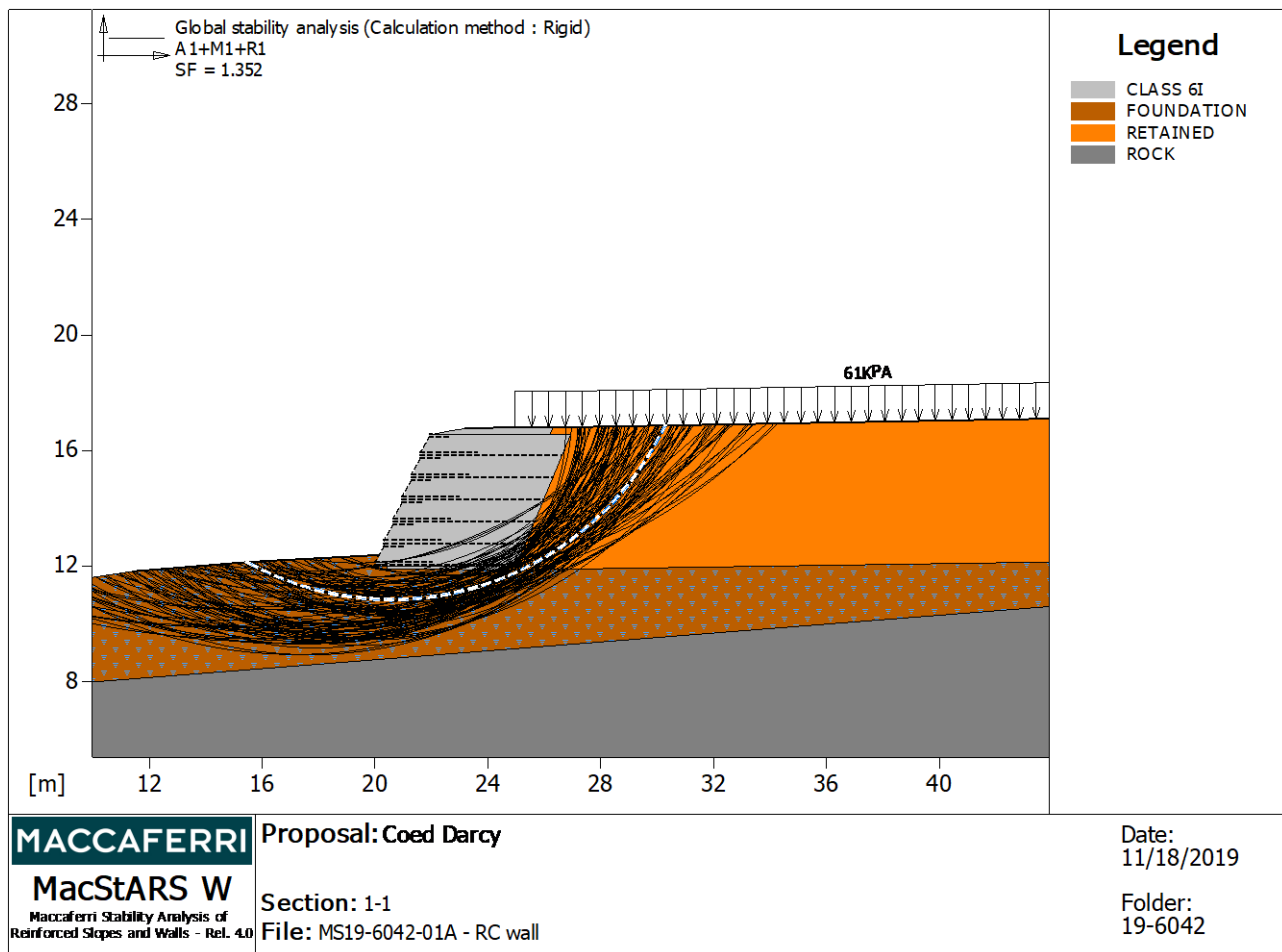
Abscissa.....[m]...: from = 24.96 To = 50.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m].....	50.00
Plastic extension ratio		0.00
Elastic extension coefficient	[m ³ /kN].....	1.10e-04
Reinforcement Stiffness	[kN/m].....	556.00
Minimum anchorage length	[m].....	0.15
Breakage Safety Factor (gravel)		1.54
Pull-out Safety Factor		1.00
Breakage Safety Factor (sand)		1.52
Pull-out Safety Factor		1.00
Breakage Safety Factor (silty sand)		1.52
Pull-out Safety Factor		1.00
Breakage Safety Factor (sandy clay)		1.52
Pull-out Safety Factor		1.00
Interaction factor reinforcement/reinforcement		0.16
Pullout coefficient reinforcement-gravel		0.90
Pullout coefficient reinforcement-sand		0.90
Pullout coefficient reinforcement-silt		0.70
Pullout coefficient reinforcement-clay		0.40

