WP 4 PILOT PROJECT DEPLOYMENT

A 4.2 – Pilot Implementation of SPB's Seismic Monitoring Innovative Procedure

Deliverable: Report on conducted seismic monitoring procedures

Partner		
Number of SPB's	No…0	Visual and dimensional screening
	No…19 permanent seismic stations (+57 temporary measurements)	Instrumental monitoring
	No…0	Detailed seismic analysis

Evaluated by TF members:

1. Istituto Nazionale di Geofisica e Vulcanologia – Osservatorio Nazionale Terremoti, Sede di Ancona

2. Marche Region – Civil Protection Service

Instrumental monitoring

(Number and description of buildings, criteria used for selection of the buildings; max 500 chars)

Continuous monitoring of 19 SP: 11 SPB already instrumented in Holistic project were maintained; 3 buildings already instrumented within the convention between INGV and Marche Region were integrated into the project Readiness; 4 new sites (Belforte del Chienti, Sarnano, Amandola and Ascoli Piceno) were instrumented to increase a widespread monitoring on the territory, also an experimental site (Università Politecnica Marche) was instrumented (this site was not originally planned in the project).

The areas considered for sites were the south-western sector of Marche Region and the Province of Pesaro-Urbino.

The last SPBs were chosen in the areas hit by the earthquake of Central Italy in 2016-2017 where the seismic activity is still high and increases the probability of recording significant seismic events during the project. Two buildings were chosen with sensors at the base and 2 low-cost accelerometers were installed on a higher floor to provide data useful to calculate further engineering parameters. The most part of SPBs are masonry buildings and only one reinforced concrete.

One of these buildings was chosen in the municipality concerned by dissemination activities and civil protection volunteers training on seismic risk (Belforte del Chienti).

Moreover for all 19 SPBs, 3 temporary measurements for each building were performed and project technical documents collected in order to characterize soil and building resonance frequency and seismic ambient noise.

Monitoring team description

(Number of team members, brief description of each member’s skills; max 500 chars)

Ladina Chiara received the master's degree in geological science and technologies from the University of Milano-Bicocca in 2008, and the Ph.D. degree in geophysics from the University of Genova in 2012. She is currently a Research with the Istituto Nazionale di Geofisica e Vulcanologia. Her main research topics include geological site effects, seismic signal processing, rapid strong motion assessment, and seismic building monitoring.
Marzorati Simone received the master's degree in environmental science and the Ph.D. degree in geological sciences. Since 2001, he has been with the Istituto Nazionale di Geofisica e Vulcanologia, where he is currently a Research. His main research topics include seismic network monitoring, seismic signal processing, rapid strong motion assessment, seismic building monitoring, and seismic data quality.

Monachesi Giancarlo He has 39 years of experience in the field of seismic monitoring on a regional scale in Central Italy (starting in 1980, and -from the year 2000 – working as a researcher of the Istituto Nazionale di Geofisica e Vulcanologia). In 2009, he was the first to carry out accelerometric monitoring in the Marche Region in real time. Since 2011 he coordinates an experimental project for accelerometric monitoring of strategic buildings of the Marche. This project has two objectives: (1) using accelerometric data to improve earthquake location and shaking evaluation; (2) analyzing the shaking data collected for each monitored building for to analyze the likely damage suffered by building.

Frapiccini Massimo is a technician at the Istituto Nazionale di Geofisica e Vulcanologia. He deals with the installation and maintenance of seismic stations; interpretation of seismic data.

Pantaleo Debora is a technician at the Istituto Nazionale di Geofisica e Vulcanologia. She deals with the configuration, installation and maintenance of seismic stations.

Speranza Gabriella geologist at the Functional Center of Civil Protection of the Marche region. She mainly deals with the prediction of ground effects caused by bad weather events and snow and avalanche problems, she is an expert in GIS for the creation of thematic maps concerning the phenomena that contribute to determining the hydro-geological risk. Given the scientific training and for purposes related to the type of work, he has a good knowledge of the territory. She has participated in the main earthquake emergencies since 2009 (L'Aquila) and the last of 2016, carrying out the preliminary post-event inspections on October 30th.

