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FEASIBILITY STUDY ON EARTHQUAKE EARLY WARNING FOR SCHOOLS IN SOUTHERN ITALY

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Evaluating the effectiveness of Earthquake Early Warning Systems (EWS) and real-time risk assessment procedures in reducing seismic risk for various industrial partners and end-users is one of the main objective of the WP7 (Strategic Applications and Capacity Building) in the framework of the REAKT-Strategies and tools for Real Time Earthquake Risk Reduction FP7 European project. In this context our group is engaged in a feasibility study on the application of earthquake early-warning procedures in two high schools (Liceo 'F. de Sanctis', S. Angelo dei Lombardi, SALI and ITIS 'E. Majorana', Somma Vesuviana, MAJI) located in the Irpinia region (Southern Italy). The area has been interested by large earthquakes both in historic and recent time. The last destructive earthquake was the 23 November 1980, M 6.9, Irpinia earthquake, which caused more than 3000 casualties and produced huge and widespread damage.

Here we present a summary of the activities carried out and the results obtained so far at the MAJI School during the last three years. In particular, a high quality accelerometric station consisting of a 24-bit ADC (Sigma/Delta) Agecodagis Kefren data-logger and a Guralp CMG-5TC accelerometer with a 0.25g full-scale has been installed. Furthermore, in order to perform a continuous seismic monitoring of the site, which includes a rather complex structure building, a total of five accelerometric stations have been installed in different parts of the school building. In particular, besides the Guralp CMG-5TC accelerometer in the school courtyard, four SOSEWIN sensors have been deployed at different locations within the building. Commercial ADSL lines provide transmission of real-time data to the EEW centre. Data streams are now acquired in real-time in the PRESToPlus (regional and on-site, threshold-based early-warning) software platform (Satriano et al, 2010).

Concerning the EEW On-Site approach, the basic idea is to use a stand-alone operating system for the rapid estimate of the local damage at the school. In this system, the early portion of the recorded P-wave signal is used to predict the Peak Ground Velocity (PGV) and Instrumental Intensity (I_{MM}) expected at the site. We performed off-line analyses to test the feasibility of such an on-site early warning procedure at the school ITIS 'E. Majorana'. The first tests were performed on 24-hour long waveforms recorded by the five stations, during four different days, with school activity but no nearby earthquakes. Indeed, the aim of these analyses was to verify the rate of false events detected by the EEW On-site system due to the anthropic activities. The P-wave picking was performed using the same picker used in PRESTo (FilterPicker5, Lomax et al, 2012). Due to the high noise level incorrect

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and false phase pickings can be automatically declared, up to 1 pick every 5 minutes for the most sensitive station (MAJI, at the top of Figure 1). This suggests that the single station EEW approaches require a specific tuning of parameters, to avoid the repeated occurrence of false alarms. Conversely, when an almost simultaneous pick at a minimum number of four stations is required before declaring an event, the rate of false alerts is significantly reduced. To account for time differences in the picks due to the low signal-to-noise ratio, we chose a 0.5-second time window for coincidence. In particular, we observed that when 3-stations are considered only 1-2 events per day are detected, while there was never a coincidence of picks within 0.5 seconds, and thus no early warning procedure would have been triggered, when 4-or 5-stations are considered.

