



## **Rockfall risk mitigation measures in the principality of Andorra**

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This communication reviews and discusses the rockfall risk management experience in the Andorra Principality during the last 20 years. Andorra is a mountainous country located in the Pyrenean Range between France and Spain with an average elevation of 1830 m. It has been historically affected by a diversity of hazardous phenomena and rockfalls are the most frequent hazard as they occur all over the country. In October 1987, a rock slide of more than 50,000 cubic meters killed three people and caused the closure of a national road for two months and the isolation of the Valira del Nord Valley. The road is now protected with a concrete gallery. In the urban area of Andorra la Vella and Santa Coloma, rockfalls have damaged buildings in 1983 and 1994. In 1997 a new rockfall event hit a building and caused an injured. This event raised the public awareness of the risk and mobilized the local authorities to take action against possible future rockfalls. The most important rockfall risk mitigation action carried out was the Rockfall Risk Management Master Plan of the Solà d'Andorra which was completed in May 1998. This Plan established restriction to the development in the most threatened sectors. The Plan gave also way to the implementation of protective works such as rockfall fences and concrete walls. The performance so far of the mentioned actions has revealed highly effective. The most important achievement is the change

in the perception of risk by the stakeholders. The awareness of rockfall hazard has raised with the public audiences, the building codes and the control works. The Andorran administration is currently engaged in an ambitious program for rock fall risk mitigation with special interest in both the urban areas and the main road network. Private developments must set up the necessary protective measures in order to obtain building permits in the threatened areas. The stability of new cutslopes must be also guaranteed by the appropriate engineering design. Despite the restrictions imposed by the steep relief and the lack of space, these measures have shown their efficacy as several rockfall events have occurred which have been intercepted by the protective works and had no damaging consequences.