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PROPOSAL FOR SECURING A ROCK MASSIF NEAR BEROUN RAILWAY STATION

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Abstract. The proposal concerns the securing of a 100 m long section of the rock slope along the lead track at Beroun railway station, where a relatively massive rock block collapsed in June 2016. The rock slope is about 30 m high and its character is mainly determined by the orientation of several discontinuity systems. It was proposed for the most dangerous discontinuities that monitoring elements be used for measuring deformations at least for half a year. Dynamic barriers and protective fences were proposed for the most endangered parts of the slope.

Keywords: Rock slope, rock fall, climbing inspection, dynamic barrier.

1. Basic geotechnical characteristics

The Geotechnical characteristics relate to a circa 100 m long section of the rock slope along the lead track at Beroun railway station (see Figure 1). The rock slope in the particular area is very steep, accessible only by using climbing techniques. The abovementioned lead track runs closely along the base of the slope. That this track be open to use is very important for the organisation and smooth running of station operations.

The rock slope dealt with by the design is flat on the top, then it is slightly sloping, passing into a steep rock half-cutting, which was formed historically by river erosion, and recently by the development of the rail track. The rock slope in the location of the rock block collapse is about 30 m high and the height decreases toward the south-west. The current character of the slope surface is given mainly by the orientation of several discontinuity systems. There are local small ridges there as well as ledges and sheer parts in some locations even overhanging.

Modest vegetation cover is evident in the steep part of the rock slope. It depends on mainly fissure systems for rooting. This process leads to widening of the fissures and long-term weathering, thus negatively affecting the partial surface stability. In the top parts, the vegetation passes into relatively continuous self-seeding vegetation.

The rock massif is made up of volcanic rock types of the Palaeozoic age – granulites, altered basalts and their tuffs. These rock types are very hard, resistant to weathering. The rock wall has a general SW – NE trend and four fundamental fissure systems can be distinguished in it (see Figure 2). Fissures (A), trending roughly parallel to the slope base, with the maximum slope line running down the slope, are the least favourable. Fissures (B) dip into the slope and are perpendicular to the system (A), thus creating potentially unstable blocks. The fissure systems (C) and (D) cut through the previous systems at angles, creating characteristic crests and reducing the sizes of the potentially unstable blocks. The discontinuity surfaces are relatively smooth or maybe in some cases, moderately undulated.

2. Existing condition and remedial action

An improving and rehabilitation action, consisted in the execution of a survey, involving the removal of rock debris, some self-seeding bushes and small weathered parts of the rock, was taken in the location of concern approximately five years ago. A block of loosened rock fell down to the space of the lead track at the beginning of June 2016. It made the operation of the track impossible. The liquidation of the extremely strong rock block, hard to drill and therefore difficult to disintegrate, was very exacting (see Figure 3).

The slope deformation, which happened obviously for the first time in the location of concern, can be characterised as displacement along predetermined discontinuity surfaces, in this particular case along the surfaces (C) and (D), with the block size limited by the discontinuity surface (B) – see Figure 4. It is in substance, the last phase of a long-term creeping movement which, under certain conditions, unexpectedly develops into a rock fall. The usual conditioning factors of the creep and unexpected change in the rate of the movement of the rock blocks comprise the geomorphological disposition of the slope, weathering, the effect of surface water as well as groundwater, and the influence of vegetation and anthropogenic actions. In the majority of cases, this includes general assessment of the location. It is a concurrent action of several effects slowly reducing the shear strength on discontinuity surfaces that triggers the above-mentioned

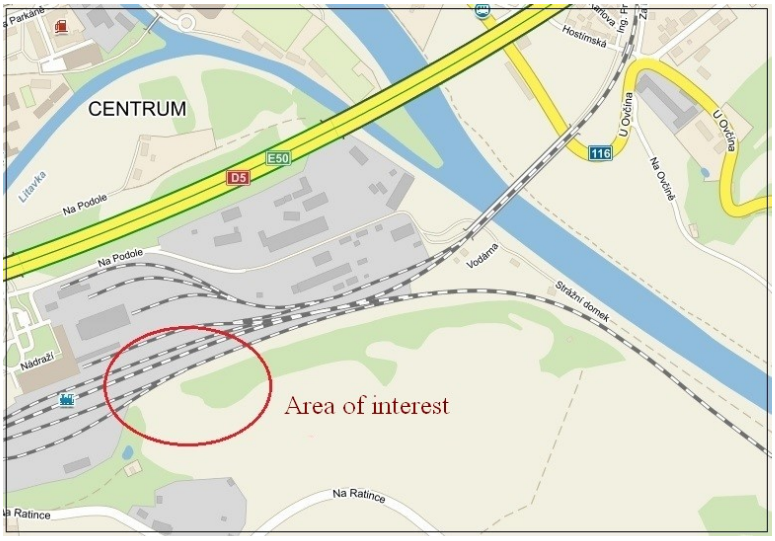

FIGURE 1. Layout of the location of concern.

FIGURE 2. Discontinuity systems on the rock wall being monitored.

creeping movement. Over a long time or also in the case of a sudden change in external conditions, the shear strength on discontinuity surfaces is exceeded by the tangential component of the dead weight of the loosened part of the rock massif, which then in fact becomes the immediate cause of the rock fall.