CHECKS RESULTS



Global Stability Check :

Multiplier combination : A1+M1+R1

Reinforcements active Forces according to Rigid Method

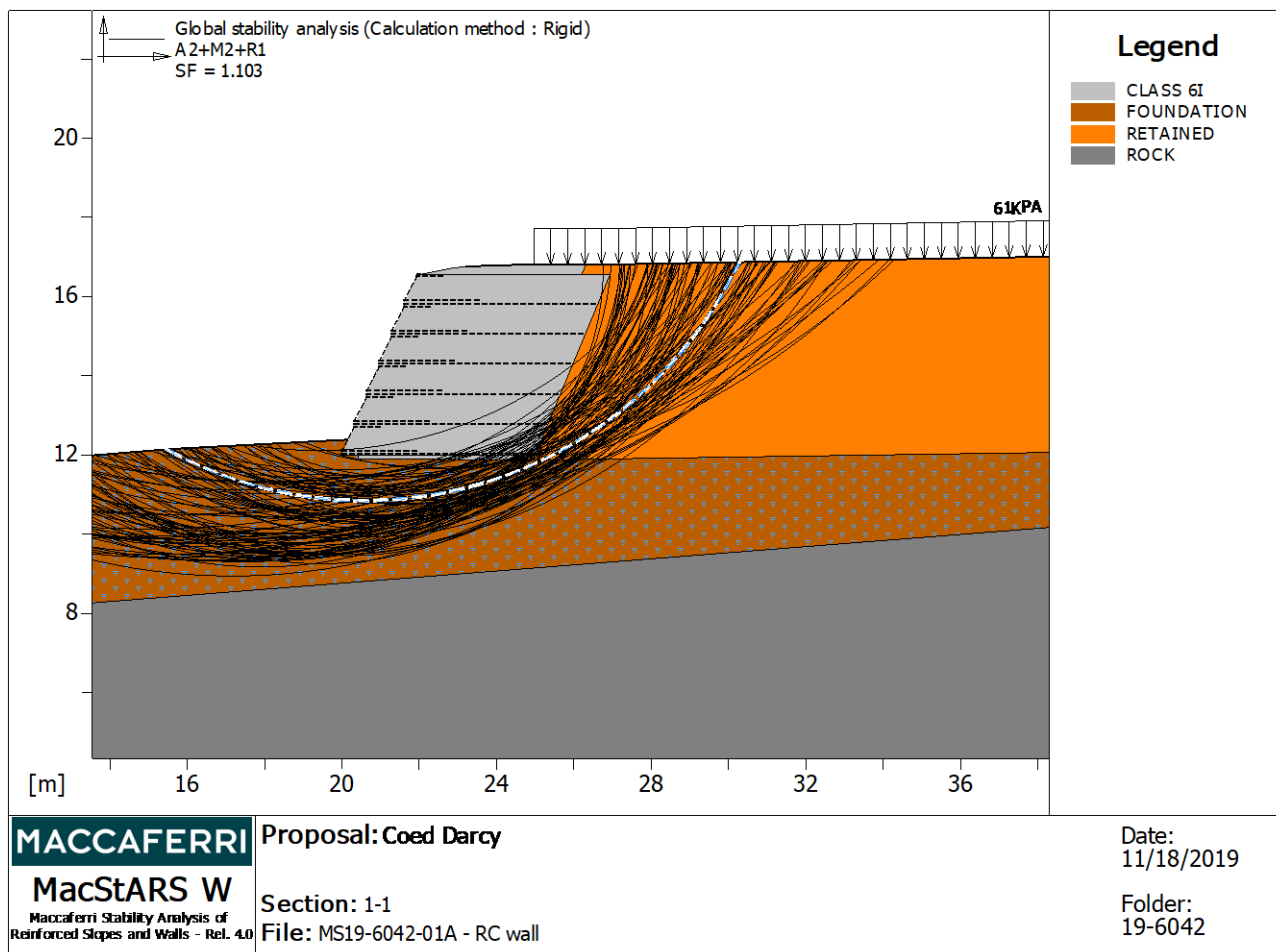
Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.352

