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Short-term countermeasures for securing cultural heritage buildings during a seismic emergency: improvements after the 1976 Friuli earthquake

S. Grimaz, P. Malisan and F. Zorzini

SPRINT-Lab, Politecnico di Ingegneria e Architettura, Università di Udine, Italy

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ABSTRACT In Italy, after the 1976 Friuli earthquake, progressive improvements were made concerning the approach and the techniques for securing and recovering historical buildings and monuments damaged by the earthquakes. The University of Udine and the Italian National Fire Service have been developing techniques to safeguard cultural heritage and strategic buildings and have reached an expertise level in this field, nowadays recognized even internationally. Competence and expertise have been achieved by capitalizing on experience with strong roots in Friuli (north-eastern Italy), which has leveraged on the synergy between science and practical application. The new techniques enabled safeguarding the cultural heritage during the seismic emergencies of L'Aquila (2009), Emilia (2012) and central Italy (2016). On the 40th anniversary of the earthquake in Friuli, an international training school in Seismic Emergency Response Management (SERM Academy) was instituted in Friuli to establish a training site for real-scale exercises, aimed at trying out new solutions and procedures for short-term countermeasures. The training site was established in Portis Vecchio, an abandoned village close to Venzone (Udine province), one of the towns most affected by the 1976 earthquake and a symbol of the reconstruction of Friuli.

Key words: seismic emergency, short-term countermeasures, 1976 Friuli earthquake, cultural heritage buildings.

1. Introduction

If an earthquake leaves a trail of destruction, that trail may also be the motivation for innovation and for future studies. Without doubt, this is what happened after the 1976 Friuli earthquake (north-eastern Italy). In fact, as a result and as a lesson learnt from the Friuli earthquake experience, there have been many advances in the scientific, technical, administrative and legislative fields (Finetti *et al.*, 1979; Grimaz *et al.*, 1997; Benedetti, 2010). Significant innovations have also been made in the seismic emergency response capability for securing buildings (countermeasures), starting from the immediate post-earthquake phase (short-term), and with a specific focus on cultural heritage buildings.

The importance of "short-term countermeasures" to safeguard cultural heritage buildings during a seismic emergency was recognised in a sentence published on the official website of the Municipality of Spilimbergo (Province of Pordenone, Italy): *"On 6 May the violent shock of* *the earthquake seemed to put an end to everything in a few seconds: the cathedral resisted even though it suffered serious damage, only the short-term countermeasures succeeded in rescuing it from the subsequent shocks of 15 September"* (see www.comune.spilimbergo.pn.it). The sentence refers to the 1976 earthquake in Friuli and to the cathedral of Santa Maria Maggiore in Spilimbergo (an historical village, located in the most affected area by the earthquake), now restored to its former splendour. The 1976 Friuli earthquake was characterized by two main events: the first on 6 May with magnitude M_L 6.4 and the second with two main-shocks on 11 and on 15 September with M_L 5.8 and 6.1, respectively (Luzi *et al.*, 2017; Slejko, 2018). The above citation highlights that shoring a monumental or historical building damaged by an earthquake in order to avoid or contain the aggravation of damage in case of aftershocks or new events is a strategic response action. This action requires complex operations, not only from a technical point of view, but also concerning the safety of operators who intervene in extremely dangerous scenarios.

The collaboration between the SPRINT-Lab researchers of the University of Udine (hereinafter, SPRINT) and the Italian National Fire Services (in Italian, Corpo Nazionale dei Vigili del Fuoco, hereinafter, CNVVF) helped develop and progressively improve methods and techniques that were positively applied and tested during the seismic events that have recently affected the Italian territory (L'Aquila, 2009; Emilia, 2012; Garfagnana and Lunigiana, 2013; central Italy, 2016) and in international missions (Nepal, 2015; Ecuador, 2016). This expertise has been achieved thanks to learning from the experiences rooted in Friuli, and through the synergy between science, experience and application practice.

In the following sections, we describe briefly the improvements in the field of short-term countermeasures, highlighting the scientific contribution given by SPRINT to the CNVVF.

2. The Italian experience in securing cultural heritage after earthquakes

Historical documental sources on earthquakes in Italy report on shoring interventions aimed at securing damaged buildings after the seismic events of Messina (1908), Avezzano (1915), Aquilonia and Lacedonia (1930), and Belice (1968) (Grimaz *et al.*, 2010b). These works mainly used shoring techniques with wooden elements. Starting from the earthquake of Friuli in 1976, the use of new shoring techniques began, such as wall retention with metal ties and scaffolding-pipes. In this period, some important provisional construction work also on historical and monumental buildings started (a notable example is the one mentioned above regarding the cathedral of Spilimbergo). The positive results obtained with such interventions, in terms of their effectiveness during the aftershocks, demonstrated their importance in the field of safeguarding historic-architectural heritage. The Irpinia earthquake, in 1980, saw the use of temporary constructions in wood and scaffolding-pipes to stabilize the *façades* of church and monumental buildings, but a major increase of attention to safeguarding cultural heritage occurred only after the 1997 Umbria-Marche earthquake. In Umbria and Marche, the securing interventions on high structures (bell towers, towers, and church *façades*) commenced with operations using steel cables and polyester strips, being easy and quick to use in the operations at considerable heights. Shoring-up work was primarily carried out by private firms, generally under the coordination of civil protection (Bellizzi, 2001; Dolce *et al.*, 2006). These techniques were also adopted during the Molise seismic emergency in 2002.

