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Miscellanea INGV

2nd General Meeting

KnowRISK

Know your city, Reduce seISmic risK through non-structural elements

Catania 15 | 17 December 2016

33

Istituto Nazionale di Geofisica e Vulcanologia

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KNOW YOUR CITY, **R**EDUCE SE**IS**MIC **R**ISK THROUGH NON-STRUCTURAL ELEMENTS

CATANIA 15 | 17 DECEMBER 2016

Editors Susanna Falsaperla, Horst Langer, Salvatore Mangiagli, Luciano Scarfì

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Immagine di frontespizio
The 24 August 2016 Amatrice earthquake: partial collapse of a masonry building
(Image credit: photo by R. Azzaro, reprocessing by M. Cascone)

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PREFACE

The European project KnowRISK (Know your city, reduce seISmic risK through non-structural elements) is a European Commission project in the area of Humanitarian Aid and Civil Protection whose primary aim is the reduction of seismic risk by actions on non-structural elements that can be performed by common citizens, thus contributing to promote communities fast recovery and resilience.
Even though the main source of victims in earthquakes is the collapse of constructions, damage in non-structural elements also contributes to increase the death toll. In many situations, especially in developed countries, non-structural damage is the main source of economic losses. And developed societies have become increasingly demanding in what regards the control of economic losses due to seismic events. A key factor for the reduction of economic losses is the protection of non-structural elements, this is, the contents of buildings and non-structural elements of the building, which usually account for 70% to 80% of its cost. In the cases of seismic events, where there isn't a large number of victims, economic losses becomes one of the strongest consequences of earthquakes. This is the case for well-built buildings, as the enforcement of modern codes of practice for earthquake resistant design aim at preventing collapse but not vibration of the buildings, thus not avoiding non-structural damage, especially to the contents. Also in very strong earthquakes, as seismic waves attenuate as the distance to the epicenter increases, soil vibrations become not strong enough to induce collapse of buildings but are still strong enough to cause cracking to non-structural elements of the buildings and damage to the contents, being economic losses the most relevant consequence of the earthquake in those zones.
For the purpose of reducing non-structural damage it is necessary to decrease the knowledge gap between the scientific community and the stakeholders that may apply that knowledge. Therefore, a relevant part of this project is directed towards transferring information to the public, in order that common citizens can take action at their own homes to reduce damage from future earthquakes. As for this purpose it is necessary to combine knowledge from different fields, the project team comprises engineers, seismologists, architects, sociologists, and other professionals that cooperate in order to produce the best possible results. In order to achieve the proposed results, the project comprises the following main tasks:

- Identification of non-structural elements that may cause damage or reduce the functionality of buildings.
- Identification of solutions for the strengthening of non-structural elements.
- Assessing the level of awareness of stakeholders and citizens.
- Promoting risk awareness between stakeholders and citizens.

The two first tasks are essentially of a technical nature, within the scope of expertise of project members. The last two tasks will be achieved by means of the development of a practical Guide of solutions for the strengthening of non-structural elements and other dissemination tools, participatory forums with local communities and other risk awareness initiatives that contribute to the spreading of knowledge by the population.

During the 2nd General Meeting in Catania, Italy, on 15-17th December 2016, the development of the project will be assessed and discussed by means of oral presentations, posters and discussions between team members and stakeholders.

Project leaders
Carlos Sousa Oliveira
Mário Lopes

Ground-motion intensity parameters for non-structural damage

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Ground-motion amplitude, frequency content and duration control the damage in both structural and non-structural components of a building. The commonly used design parameters for structural components are peak ground acceleration, and pseudo-spectral acceleration. The non-structural components are affected not entirely by the ground motion but instead by a part which is filtered by the structure. In this sense, seismic loading of non-structural components becomes structure dependent. Components that are properly anchored to the structural systems are sensitive to relative displacement of structural components, which is thought to be well represented by interstory drift. On the other hand, free standing components are sensitive to floor accelerations.

