NUMERICAL MODELLING OF ACCELERATION RESPONSE OF ROCKFALL CATCH FENCES UNDER IMPACT LOADING

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SUMMARY

Rockfall catch fences are flexible mechanical structures which are used on hillsides to protect nearby infrastructure from being damaged by falling rocks. They consist of steel wire meshes, posts, wire ropes and ground anchors (Figure 1). Catch fences intercept and capture falling rocks by dissipating their kinetic energy mainly by elasto-plastic deformation of meshes and posts.

Catch fences need to be monitored to ensure that they are fully functional. Physical inspections are expensive and time-consuming. An alternative solution is to use vibration sensors to monitor the structural response of the catch fences and to detect any significant rockfall impact [1]. However, the wide range of possible impact scenarios makes it difficult to define the characteristic parameters for a suitable sensor. Furthermore, it is important to define acceleration thresholds to distinguish between significant and insignificant impacts on catch fences and thus to avoid false warnings.

1: Introduction

Real-time rockfall monitoring system on catch fences is currently under development [1]. In this system, sensors are attached at the top of the posts to detect the vibration generated by impacts between falling rocks and the fences (Figure 1). The sensor has an accelerometer that detects the vibration response in the posts due to impacts. A minimum response threshold is important to prevent false alarms due to minor impacts by small rocks or high-speed winds. Also, a maximum response threshold is important to ensure that the accelerometer is capable of measuring impacts at high velocities. Identifying the response thresholds for a suitable accelerometer is a difficult task due to the enormous impact scenarios between rocks and catch fences. Therefore, a finite element (FE) model of catch fences is developed using Abaqus, the finite element software [2], to predict the mechanical response of the fence under various impact scenarios. In this model, finite element explicit calculation scheme was used to calculate the acceleration response at the top of the posts.

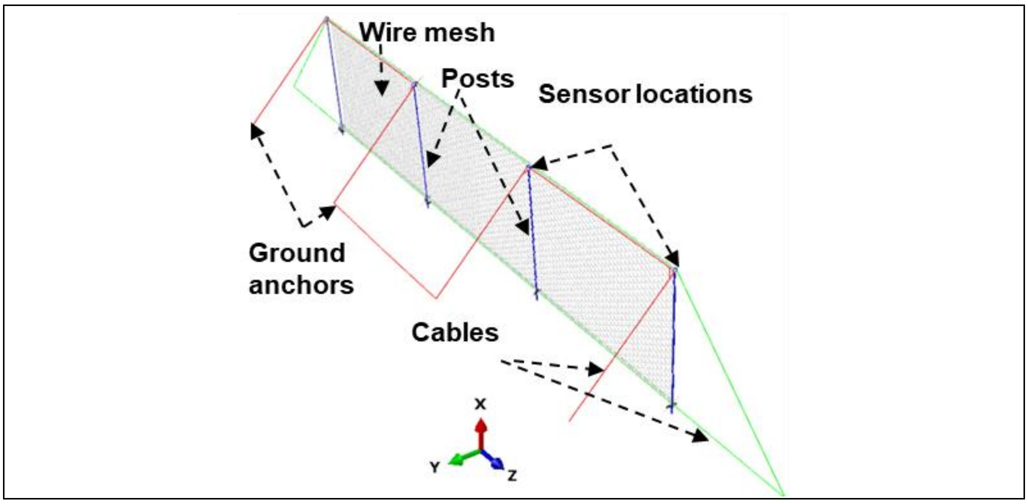

Figure 1: **FE model of rockfall catch fence.**

2: Model validation

The developed FE model was validated by full-scale impact tests where concrete masses were dropped on horizontally constructed catch fences from a certain height. In these tests, four accelerometers were attached at the top ends of the posts to measure the acceleration components in three-directions. In this study, an impact test of 750 kg tetrahedral mass dropping on a 9-meter long catch fence with an impact velocity of 7.6 m/s is presented (Figure 2). The model predicted the overall deformation of the catch fence very well. However, it overestimated the acceleration response at the top of the posts particularly in the vertical direction (z-direction in Figure 2).

