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EUCENTRE and seismic emergency: technical preparedness activities and response after the central Italy earthquake

Autohrs:



Chiara Casarotti, PhD. CE

European Centre for Training and Research in Earthquake Engineering (EUCENTRE Foundation), Italy
chiara.casarotti@eucentre.it

Corresponding author



Simone Peloso, PhD. CE

European Centre for Training and Research in Earthquake Engineering (EUCENTRE Foundation), Italy
simone.peloso@eucentre.it



Barbara Borzi, PhD. CE

European Centre for Training and Research in Earthquake Engineering (EUCENTRE Foundation), Italy
barbara.borzi@eucentre.it



Assoc.Prof. **Alberto Pavese**, PhD. CE

University of Pavia, Italy
 Department of Civil Engineering and Architecture
a.pavese@unipv.it

Subject review

Chiara Casarotti, Simone Peloso, Barbara Borzi, Alberto Pavese

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The ASA (Advanced Seismic Assessment) module is a post-earthquake technical intervention service, developed over the years by the EUCENTRE Foundation through a series of national and European pilot projects, field exercises, and direct experience, after the latest major seismic events that struck Italy since 2009. The system consists of a service managed at the headquarters in Pavia for the development of damage scenarios, and of a mobile unit for the on-site damage assessments. After the Central Italy earthquake, the Foundation has been involved for about eight months in several activities, including provision of technical support to the Italian Department of Civil Protection, joint reconnaissance with internationally acknowledged research institutes.

Key words:

Italy earthquake 2016, post-earthquake survey of buildings, module for advanced seismic assessment of earthquake-damaged buildings, damage scenarios, territorial management system

Pregledni rad

Chiara Casarotti, Simone Peloso, Barbara Borzi, Alberto Pavese

EUCENTRE i potresni rizici: aktivnosti tehničke pripreme i odgovor nakon potresa u središnjoj Italiji

Modul za napredne seizmičke procjene je služba za tehničku intervenciju nakon potresa koju je EUCENTRE tijekom godina razvijao kroz niz nacionalnih i europskih pilot-projekata, terenskih vježbi i izravnih iskustava nakon posljednjih velikih potresnih događaja koji su pogodili Italiju od 2009. Sustav se sastoji od službe čije se središte za izradu scenarija štete i mobilne jedinice za procjenu oštećenja na terenu nalazi u Paviji. Nakon potresa u središnjoj Italiji, EUCENTRE je oko osam mjeseci bio uključen u niz aktivnosti, uključujući tehničku podršku talijanskom Odjelu civilne zaštite, zajedničku izviđačku misiju s međunarodno prepoznatim istraživačkim institutima.

Ključne riječi:

potres u Italiji 2016., pregled zgrada nakon potresa, detaljna procjena potresom oštećenih zgrada, scenariji štete, teritorijalni sustav upravljanja

Übersichtsarbeit

Chiara Casarotti, Simone Peloso, Barbara Borzi, Alberto Pavese

EUCENTRE und Erdbebenrisiken: technische Vorbereitungsmaßnahmen und Reaktion nach Erdbeben in Mittelitalien

Das ASA-Modul (detaillierte Bewertung erdbebengeschädigter Gebäude) ist ein technischer Interventionsdienst nach Erdbeben, der vom Institut EUCENTRE im Laufe der Jahre im Rahmen einer Reihe nationaler und europäischer Pilotprojekte, Feldübungen und direkter Erfahrungen nach den letzten großen Erdbebenereignissen, die Italien im Jahr 2009 getroffen haben, entwickelt wurde. Das System besteht aus einem Dienst, dessen Zentrum für die Entwicklung von Schadensszenarien und mobile Einheiten für die Schadensbewertung vor Ort sich in Pavia befindet. Nach dem Erdbeben in Mittelitalien war das Institut etwa acht Monate lang an einer Reihe von Aktivitäten beteiligt, darunter an der technischen Unterstützung des italienischen Katastrophenschutzdienstes, an einer Aufklärungsmission zusammen mit international anerkannten Forschungsinstituten.

Schlüsselwörter:

Erdbeben in Italien 2016, Gebäudeinspektion nach Erdbeben, Modul für detaillierte Bewertung von erdbebengeschädigten Gebäuden, Schadensszenarien, territoriales Managementsystem

1. Introduction

The EUCENTRE Foundation (Pavia, Italy) manages a complex technical support system for seismic emergencies, which has been developed and refined over the years, starting in 2005, through pilot projects, exercise activities in real and simulated contexts, and deployment following real earthquakes. The institutional role of the Foundation as the Centre of Expertise of the Italian Civil Protection Department is to provide technical and scientific support in the field of seismic risk involving three fundamental aspects, namely the prevention, preparedness and response to emergency situations.