In regard to free standing objects, sliding, initiation of rocking, and ultimately overturning are the relevant damage states in terms of their fragility. Although extensive research has been carried out, starting with the pioneering work of Housner [1963], on rocking of rigid blocks during earthquakes, the application of some the theory to fragility of free-standing building contents is only recently becoming popular, with some excellent studies being reported in the last few years [Di Sarno et al., 2015b; Dimitrakopoulos and DeJong, 2012; Deimitrakopoulos et al., 2009; Di Sarno et al., 2015a; De Biasio et al, 2015; Cosenza et al., 2014; Petrone et al., 2016]. Most of these studies have focussed either on free standing monuments or contents inside hospital buildings. The recent study of Petrone et al. [2016] investigated different intensity parameters that are efficient to predict onset of rocking and overturning of hospital shelves. Studies of this type are limited, mainly due to the costs involved in experimental testing of full-scale models. However, at least for rocking and overturning, which is the most critical damage state in terms of injuries due to household contents, numerical modelling has been shown to be effective [Petrone et al., 2016]. The objective of this study is to investigate the efficacy of numerical modelling in predicting the rocking and overturning of common free-standing household furniture during earthquakes.

Numerical modelling will be performed on rigid blocks of different dimensions, mass distribution, and aspect ratios, performing incremental dynamic analysis to induce rocking and overturning. The most appropriate intensity measure can then be identified as the one which predicts the damage states with least uncertainty. Given the costs involved in full-scale shake table tests, scaled models will be tested in a small scale shake table. The results of such testing will be compared with numerical simulations to examine whether tests on scaled models are reliable enough for these kinds of studies. Finally, a full-scale shake table test of a typical bedroom is being organized in LNEC during the course of this project. Some furniture in the test set-up will be instrumented to record their response, and shaking intensity will be increased until rocking and overturning is observed. By repeating such tests with various ground motions, it is possible to identify which characteristics of ground motion are more crucial for onset of rocking and overturning. The results from this full-scale test will be compared with scaled model tests as well as numerical simulation to examine the validity of scaled testing, and to understand scale effects. earthquakes. earthquakes will be used. Spatial distribution of ground motion. A new innovation in this study will be to include the effects of restraints provided by walls, which are generally been ignored in most of the published studies. In addition, energy dissipation during impact with the wall and/or floor and its effect on overturning will be investigated.

References

Housner G.W., (1963). *The behavior of inverted pendulum structures during earthquakes*. Bull Seismol Soc Am 53:403–417.

Di Sarno L., Petrone C., Magliulo G., Manfredi G., (2015b). *Experimental seismic performance assessment of hospital building contents*. In: 2nd conference on improving the seismic performance of existing buildings and other structures. San Francisco, CA, USA.

Dimitrakopoulos E., DeJong M., (2012). *Overturning of retrofitted rocking structures under pulse-type excitations*. J Eng Mech 138:963–972.

Dimitrakopoulos E., Kappos A.J., Makris N., (2009). *Dimensional analysis of yielding and pounding structures for records without distinct pulses.* Soil Dyn Earthq Eng 29:1170–1180.

Di Sarno L., Petrone C., Magliulo G., Manfredi G., (2015a). *Dynamic properties of typical consultation room medical components*. Eng Struct 100:442–454.

De Biasio M., Grange S., Dufour F., Allain F., Petre-Lazar I., (2015). *Intensity measures for probabilistic assessment of non-structural components acceleration demand.* Earthq Eng Struct Dyn 44:2261–2280.

Cosenza E., Di Sarno L., Maddaloni G., Magliulo G., Petrone C., Prota A., (2014). *Shake table tests for the seismic fragility evaluation of hospital rooms*. Earthq Eng Struct Dyn 44:23–40.

Petrone C., Di Sarno L., Magliulo G., Cosenza E., (2016). *Numerical modelling and fragility assessment of typical building contents*. Bulletin of Earthquake Engineering, DOI 10.1007/s10518-016-0034-1.

Identification of the most vulnerable non-structural components in the Portuguese pilot area to develop risk communication tools and strategies

