Proceedings of the XVIII ECSMGE 2024
GEOTECHNICAL ENGINEERING CHALLENGES
TO MEET CURRENT AND EMERGING NEEDS OF SOCIETY

ISBN 978-1-032-54816-6
DOI 10.1201/9781003431749-231

ECSMGE 24
XVIII EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING

Stabilization of excavation slopes between km 0+000 and km 2+000 of the EN337, in the municipality of Vouzela

Stabilisation des pentes d´excavation entre le km 0+000 et le km 2+000 de l´EN337, dans la commune de Vouzela

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ABSTRACT: With this paper it is intended to present a case study referring to the cut slopes that occur between the kilometric points 0+000 and 2+000 of the EN337 national road, whose stabilization is within the scope of the intervention foreseen for the infrastructures and municipal equipment which were affected by the great fire that occurred in Portugal's Centre region. This fire, which broke out in June 2017, affected around 75% of the area in the municipality of Vouzela, having burned around 85% of the forest area, causing 8 deaths, losses of more than 8 million euros in agriculture and 4,75 million euros in infrastructure and municipal equipment. The occurrence and characteristics of this type of fire was aggravated by the extreme phenomena (fire) associated with climate change. It is assumed that the elimination of the vegetation area had the immediate consequence of aggravating the phenomena of the local geological formations (fracturing), thus increasing the risk of rock falls onto the road.

RÉSUMÉ: Cette communication entend présenter une étude de cas de pentes coupées qui se produisent de long de 2 km de l´EN337, conformément à l´intervention prévue par les infrastructures et équipements municipaux touchés par le grand incendie dans la région Centre. Cet incendie, qui s´est déclaré en juin 2017, a touché environ 75% de la superficie de la commune de Vouzela, ayant brûlé environ 85% de la superficie forestière, causant 8 morts, des pertes de plus de 8 millions d´euros in infrastructures et équipements municipaux. La survenue et les caractéristiques de ce type d´incendie ont été aggravées par les phénomènes extrêmes liés au changement climatique. Il est supposé que la suppression de la zone de végétation a eu pour conséquence immédiate d´aggraver les phénomènes des formations géologiques locales, augmentant ainsi les risques de chutes de pierres sur la route.

Keywords: Slopes; fire; deaths; climate; risk; rehabilitation; rock fall.

1 INTRODUCTION

As a consequence of the large fire which occurred in the municipality of Vouzela in June 2017, and the deforestation that has followed, the existing slopes' vulnerability to the erosive processes was increased. Ultimately, this led to the decrease of the slopes' stability in the affected area which. This paper's case study corresponds to the EN337 cut slopes that are present between km 0+000 and 2+000, and it is based on the slope stabilization project elaborated by this paper's authors (Elsamex, 2019).

Based on surface recognition, it was found that the existing geology at the site essentially comprise granite rock with degrees of alteration varying essentially between slightly weathered to moderately weathered (W2) and moderately altered (W3) and slope deposits, formed by the alteration of the rock mass, chaos of boulders and topsoil.

By analysing the existing situation, it was verified the existence of zones of block chaos at different heights of the slope and areas of outcrop of the rock mass that were slightly weathered and highly jointed, giving rise to discontinuity planes unfavourable to stability.

In order to reduce the increased risk of falling rock blocks, stabilization solution were defined for it, which include measures to prevent falling rock blocks and consolidation of the rock mass also prevents rockfalls, namely:

- Controlled removal of rock blocks;
- Application of mortared stone wall;
- Application of rockbolts;
- Installation of triple torsion wire mesh (Figure1);
- Installation of HEA panels (High Energy Absorption Panel) (Figure 2).

2 GEOLOGY

According to the explanatory notice on sheet 17-A (Viseu) of the Geological Chart of Portugal, the area under study is characterized exclusively by the presence of magmatic rocks, more specifically by Hercynian granitoids. The identified granitoid facies was framed within the deformation features of the surrounding rocks, taking as a reference the 3rd phase of Hercynian deformation, with which the granites of the region are related. Therefore the granites present in EN337 are late to post-tectonic (relative to D3). In relation to mineralogical composition, they are considered as granites with 2 micas.

Figure 1. View of the slope showing the heavily fractured rock mass at a high elevation with potential for instability.

3 SURFACE RECOGNITION AND DESCRIPTION OF THE EXISTING SITUATION

In order to accurately describe the existing conditions, a geological survey was performed between the kilometric points 0+000 and 2+000 of the EN337 road. The referred survey concerned the cut slopes that are present on the right side of the road.

The weathering grade of the rock mass, according to what was observed, varies essentially between little altered (W2) and moderately altered (W3) along the slope.

Between km 0+950 and 0+980, the rock massif is visible only at a height of around 10m, in a sub vertical structure (Figure 1). The massif appears much fractured, with loose blocks of medium large size with potential for instability.

Between approximately km 1+020 and km 1+090, a scenario similar to the previous one was observed, with the difference that the outcrop of the granite outcrop is visible from area adjacent to the road, i.e., it emerges at a higher elevation, low, extending in height (Figure 2).

To support the work developed, a topographic survey was carried out using a drone. This allowed a perception not only of the position and size of the blocks, as well as, the elevation at which the rock blocks are located in relation to the EN337 (Figure 3).

Figure 2. Slope featuring loose blocks with kinematic potential.

Figure 3. General aerial view of the site under study.