Outputs of performed activity

(Description of the activity, equipment used; max 2000 chars)

Permanent seismic instrumentation was installed at the base of the buildings. The ground motion was recorded with accelerometer sensors during significant seismic events. The aim of permanent monitoring is to record the seismic input at the base of the monitored structure and to assess the impact of the earthquake. Continuous recording allows to archive the instrumental seismic history of the monitored buildings and construct a database of engineering parameters. These parameters are useful to evaluate the relationship between the ground acceleration and macroseismic intensity, engineering fragility curves and amplification effects.

13 permanent stations were equipped with a 24 bit GAIA2-INGV data logger and a Colybris accelerometer with high dynamics, high gain and low instrumental noise. In two cases, stations equipped with the accelerometric sensor Episensor FBA and a 24 bit GAIA2-INGV data logger. The other 4 stations at the base were equipped with instrumentation Lunitek (data logger Atlas and Mems accelerometer LTME-90), the same instruments were used for the upper floor of the buildings.

The accelerometric stations have been installed in basements and sensors were fixed to the ground. At each site the GPS antenna was installed outside the building, for the synchronization of the recorded signal with others stations of INGV Ancona so they are integrated in the seismic network and they are available for earthquake localization and shake map. The stations record ground acceleration continuously, with a sampling of 200 sps.

The seismic signals of earthquakes with the local magnitude ≥ 3.0 were processed to extract accelerometric waveforms of the events from the arrival time of the P and S phases. The semi-automatic procedures were developed to calculate the value of engineering parameters, for example one of the commonly used is peak ground acceleration.

Temporary seismic analysis consisted of three measurements (top, base and outside the building) of ambient seismic noise with velocimetric sensors. Temporary seismic analysis have been performed to obtain an estimate of the vibratory characteristics of the structures through spectral analysis techniques with the aim to identify soil-structure interaction. The measurement at the top of the building was performed with the aim to extrapolate the main dynamical behaviour of the building. The fundamental frequency of vibration of the building was extracted from the record of this measurement. The measurement at the base of the building near the permanent instrument helps to verify possible coupling between permanent sensor and structure. The fundamental frequency of the soil was evaluated with the last measurement outside the building in free field where it was possible. Only in one municipality was not possible to perform the free field measurement.

Temporary seismic survey was performed with Reftek-130A 24-bit data logger and a velocimetric sensor Lennartz 3D/5s. Most of the sensors were oriented with their North-South axis parallel to the longitudinal axis of the building and consequently with orientation of the East-West axis along the transverse axis of the building. Such measures lasted at least 30 minutes and up to 2 hours.

A scientific program was used to analyze seismic noise signals. The data processing was performed selecting the windows of three components signal to exclude those that were particularly disturbed by transients of high energy generated from sources very close, such as human activities or the transit of vehicles. Each selected signal window was used to calculate the Power Spectral Density (PSD) and Horizontal to Vertical Spectral Ratio (HVSR). So, to get more information from the spectral analysis, the direction of oscillation at the fundamental frequency was added to the results, obtained by the comparison of the longitudinal and transversal recording of the motion on the building.

Analogously, temporary seismic analysis were performed outside of buildings, in free field, to evaluate the resonance frequencies of soils. These additional measurements allow to investigate the soil-structure interaction. Indeed, if the fundamental frequency of the ground is similar to the natural period of the building it is possible a resonance effect during an earthquake.

During the project seismic surveys were carried out, information on surface geology was collected through thematic and digital maps and morphological characteristics were defined using geospatial analyses performed by Geographical Information System (GIS) technologies. Digital data raster were collected and organized for the characterization of the geological formations of the surface under buildings. Geological cartography of Marche Region was available at 1: 10,000 for the most part of the territory. The information about geological and morphological characteristics allowed to propose a classification of the various categories of the sites according to Eurocode 8 for the subsoil and topographical conditions.

Annexes delivered to PP

(Description of annexes delivered to PP by monitoring team members which are substantial part of this summary)

Critical faced issues and envisaged changes

(critical issues faced and envisaged changes; max 1000 chars)

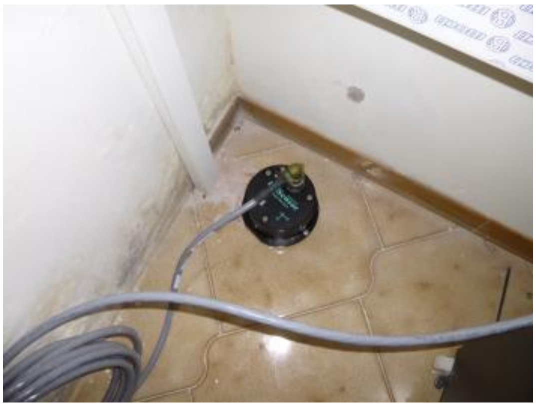
Developing an enhanced monitoring procedure combining the low cost and non invasive instrumental seismic measurements.