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Many non-structural components in buildings such as furnishing, equipment, electrical and mechanical fixtures, architectural features, shelves and glass may pose hazard when they slip, tip over, fall or collapse during an earthquake. Therefore, it is extremely critical to identify and eliminate non-structural hazards.
A comprehensive seismic non-structural survey and analysis of a building may require almost as much time as a structural analysis. The non-structural data collection is time-consuming because there are more items to observe and inventory, and they are spread throughout a building. Moreover, analysis of existing reports may be difficult as post-earthquake building surveys usually are not so much concerned with non-structural damage and performance of ornamental features and fixtures.
For the Portuguese case the information related to most vulnerable non-structural components was based on two earthquakes: one occurred in 1969 (affecting the mainland territory) and the other in 1998 (Azores). Although it is outside the Portuguese case study area, the information available from the 1998 Faial earthquake (Azores) was analysed and compiled in order to identify some of the most common situations of non-structural vulnerability in Portugal. In relation to the M7.2 1969 southwest of Iberia, there is a large inventory of data with damage to non-structural elements such as chimneys, parapets or decorative elements. We use this information to better understand the effects of a far large magnitude event earthquake.
On the basis of knowledge gained with this identification (with previous earthquakes) and with the identification of the most vulnerable elements in the pilot area of Alvalade, related with schools and housing stock, we are able to prepare the Task E, which involves:
- Engagement of students in discovering the most vulnerable non-structural components in their schools;
- Engagement of students in discovering the most vulnerable non-structural components in their homes;
- Engagement of citizens in the discovery of their own neighbourhood through the use of Risk Maps;
- Propose and create protective solutions and strategies to eliminate non-structural hazards;
- Development of a Practical Guide for lay people on non-structural risk reduction.

Figure 1 illustrates how structural elements in our schools or houses can be impacted.

Figure 1. Identification of some non-structural components in the interior of schools and in housing stock of Alvalade (Portuguese pilot area).

Shake table tests for seismic performance assessment of non-structural elements

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Non-structural components and building contents are responsible for a substantial amount of damages and losses caused by earthquakes, particularly for the low intensity ones. In these earthquake events, where structural damage is minimal in well seismically designed buildings, damage to the contents can be extensive, causing large disruption, and casualties can be considerable.
Data about the seismic performance of non-structural elements is scarce and difficult to obtain. The data collected comes typically from earthquake events [ATC, 2008; Ferner et al., 2014] or from shake table tests [Ventura and Kharrazi, 2004; Peña et al., 2007] combined with numerical simulations [Petrone et al., 2016].
Non-structural components and building contents are known to be sensitive to different phenomena related with either absolute acceleration or relative displacement [Murty et al., 2013], see Figure 1. These result from building seismic responses and, therefore, non-structural elements are affected by storey motions which are quite different from the ground motions.

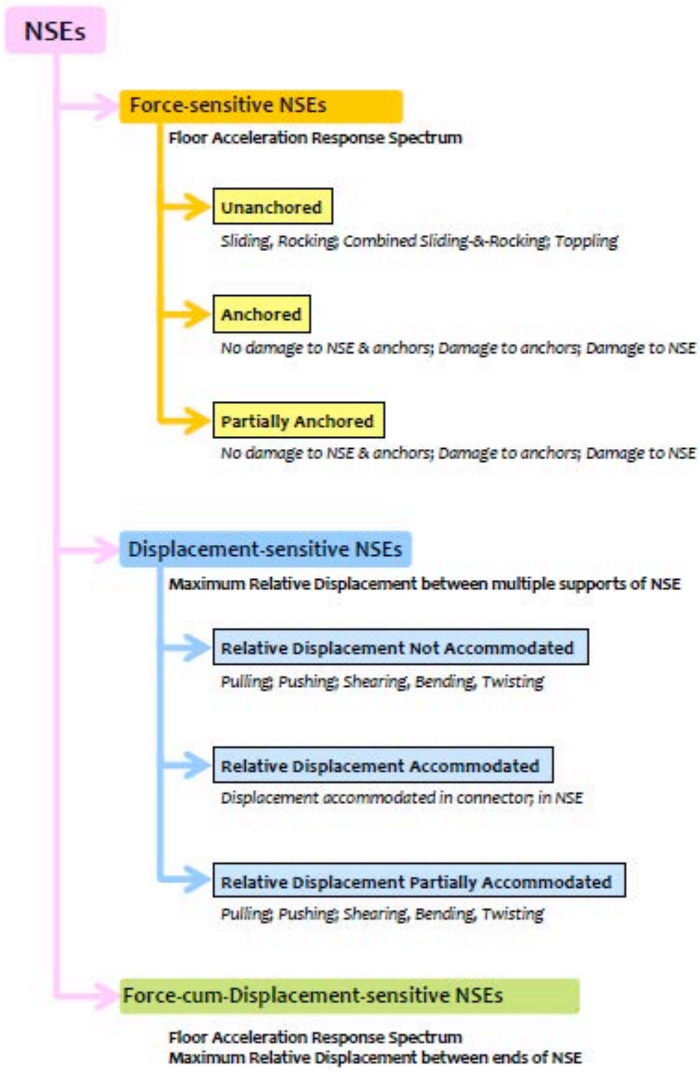

Figure 1. Behavioural and design aspects of Non-Structural Elements [Murty et al., 2013].