The onsite service supports numerical and experimental evaluation of complex and / or strategic structures, but it is also designed to support ordinary evaluation activities. Since the creation of this service, it has been funded by the Civil Protection Department [1], initially as a bare operational support in terms of human resources and numerical methods. Today it has become a "capacity" according to the definition of the European Civil Protection Mechanism [2-4], conceived as an independent service for rapid response to emergencies, coded in terms of tasks, capability, main components, self-sufficiency, and preparation. The first important milestone was the STEP pilot project [5], under which the technical and technological capacity of the Mobile Unit for post-earthquake structural evaluation [6] was developed. After that, within the DRHOUSE project framework [7-9], EUCENTRE was responsible for implementing the Advanced Structural Assessment (ASA) module [10]: the system was integrated with a set of components designed primarily to meet self-sufficiency requirements, to manage logistical and health aspects for worldwide deployment, to involve volunteer professionals, and to develop operational procedures for the preparation, standby, activation, and management of emergency phases. The last step in this development has been the recently concluded MATILDA project [11], within which the module has been made "multi-national" by sharing Italian competences with Slovenian and Croatian emergency management organisations.

Over the years, the service has been tested in several exercises (e.g. in Patras [12] or during the international ModEX Exercise at Tritolwerk [13], Figure 1), and in training of both internal staff and professional volunteers, and, above all, it has been deployed to support the technical relief activity after the last three major Italian seismic events: L'Aquila in 2009 [14, 15], Emilia in 2012 [16, 17], and the recent long-lasting seismic sequence in Central Italy between August 2016 and January 2017 [18].



Figure 1. Mobile Unit for structural assessment at ModEX exercise (Tritolwerk, Austria, June 2016)

Deployment procedures and the extent of involvement always depend on specific operating conditions in each particular emergency environment. In the case of Italian events, the intervention usually lasts throughout the crisis, or until the Civil Protection Department requires such engagement, and involves turnover of teams, close support from the central unit, and a rather flexible operating scheme, according to the needs of the moment. In the case of wide-range deployment, the mission is conceived to be more intense and independent from the central unit.

Regarding the territorial risk management system service, since 2009, the Italian Civil Protection Department has funded development of web based GIS platforms to interface vulnerability data on national structures and infrastructures. The initial goal was to create risk maps aimed at identifying the most critical conditions. The purpose was then extended to the production of real-time scenarios in the case of earthquake events. Over the years, tools for calculating scenarios have evolved considerably, in particular with regard to the estimation of shaking scenarios: in the first releases the seismic source was modelled as lumped, then several attenuation relations were implemented and, currently, it is possible to also consider the fault within the attenuation model itself. Additionally, it is also possible to import shake maps to integrate the recorded data. The OpenQuake computing engine has also been integrated in order to provide scenarios that are up to date with the current state of the art and research. During eight years of activity, the database has been enhanced and the systems now feature a user friendly graphical interface that allows access to large amount of national data for vulnerability assessments.

The platform has been used to support decision makers in recent seismic emergencies, but also in the context of Civil Protection Exercises (Calabria 2011, Pollino 2012) and for assessing damage scenarios assuming the activation of faults in areas with significant seismic swarms.

2. Preparedness activities for emergency technical support

The integrated system consists of a service managed from the headquarters in Pavia with regard to the territorial risk management system for damage scenarios, and of a mobile unit deployed on site for the evaluation of damaged structures.

2.1. The territorial risk management platform

The platform is aimed at defining the seismic risk for national structures and infrastructures, including the residential building stock, schools, road system, ports, airports, and dams. From the home page, the user is able to access webgis services that handle exposure, vulnerability and hazard data (Figure 2). The generated maps allow identification of the most critical situations and definition of priority actions.

During an emergency, all webgis services are able to supply real-time damage scenarios: supposing a seismic event occurrence,

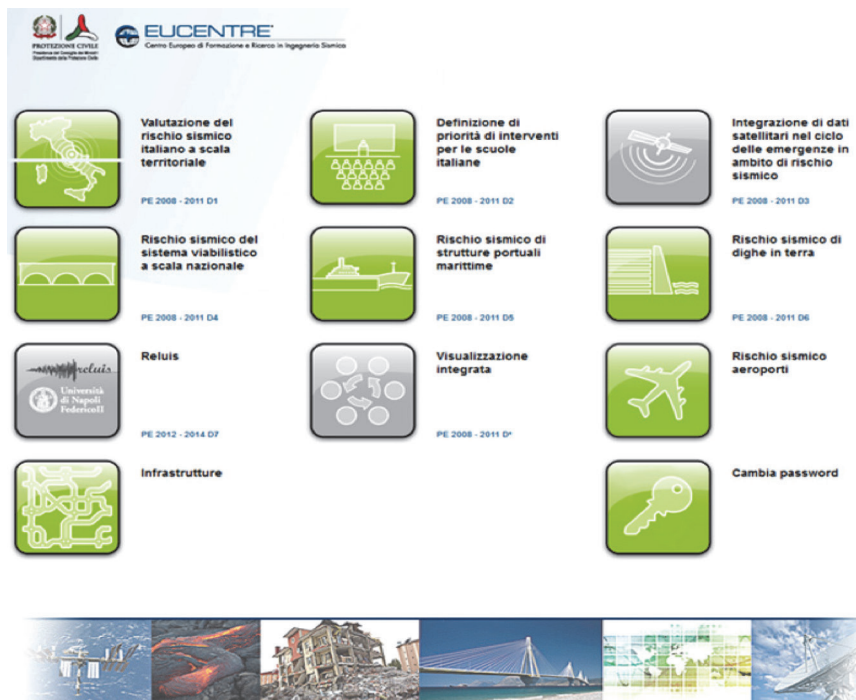


Figure 2. Homepage of the territorial risk management platform

it is possible to calculate the run-time shake scenario using attenuation relationships among the most recent published literature, or by uploading shake maps, including accelerometer-recorded data. The shaking scenario is then combined with the seismic vulnerability of the structures, for the evaluation of the real time damage scenario. The OpenQuake engine has also been implemented within the webgis services of the damage assessment tool, as an alternative to the in-house developed routines. The OpenQuake engine is an open source computing engine developed by the Global Earthquake Model (GEM) Foundation, which has been tested and used in more than 80 countries worldwide.