Surfaces searching range

Starting range, abscises [m]		Arrival range, abscises [m]	
First point	Second point	First point	Second point
5.00	19.00	21.00	40.00
Number of starting point on the starting segment.....:		100	
Total number of trial surfaces.....:		1000	
Minimum base length of slices.....[m].....:		0.50	
Superior limit search angle.....[°].....:		0.00	
Inferior limit search angle.....[°].....:		0.00	

Multiplier	Class
1.50	Variable unfavourable
1.00	Angle of shearing resistance (Tan phi)
1.00	Effective cohesion
1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability



Global Stability Check :

Multiplier combination : A2+M2+R1

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.103

Surfaces searching range

Starting range, abscises [m]		Arrival range, abscises [m]	
First point	Second point	First point	Second point
5.00	19.00	21.00	40.00
Number of starting point on the starting segment.....:		100	
Total number of trial surfaces.....:		1000	
Minimum base length of slices.....[m]:		0.50	
Superior limit search angle.....[°]:		0.00	
Inferior limit search angle.....[°]:		0.00	

Multiplier	Class
1.30	Variable unfavourable
1.25	Angle of shearing resistance (Tan phi)
1.25	Effective cohesion
1.00	Weight density
1.00	Tensile strength of reinforcement
1.00	Pullout resistance of reinforcement
1.00	Ground resistance for overall stability

MacStARS W – Rel. 4.0

Maccaferri Stability Analysis of Reinforced Slopes and Walls
Officine Maccaferri S.p.A. - Via Kennedy 10 - 40069 Zola Predosa (Bologna)
Tel. 051.6436000 - Fax 051.236507

Geoman Ltd.

Project Title.....: Coed Darcy

Cross Section.....: 1-1

Site.....:

Folder.....: 19-6042

File.....: MS19-6042-02A - RC wall

Date.....: 11/18/2019

Checks according to: BS 8006-1:2010
 Wall - Cat. 2 (medium)

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SOIL PROPERTIES

Soil: CLASS 6I

Description:

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	35.00
Ru value		0.00
Weight Class	: Mass of the reinforced soil body	
Bulk unit weight - above GWT	[kN/m ³]	19.00
Bulk unit weight - below GWT	[kN/m ³]	19.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: FOUNDATION

Description: Firm-stiff CLAY or medium-dense SAND

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	30.00
Ru value		0.10
Weight Class	: Foundation soil	
Bulk unit weight - above GWT	[kN/m ³]	20.00
Bulk unit weight - below GWT	[kN/m ³]	20.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: RETAINED

Description: MADE GROUND or Class 1/2C Upfill

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	27.00
Ru value		0.00
Weight Class	: Earth pressure (mass of the backfill) behind the structure	
Bulk unit weight - above GWT	[kN/m ³]	19.00
Bulk unit weight - below GWT	[kN/m ³]	19.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

Soil: ROCK

Description: weathered SANDSTONE

Cohesion Class	: Soil material factor c'	
Cohesion	[kN/m ²]	0.00
Friction Angle Class	: Soil material factor $\tan(\phi)$	
Friction Angle	[°]	35.00
Ru value		0.00
Weight Class	: Foundation soil	
Bulk unit weight - above GWT	[kN/m ³]	20.00
Bulk unit weight - below GWT	[kN/m ³]	20.00
Elastic Modulus	[kN/m ²]	0.00
Poisson's ratio		0.30

STRATA PROFILES

Stratum: BACKFILL

Description:

Soil : CLASS 6I

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
20.25	12.39	22.03	16.56	22.87	16.72	23.21	16.76
24.41	16.80	26.30	16.80				

Stratum: FOUNDATION

Description:

Soil : FOUNDATION

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	10.14	11.43	11.82	15.60	12.15	20.25	12.39
20.44	11.90	24.87	11.87	50.00	12.23		

Stratum: RETAINED

Description:

Soil : RETAINED

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
24.41	11.88	26.30	16.80	50.00	17.21		

Stratum: ROCK

Description:

Soil : ROCK

X	Y	X	Y	X	Y	X	Y
[m]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
0.00	7.22	50.00	11.07				

REINFORCED BLOCKS

Block : GTM

Block dimensions.....[m].....: Base width.....= 5.00 Height.....= 4.56
 Block Origin.....[m].....: Abscissa.....= 20.00 Ordinate..= 12.00
 Face inclination.....[°].....: 23.00