In 2009, following the violent Abruzzo earthquake of 6 April the entire historic centre of L'Aquila town was declared a "red zone", to be accessed only by rescue personnel. A large number of buildings, although without significant damage, were declared unusable because they could not be reached safely or because they were close to other hazardous buildings or subject to other risk situations. A primary role was assigned to the CNVVF in the post-earthquake emergency management due to the complexity of the scenario, coupled with the urgency and the typology of security measures for the restoration of road accessibility and the preservation of the large number of historical and monumental buildings. This introduced a significant change in the approach of securing buildings, moving from the management of each single intervention to a management plan based on an overall "urban shoring" process (Grimaz, 2011). A specific coordination unit for the planning and management of securing operations was set up within the CNVVF. This unit, which worked with the scientific support of SPRINT, designed standardized solutions, including compiling a handbook (Fig. 1) providing guidelines (Grimaz *et al.*, 2010a), to make the construction of temporary interventions faster and safer. More than 400 (simple and complex) interventions (Cimbolli Spagnesi, 2014) were undertaken in the affected area, mainly on historical and monumental buildings. Some complex interventions were made in the city of L'Aquila to safeguard the Spanish Castle, the church of Anime Sante, the church of Paganica, and in other monuments in the surrounding villages as, for example, the San Felice Martire church in Poggio Picenze (L'Aquila province) and the church of Sant'Eusanio Forconese (L'Aquila province). In the church of Anime Sante a sturdy steel structure, called

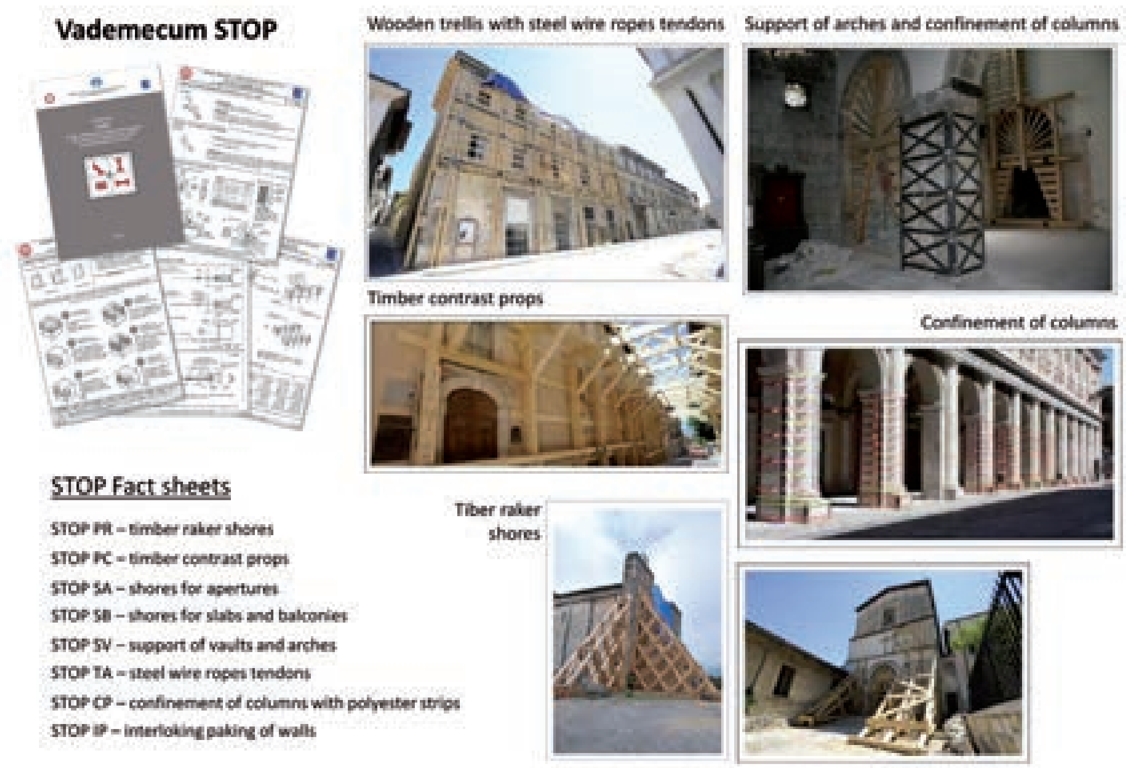


Fig. 1 - Vademecum STOP. Shoring template and operating procedures for securing buildings damaged by earthquake. On the left: fact sheets for different standardized solutions. On the right: examples of STOP solutions.

an "octopus", was constructed to secure the dome (Fig. 2). At the Poggio Picenze church, an innovative solution, for the first time using carbon-fibres, was devised to brace the severely damaged bell tower (Fig. 3).

During the 2012 Emilia earthquake, the new standardized solutions facilitated the process of securing the buildings. The numerous interventions also highlighted the importance of a preparatory phase, i.e. the phase in which experts outline the general situation, recognize the critical problems and define the priorities of intervention. Overall, in the Ferrara, Mantua, and Rovigo provinces, more than 120 provisional works were carried out on historical buildings. Many of these were complex operations on bell towers or domes of cathedrals and basilicas. Recently, after the 2016 central Italy earthquakes, 286 interventions were carried out to secure historical buildings and guarantee the safe use of roads in the affected area. The interventions were done after a very rapid preliminary phase to pinpoint critical situations and prioritize needs. One of the main works was on the San Benedetto basilica in Norcia (Perugia province) (Fig. 4). The central Italy earthquake also saw the introduction, as part of short-term countermeasures, of the controlled dismantling procedure for monumental buildings and artefacts. Specialized teams of the CNVVF dismantled about ten monuments or portions of them that were in precarious conditions, thus preserving the cultural heritage from certain destruction caused by potential aftershocks. The controlled dismantling enables the rebuilding of the monument at the end of the emergency phase, safeguarding the integrity of cultural heritage. Fig. 5 summarises the main improvements in the post-earthquake short-term countermeasures activities in Italy in the last century.

