Seismic and Geodetic Monitoring of the Federico II school of Engineering Building (Naples, Italy)

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The monitoring of ground shaking and the resulting structural dynamics play a crucial role in assessing and managing risk in regions exposed to earthquakes. As part of the PNRR RETURN project (Vertical Spoke 3, WP2, Task 4), a state-of-the-art seismic and geodetic monitoring system was developed and implemented to assess and monitor the dynamic behaviour of a strategic structure in the Campi Flegrei area (currently experiencing volcanic unrest and seismic activity): the main building of the University of Naples Federico II school of Engineering, that is an eleven-story reinforced concrete structure.
The monitoring system consists of three stand-alone multi-instrument stations, each equipped with triaxial cost-effective accelerometers (ADEL ASX200) and velocimeters (Lunitek Sentinel Geo 4.5Hz). These co-located sensors provide high-sensitivity measurements of the structure's dynamic response, especially in the event of strong motion. To complement this setup, two GNSS LZERO units were installed on the building's roof, enabling sampling at 1 Hz to precisely measure displacements and rotations using accurate geodetic baselines. In addition to monitoring dynamic responses, the geodetic system also provides critical insights into slow displacements caused by possible uplift/subsidence caused by volcanic unrest (i.e. so-called *bradyseism*), offering a broader perspective on structural behaviour in this geologically active area.
The data collected by these instruments is streamed in real-time to a central aggregation and analysis unit, which feeds the SeisComp server facility at the Seismological Research Centre of OGS in Udine via Seedlink. The data is archived and made accessible to the scientific community via FDSN web services, ensuring seamless integration with existing seismic monitoring frameworks. To increase operational efficiency, the system is equipped with an automatic module that can cut and export seismic data traces in the event of significant seismic activity.
The monitoring system was tested during the ongoing seismic sequence in the Campi Flegrei area, which is characterized by low-to-moderate magnitude events. This sequence includes several earthquakes with a magnitude greater than Md 3.0, including those of magnitudes Md 3.4 and Md 3.5 recorded on June 18 and June 8, 2024, respectively. These events were recorded and processed using the SeisComp system, providing data for comprehensive analyses.

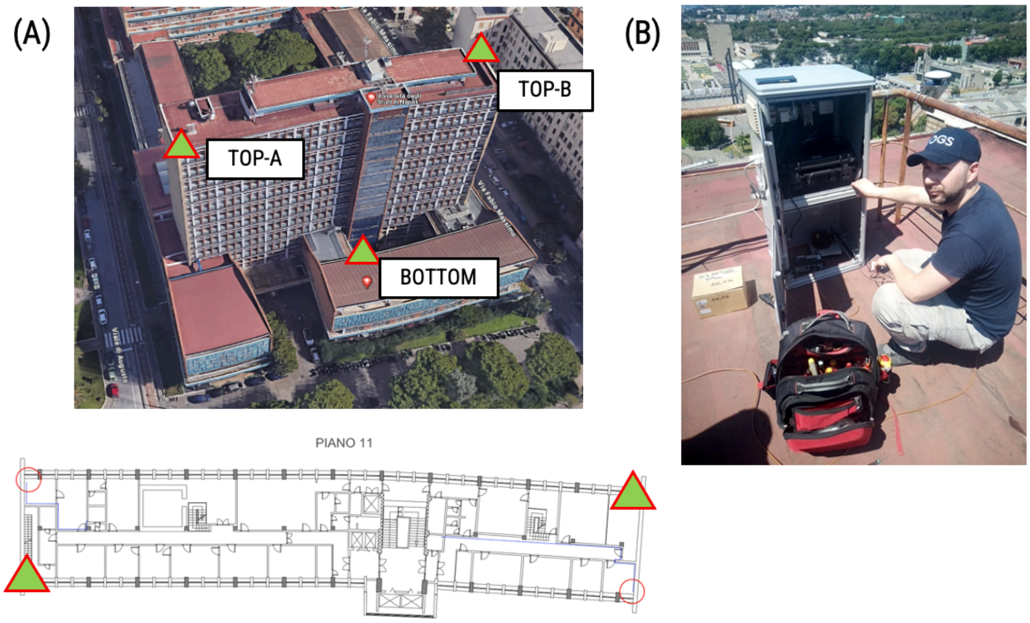

Fig. 1 – (A) Layout of monitoring stations across the structure, illustrating the distribution of three accelerometer and velocimeter stations paired with GNSS units. (B) Detailed view of the GREI station installed on the roof, highlighting its integration of GNSS and seismic sensors for comprehensive displacement measurements.