Structural embankment type.....: Sandy Clay
 Structural embankment.....: CLASS 6I
 Backfill soil.....: CLASS 6I
 Covering soil.....: CLASS 6I
 Foundation soil.....: FOUNDATION

Brinch Hansen, Vesic or Meyerhof bearing capacity parameters

Embedment depth.....[m] : 0.50
 Natural soil slope.....[°] : 0.00

Reinforcements pattern :

Linear Composites - ParaGrid - 50

Length.....[m].....= 2.00

Vertical spacing.....[m].....= 0.76
 Wrapped length.....[m].....= 0.67

Linear Composites - ParaGrid - 50

Length.....[m].....= 5.00

Vertical spacing.....[m].....= 0.76
 Offset.....[m].....= 0.00

SURCHARGE LOADS

Distributed Loads : 61 KPA

Description :

Class : Traffic load behind reinforced soil block

Magnitude.....[kN/m²]...= 61.00 Inclination angle.....[°]...= 0.00

Abscissa.....[m]...: from = 26.00 To = 40.00

Distributed Loads : 61KPA

Description :

Class : Traffic load on reinforced soil block

Magnitude.....[kN/m²]...= 61.00 Inclination angle.....[°]...= 0.00

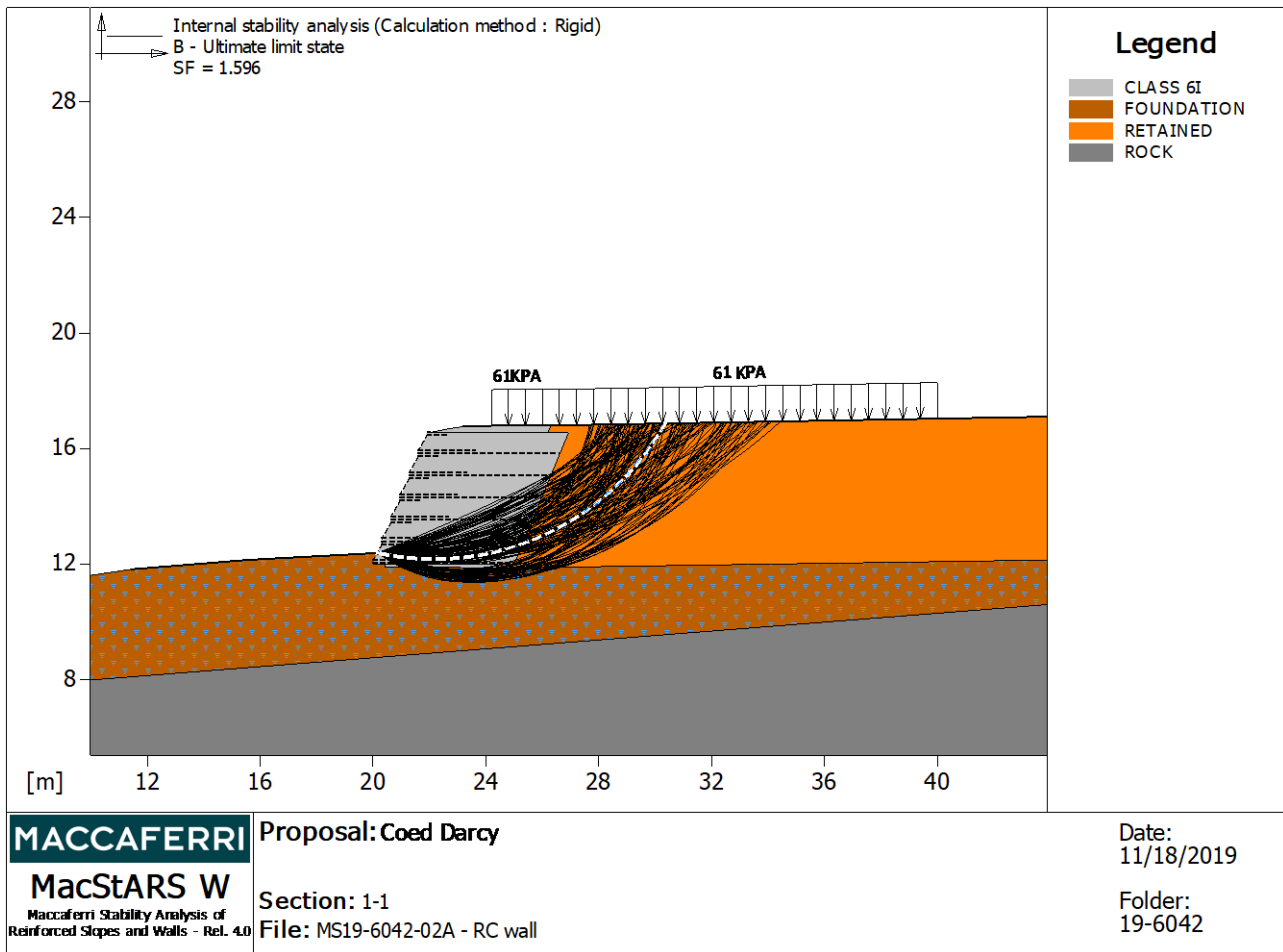
Abscissa.....[m]...: from = 24.20 To = 26.00