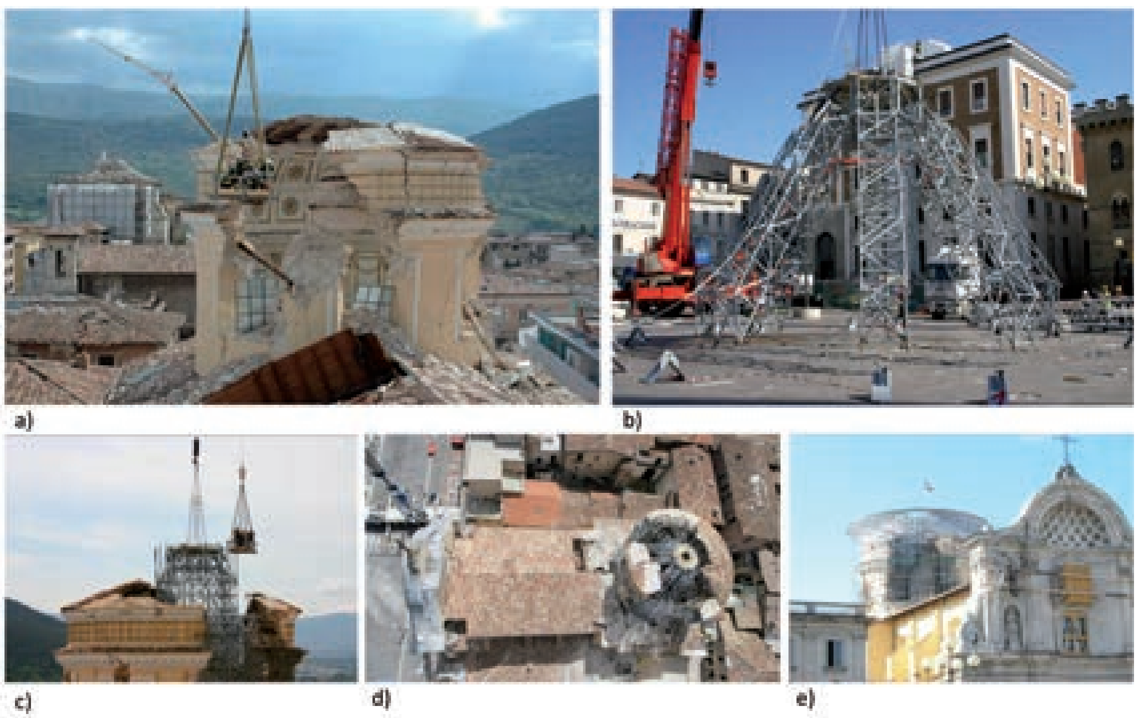


Fig. 2 - Short-term countermeasures for securing the dome of Anime Sante cathedral in L'Aquila after the 2009 Abruzzo earthquake, realized by CNVVF: a) damage situation of the dome; b) preparation of the "octopus" in a safe place; c) mounting operations by crane; d) in-place "octopus"; e) completed work.


a)

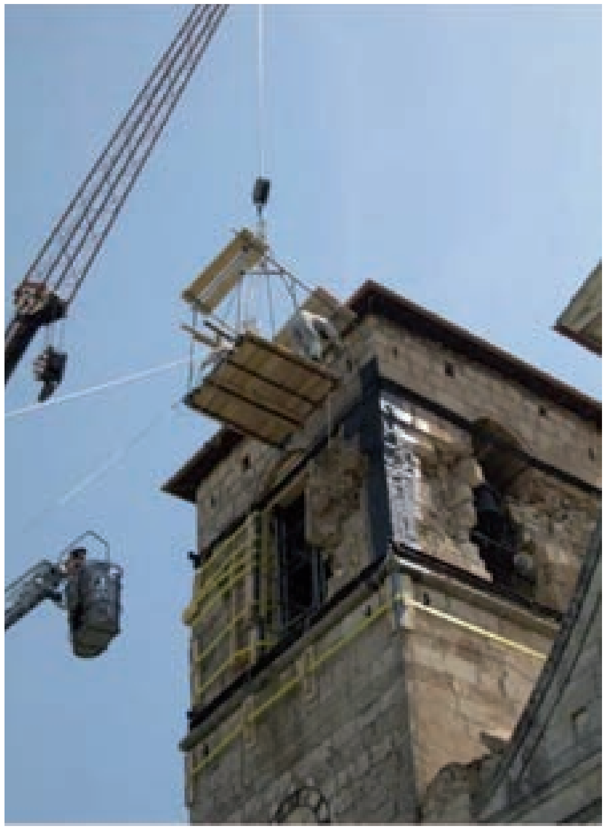
c)

b)

Fig. 3 - Short-term countermeasures for securing the bell tower of the San Felice Martire church of Poggio Picenze (L'Aquila province) realized by CNVVF after the 2009 Abruzzo earthquake: a) damage situation of the bell tower; b) application of carbon-fibers for reinforcing the damage pillar; c) completed intervention.


a)

b)

c)

Fig. 4 - Short-term countermeasures for securing the façade of the San Benedetto basilica in Norcia (Perugia province) after the 2016 central Italy earthquake: a) the damage situation after the 30 October 2016 main-shock; b) positioning by crane of the scaffold structure built in safety place; c) completed securing works.