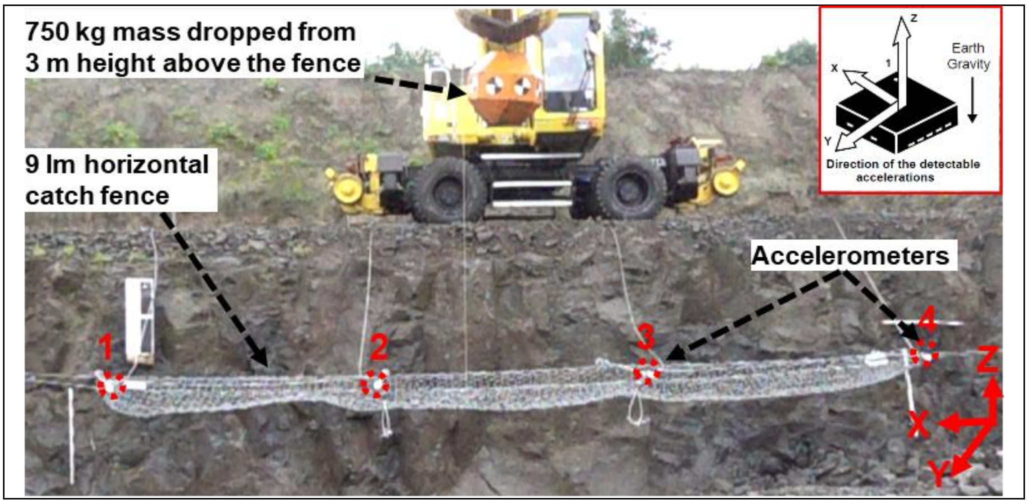

Figure 2: **Full-scale impact test on a rockfall catch fence.**

3: Results and discussion

For illustrative purposes, the Abaqus calculation of acceleration component in the vertical direction for a single node on the top of Post 2 is plotted with the measured data in Figure 3. The calculated (raw) data are recorded for every time increment of the explicit solver to include the highest possible frequency response. In this figure, the first contact between the falling mass and the catch fence is at 0 s. The figure shows that the calculated and measured data are not correlated where the highest calculated acceleration (162 g at 0.109 s) overestimates the highest measured acceleration by more than 20 times.

The explicit dynamic analysis of elastic-plastic impact behaviour using the finite element method can be corrupted by noise at high frequencies; this particularly affects the calculation of accelerations [3]. To remove this effect, data filtering using digital signal processing (DSP) was conducted by using a low-pass filter to delete the response obtained at frequencies higher than a prescribed frequency threshold (cut-off frequency). Following a procedure given in [3], the calculated (raw) data was regularised in MATLAB to obtain data at equal time increments (constant sampling rate). Then, the Butterworth filter with cut-off frequency of 1 kHz and order two was used to remove unwanted signals. The filtered acceleration data are presented in Fig. 4, which correlated very well with the measurements.

To demonstrate that the filtered data are valid, and to avoid corrupted results by aliasing, the filtered data of acceleration response were integrated to calculate the velocity and displacement components. For illustrative purposes, the integrated results for the vertical displacement is plotted in Figure 5 with the data obtained directly from the Abaqus/Explicit analysis for the same point where an excellent agreement is achieved.

