Design of rockfall protection galleries

Abstract

Last decades, some mountainous regions experienced an important population growth that implied the construction of numerous buildings and infrastructures, sometimes in areas where the probability of a rockfall is high. This makes it necessary to find measures to protect human activity against these phenomena.

There are several options to reduce the risk of rockfalls. The construction of a structure that protects, in a permanent way, those goods and people placed in the trajectory of the rock is a common option. Protection galleries are a good choice when the area that has to be protected is narrow and well limited, like roads and railways, and safety in the area below the structure can be neglected. Also, the bearing capacity of the soil has to be enough for a rigid structure like a gallery and the length of the protected area must be limited because of the high construction cost of these structures. In addition, traditional galleries, designed with a soil layer over their cover, are only valid when it is necessary to protect in front of either medium or small sized rock falls.

In Spain, the main problem when designing a protection gallery is the non existence of neither official regulations nor a widely accepted reference method. Some countries like Japan and Switzerland have regulated the design of these structures but, in spite of this, these regulations only concern protection galleries with a soil layer over their cover, and thus, they neglect the design of new types of galleries that have appeared recently. Also, the impact load estimated according with these regulations does not always correspond with the impact load measured in experiments performed by different authors.

The impact of a rock on a soil layer is a complex phenomenon. To understand it correctly it is necessary to comprehend all the mechanisms involved in the dynamic behaviour of the soil layer during the collision of a mass, the interaction between the soil layer and the gallery, and the dynamic response of the structure. Throughout the years, different approximations to study the impact of a rock on a soil layer have been developed. These approximations basically differ in the way they consider the soil behaviour and the dynamics of the collision, and their results are greatly dispersed. In the present study, multiple experimental results found in literature are compared with the estimates calculated according to proposals made by different authors. By doing so it is possible to establish a method to design this type of galleries. Also, to make this method more comprehensible, an example is included.

In order to improve the limited energy absorption capacity of rock sheds designed with a soil layer over their cover, galleries with layers of different materials or combinations of them have been proposed. Those with layers of expanded polystyrene (EPS), either conventional or reinforced, as well as those with combinations of EPS layers with layers of other materials, stand out. These systems function due to the high energy absorption capacity shown by EPS as it strains during the impact. Although they are a good option to increase the impact energy the gallery can withstand, these systems present several limitations as the low impact energy with which they have been tested or, in some cases, the non existence of experimental studies to corroborate all the hypothesis admitted. Even though, a dimensioning method is proposed in the present study for each of these galleries. Also, a simple calculation example is included.

Allowing the yielding of some parts of the structure is the base of another efficient system to increase the energy absorption capacity of rock sheds. By doing so, the impact energy is partly absorbed in the deformation of these zones. The greatest impact energy in the experimental studies found in literature (7.83 MJ) is tested on a gallery that functions according to this basic principle. In the present study, the possible limitations of these galleries are analized and a simple calculation of these structures is included.