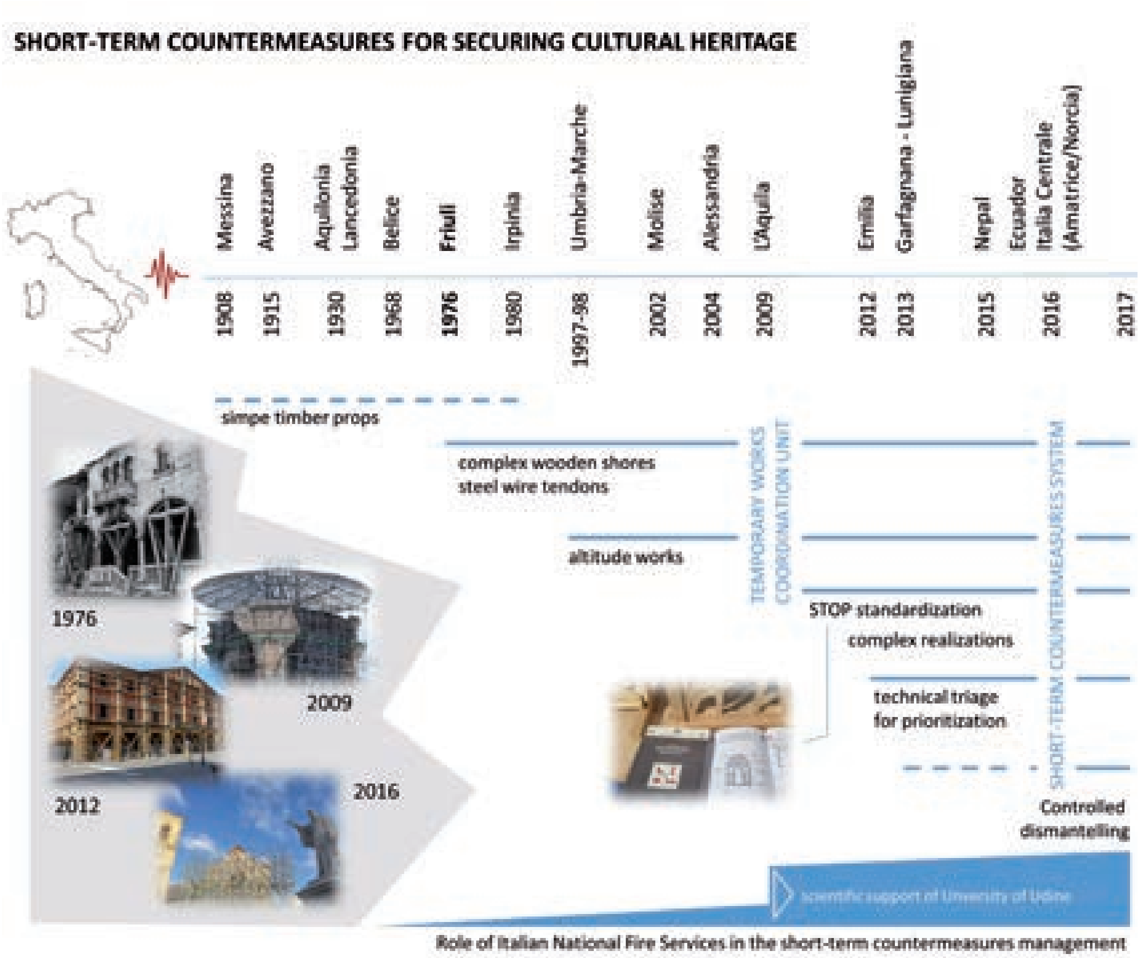


Fig. 5 - Main improvements in post-earthquake short-term countermeasures management in Italy.

3. The scientific contribution to innovation and improvements

On occasion of the 2009 L'Aquila earthquake, an institutional collaboration began between CNVVF and SPRINT in the field of short-term countermeasures. This synergy between science and practice has led to significant innovations in this field. The main technical and organizational improvements are briefly summarized in the following.

3.1. Technical innovations

The technical innovations to implement short-term countermeasures can be traced back to the following main aspects:

3.1.1. Standardization

After the L'Aquila earthquake, specific efforts were made to design and develop methods and techniques for making the securing operations at an urban scale more effective. In particular, the researchers of SPRINT standardized solutions and developed technical datasheets for sizing provisional devices such as retaining and supporting props, ties, rims, etc., including graphs and constructive details (connections between elements, fastenings, knots, etc.). The standardization led to drafting a handbook of technical sheets (called STOP vademecum) for fire-fighters (Grimaz *et al.*, 2010a). The STOP vademecum had a very positive impact both on the construction phases of short-term countermeasures and on the improvement of the safety conditions of the fire-fighters during the interventions.

3.1.2. Safety and compatible solutions

The new solutions were conceived considering also the construction phases and the potential practical problems occurring to operators during the work. Specific attention was addressed to personnel safety. The STOP solutions were designed to permit the preparation of the structure, to be in a safe area as much as possible, and subsequently the installation with techniques that minimize the exposure time of personnel in hazardous areas. This attention to safety was a key element also during complex interventions, in particular on the occasion of 2012 Emilia earthquake, when the SPRINT researchers conceived and designed the innovative solution for securing the upper part of the cupola (in Italian "ghirlanda") of the Santa Barbara basilica in Mantua, being seriously damaged by the main-shock of 29 May 2012 (Fig. 6); the intervention was at high altitude. The temporary work was planned in order to achieve both an increase in personnel safety during the mounting sequence (safety) and the realization of a securing structure that enabled the subsequent definitive reinforcement intervention without constraints (compatibility).