Practical recommendations exist to perform shake table tests taking this into consideration [FEMA, 2007] and even to tackle with the problem of non-structural components and building contents at various levels [FEMA, 2010; FEMA, 2011; Murty et al., 2013]. However, as already mentioned, data is scarce and there is room for development of new protective measures.

It is therefore important to carry out further research on the seismic performance of non-structural elements in order to minimise the losses, both human and economic. The KnowRISK project includes, in task C, the simulation of a room furnished on a shake table which will be used to obtain information about the performance of various simple protective measures to minimise the risks.

The motions to be imposed in the shake table test will simulate the effects at a storey level of typical buildings. This requires the existence of time history records, both on the ground and on the structure, in order to be able to establish the correspondence, on one hand, between the intensity of the storey motions and the intensity of the ground motions and, on the other hand, between the intensity of the ground motions and a design seismic response spectrum.

Several storey motions were selected from the Iceland earthquake database. The motions will be imposed with increasing levels of intensity in order to assess the performance to different earthquake levels of the simple protective measures that will be implemented.

Several pieces of furniture will be instrumented with accelerometers in order to measure their seismic response. The results that will be presented depend on the schedule of the shake table tests.

References

Ventura Carlos E., Mehdi H.K. Kharrazi, (2004). *Performance of OFC's in earthquakes by shake table tests.* Paper No. 80, 13th World Conference on Earthquake Engineering (13WCEE). Vancouver, B.C., Canada, August 1-6, 2004.

Peña F., Prieto F., Lourenço P.B., Campos Costa A., Lemos J.V., (2007). *On the dynamics of rocking motion of single rigid-block structures.* Earthquake Engineering and Structural Dynamics, 36:2383-2399, DOI: 10.1002/eqe.739, 2007.

FEMA (2007). *Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components*. FEMA 461, June 2007.

ATC (2008). *Reducing the Risks of Nonstructural Earthquake Damage*. State-of-the-Art and Practice Report. ATC-69, 2008.

FEMA (2010). *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds*. FEMA P-424, Risk Management Series, December 2010.

FEMA (2011). *Reducing the Risks of Nonstructural Earthquake Damage - A Practical Guide.* FEMA E-74, January 2011.

Murty C.V.R., Rupen Goswami, Vijayanarayanan A.R., Pradeep Kumar R., Mehta Vipul V., (2013). *Introduction to Earthquake Protection of Non-Structural Elements in Buildings.* Gujarat State Disaster Management Authority, Government of Gujarat, 2013.

Ferner H., Wemyss M., Baird A., Beer A., Hunter D., (2014). *Seismic performance of non-structural elements within buildings.* Paper 069, 2014 New Zealand Society for Earthquake Engineering (2014NZSEE) Conference, 2014.

Petrone C., Di Sarno L., Magliulo G., Cosenza E. (2016). *Numerical modelling and fragility assessment of typical freestanding building contents*. Bulletin of Earthquake Engineering, DOI 10.1007/s10518-016-0034-1, 2016.

Observed non-structural damage in recent South Iceland earthquakes

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Background

Seismic hazard in Iceland is moderate to high and since 2000 three destructive earthquakes of magnitude greater than six have occurred in the country. Two of these earthquakes struck in June 2000 in South Iceland, the first on June 17 at 15:41, (GMT) and the second one on June 21 at 00:52 (GMT). Both events were right-lateral strike-slip earthquakes with fault striking in the north-south direction. Approximated focal depth were 6.3km and 5.7km, respectively. They were of equal size, Mw=6.5. The highest recorded PGA was 0.64g at 5.7km distance from the fault in the first one and 0.84g at 3.1km distance from the fault in the second one. Then the third earthquake of Mw=6.3 also in South Iceland occurred on May 29, 2008, 15:45 (GMT). It was like the others a shallow right-lateral strike-slip earthquake, with fault striking in the north-south direction and the highest PGA as 0.88g. The faults were all located in a 35km wide East-West direction belt. They occurred in the middle of the South Iceland lowland which is the largest agricultural region in Iceland, with number of small villages, farms and modern infrastructure. Roughly five thousand residential buildings were affected by the two earthquakes in June 2000 and other five thousand in May 2008. Lot of buildings were damaged but none of the collapsed and no people was killed or badly injured.