PROPERTIES OF THE USED REINFORCEMENTS

Linear Composites - ParaGrid - 50

Tensile strength UTS	[kN/m] :	50.00
Plastic extension ratio	:	0.00
Elastic extension coefficient	[m³/kN] :	1.10e-04
Reinforcement Stiffness	[kN/m] :	556.00
Minimum anchorage length	[m] :	0.15
Breakage Safety Factor (gravel)	:	1.54
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (silty sand)	:	1.52
Pull-out Safety Factor	:	1.00
Breakage Safety Factor (sandy clay)	:	1.52
Pull-out Safety Factor	:	1.00
Interaction factor reinforcement/reinforcement	:	0.16
Pullout coefficient reinforcement-gravel	:	0.90
Pullout coefficient reinforcement-sand	:	0.90
Pullout coefficient reinforcement-silt	:	0.70
Pullout coefficient reinforcement-clay	:	0.40

CHECKS RESULTS



Internal Stability :

Multiplier combination : B - Ultimate limit state

Reinforcements active Forces according to Rigid Method

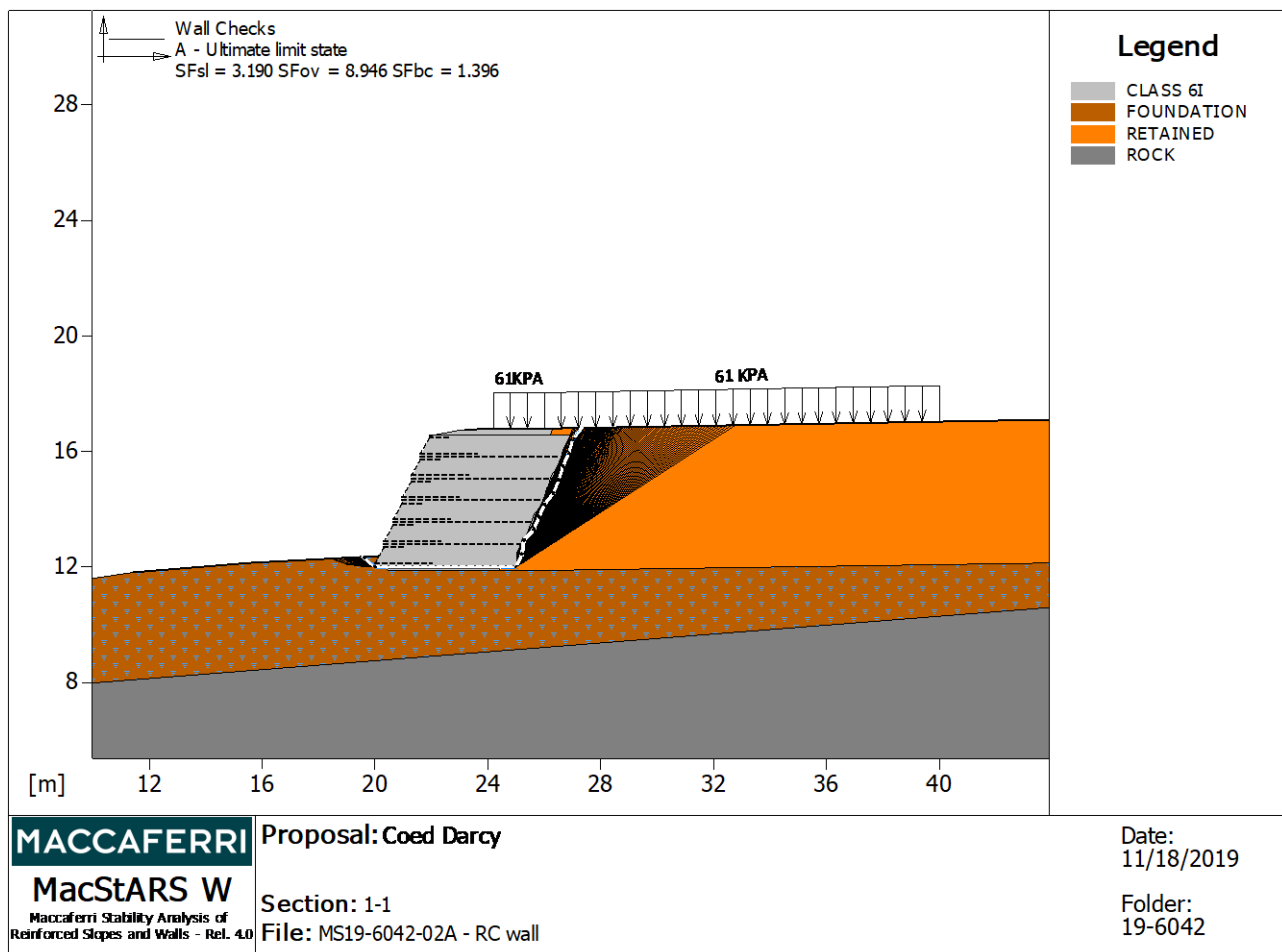
Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.596