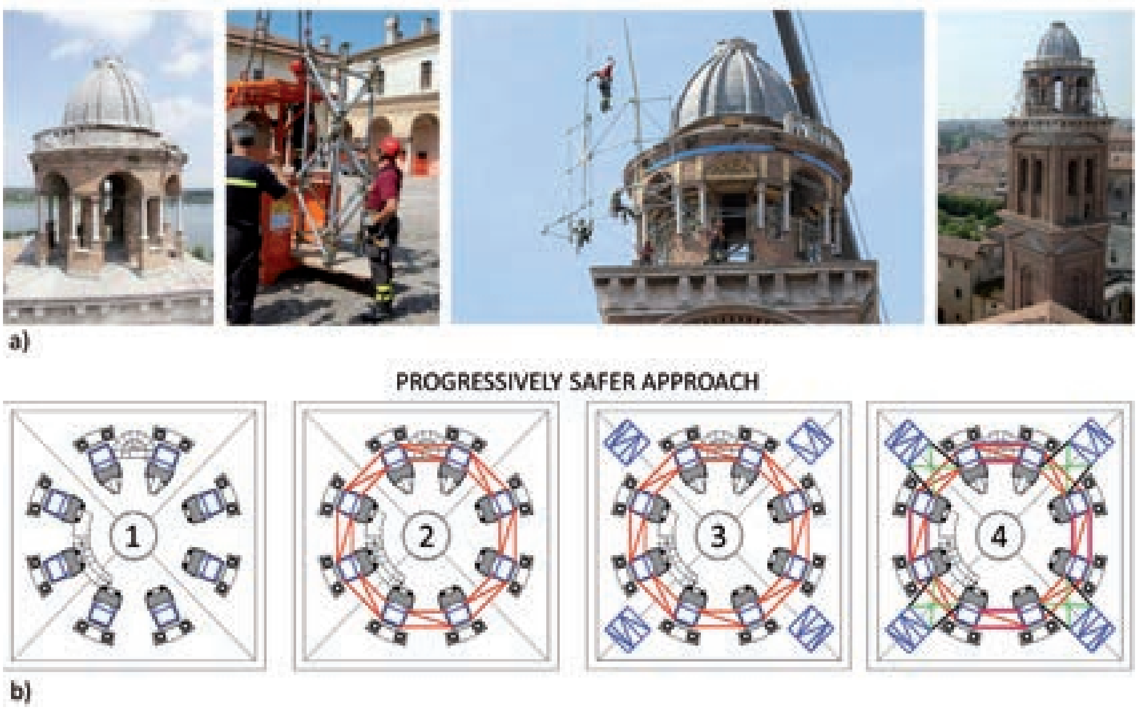


Fig. 6 - Short-term countermeasures for securing the cupola of Santa Barbara basilica in Mantua after the 2012 Emilia earthquake: a) preparation of scaffold parts in a safe place and mounting operations by CNVVF personnel; b) the steps of mounting are designed progressively increase the safety of operators.

3.1.3. Experimentation of new solutions

The L’Aquila and Emilia experiences highlighted the problem of securing roads in unsafe conditions owing to damaged buildings facing the street. As a practical response to this question, in 2014, an innovative solution of short-term countermeasures was tested during a full-scale exercise "SERMex 2014" in Friuli. During the exercise, SPRINT and CNVVF tested a new technique to brace a crumbling wall facing a road, whose potential collapse could cause a severe risk (Fig. 7). On the hazardous *façade*, fire-fighters applied a wooden trellis retained by steel cables, designed by researchers of SPRINT, with the aim of avoiding, in the event of seismic shock, the collapse towards the street. The new solution was also conceived for reducing the operation time. This experimentation was a good test; firstly because the structure was made in only two and a half days (in rainy conditions); secondly, because on 30 January 2015, the structure was stressed by a M_L 4.1 earthquake (Luzi *et al.*, 2017) with its epicentre in Moggio Udinese (Udine province), only 6 km far from the construction site (Fig. 8). The ground motion caused the collapse of portions of the roof that fell inside the building. The containment work proved its full effectiveness, preventing the fall of material and structural parts on the road. This experience was a useful reference point for the securing activities during the 2016 central Italy earthquake.

Fig. 7 – Construction stages of the experimental solution (trellis laterally anchored): a) initial situation of the old kindergarten with roadside facing wall; b) preparation of the trellis in a safe area; c) positioning the trellis with a crane; d) completed work with lateral anchoring steel wire tendons.