The system therefore has a twofold purpose for both prevention and response phases. By means of the risk assessment instrument, it constitutes a valuable tool for decision makers to establish priority actions within the context of seismic risk reduction plans. Within the emergency framework, it enables a quick estimate of the earthquake impact in terms of expected damage through real-time scenarios.

Finally, an additional platform has been developed [19] for the analysis of historical damage observed during past Italian earthquakes: it organizes and stores the database of the national damage data collected over the years. The service, called Da.D.O. (Database di Danno Osservato), is accessible by operators and scientific community [20].

2.2. ASA module for on-site structural assessments

The structural damage assessment module is made of multiple components. The headquarters provides both logistical/management and technical expert support.

The following components operate at the crisis site:

- assessment teams,
- experimental team, with the Mobile Lab equipment both for carrying out tests on structures, materials and soils, and for managing acquired data (database and transmission),
- a local coordination node offering also liaison function with the general coordination centre (the Italian Civil Protection, in Italian context).

The Mobile Unit is a high-performance system for quick and complete collection, storage, analysis and transmission of data, and is closely connected to the Central Unit for additional expert support. The Mobile Unit's experimental equipment includes a thermo-camera, an endoscopy probe, pachometers, sclerometers, sonic and ultrasonic testing instruments, accelerometers, geophones, inclinometers, flat jack testing system, and a dedicated system of data acquisition.

The inspection system is completed with a UAS (Unmanned Aerial System), useful for inspecting inaccessible locations.

With regard to the data management and transmission system, the EUCENTRE database architecture has been developed for storing and managing the data acquired and processed during surveys and experimental tests. To facilitate on-site data collection, regardless of the connectivity state, the Mobile Unit has been equipped with an internal database, as a local mirror of the main database located at the Pavia headquarters. The communication centre function has also been designed for the transfer and sharing of data with third parties, enabled by the various solutions implemented in the Mobile Unit's architecture: Wi-Fi, for data exchange among the inspection teams, the experimental team and the Mobile Unit database, 4G and satellite connection, for updating information stored in the cloud and for linking the Mobile Unit to the Central Unit, or to anyone who is able to connect to a videoconferencing system.

The operational scheme is shown in Figure 3. First, a visual inspection of the structure is carried out in order to collect typological/dimensional information and, consequently, to evaluate the vulnerability characteristics and the apparent damage of the artefact. Based on that, the evaluators provide a preliminary (level 0) assessment and request experimental investigation, if needed. This is followed by the phase involving characterization of the structure and materials, the aim being to estimate the residual capacity by means of simplified models (e.g. [14, 15]). At the end of the process, the database is updated and the assessment outcome is sent to the competent authority. The technical component of the module is complemented by the logistical element of the base camp, designed to be installed as a part of an international reception facility. The entire system is then

