# ROCKFALL PROTECTION

## EXPERIENCE FROM SLOVENIA

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## ROCKFALL HAZARD AND PROTECTION IN SLOVENIA

In Slovenia larger rockfall phenomena, like large scale failures, are not very common. They occur in the seismically active Upper Soča valley and even there are limited to smaller areas. More frequently we face rockfall and blockfall that put at risk residential and business premise, roads and railroads. Data, gathered by PUH d.d., show that rockfall is a major hazard for 175 km i.e. 2,8% of the total of 6.215 km state roads. Ever more frequent and intensive weather extremes and continuous increase of damage potential are calling for permanent supplementing of rockfall hazard assessment and selection of reliable and lasting solutions. In selection of the solutions, environmental adequacy is ever more important. The problems are solved with measures of active and passive protection. The analysis of adequacy of the carried out rocfall control measures sets guidelines for the future action.

The principles of rockfall protection are determined by the extent of hazard. Where there is risk of large scale failures, spatial measures are the most rational solution. The line of the roads should be deviated, or protected by adequately designed galleries when this is not possible. In case of rockfall and blockfall hazard the method of primary or secondary active protection depends mostly on location and magnitude of the phenomena with regard to the structure at risk, to technical possibilities and to environmental acceptance of control measures.

**Fig. 1, 2:** The Polica slope on highway Ljubljana – Obrežje; situation before and after the measures carried out in 2005

Primary protection is carried out on the areas where rockfall phenomena take place. Standard rockfall control was carried out with plain or reinforced mesh drape, with which restrained the falling rocks. In recent years deep anchored steel wire mesh with high tension strength is coming forward because it enables not only slope stabilization but also revegetation of very

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steep slopes. In Slovenia this system of rockfall control was carried out in the largest extent on the slopes Polica (Fig. 1, 2) and Mali vrh on the Malence – Višnja gora highway - slopes exposed to intensive weathering, rockfall and superficial sliding. To stabilize the surface, high-tensile steel wire mesh was used in combination with nailing (nail length was 4 – 7 m). Tensile strength of the individual wires is more than 1,770 N/mm$^2$. The slope was also revegetated (hydroseeding and planting of willow cuttings). The results are very good.

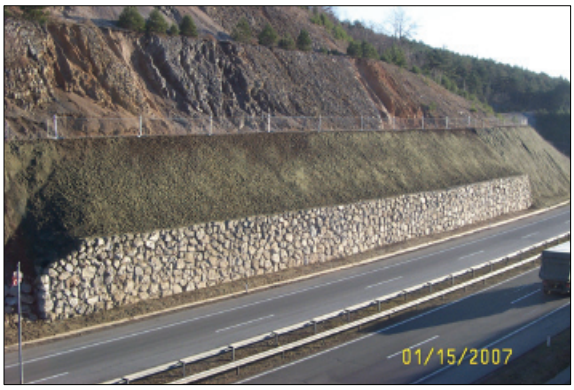


Fig. 3, 4: Rockfall control measures – combination of stone masonry, mesh with high tension strength and rockfall barriers on the top of the first slope on highway Razdrto-Divača (2006)

Secondary protection is used when rocks have already been released. For retaining loose rocks we use up to date rockfall barriers that can retain falling rocks and boulders as well. They can retain from 75kJ up to over 5000 kJ of dynamic pressure. The rockfall barriers can be combined with avalanche protection measures. These rockfall barriers were introduced in Slovenia in larger scale in 1993. Since then over 1800 meters of these up to date protective structures have been raised. All the structures are generally raised on critical, difficult to access points above the road sections, which are subject to a permanent rockfall hazard.

**Fig. 5, 6**: Rockfall barriers on slopes Mežakla (2003) and above state road next to Col settlement (2006)

## CONCLUSION

Practical cases presented in this article prove that up to date rockfall control measures can successfully substitute older measures that cost more money and are less environmental friendly. It has to be noted however, at least in the case of rockfall barrier, that these structures can serve their purpose only when they are regularly checked, cleaned and maintained. We should not overlook also the fact, that even with all the newest and most effective rockfall protection measures, the traffic safety is basically determined with its laying out and adequate vegetative protection of the slopes above.

**Keywords:** Rockfall , Rockfall protection structures, Rockfall barier, Traffic safety