4 STABILIZATION SOLUTIONS

The controlled removal of rock blocks becomes necessary due to different facts, namely:

- Proximity to the road;
- Location at great heights, allowing the gain of kinetic energy;
- Subvertical slope of the massif where the rock blocks are located;
- Degradation of local friction conditions at the base of the blocks, due to weather or fires.

The recommended solutions include measures to prevent the potential fall of blocks along the slope, particularly in areas where highly fractured granite emerges, and active measures to consolidate the slope in areas of the granite mass with unfavourable discontinuity planes.

The application of triple-twist metal mesh (Figure 4) was defined for areas of the granite massif that present simultaneously a low degree of alteration and a high degree of fracture, which could consequently imply the detachment of blocks of different dimensions and subsequent fall to the road.

The solution for applying HEA panels (Figure 5) was defined only for areas where the isolated removal of blocks is unfeasible, due to steeper slopes and more significant slope heights. This solution aims to maintain rock blocks of considerable size in their position.

With the purpose of consolidating rock masses in areas where unfavourable joint planes are present, it was recommended to install localised rockbolts in exposed granitic masses with a low weathering grade (Figure 6). With its application, it was intended to prevent further development of the existing failure's surfaces and therefore increase stability.

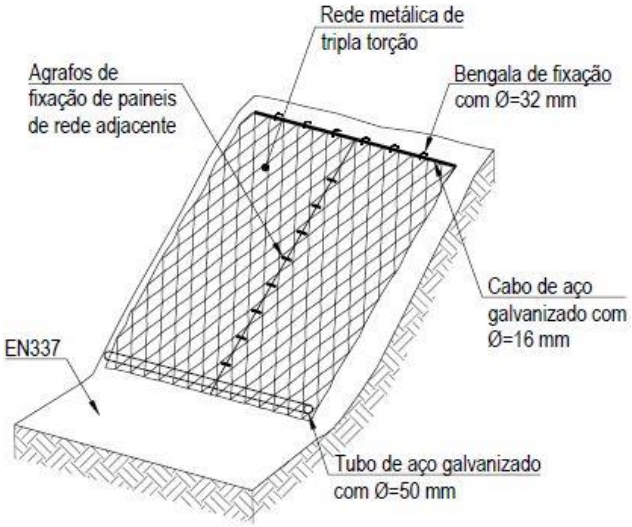

Figure 4. Triple twist wire mesh fastening diagram.

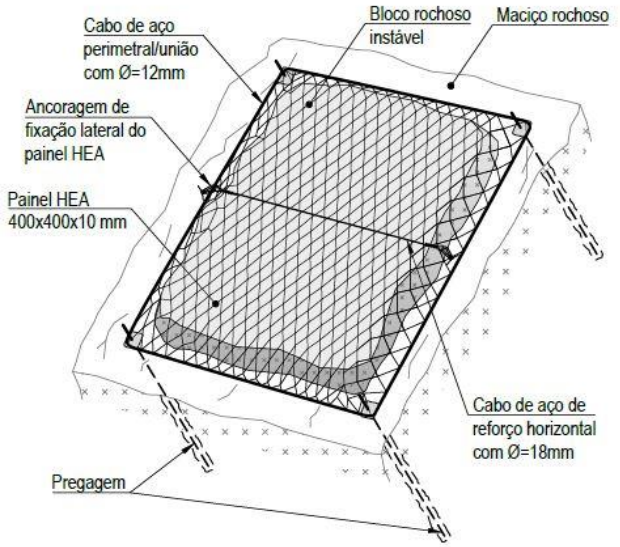

Figure 5. HEA panel fixing diagram.

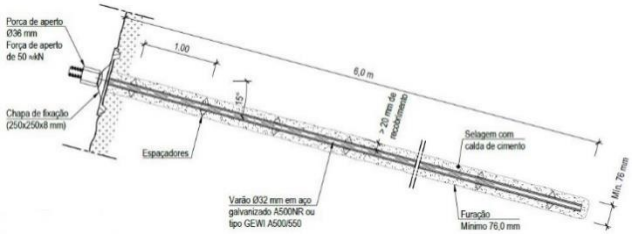

Figure 6. Rockbolt detail.

5 IMPLEMENTATION SOLUTIONS

Below, some photographs of the on-site works carried out within the scope of the solutions implemented are presented (see Figures 7 to 9).

Figure 7. Application of triple twist net and nailing in excavation slope.

Figure 8. Application of HEA panels and nailing in excavation slopes.

Figure 9. Application of punctual nailing in excavation slopes.

6 CONCLUSIONS

Following the large fire, which occurred in the municipality of Vouzela in June 2017, and the consequent deforestation, thus accelerating the erosion process and increasing the instability of slopes the need arose to carry out of the Execution Project for "Stabilization of Excavation Slopes of EN337 between km 0+000 and km 2+000".

In order to reduce the increased risk of falling rock blocks, stabilization solutions were defined, which include measures to prevent falling rock blocks and consolidate the rock mass, namely:

- Application of specific nails;
- Installation of metal mesh and triple twist;
- Installation of HEA panels (High Energy Absorption panel).

Triple wired mesh was applied in the most critical areas, whose locations comprised: i) Slopes that present clear signs of instability; ii) The steepest slopes and; iii) The higher slopes. In these areas, in addition to the triple wire mesh, it is also recommended to apply HEA panels whenever large and loose rock blocks are present.

ACKNOWLEDGEMENTS

The authors are grateful for the documentation support provided by municipality of Vouzela.

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