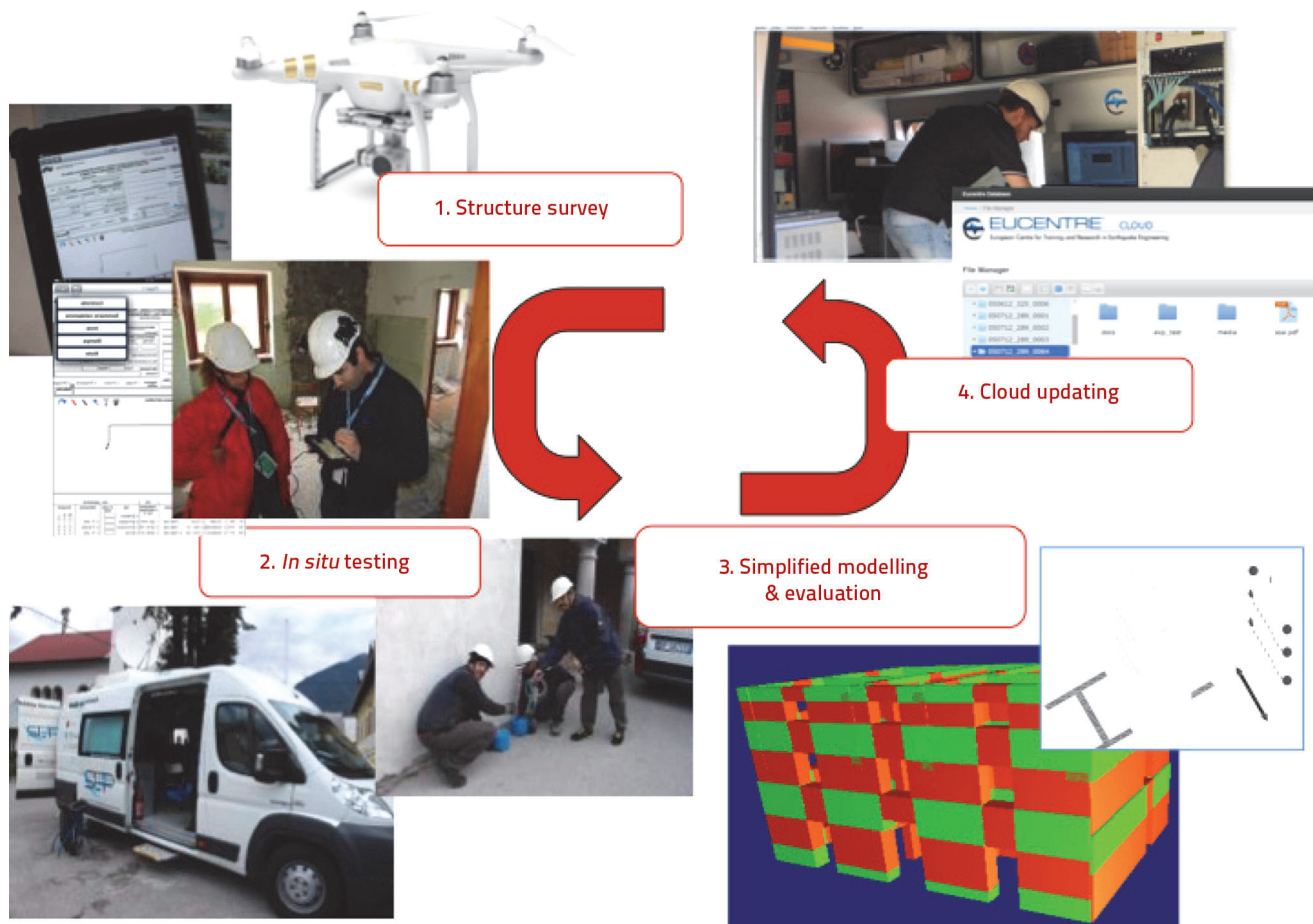


Figure 3. Structural evaluation: operational scheme

ruled by the operating procedures defining the actions of the module at various stages, i.e. initial implementation, periodic maintenance operations, and subsequent deployment phases, according to the scenarios defined for specific emergency conditions.

3. Activities in the context of the Central Italy earthquake

The EUCENTRE Foundation, as a seismic engineering research centre and centre of knowledge of the Italian Civil Protection Department (CPD), conducted several activities of different nature following the seismic event that occurred in central Italy on 24 August 2016.

In compliance with the national CPD's procedures, EUCENTRE activated: 1) the territorial management platform group for the production of real-time damage scenarios in different contexts, 2) the Structural Assessment Intervention Module, and the developers of DESIGNA system (Distributed Environment to

Support Individual and General Need Accommodation), in order to meet the temporary housing management needs. Training of groups in charge of surveying precast structures has also been provided.

Within nine months of intense field activity, the Foundation teams conducted more than 700 inspections (Figure 4) in the four regions struck by the earthquake. Most of the surveys were carried out on monumental buildings, school structures, public

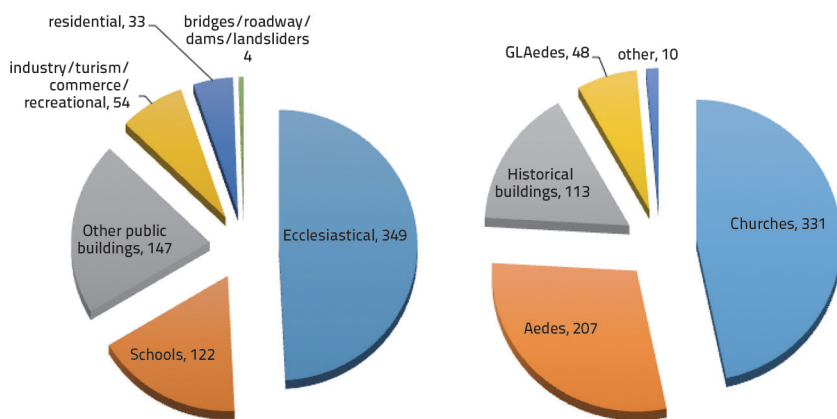


Figure 4. Surveyed building typologies (left) and delivered inspection form types (right)



Figure 5. Activities in the context of the Central Italy earthquake

buildings, and manufacturing facilities. Various inspection forms have been delivered, i.e. forms for Churches, Historical Buildings forms [21], Aedes (ordinary buildings) forms [22] and GL-Aedes (precast structures) forms [23].

Starting from the end of August 2016 to May 2017, 652 man days were deployed. An overview of activities carried out in 2016/2017 by EUCENTRE in the context of the Centre of Italy seismic emergency is presented below, and a brief summary is given in Figure 5.