In Iceland all buildings are registered in an official database which contains detailed information about them such as type of use, date of construction, number of storeys, main building material, and geographical location. In addition, it includes information about replacement value for insurance purposes. Most of the residential buildings in the area are low-rise (1-3 storeys) in-situ casted RC buildings and timber buildings. In addition, there are brick buildings made of hollow pumice blocks. Seismic codes were implemented in Iceland around 1980 so in earlier studies of the data is has been common to distinguish between buildings built before and after 1980, i.e. Pre1980 RC and Timber buildings and Post1980 RC and Timber buildings. On the other hand, almost all the pumice buildings were built before 1980 (>95%) so they are commonly treated as one class.

Natural catastrophe insurance of buildings is mandatory in Iceland and is administrated by the Iceland Catastrophe Insurance (ICI). Therefore, after catastrophic events like large earthquakes, the repair cost for every damaged building is estimated by trained assessors in order to settle the individual insurance claims. After the two earthquakes in 2000 the loss assessment work started after the second event, meaning that for buildings affected by both events (i.e. buildings located between the two faults) it was impossible to determine what damage was caused be the first event and what by the second event.

The loss data from the 2008 event has been used to evaluate vulnerability relationships and damage statistics [Bessason et al., 2012; Bessason et al., 2014]. Furthermore, the loss data from all the three earthquakes has been used to evaluate fragility curves [Bessason et al., 2016]. There is an ongoing study to extract more information and knowledge from the data.

Non-structural damage

The damage factor (DF), defined as the ratio of estimated total loss (structural and non-structural loss) to replacement value was low in all the three earthquakes even in the epicentral area [Bessason et al., 2016]. However, the scatter was quite wide including both undamaged buildings (DF=0) as well as total damaged buildings (DF=1). The Post1980 RC and timber behaved better than Pre1980 buildings and Pumice buildings were most vulnerable [Bessason et al., 2016].

The loss data from the 2000 earthquakes was classified in five subcategories, two classes for structural damage and three classes for non-structural damage (Table 1). The loss data from the 2008 earthquakes is more detailed and is split in 10 subclasses and each of them in 5-7 sub subclasses, in total 62 headings. It is however easy to aggregate the 2008 data in same subclasses as the 2000 data (Table 1). The loss data shows that at all intensity levels number of buildings was undamaged [Bessason et al., 2016]. Using the details of the data and only focusing on damaged buildings it was possible to construct empirical probability density functions which show how the loss was split between the five subcategories (Fig. 1). Buildings exposed to all ground motion intensities are assembled (PG>0.05g). For all the three earthquakes and all the five building typologies non-structural damage (sum of columns 3, 4 and 5) is higher than structural damage (sum of columns 1 and 2). For the 2008 earthquake it is in some cases up to 90% of the damage (Fig 1c). The results also show that damage in subcategory 4 is in all cases highest, i.e. damage of interior fixtures, paintwork, flooring, wall tiles, windows, doors, etc. (Fig. 1). More detailed analysis of the damage after the 2008 earthquake showed that damage of indoor paintwork and flooring dominated the overall damage [Bessason et al., 2014].

Table 1. Subcategories of damage used in the survey after the 2000 earthquakes.

Category	No.	Subcategory
Structural damage	1	Excavation, foundations and bottom slab
	2	Interior and exterior supporting structure (walls, columns, beams, roofs)
Non-structural damage	3	Interior finishing work (partition walls, mortar, suspended ceilings, cladding)
	4	Interior fixtures, paintwork, flooring, wall tiles, windows, doors, etc.
	5	Plumbing (cold water, hot water and sewer pipes),radiators, electrical installations