Block GTM	Surfaces searching range	
	Arrival range, abscises [m]	
	First point	Second point
	23.00	40.00
Number of starting point on the starting segment.....:		1
Total number of trial surfaces.....:		1000
Minimum base length of slices.....[m].....:		0.50
Superior limit search angle.....[°].....:		0.00
Inferior limit search angle.....[°].....:		0.00

Multiplier	Class
1.00	Traffic load behind reinforced soil block
0.00	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)
1.60	Soil material factor c'
1.00	Soil material factor cu
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure

1.30	Pull-out factor (= $f_p \times f_n$)
1.00	Danger level of the work



Wall Checks :

Multiplier combination : A - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 620.20

Active force.....[kN/m] : 149.53

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 3.190

Restoring moment.....[kN*m/m] : 3771.80

Overturning moment.....[kN*m/m] : 421.62

Overturning class.....: Overturning

Overturning safety factor.....: 8.946

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 350.00

Active pressure.....[kN/m²] : 185.76

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 1.396

Equivalent bearing area.....[m] : 5.00

Eccentricity of normal force.....[m] : -1.11

Lever arm of overturning force.....[m] : 2.82

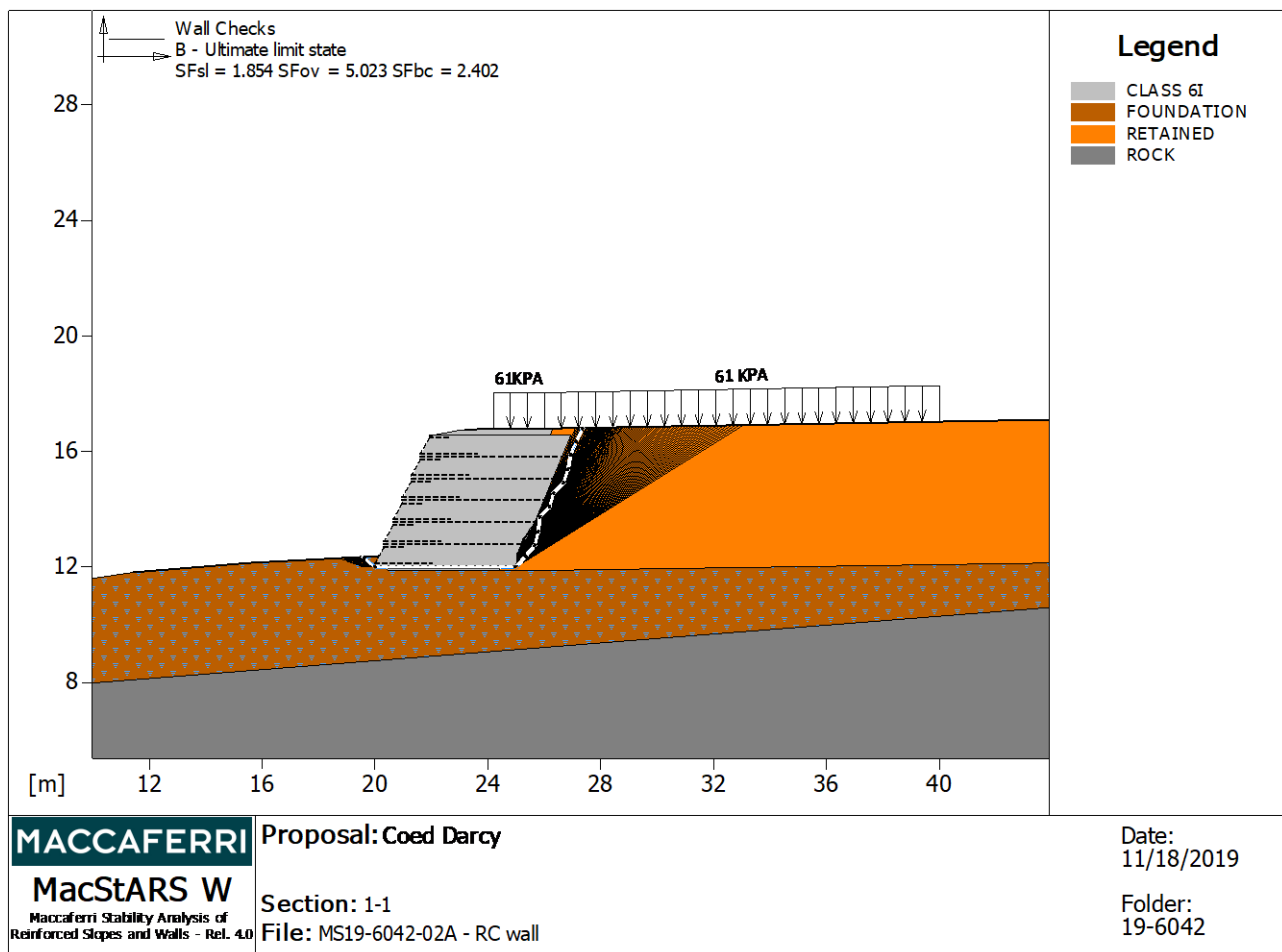
Normal force on the base.....[kN] : 928.78

Outer edge stress.....[kN/m²] : -461.57

Inner edge stress.....[kN/m²] : 1128.37

Multiplier	Class
1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning



Wall Checks :