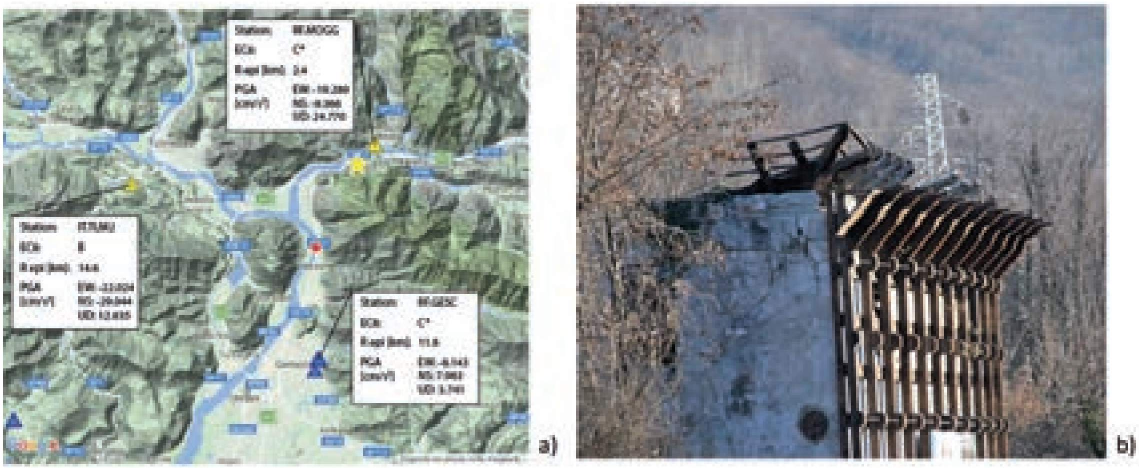


Fig. 8 - Natural testing of 30 January 2015: a) location of the earthquake epicentre of 30 January 2015 (yellow star), indication of the location of the site of the experimental work (red circle) and seismometric stations (blue and yellow triangles) with reported instrumental data; b) effects on the experimental structure caused by the event on 30 January 2015. It is possible to note the collapse of the roof of the building internally and the good performance of the containment structure which prevented the collapse and fall of material on the road in front of the *façade*.

Fig. 9 – Controlled dismantling of the remaining parts of the bell tower of the Civic Tower of Amatrice (Rieti province), still standing after the main-shock of October 30, 2016: a) view of the intervention work from a distance; b) close up view.

3.1.4. Controlled dismantling

During the central Italy emergency, SPRINT researchers designed the procedures for dismantling the upper part of the bell tower (Torre Civica) of Amatrice (Rieti province), severely damaged by the earthquake of the 24 August 2016 (Fig. 9). This solution was introduced as a last resort to save the cultural heritage in very precarious conditions. The dismantling concept is based on the idea of anticipating the certain destruction caused by future seismic events, proceeding with a controlled dismantling of the precarious portions. The bell tower dismantling work was delayed because the removal of rubble had still not been authorised; just a few days before the start of dismantling work the main shocks of 26 and 30 October, as expected, caused the collapse of most of the upper part of the tower. Moving on from this experience, about ten monuments underwent a controlled dismantling action, in the larger area affected by the latter shocks. In these cases, the portion of buildings and monuments were saved, thus permitting the future restoration and preservation of cultural heritage.

3.2. Organizational improvements

The organizational improvements to implement short-term countermeasures can be traced back to the following main aspects:

3.2.1. Rapid expert evaluations for decision-making support

During the 2012 Emilia earthquake, the need to prioritize the interventions prompted fire-fighters and researchers to introduce new strategies for the rapid assessment of structural criticalities. This

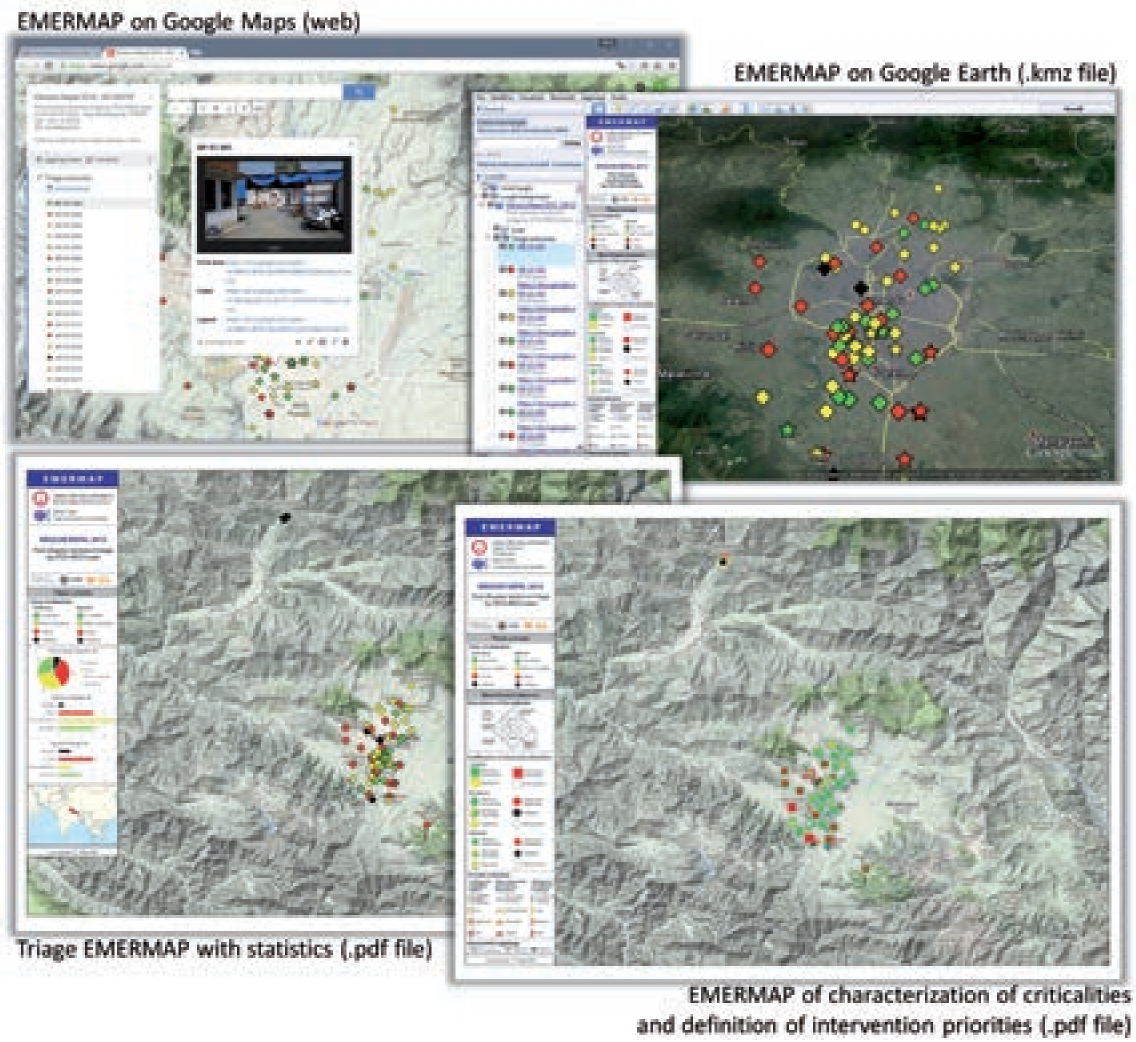


Fig. 10 - Example of EMERMAPs produced by Scientific Unit of SPRINT during the international mission in Nepal 2015.