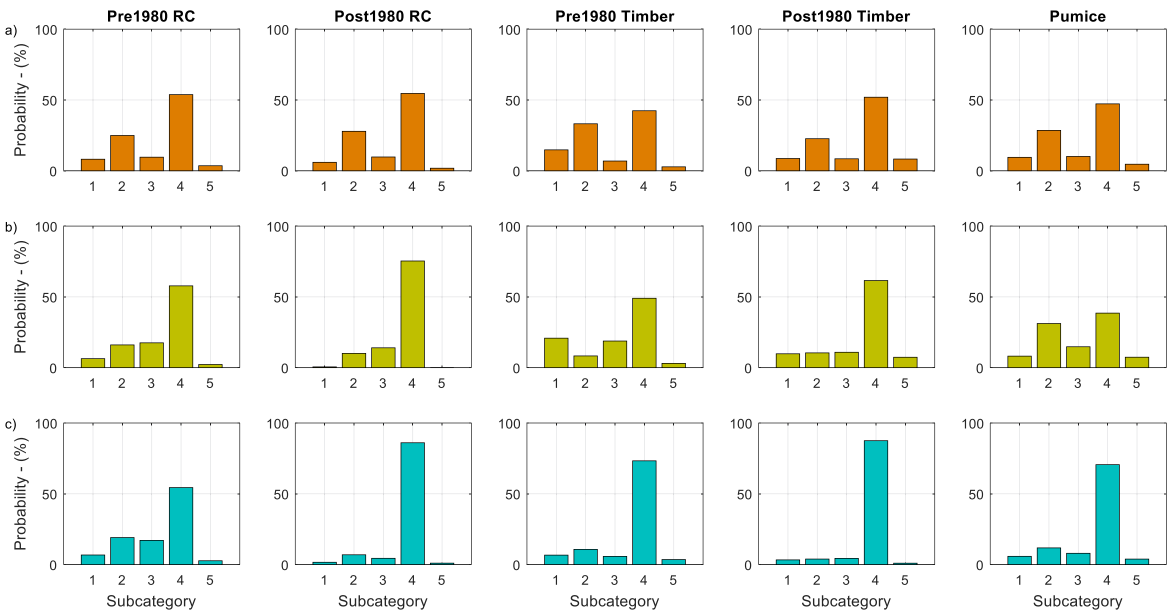

Figure 1. Classification of damage data in five subcategories for five building classes; a) 17 June 2000 Mw6.5 earthquake; b) 21 June 2000 Mw6.5 earthquake; (c) 29 May 2008 Mw6.3 earthquake.

References

Bessason B., J.Ö. Bjarnason, A. Guðmundsson, J. Sólnes & S. Steedman, (2012). *Probabilistic damage curves for low-rise buildings based on field data.* Earthquake Spectra, 28(4);1353-1378.

Bessason B., J.Ö. Bjarnason, A. Guðmundsson, J. Sólnes & S. Steedman, (2014). *Analysis of damage data of low-rise buildings subjected to a shallow Mw6.3 earthquake*. Soil Dynamics & Earthq. Eng, 66;89-101.

Bessason B. & J.Ö. Bjarnason, (2016). *Seismic vulnerability of low-rise residential buildings based on damage data from three earthquakes (Mw6.5, 6.5 and 6.3).* Engineering Structures, 111;64-79.

Seismic hazard scenario for South Iceland lowland

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Iceland is seismically very active, and has experienced many moderate to large earthquakes. Seismicity in Iceland is due to tectonic earthquakes originating near the rift between the Eurasian and the North-American plates, commonly known as the Mid-Atlantic ridge, as well as those due to volcanic activities. Tectonic earthquakes are less frequent and more damaging, while small volcanic earthquakes which cause no physical damage are frequently felt.

Estimation of seismic hazard in Iceland has been an active research field for a few decades. Early efforts were focused on producing iso-acceleration and iso-intensity maps based on observations from past earthquakes (see, e.g., Halldórsson [1992]). Probabilistic seismic hazard map corresponding to 0.2% annual probability of exceedance of horizontal peak ground acceleration (PGA) was prepared by Sigbjörnsson and Baldvinsson [1992]. After the south Iceland earthquakes of 2000, additional data required for calibration of empirical ground-motion prediction equations (GMPEs) in Iceland became available and more detailed studies on probabilistic seismic hazard assessment (PSHA) using instrumental ground-motion measures followed. Solnes et al. [2004] used a simulated parametric catalogue and a locally calibrated GMPE based on Brune's source spectrum to compute 475-year return period hazard map for horizontal PGA.