3.1. Activities at Central Seat in Pavia

For housing, schools and other infrastructure, damage scenarios have been produced for the major shocks, i.e. August 24, 2016 with Mw 6.1, October 26, 2016 with Mw 5.4, October 26, 2016 with Mw 5.9, and October 30 2016 with Mw 6.5.

For each shock, several modelling assumptions have been considered, assuming initially a point source, then enhancing the results by modelling the fault and the fault mechanism and using the shake maps provided by INGV (National Institute for Geophysics and Volcanology). Figure 6 shows the damage scenario in terms of percentage of collapsed buildings, corresponding to the shake map of the main shock that occurred on 24 August. According to the field experience reported by inspectors, the numerical scenarios appear to be fairly representative of the damage observed by field inspections. Unfortunately, at the present time, such data are not readily available for a long period after the emergency, since the collection is not yet automatized.

Several exploratory scenarios have been produced for residential buildings, using sources, source mechanisms, and the maximum expected magnitude provided by INGV. In particular, the

seismogenic structures of Bove, Gorzano and Montereale were considered. Such sources were modelled for expected Mw magnitudes of 6.1 and 7, with different geometries of the corresponding faults. It was possible to deliver a large number of scenarios (184) for residential buildings because the tools developed by EUCENTRE allow evaluation of various combinations of parameters, i.e.: i. it is possible to select various attenuation relationships (Cauzzi e Faccioli, 2008 [24], Boore e Atkinson, 2008 [25], Akkar e Bommer, 2010 [26], Bindi, 2001 [27]), ii. the uncertainty related to the estimation of the attenuation relationship is considered by computing the scenario for medium spectrum and medium spectrum \pm standard deviation, iii. the source can be modelled firstly as point source but also taking into account the size of the fault, or by using externally derived shake scenarios (e.g. from shake maps).

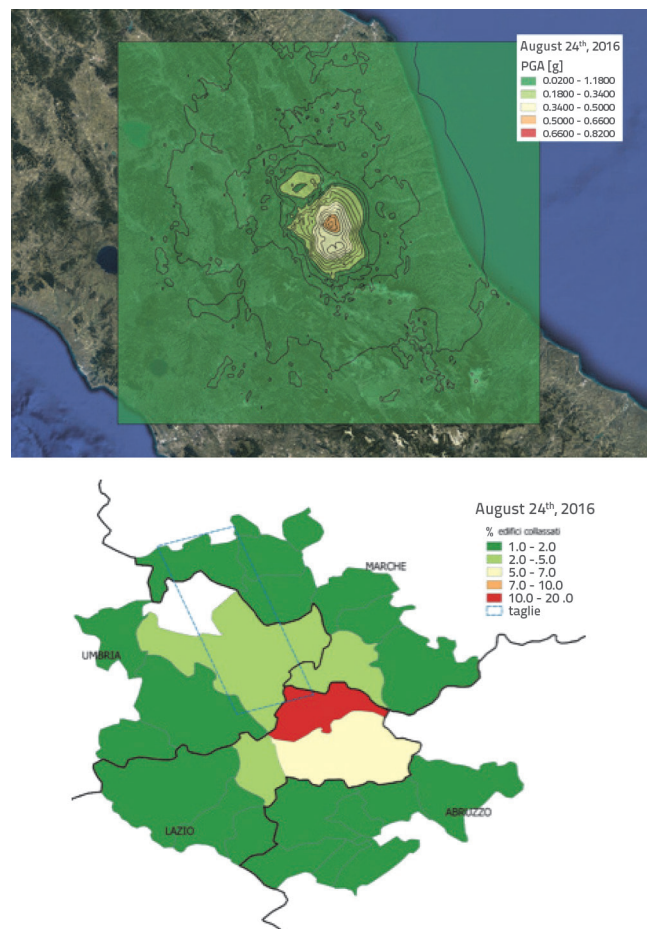


Figure 6. Shake map (top) and corresponding damage scenario (bottom) for the main shock (24 August)

The outcome of the scenarios was made available by using an automatic report exported by the webgis service in the format established in agreement with the National Civil Protection Department. The following data were also made available: i. seismic assessment databases of Umbria and Lazio schools (Excel format); ii. data on the bridges of SS4 (Via Salaria), generally well known due to seismic verification conducted in 2009 by ANAS (one of the main national road owner); such data have been digitalized by EUCENTRE in order to carry out the automatic FE modelling for the calculation of fragility curves; iii. data on dams located in the areas affected by the earthquake. Given the emergency context, one of the crucial aspects was the immediate availability of such data, which was possible thanks to the relational databases from webgis applications developed during preparatory activities.