assessment process was conceived as a decision-making support tool, and for this reason, it was carried out using innovative technologies and computer applications devoted to mapping, assessing points and intervention priorities in real time. Emergency maps, called EMERMAPs (Fig. 10), allowed scheduling securing interventions and their implementation according to STOP standards. Thanks to this first experience, the SPRINT researchers developed specific forms for evaluating critical structural points of damaged buildings and for identifying the necessary countermeasures. The aim of the procedure and related tools was to acquire the essential elements for facilitating the decision-making process as quickly as possible. This procedure, called technical triage, was applied for the first time on a small scale in 2013 after the Garfagnana and Lunigiana earthquake (central Italy) and during the CNVVF international missions in Nepal, 2015 and Ecuador, 2016. Successively, the triage procedure has been extensively applied in 2016 in central Italy, allowing the assessment of more than 35,000 buildings (mainly in historical centres) in a few weeks.

3.2.2. New technologies to support evaluations

The collaboration between CNVVF and SPRINT permitted the experimentation of new supporting technologies for the rapid and safe evaluations in critical conditions. The multirotor drones were tried out for detailed evaluation of building damage and employed as a support for technical inspectors (Fig. 11). This technology enables analysing, from at a safe distance, tall structures such as bell towers and to investigate non-accessible or very dangerous areas. The use of drones, tested during the SERMex 2014 exercise in Friuli, was extensively applied in the whole affected area of the central Italy earthquake, with significant benefits.

Fig. 11 - Use of drones to assess the safety conditions of buildings damaged by the earthquake:
a) the drone is piloted from a remote safe place; b) the drone investigates an area not visible from the ground.

3.2.3. Systemic organizational response

During the international missions in Nepal (2015) and Ecuador (2016), a new organizational solution was experimented for the real-time production of post-earthquake safety assessment reports and EMERMAPs, useful for planning short-term countermeasures.

An innovative solution, based on the use of cloud and ICT technology, allowed splitting the phase of inspection from the elaboration and mapping. Thanks to this new organization, trained inspectors acquire data on site, and a remote scientific unit elaborates these data to create the EMERMAPs and reports almost in real time. During the Nepal (2015) mission, a technical team of 4 fire-fighters, with remote support of SPRINT researchers, evaluated the safety conditions of more than 90 UN strategic buildings, in ten days. Furthermore, the team assessed the critical points of the Patan Durbar UNESCO-protected site of Kathmandu and designed, using the STOP standard, urgent technical countermeasures for the protection of the main damaged monuments. The effectiveness of the operations received the explicit and formal appreciation of UNESCO. This led the CNVVF to establish a new technical-specialist system expressly devoted to managing the short-term countermeasures, called Short-term Countermeasures System (STCS) (Grimaz *et al.*, 2016). The STCS operated extensively during the 2016 central Italy earthquake and permitted facing the complex scenario with an expertise and effectiveness unthinkable before.

3.3. Making the most of the experience by training and capacity building

Capitalizing on the experience in the field of short-term countermeasures has strong roots in Friuli. In the following part, we briefly summarize the main steps that characterize this process.

3.3.1. The roots in the Friuli experience

In 2008, the University of Udine organized in Venzone (Udine province) a cycle of master courses on “seismic risk management” to address seismic risk management issues: prevention, emergency management, and reconstruction. The courses, named “SERM school”, aimed at capitalizing on the "Friuli experience" on the scientific, technical and operational levels, involving administrators, experts, scholars, civil protection workers, and fire-fighters. During the SERM courses, the small village of Portis Vecchio, close to Venzone, was chosen as a visiting site to directly analyse the seismic damage on buildings. Being severely damaged after the 1976 earthquake, the village was abandoned and relocated a little further north, because of serious landslide hazard in the area.

The SERM initiative and the Portis Vecchio village have close connections with the improvements on the short-term countermeasures described in the previous section. In fact, in 2009, during one of the SERM courses, the L’Aquila earthquake occurred and the dramatically complex scenario was analysed in the classroom. These debates created the premises that inspired the researches of SPRINT on compiling the STOP vademecum for the standardization of short-term countermeasures for securing the damaged buildings.

3.3.2. Specialist training and European projects

After the L’Aquila experience and the drafting of the STOP vademecum, in order to make the most of the experience, CNVVF and SPRINT drew up a Manual for Short-term Countermeasures (STOP handbook) to be used for advanced training activities within the CNVVF (Grimaz *et al.*, 2010b).

The STOP approach inspired the European project called DR-HOUSE (Dolce *et al.*, 2012), coordinated by the National Civil Protection Department. The project led to the setting up of specific fire fighting unit called STC (Short-Term Countermeasures) within the European Civil Protection Device. DR-HOUSE enabled establishing specialized teams trained for the implementation of the works according to the methodologies of the vademecum STOP. Subsequently, a second European project, called MATILDA (Multinational Module on Damage Assessment and Countermeasures) allowed defining interoperable international units for the construction of short-term countermeasures with STOP standards. The international team was involved in the ModEX international exercise, carried out in Tirolwerk (Austria) (www.youtube.com/watch?v=WjLWX2EXRg0). Today, the STC unit is one of the official units of the Voluntary pools of European Union.

