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Study of the dynamic response of prone-to-fall spurs using seismic noise

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Rock-falls are characterized by their suddenness and the difficulty to identify clear precursory patterns. Recently, ambient seismic vibration recordings have been used to estimate the degree of mechanical coupling between a rock mass and a 21 000 m3 unstable limestone column, studying its natural frequencies (Lévy et al., 2010). During the monitoring period, the column first resonance frequency showed a sharp decrease a few weeks before the rupture, owing to the drop in mechanical coupling caused by the failure of limestone rock bridges.

The method, which consists in measuring the spectral characteristics of the seismic noise with low-eigenfrequency seismometers (0.2 to 2 Hz), has been applied on other rock mass types, characterized by more complex deformation and breakage processes. Four additional unstable masses in the Alps have been instrumented into various geological contexts: limestone, argillite, granite, and a shale-sandstone series.

For each chosen site, ambient vibration Fourier spectra on the prone-to-fall spur showed clear energy amplification at some frequencies, contrary to the spectra on the rock mass. Numerical modeling of the spur seismic response has identified those peak frequencies as column natural frequencies. The seismic spectral azimuthal repartition computed for each sensor showed a good agreement with the modal shape and the predicted rock fall motion. The origin and value of the resonance frequencies were found to differ according to the site characteristics (mass and mechanical properties of the instability, contact parameters).

For three sites, the first natural frequency has been monitored during a few months, along with meteorological parameters. One site showed a significant correlation between the first resonance frequency and the ambient temperature, implying reversible variations of the natural frequency, while the two others were found to be little sensitive to thermal effects

Those results show the ability of ambient noise recordings to identify natural frequencies of unstable rock spurs in various geological contexts and to monitor their evolution. In some conditions, thermal effects have to be taken into account for separating reversible variations from permanent drops (damaging).

References

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