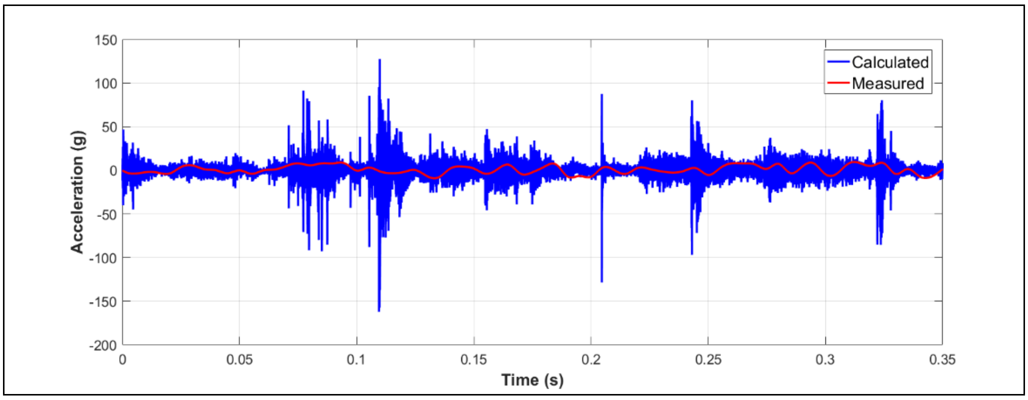

Figure 3: Calculated (raw) and measured acceleration response of Post 2 in the vertical direction.

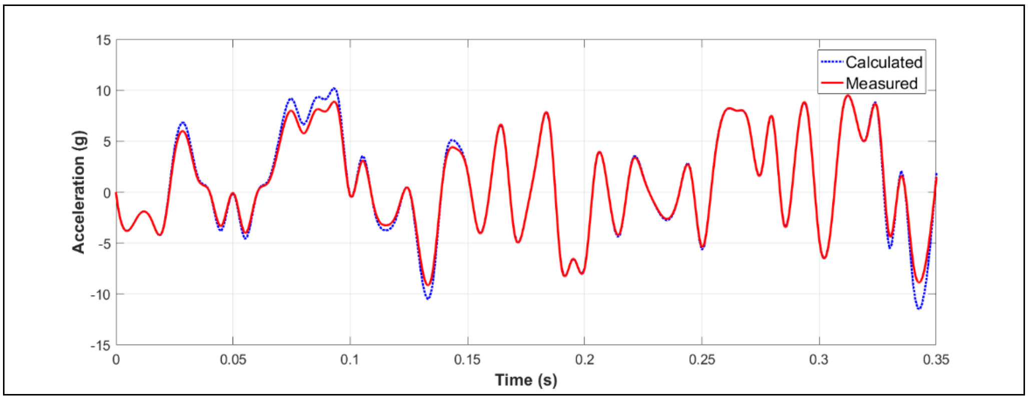

Figure 4: Calculated (filtered) and measured acceleration response of Post 2 in the vertical direction.

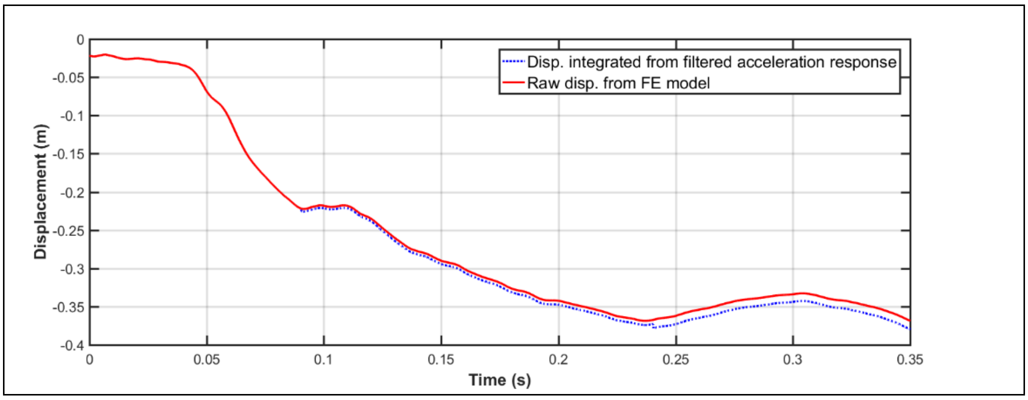

Figure 5: Comparison between filtered and unfiltered displacement response of Post 2 in the vertical direction.

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