3.3.3. *A posteriori* and on-field observations

Extensive evaluations were carried out after the 1976 Friuli earthquake both on the damage mechanisms of structures and on the temporary interventions mainly done on churches and bell towers (Doglioni *et al.*, 1994). These *a posteriori* evaluations permitted the identification of different classes of damage mechanisms and facilitated the standardization of the solutions for the stabilization of the structures. On-field observations were conducted after the 2009 L'Aquila earthquake to evaluate the infrastructure problems (Grimaz and Maiolo, 2010). These observations highlighted an increase of the fire hazard associated with the diffuse presence of gas pipelines also in historical centres and in historical buildings.

During the 2012 Emilia earthquake, specific observations focused on recognizing the effects of the ground motion on the damage of buildings, identifying the major importance of the vertical component of the ground motion in the damaging process of masonry structures, and especially on historical buildings. These effects were observed mainly in the near field area (Grimaz and Malisan, 2014). The observations suggested some variations in the procedure of construction of short-term countermeasures in order to take into account, for safety reasons, the ballistic effects on the trajectories of objects during their falling down, caused by the combination of horizontal ground motion component with a strong vertical component. The on-field observations also highlighted the effects of the progression of damage during the successive shocks (Grimaz and Malisan, 2017). This phenomenon, known as cumulative damage, plays a very important role in the process of planning the short-term countermeasures especially in red zone areas, where the damaged buildings have a greater susceptibility to collapse and where the collapse mechanisms are closely related to the damage caused by previous loads.

3.3.4. Full scale exercise in Friuli

In 2014, the CNVVF and researchers of SPRINT organized a national exercise in Friuli, close to Venzone. In order to emphasize the original link with the SERM school, the exercise was named SERMex 2014. The aim was to test the effectiveness of the new developed methods for evaluating the structural critical points through the triage procedure, and to test the rapid and effective management of new solution of short-term countermeasures. The exercise was also intended to try out, for the first time, the use of new remote sensing technologies to support emergency technical assistance (multirotor and fixed wing drones). The site chosen for the exercise was

Portis Vecchio of Venzone (Udine province), a “ghost village”, abandoned and unchanged after the 1976 earthquake. The “survivor” buildings are exactly as they were at the time of their final abandonment, creating a particularly suitable scenario for full-scale exercises for Civil Protection and Fire Services purposes.

3.3.5. An international training school in Friuli: the SERM Academy

The exercise "SERMex 2014" fully confirmed the suitability and uniqueness of the Portis Vecchio site for setting up a training camp. The site is particularly suited to host real-time exercises on the analysis of seismic failures, on urgent intervention techniques, for assessing the structural vulnerability and the safety of road and damaged buildings, and for testing the interoperability at regional, national and international scale. Its geographical location is also suitable for promoting cross-border, transnational and interregional cooperation in the field of civil protection. The real perspective is to establish an internationally valued site involving Austria and Slovenia in a project that can become a *unicum* at European level. In May 2016, on occasion of the 40th anniversary of the Friuli earthquake, these distinctive features led the Friuli Venezia Giulia Region, the CNVVF and the SPRINT to start up an international school for seismic emergency response management (SERM Academy). The site of Portis Vecchio will thus become a permanent training ground for a number of training activities related to the management of a seismic event, also with a view to improving cross-border interoperability between the different actors in the system of civil protection. A further full-scale exercise was done in September 2017 to test the improvements made after the last experience of central Italy. The focus is on improving the tools to simplify and standardize the link between the technical activities of CNVVF and the administrative acts of mayors aimed at establishing the red zones and declaring specific damaged buildings “unusable”.

4. Conclusions

Significant improvements in the field of short-term countermeasures can be observed in the last decades, especially with regard to the securing operation of cultural heritage. These enhancements have been achieved through a careful process of capitalizing on experience with its roots in the 1976 Friuli earthquake and by leveraging on the synergy between science, experience, and practical application. The new approach and expertise have been applied and tested during the emergency management of earthquakes that have recently affected Italy and other countries.

Thanks to such progress, today, fire-fighters, university researchers and cultural heritage administrators work together in a coordinated way with a common purpose: saving, as far as possible in a specific context, monuments and historical buildings. Moreover, the last major Italian earthquake (central Italy, 2016) confirms the effectiveness of this approach, especially on the securing of cultural heritage buildings. The standardization of procedures has enabled establishing within the CNVVF a special unit for operating at international level and that is now an official part of the voluntary pool of the European Union.

The SERM Academy has recently been set up following the 40th anniversary of the Friuli earthquake; it is an international training school on seismic emergency response management.

The school's training site is based in Portis Vecchio of Venzone, and its main objective is to share the knowledge on short-term countermeasures after earthquakes as part of the emergency management, at national and international levels.

With the launch of the SERM Academy, it may be said that, forty years later, the Friuli earthquake is still teaching, both in technical terms but also from a methodological point of view. Indeed, the school is seeking to expand the coordinated and systemic response over borders, operating within a European civil protection vision. As a matter of fact, it is well known that country boundaries can stop people but cannot stop earthquake effects.

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Corresponding author: Stefano Grimaz
Safety and Protection Intersectoral Laboratory, Polytechnic Department of Engineering and Architecture, University of Udine
Via del Cotonificio 114, 33100 Udine, Italy
Phone: +39 0432 558731; e-mail: stefano.grimaz@uniud.it