A climbing inspection of the rock slope [1] was conducted after the fall of the rock block on the lead track. The inspection lay in removing rock debris and loose rock fragments or small rock blocks and liquidation of a part of the self-seeding vegetation. This work ensures safer operation along the lead track as well as the possibility for relatively safe execution of other rehabilitation work in the future. Detailed photographic documentation allowing for tipping the locations on the rock massif fissures and dislocations recommendable for the installation of mechanical deformation monitoring elements was provided during the inspection. The monitoring elements need to be installed on about 10 dangerous discontinuities without any unnecessary delay. They should be observed at around half-year intervals always before and after a climatic change – at the end of autumn and at the beginning of spring. Contingent smaller-extent cleaning of the wall and inspection of the wall condition will be carried out concurrently with the unavoidable climbing checks of the measuring instruments, so that the possibility of the loss of stability of some of the larger rock block can be assessed. Increased attention has to be devoted to areas No. 1 and 2 (see Figure 5), where the danger of loosening rock blocks is greatest. The inspection of the wall and the photographic documentation signal the possibility of some blocks losing their stability in the above-mentioned areas.

FIGURE 3. Fallen rock block after partial disintegration.

FIGURE 4. The location of a loosening of the fallen rock block.

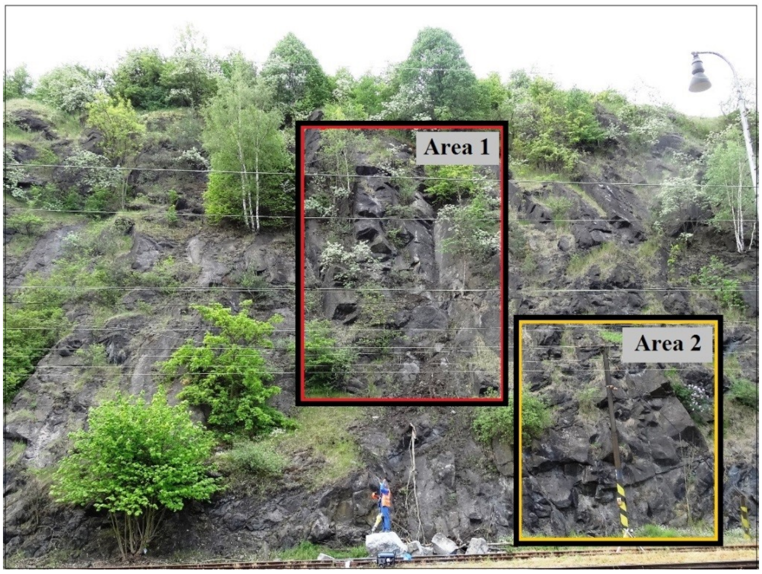

FIGURE 5. Dangerous areas of the rock wall.

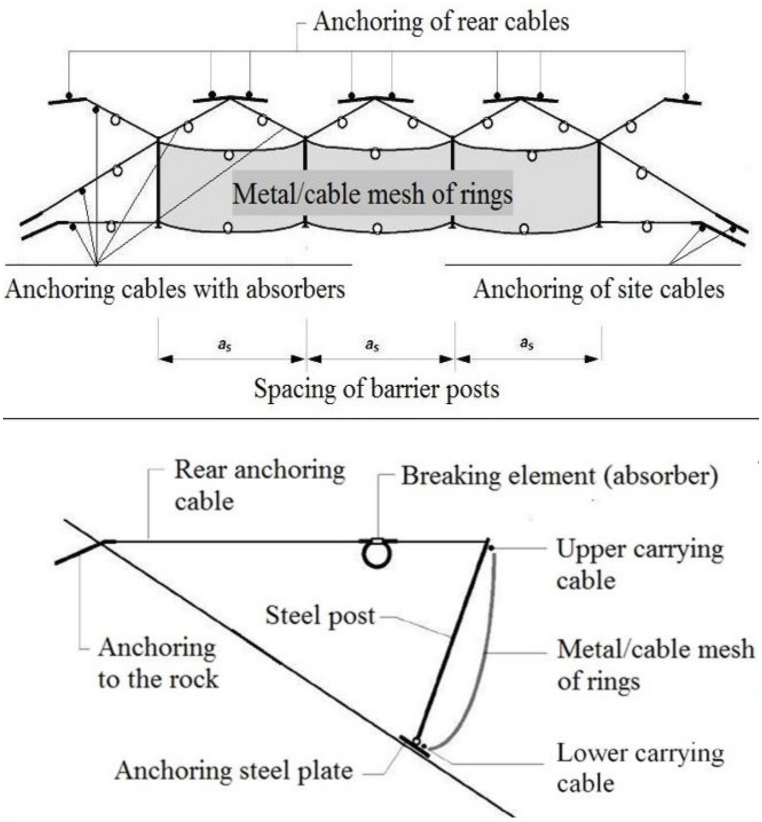

Figure 6. Dynamic barrier – schematic view and cross section.

