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Technical Note

Experimental testing of low-energy rockfall catch fence meshes

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ABSTRACT

Flexible catch fences are widely used to protect infrastructure like railways, roads and buildings from rockfall damage. The wire meshes are the most critical components for catch fences as they dissipate most of the impact energy. Understanding their mechanical response is crucial for a catch fence design. This paper presents a new method for testing the wire meshes under rock impact. Wire meshes with different lengths can be used and the supporting cables can be readily installed in the tests. It is found that a smaller boulder causes more deformation localisation in the mesh. Longer mesh length makes the fence more flexible. Under the same impact condition, the longer mesh deforms more along the impact direction and shrinks more laterally. Supporting cables can reduce the lateral shrinkage of the mesh effectively. Most of the impact energy is dissipated by stretching of the wires. Wire breakage has not been observed.

1. Introduction

Rockfall catch fences are frequently used to protect infrastructure like railways, roads and buildings from rockfall damage (Muraishi et al., 2005; Bertrand et al., 2008; Buzzi et al., 2013). They are classified based on the energy dissipation capacity. A fence which can dissipate impact energy below 100 kJ is classified as low-energy fence (Buzzi et al., 2013). Low-energy catch fences are more widely used than the high-energy ones in most areas of the world. A typical catch fence system consists of a steel wire mesh, supporting cables, posts and ground anchors. The wire mesh is the most critical component because it dissipates most of the impact energy when a fence is hit by a falling rock (Gentilini et al., 2013; Thoeni et al., 2013). It is produced by twisting continuous pairs of steel wires to form different opening shapes with the most common ones being hexagon and diamond (Bertrand et al., 2008; Buzzi et al., 2013). Fig. 1 shows a single cell of a double-twisted hexagonal wire mesh which will be used in the present study.

Mechanical response of the wire mesh has significant influence on energy dissipation capacity and failure modes of rockfall catch fences (Peila et al., 1998; Gerber, 2001; Peila and Ronco, 2009; Tran et al., 2013). Various approaches have been used to study the wire mesh response under different loading conditions. Some methods, such as uniaxial extension tests and punching tests, have focused on the response of the wire meshes under quasi-static loading conditions (Bertrand et al., 2008). In a uniaxial extension test, a wire mesh panel is stretched along its longitudinal direction until wire breakage occurs. In a punching test, a square wire mesh panel is fully constrained at four sides and punched by a spherical mass at the centre of the panel until perforation is observed. In both tests, the loading rate is low and constant. These tests are useful for the design of other rockfall mitigation structures such as gabion structures and rock netting where quasi-static loading conditions are expected (Bertrand et al., 2008). However, the results of these tests cannot be directly used in designing of rockfall catch fences, because these tests cannot reproduce the real loading scenarios under rock impact.

Impact tests on the wire mesh are thus needed for rockfall catch fence design. At present, impact tests are conducted on either a single wire mesh or full-scale catch fences (e.g. Bertolo et al., 2009; Gottardi and Govoni, 2010; Tran et al., 2013; Bertrand et al., 2012; Gentilini et al., 2013; Mentani et al., 2017). Full-scale tests can offer important insight into the dynamic response of a catch fence system. But they are expensive and time-consuming. Moreover, they are more suitable for evaluating the performance of an entire fence structure which includes the wire mesh, posts, cables and all other components, rather than the mechanical response of wire mesh itself, which is crucial for developing preliminary catch fence

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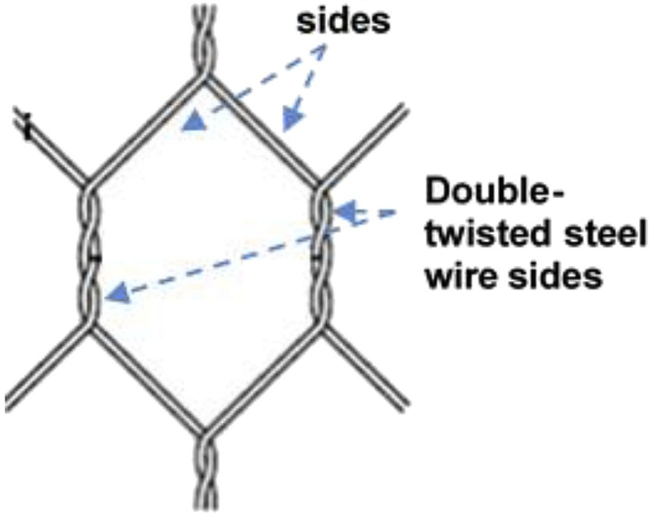

Fig. 1. A single cell of double-twisted hexagonal wire mesh.

designs (Gentilini et al., 2013; Thoeni et al., 2013; Al-Budairi et al., 2017). Mentani et al. (2017) has reported impact tests on a single wire mesh, in which a square mesh is fully constrained at all four ends. Such constraint is different from what is used in a real design wherein the longitudinal sides of the wire mesh are either free or attached to a supporting cable (Al-Budairi et al., 2017). Lateral mesh deflection which needs to be properly considered in catch fence design has not been investigated in these tests.

