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Original
Active and passive seismic methods for characterization and monitoring of unstable rock masses: field surveys, laboratory tests and modeling / Colombero, C.; Baillet, L.; Comina, C.; Jongmans, D.; Vinciguerra, S.. - In: GEOPHYSICAL RESEARCH ABSTRACTS. - ISSN 1607-7962. - 18(2016), p. EGU2016-7513. ((Intervento presentato al convegno EGU General Assembly 2016 tenutosi a Vienna (Austria) nel 17-22 April 2016.

Availability:
This version is available at: 11583/2746550 since: 2019-08-07T10:40:42Z

Publisher:
Copernicus GmbH

Published
DOI:

Geophysical Research Abstracts
Vol. 18, EGU2016-7513, 2016
EGU General Assembly 2016

Active and passive seismic methods for characterization and monitoring of unstable rock masses: field surveys, laboratory tests and modeling.

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Appropriate characterization and monitoring of potentially unstable rock masses may provide a better knowledge of the active processes and help to forecast the evolution to failure. Among the available geophysical methods, active seismic surveys are often suitable to infer the internal structure and the fracturing conditions of the unstable body. For monitoring purposes, although remote-sensing techniques and in-situ geotechnical measurements are successfully tested on landslides, they may not be suitable to early forecast sudden rapid rockslides. Passive seismic monitoring can help for this purpose. Detection, classification and localization of microseismic events within the prone-to-fall rock mass can provide information about the incipient failure of internal rock bridges. Acceleration to failure can be detected from an increasing microseismic event rate. The latter can be compared with meteorological data to understand the external factors controlling stability. On the other hand, seismic noise recorded on prone-to-fall rock slopes shows that the temporal variations in spectral content and correlation of ambient vibrations can be related to both reversible and irreversible changes within the rock mass.
We present the results of the active and passive seismic data acquired at the potentially unstable granitic cliff of Madonna del Sasso (NW Italy).
Down-hole tests, surface refraction and cross-hole tomography were carried out for the characterization of the fracturing state of the site. Field surveys were implemented with laboratory determination of physico-mechanical properties on rock samples and measurements of the ultrasonic pulse velocity. This multi-scale approach led to a lithological interpretation of the seismic velocity field obtained at the site and to a systematic correlation of the measured velocities with physical properties (density and porosity) and macroscopic features of the granitic cliff (fracturing, weathering and anisotropy).
Continuous passive seismic monitoring at the site, from October 2013 to present, systematically highlighted clear energy peaks in the spectral content of seismic noise on the unstable sector, interpreted as resonant frequencies of the investigated volume. Both spectral analysis and cross-correlation of seismic noise showed seasonal reversible variation trends related to air temperature fluctuations. No irreversible changes, resulting from serious damage processes within the rock mass, were detected so far.
Modal analysis and geomechanical modeling of the unstable cliff are currently under investigation to better understand the vibration modes that could explain the measured amplitude and orientation of ground motion at the first resonant frequencies.
Classification and location of microseismic events still remains the most challenging task, due to the complex structural and morphological setting of the site.