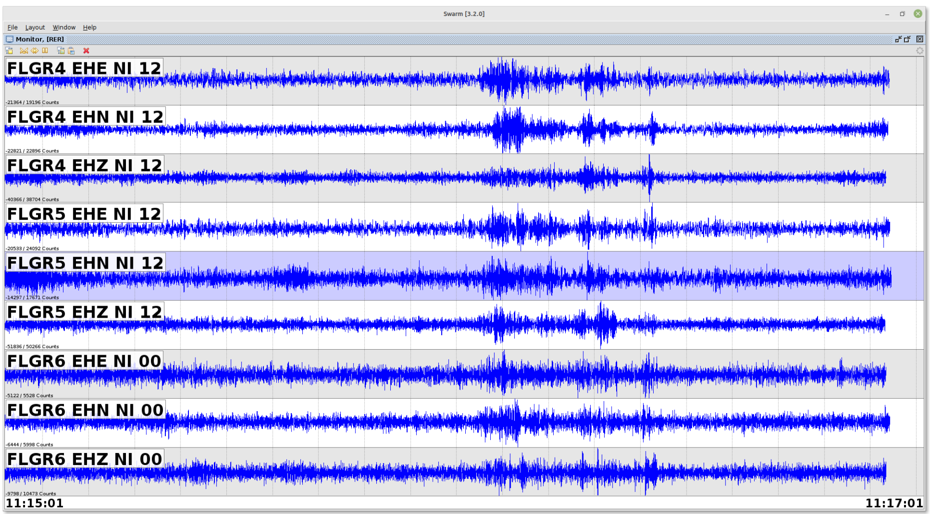

Fig. 2 – Example of velocimetric streams (three components: E-W, N-S, U-D) recorded by three monitoring stations during a minor event in the Campi Flegrei seismic sequence.

The recorded data will be integrated into a unified dataset combining geodetic (GNSS), velocimetric, and accelerometric streams using Kalman filtering techniques, which are currently being refined. This work-in-progress sensor-fusion approach aims to enable precise estimation of inter-storey displacements, critical for evaluating both translational and rotational movements under dynamic loading. As the integration process advances, the combination of displacement measurements with numerical structural modelling is expected to support the early detection of threshold exceedances and contribute to the development of predictive maintenance strategies. In the meantime, the continuous data streams are already facilitating rapid response and providing input for long-term structural safety evaluations.

Future developments will focus on the integration of geodetic and seismic data streams, with particular attention to the optimization of Kalman filtering techniques for accurate estimation of structural displacements in near real-time. This includes refining algorithms to improve the synchronization and fusion of GNSS, accelerometric, and velocimetric data, enabling a more accurate evaluation of changes in the dynamic behaviour and potentially occurring damage.

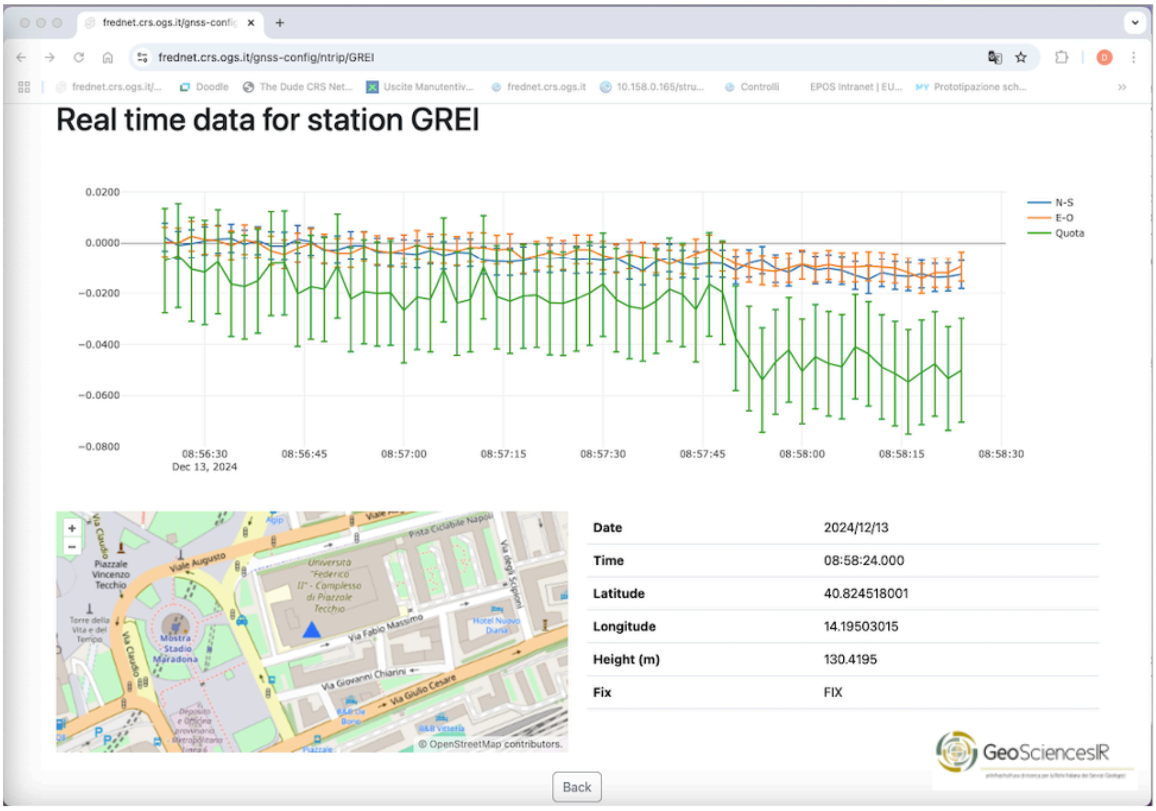

Fig. 3 – A real-time GNSS streaming web interface for the GREI station, developed as part of the GeoScience PNRR project, provides visualization of displacement data across E-W, N-S, and U-D components.

The insights gained from this proof-of-concept application are instrumental in tailoring the system to provide robust, real-time hazard assessment tools that integrate seamlessly with emergency response protocols.

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