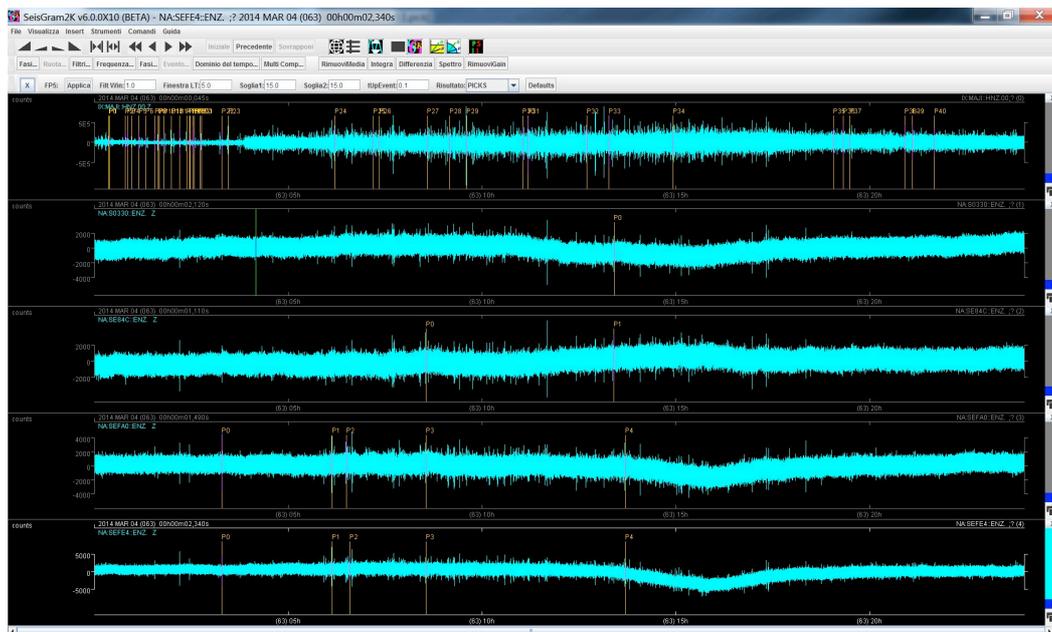


Figure 1. Waveforms recorded on Tuesday, 4 March 2014 by the five stations installed at MAJI.

The second test was carried out considering the only relevant earthquake recorded so far by the system, that is the Matese earthquake (2013/12/29 17:08:43, ML 4.9), for which only 4 stations were available. The distance from the school to the hypocenter was about 55 km. We applied a low-pass filter (10 Hz) to the waveforms to reduce the high frequency noise contamination and we verified that the seismic stations correctly picked the P-wave onset of the event. For the less sensitive SOSEWIN stations, that use an internal MEMS sensor, it was also necessary to decrease the threshold parameter of the picker. All the stations picked within 0.5 seconds from the arrival of the P-wave. The accelerometric records have been double integrated to get displacement waveforms and a high-pass filter with cut-off frequency of 0.075 Hz has been applied to reduce the noise introduced by the double integration operation, as it is usually done in Early Warning applications. Then, the initial peak displacement amplitude has been measured at each station, within 3 seconds of signal after the P-wave detection (Figure 2).

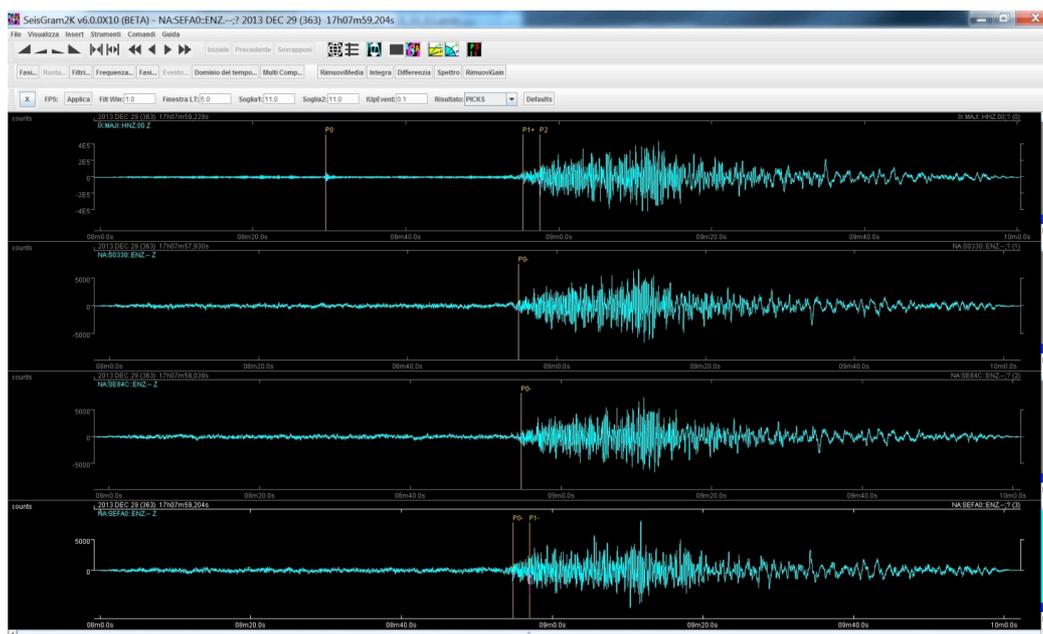


Figure 2. Matese earthquake recordings on 2013/12/29. Filtered traces (LP 10 Hz), decreased picker threshold (11 instead of 15).

Concerning the EEW Regional approach, we present the preliminary results of an integrated EEW system that combines the software PRESTo and a newly developed prototype hardware device installed at the school, a low-cost EEW “sentinel”. In this case, playbacks of both recorded and synthetic events have been run in PRESTo and used for the delivery of warnings in real-time to the MAJI School. These data have also been used to run an EEW drill at a few school classes.

Finally, the preliminary results of the vulnerability study carried out at the school will be also shown. Indeed, after some preliminary in-situ surveys, structural and non-structural components, which are involved in the vulnerability analysis, have been identified. Hence, geometrical and mechanical model definition was performed and dynamic properties were carried out through a modal analysis. The evaluation of the seismic capacity has been performed through an incremental nonlinear static analysis approach, thus identifying seismic intensity levels leading to different damage states in structural and non-structural components.

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