Multiplier combination : B - Ultimate limit state

Considered block : GTM

Resisting force.....[kN/m] : 360.46

Active force.....[kN/m] : 149.53

Sliding class.....: Sliding along base of structure

Sliding safety factor.....: 1.854

Restoring moment.....[kN*m/m] : 2149.80

Overturning moment.....[kN*m/m] : 427.98

Overturning class.....: Overturning

Overturning safety factor.....: 5.023

Imposed ultimate bearing pressure

Ultimate bearing pressure.....[kN/m²] : 350.00

Active pressure.....[kN/m²] : 107.94

Pressure class.....: Bearing capacity

Bearing capacity safety factor.....: 2.402

Equivalent bearing area.....[m] : 5.00

Eccentricity of normal force.....[m] : -0.69

Lever arm of overturning force.....[m] : 2.86

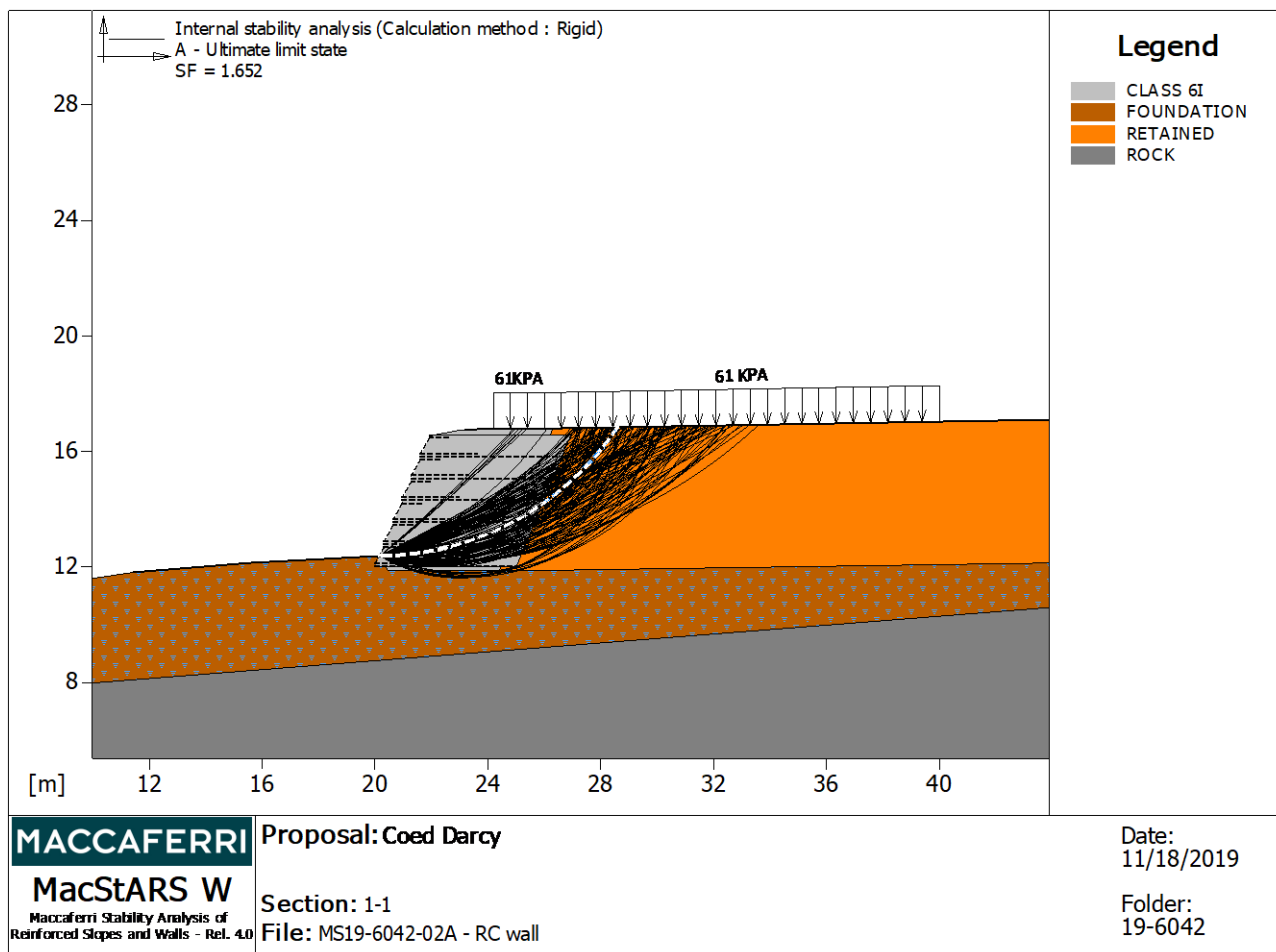
Normal force on the base.....[kN] : 539.72

Outer edge stress.....[kN/m²] : -21.51

Inner edge stress.....[kN/m²] : 319.74

Multiplier	Class
1.50	Traffic load behind reinforced soil block
0.00	Traffic load on reinforced soil block
1.00	Soil material factor tan(phi)

1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.00	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.30	Sliding along base of structure
1.35	Bearing capacity