A method for testing the dynamic response of low-energy rockfall catch fence meshes is presented in this note. Boundary conditions which are close to reality can be applied in these tests. Specifically, a testing rig is designed and fabricated to conduct impact tests on a wire mesh panel. Different rock sizes and impact velocities can be used and the length of the wire mesh panel can be adjusted. Supporting cables can also been installed along the edges of the mesh. The equipment, test procedure and test results are presented. The test results can be used for proposing preliminary design of low-energy rock catch fences in which the impact energy is mainly dissipated by mesh stretching (Al-Budairi et al., 2017).

2. Testing rig

A testing rig is designed for impact tests on wire mesh panels at QTS Group Ltd., as shown in Fig. 2. The rig is 6.5 m long, 3.5 m wide and 5 m high. The rig is fixed on the ground by ten vertical posts and safety mesh is installed around it. Two rectangular supporting beams are laterally attached to the rig to hold the wire mesh panels and supporting cables. The distance between these beams is adjustable to fit various panel lengths. In this study, two panel lengths of 2 m and 4 m are considered.

3. Testing procedure

The wire mesh panels are horizontally attached to the rig with the ends being clamped to the supporting beams and the lateral edges being either free or connected to supporting cables. All the meshes are installed manually and there is initial mesh deflection due to gravity. Fig. 3 shows the method for clamping the ends of the panel to the supporting beams. Each end is clamped by bolts and nuts (13 on each beam) between the upper face of the supporting

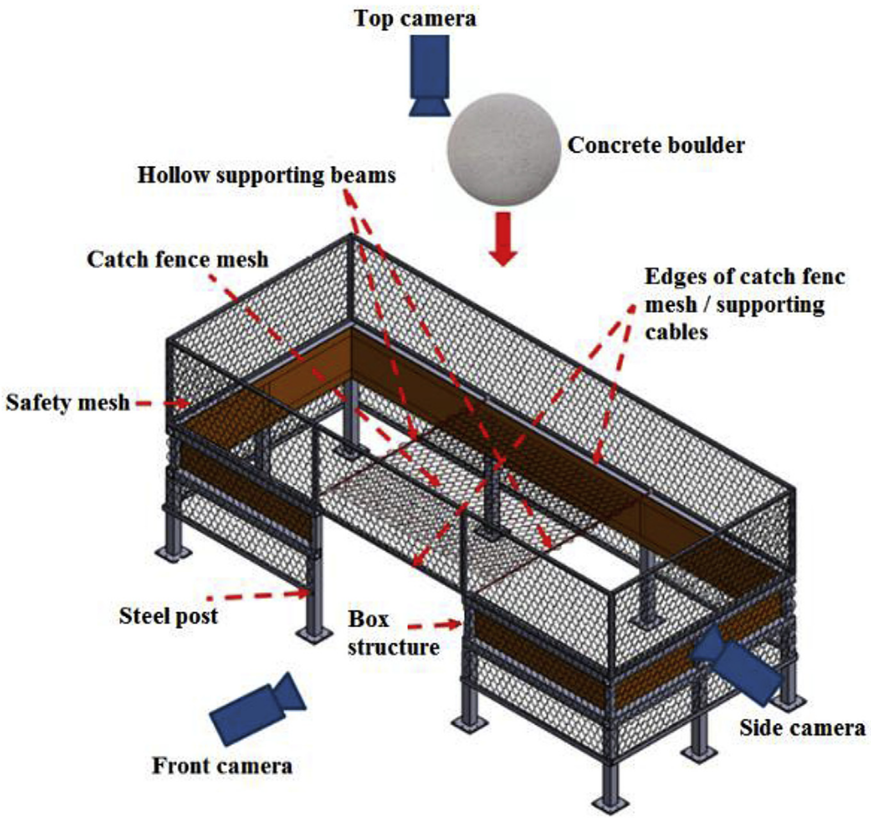

Fig. 2. Illustration of the test rig and testing setup.

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