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Commentary

Geology of Rockfall Causes and Embankments

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DESCRIPTION

A rockfall is one of the most devastating natural disasters in mountainous areas, destroying infrastructure and killing people. Blocks fall off of steep cliffs and slide down the slopes with a lot of energy and motion. These occurrences are caused by a combination of manmade activity and the following natural phenomena: earthquakes, rains, freeze-thaw cycles, and high winds. Compared to other slope disasters, these accidents occur more frequently. The size of the rocks varies as well, ranging from boulders the size of vehicles to smaller rocks and gravel. No matter how big the block is, collisions with people, cars, or other structures result in fatalities or substantial financial losses.

The main causes of rockfall are favorable geology and climate, which include root-wedging, freeze-thaw cycles, discontinuities within the rock mass, weathering sensitivity, ground and surface water, and external stressors. Wind-blown trees may exert pressure at the root level, which can cause rocks to become loose and lead to a fall. A talus or scree is formed at the bottom where the rock fragments accumulate. A mass-wasting process, such as an avalanche, may be triggered by rocks falling off the cliff, dislodging additional rocks.

An incompetent cliff is one that has ideal geology for a rockfall. One can be deemed competent if it is less likely to experience a rockfall and is better consolidated. Rockfalls in mountains at higher altitudes may be brought on by the permafrost-covered rock masses melting. In lower-elevation mountains with warmer climates, rockfalls may be caused by weathering that is accelerated by non-freezing conditions.

Therefore, in rockfall-prone areas, it is crucial to implement protection or mitigation measures. The two main types of rockfall prevention strategies are active measures and passive measures. The former type uses concrete, wire ropes, bolts, or drapery systems to firmly anchor shaky rocks on a slope face. On the other hand, the latter group uses protective structures placed at the bottoms of the mountain slopes to impede rockfalls and absorb kinetic energy. Identification of rockfall-prone locations and prospective sources, analysis of rockfall risks, risk assessment of the areas, and formulation of countermeasures are all necessary for such implementation.

Embankments are a common form of passive protection, similar to safety fences, nets, and rock sheds. Protection embankments today come in many different shapes and materials (i.e., compacted ground, rocks, and geosynthetic materials). The most popular of them are reinforced soil embankments. In this technique, wire meshes, geotextiles, wood and steel bars, or a combination of waste items are used to support an earth fill (e.g., shredded tires). The impact of rockfalls causes the embankment to distort, which absorbs the energy. To stop boulders with significant rotational energy from passing over, the embankment typically features a trapezoidal cross section and severe dip angles of up to 70° on the front side face.

The amount of energy that the protection structure will withstand must be precisely estimated by the designers. Additionally, the placement of the protection structure on a construction site has a big impact on how well it can stop rockfalls. The trajectory, passing heights, and kinetic energy of potential rockfall events should be taken into account while designing the structure to ensure its overall performance. A frictional model based on the "sled model" has been used in practise to estimate the kinetic energy displayed by falling blocks in a clear and simple manner. Since the sled model was developed to simulate mass sliding, various restrictions on its application to rockfalls are understood. One significant drawback is that the model frequently overestimates the kinetic energy when a block is falling with a radius of several meters or sliding down a slope with a length of many tens of meters. This is because typical mechanisms, such as the energy loss of the block brought on by ground deformation during collisions with the slope surface, were not taken into account.

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