Possible interaction of the structures with the soil during earthquakes, passive measurements of construction parameters and soil using microtremors and accelerations.

Photos (if available)


Apecchio Municipality *Ascoli Piceno Municipality*


Belforte del Chienti Municipality *Fano*



Treia seismic station *Moresco*

Fig. 1 examples of SPBs – permanent seismic stations implementation

Fig. 2 examples of SPBs – temporary seismic stations measurements

Detailed seismic analysis for SPBs

(Number and description of buildings, criteria used for selection of the buildings; max 500 chars)

Monitoring team description

(Number of team members, brief description of each member's skills; max 500 chars)

Outputs of performed activity

(Description of the activity, equipment used; max 2000 chars)

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Critical faced issues and envisaged changes

(critical issues faced and envisaged changes; max 1000 chars)

Photos (if available)

Assessment of partner's pilot deployment

1. Target group benefiting from the overall outputs produced by the pilot deployment

a) General public (Inhabitants affected by project pilot activities)

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

b) Local, regional and national public authorities

Not relevant at all			Extremely relevant	
1	2	3X	4	5

Explain briefly (max 500 chars)

Local public authorities involved as involved in the 2016-2017 post-earthquake experience. The pilot project provides additional information to the authorities with a view to prevention.

c) Regional and local environmental agencies and associations involved in environmental protection activities

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

d) Local technical professional orders associations

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

e) Civil Protection regional/county units and Volunteeers associations

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

2. What kind of innovation affected the pilot deployment

a) Process Innovation (a new or improved way or techniques to do)

Not relevant at all		Extremely relevant		
1	2	3	4X	5

Explain briefly (max 500 chars)

b) Tecnological Innovation (a new equipment or software)

Not relevant at all		Extremely relevant		
1	2	3	4X	5

Explain briefly (max 500 chars)
The use of new tools has been experiment, in particular, low-cost sensors so as to be able to evaluate their performance and hypothesize greater use. Also the experimentation of different transmission systems was used to find the best solution depending on the municipal context.

c) Organizational Innovation (new organizational methods)

Not relevant at all		Extremely relevant		
1	2	3	4X	5

Explain briefly (max 500 chars)
greater collaboration with local public authorities (municipalities) was encouraged.

3. Sustainability of innovation

a) Environmental:

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

b) Economic:

Not relevant at all			Extremely relevant	
1	2	3X	4	5

Explain briefly (max 500 chars)
low-cost sensors

a) Social:

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

4. Horizontal Principles

a) contribution to sustainable development

Not relevant at all			Extremely relevant	
1	2	3	4	5

Explain briefly (max 500 chars)

b) contribution to equal opportunities and non-discrimination

Not relevant at all			Extremely relevant	
1	2	3	4X	5

Explain briefly (max 500 chars)
no discrimination, work groups equally divided.

c) contribution to equality between men and women

Not relevant at all			Extremely relevant	
1	2	3	4X	5

Explain briefly (max 500 chars)

Pilot deployment report

achieved results (1000 chars)	19 SPB were instrumented at the base and two on the upper floors. Temporary noise investigations have been carried out for all buildings.
faced critical issues (1000 chars)	Some buildings are historic, with some logistical difficulties highlighted.
observed changes in the resilience (1000 chars)	Awareness on earthquakes increased.

Data summary (number of monitored buildings)

Partner	Visual and dimensional screening	Passive measurements for SPB's	Detailed seismic analysis for SPBs
LP Molise Region **(LP)**			
Dubrovnik-Neretva Region **(PP 1)**			
Marche Region **(PP 2)**	0	19 permanent stations (+57 temporary measurements)	0
Split-Dalmatia County **(PP 3)**			
FVG **(PP 5)**			
Zadar County **(PP 6)**			