3.2. In situ activity

Since 24 August, internal emergency alert procedures have been triggered for the management and coordination of activities. To this end, an EUCENTRE liaison officer was sent to the CPD Coordination Centre (namely Di.Coma.C) in Rieti. This officer was directly available with regard to the preparation of intervention strategies in which the Foundation was involved. His role was also to facilitate an organic plan with respect to other units within the CPD emergency management. The same person was the reference for the EUCENTRE field teams. In the phase preceding the seismic sequence that occurred in late October 2016, the Foundation focused essentially on schools, public buildings and churches, for a total of 193 inspections. Then,

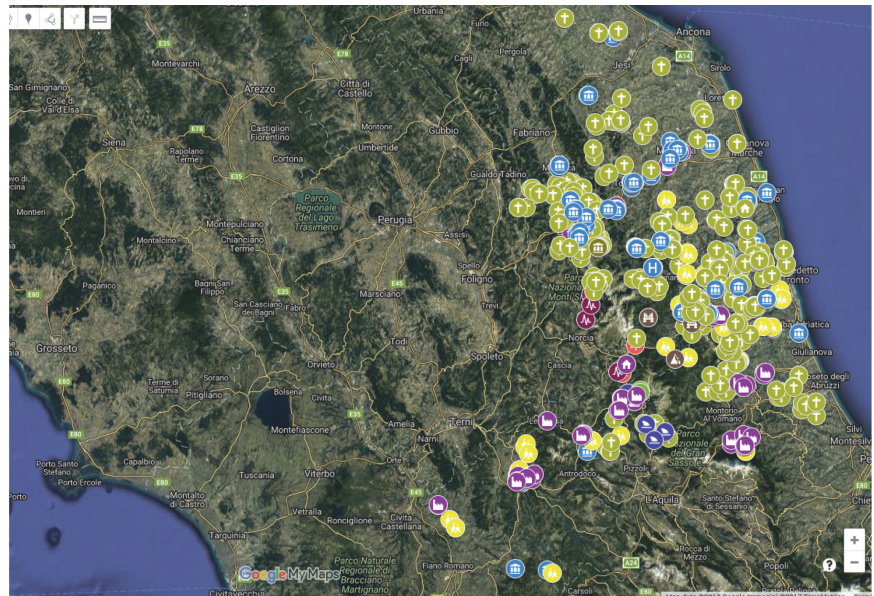


Figure 7. Map of surveys (green – churches, violet – industries, blue – public buildings)

from November 2016 to May 2017, 516 inspections of different nature were carried out: ordinary surveys involving buildings of various occupancy types (schools, public, commerce, etc.), precast structures surveys, additional checking of previously inspected buildings, technical support teams, reconnaissance of landslides, bridges, dams, and monumental buildings usability assessment. The activities were carried out mainly in the Marche region, and to a minor extent in Lazio and Abruzzo (Figure 7), and involved structures of different nature and type of construction, and structures for heterogeneous use (Table 1). The proportions of the outcomes greatly differed depending on the type of building inspected (Figure 8). Thus, the outcomes ranged from "A" (fully usable), "B" (usable after quick measures), "C" (partly usable), "D" (to be surveyed again), to "E" (totally unusable). Outcome "F" is related to unusability not due to the state of the building itself but to external risk. As expected, historical masonry buildings suffered more damage when compared to other types of structures.

Table 1. Use of inspected structures and type of survey form

Application \ Type	Ordinary buildings	Church	Historical buildings	Precast buildings	Other	Total
Other public buildings	63	2	65	16	1	147
Commerce	3					3
Ecclesiastical		329	20			349
Landslide/dam/geo					1	1
Bridge/viaduct			1		2	3
Manufacturing	6			19		25
Housing	7		26			33
Tourism	15		1	2		18
Recreational	5			3		8
Schools	113			8	1	122
Total	212	331	113	48	5	709

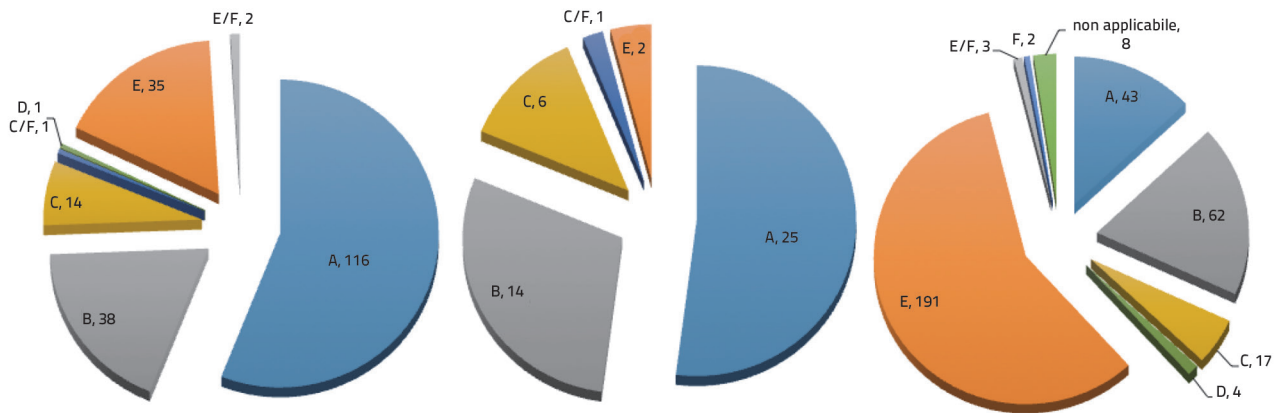


Figure 8. Usability outcomes: ordinary buildings (left), precast structures (centre) and churches (right)