1.00	Overturning



Internal Stability :

Multiplier combination : A - Ultimate limit state

Reinforcements active Forces according to Rigid Method

Stability analysis with circular surfaces according to Bishop's Method

Evaluated Safety Factor.....: 1.652

Surfaces searching range
Arrival range, abscises [m]

Block	First point	Second point
GTM	23.00	40.00

Number of starting point on the starting segment.....: 1
 Total number of trial surfaces.....: 1000
 Minimum base length of slices.....[m].....: 0.50
 Superior limit search angle.....[°].....: 0.00
 Inferior limit search angle.....[°].....: 0.00

Block : GTM
Linear Composites - ParaGrid - 50

Y	Tb breakage	Tp pullout	Td design	Tb/Td 1/Fmax	Tp/Td
[m]	[kN/m]	[kN/m]	[kN/m]		
0.760	50.0	87.7	32.9	1.52	2.67
1.520	50.0	87.8	32.9	1.52	2.67

Multiplier	Class
1.50	Traffic load behind reinforced soil block
1.50	Traffic load on reinforced soil block

1.00	Soil material factor $\tan(\phi)$
1.60	Soil material factor c'
1.00	Soil material factor c_u
1.50	Earth pressure (mass of the backfill) behind the structure
1.00	Foundation soil
1.50	Mass of the reinforced soil body
1.00	Category of structure
1.30	Pull-out factor ($= f_p \times f_n$)
1.00	Danger level of the work