Figure 7. Detail of a loop-type breaking element (energy absorber) of the dynamic barrier.

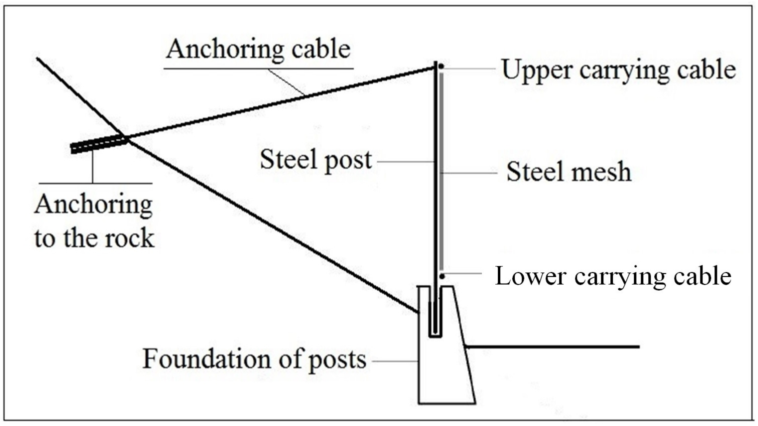

Figure 8. Protective fence – schematic cross section.

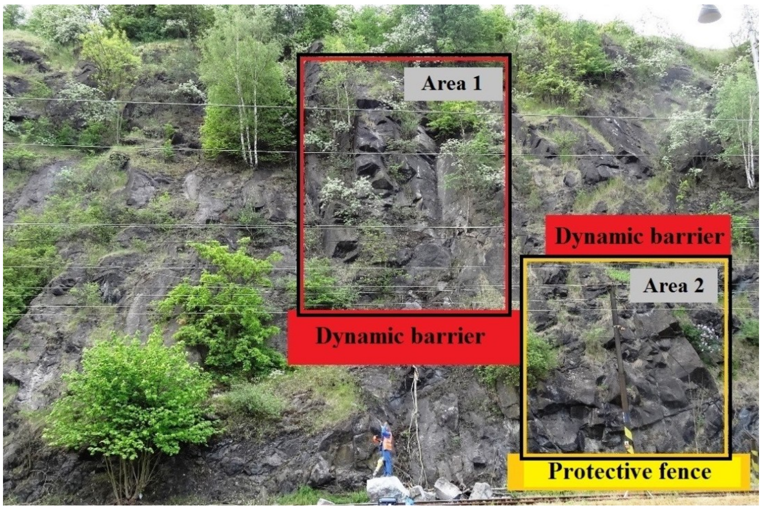

Figure 9. Locations for the placement of dynamic barriers and the protective fence in the endangered areas of the rock wall.

3. Proposal for rehabilitation measures

Taking into consideration the exposed section of the rock slope above the lead track, the author of the assessment contemplated carrying out a design for rehabilitation measures which would reliably ensure operational safety in the railway yard. It would comprise a dynamic barrier under the particular area No. 1, possibly even above the area No. 2, and a protective fence or another type of a solid barrier under this area No. 2.

Dynamic barriers are structures tested experimentally as well as in practice, which are capable of restraining a falling rock block with the maximum kinetic energy of up to 5,000 kJ. This capability is provided by the combined action of a net with a metal/cable mesh of rings and a system of binding cable with a system of posts, which involves a multiple anchoring to the rock substrate in the directions transverse, longitudinal and perpendicular to the slope. The cable anchoring elements are equipped with an efficient breaking system (energy absorbers of various types). Materials concerning the rehabilitation of unstable rock massifs provided by [2]. The diagram of the breaking system of a dynamic barrier is presented in Figures 6 and 7, and protective fence in Figure 8.

It will be suitable to install the dynamic barriers on the rock slope of concern roughly at one third of the height of the wall under the area No. 1 and possibly above the area No. 2, approximately in the middle of the wall height. The barriers will be 2 m up to 2.5 m high. The locations for the placement of the dynamic barriers and protective fence are schematically indicated in Figure 9. All of presented figures were captured during climbing research by [3].

4. Conclusions

The rock slope located south-east of Beroun railway station can be assessed as an endangered location, which poses a potential and rather hard to predict threat to the existing lead track. It was therefore recommended that simple mechanical monitoring elements be installed for monitoring the deformations on dangerous discontinuities. The monitoring of deformations on selected fissures, combined with the inspection and basic cleaning of the wall, possibly with tipping of the endangered blocks which will have to be removed from the wall, should be carried out at half-year intervals at a minimum.

It will be necessary in the case of more pronounced manifestations of deformations to consider the implementation of more radical rehabilitation measures and structures, in particular the installation of dynamic barriers and protective fences. An active approach of the Railway Infrastructure Administration which is a state organisation, is considered desirable.

References

[1] Inspection. Inspection of the location dated 9th june 2016.

[2] Materials concerning the rehabilitation of unstable rock massifs provided by GEOBRUGG AG, STRIX a. s., MACCAFFERI s. r. o.

[3] J. Barták, OREMO. Climbing research and photographic documentation of the location of concern carried out by OREMO and Barták J., 02/2011.