Monumental building surveys in the affected areas were conducted under the joint coordination of the Department of Civil Protection and the Ministry of Cultural Heritage and Tourism, in collaboration with the Reluis Consortium (Italian Network of University Laboratories of Seismic Engineering). In the first cycle of surveys (before 26 October), a joint EUCENTRE-University of Pavia team was available each week. A total of 93 churches were inspected in the provinces of Ascoli Piceno, Macerata, Fermo, L'Aquila and Teramo. In the second cycle of inspections (from January to March), the Foundation guaranteed a weekly presence of at least 2 teams. Surveys were conducted on 238 churches and 112 palaces, by filling in church forms and historical building forms. For the latter, only the damage was surveyed, without any appraisal of usability. As shown in Figure 8 (right), 61 % of the churches for which a result was issued were no longer usable. Most of them were historical masonry structures. A team specializing in precast structures was also operating from November 2016 to January 2017. This team mainly assessed manufacturing, receptive or commercial structures, for a total of 48 precast buildings. As can be seen in Figure 8 (centre), 52 % of the inspected structures were fully usable. Most of Aedes forms (82 %) were related to ordinary surveys involving school or public buildings (Table 1). Their outcomes mainly pointed to full usability (68 % of schools and 52 % of assessed public buildings), while only 9 % and 13 % respectively were completely unusable (Figure 9).

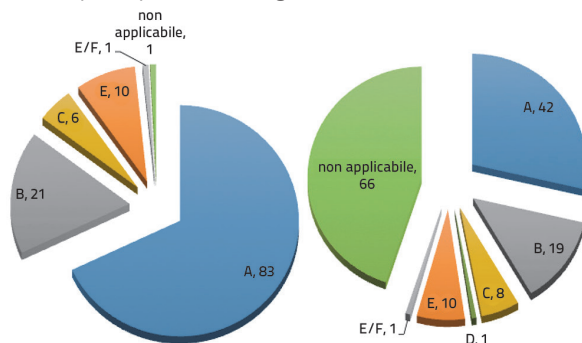


Figure 9. Usability outcomes for schools (left) and other public buildings (right)

3.3. Other technical, scientific and dissemination activities

A number of activities carried out by the Foundation on a voluntary basis are described to complete the overall picture of the role played by EUCENTRE in the recent seismic emergency. Among these, the most important were the technical-scientific reconnaissance activities, undertaken jointly with some internationally renowned research institutes. From 5 to 8 September 2016, EUCENTRE participated in the first post-event geotechnical reconnaissance within the team of GEER (Geotechnical Extreme Events Reconnaissance) in the provinces of Rieti, Ascoli Piceno, L'Aquila and Perugia. The related activities are reported in synthetic technical reports published shortly after the event [28] and in a more detailed report [29] with additional studies. From 12 to 16 September 2016, EUCENTRE joined EERI (Earthquake Engineering Research Institute) for a technical reconnaissance visit to Central Italy, as part of the Learning from Earthquakes (LFE) program, to study earthquake impact on the affected areas. At the end of the mission, the team shared the experience in a web-based reconnaissance seminar, available at the Clearinghouse website [30]. A further mission was conducted from 8 to 12 May 2017, to assess the effects of an important seismic swarm that occurred between October 2016 and January 2017. From 18 to 21 October 2016, EUCENTRE joined the AFPS (Association Française du Génie Parasismique) team in the post-event reconnaissance conducted in the provinces of Rieti, Ascoli Piceno and L'Aquila at the dams of Scandarello, Poggio Cancelli, Rio Fucino, and Sitter Pedicate. The results of the mission were included in the sections "Dams" and "Retaining walls, rockfall barriers and road embankments" of the GEER report [29], and in the section on dams of the AFPS report [31]. Finally, EUCENTRE joined geotechnics, geology, seismology and geomatics experts of the GEER Italy-United States team, which conducted the main landslide-survey phase with LIDAR and UAVs from 30 November to 5 December 2016. These activities are reported in a synthetic summary [32] and in a detailed technical report [33].

In early December 2016, the Department of Civil Protection engaged the Reluis Consortium, on behalf of the Italian Government, to urgently carry out an evaluation activity on the possibility of restoration / adaptation of schools classified unusable, in order to support decisions for the re-activation of interrupted school services. The joint teams of the University of Pavia-EUCENTRE evaluated four schools in Force, Falerone, Montalto in Marche, and Acquasanta Terme.

At the end of its mission, EUCENTRE has been involved in the dissemination aspects related to the earthquake emergency, and in particular: i. periodical updates on the website regarding the current activities, followed with interest by the national and international community, with nearly 34,000 visitors from August 2016 to March 2017, ii. The "Clearinghouse" website, in Italian and English, jointly with EERI, to collect scientific reports, articles, media, etc., addressed to and fed by the scientific community, with more than 8000 visitors in the same period; iii. A web-seminar on EERI Reconnaissance Mission and the seminar "Earthquakes of Central Italy from August to October 2016", which proved valuable for sharing and discussing with INGV colleagues.

4. Conclusions

Just as it has done during major seismic events that have hit Italy over the last decade, and also after the Amatrice earthquake, the EUCENTRE Foundation currently provides an emergency technical support to the national Civil Protection department, and performs a number of additional technical and scientific activities.

Over the nine months following the first event of the long-lasting sequence, and depending on the needs and requests, the activities included production of damage scenarios, experimental diagnostics and numerical assessment of structures and infrastructure facilities, and damage reconnaissance.

The field experience of EUCENTRE and colleagues involved in emergency activities has once again highlighted the unquestionable potential of the system and, on the other hand, a series of lessons have been learned for improving both the system and, generally speaking, the emergency technical management, both as regards decision support tools and field operations.

Concerning decision support systems, it is possible to strengthen platforms for the definition of seismic risk and damage scenarios by enriching the data base, especially through inclusion of other strategic infrastructures such as hospitals, firefighting stations, industrial plants at high risk of accidents, and all that is relevant for emergency management [4]. In this way, the scenario of damage could become an input for network analysis, which is currently implemented only for the roadway system and for the system integrating roads, ports, and airports. A viable path to enriching the data base could be the opening up of the platform to a community of users that could, on the one hand, benefit from the results obtained by seismic risk evaluation and, on the other hand, correct or enrich the information on the structures.

The shaking scenario forecasts will benefit from inclusion of the local amplification effects evaluated through seismic micro-zonation studies funded on the basis of a national law [34]. The integration of this improvement is currently underway.

In order to improve estimation of the residential asset damage scenario, it would be advisable to enhance the exposure database by adding information on the spatial distribution of buildings and information that would provide a better description of the vulnerability. In fact, buildings are currently considered only in terms of composition of the municipal building stock.

In addition, the integration of the damage accumulation phenomenon in vulnerability assessment models would be a key point in the case of multiple large magnitude shocks, such as those that occurred in central Italy on 30 October 2016. This will allow modelling the inevitable change in structural response of buildings already affected by previous shocks.

A further step forward would be the inclusion of data about the economic value of building assets in order to enrich the scenarios with the assessment of losses caused by direct and indirect damage (i.e. network assessments). With this kind of valuation, the "stakeholders" potentially interested in the platform results would include international insurance companies and governmental agencies that have to allocate resources for reconstruction.

Regarding field operations, a major and urgent need is to update damage survey tools in keeping with the modern technology that is currently available to everybody. In this respect, the future lies in data collection through webapp for all survey forms that are currently in use. The important advantage of the webapp is that it can be used on various operating systems (Android, macOS, windows mobile, etc.), while still being independent from connectivity conditions through local save.

The smart data collection, alongside an appropriate management system, would bring enormous advantages in emergency situations, such as: i. the possibility of remote registration of technicians, ii. registered survey assignments, iii. data exchange (contact inspections, addresses, etc.) using a cloud platform, iv. automated basic completeness checks ("error"), v. automated logic controls ("alert"), vi. real-time delivery of survey forms, vii. automated data storage; viii automated production of survey result statistics and their mapping on the territory to support the emergency-management decision makers.

In this way, the times of bureaucracy and territorial dispersion of technicians would be reduced and number of inspections increased, resources dedicated to manual data storage could be re-targeted, and the possibility of random errors associated with manual input, and errors due to incomplete data sheets, would be prevented. Technical inspectors will be assisted in their evaluation by a logical inconsistency tool.

Given that a lot of official paperwork with public administration is now electronically processed, the management of privacy, security and secure login, are issues that can properly be managed with current technology. It is believed that the ability to set up such a system as a preparedness activity has now reached sufficient maturity.

It should also be noted that such system, as in many public administration procedures, would not be incompatible with the paper method used by technicians (the number of which is, in our opinion, progressively reducing) that are comfortable with the present system and generally need support with submission of evaluation forms: the paper-related burden would be significantly reduced in favour of increased efficiency in global management.

Another problem is the apparently insufficient number of technicians that are able to compile survey forms. As the training protocol on the subject is today well defined in terms of duration and content, a fair solution could be the preparation of standard recorded course modules taught through an e-learning system. In this way, a significantly larger number of practitioners would be trained at negligible cost. In addition, a virtual support service at regional or university level could also be implemented.

Notwithstanding the great work done by the many persons that provided support in these dramatic events, it is believed that today there is an ample room for improvement of the system through tools that can be handled affordably within preparedness activities, all of which involves participation of the different possible stakeholders and exploitation of the full potential of technological advances.

On the European scale, as already mentioned, the ASA module has been implemented within the UCPM (Union Civil Protection Mechanism) perspective as a module that can provide support in international emergencies. Within this framework, several possibilities of contribution to the UCPM can be envisaged:

first by supporting the development of operative procedures on data collection and analysis for damage survey, then by sharing experience and best practices in the scope of training, and by potential involvement in the rescEU or the European Civil Protection Pool [4].

Concerning the platform for damage scenarios, it would be very useful to have it implemented in the Emergency Response Coordination Centre (EERC), in order to visually appraise the situation at a large scale to organize focused interventions in the most critical areas, and to better coordinate response capacities. The platform could be integrated within existing tools developed in the scope of DG-ECHO projects on the multi-hazard monitoring, in order to provide a powerful tool for the risk assessment, eventually together with the creation of a pool of technical experts that are able to support the ERCC with regard to situation assessments in crisis situations.

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