Modern seismic design codes place more emphasis on life safety performance level by avoiding collapse. Although performance based seismic design is gaining popularity in research, the current design code for seismic resistance in Europe, EC8, does not fully incorporate principles of performance based design directly. It, however, address some aspects of this philosophy by defining multiple performance requirements, which are:

1. No-collapse (or life safety) performance level;
2. Damage limitation performance level.

In addition, capacity design provisions are introduced in EC8 to prevent global collapse during very rare (maximum credible) earthquakes. In such cases, although immediate global collapse is prevented, damage beyond reparability is accepted. What is lacking in the modern design codes is a more systematic provision for control of damage caused by building contents. Although some regulations exist for heavy machinery and equipment, no clear guidelines for safety of common household appliances are provided. Although damage limitation performance level, assures, to a certain degree, limitation of financial loss due to frequent earthquakes, it does not properly address the issue of injuries or potential casualties caused by loose objects inside buildings. There is a general lack of research regarding what threshold intensity should be used to control damages to and due to building contents during frequent earthquakes. At the same time, it is inevitable that damage limitation and life safety performance levels will most likely result in significant movement of building contents, resulting in injuries and financial loss. The unanswered question then is what level of hazard is suitable for design of anchors and connections for securing building contents. The answer to this question is not straight-forward, but depends on local construction practice as well as socio-economic conditions of the area affected by earthquakes. There are two main considerations that need attention. As a first alternative, buildings contents can be secured to withstand hazard level corresponding to life safety performance level. This is justified also by the fact that building contents pose threat to life either by impact or by blocking escape routes. Since anchoring of contents is not heavily costly, a 475-year mean return period level hazard would be appropriate in this alternative. The other alternative is that building contents are secured to withstand 95-year mean return period hazard. The drawback with this alternative is that considerable financial and economic loss may be expected in areas where moderate to strong earthquakes occur frequently. It should, however, be distinguished between non-structural components that pose threat of injury or death, or those that are mainly associated with functional and financial loss. The latter categories may be designed for 95-year mean return period, except in critical facilities where immediate occupancy after an earthquake is crucial.

The discussion above highlights the challenge of selecting a suitable scenario for non-structural damage. It was also indicated that this selection partly depends on building practice. For example, wind load requirements in Iceland are so stringent that most of the buildings safely withstand very high level of ground acceleration during earthquake without much structural damage. The experience from the three recent

earthquakes, the two in June 2000 and one in May 2008 have shown that, even in areas which experienced ground shaking twice the level of prevalent seismic design requirements, structural damage was negligible compared to non-structural damage (see Bessason and Bjarnason, [2016]; Rupakhety et al., [2016]). However, significant non-structural damage was suffered. In addition, damaging earthquakes in SISZ happen in sequences and are often of similar size (Mw 6.3-6.5), although larger earthquakes can be expected in the eastern part of SISZ. In this context, for the SISZ area, a suitable scenario earthquake is the one that corresponds to life safety performance level.
The three recent earthquakes, namely the 17 June 2000 Mw 6.5 Earthquake, the 21 June 2000 Mw 6.4 Earthquake, and the 29 May 2008 Mw 6.3 Earthquake fall within the expected scenario obtained from hazard de-aggregation. Ground motion data from these earthquakes are well recorded in SISZ (see Sigbjörnsson et al, [2009]; Sigbjörnsson et al., [2007]). The two earthquakes of June 2000 are selected as the suitable scenario for this study area. Scenario hazard is estimated from the recorded data, and supplemented by using attenuation equations as well as finite fault simulations.

References

Sigbjörnsson R., Snæbjörnsson J.Th., Higgins S.M., Halldórsson B., Ólafsson S., (2009). *A note on the M6.3 earthquake in Iceland on 29 May 2008 at 15:45 UTC*. Bulletin of Earthquake Engineering 7(1):113–126.

Sigbjörnsson R., Olafsson S., Snæbjornsson J.Th. (2007). *Macroseismic effects related to strong ground motion: a study of the South Iceland earthquakes in June 2000*. Bulletin of Earthquake Engineering, 5(4):591-608.

Halldórsson P. (1992). *Seismic hazard assessment based on historical data and seismic measurements*. International conference on preparedness and mitigation for natural disaster, Iceland.

Sigbjörnsson R., Baldvinsson G.I., (1992). *Seismic hazard and recordings of strong ground motion in Iceland.* In: Proceedings of the 10th world conference on earthquake engineering, Rotterdam, The Netherlands, vol 1, p 419–424.

Bessason B., Bjarnasson J.Ö., (2016). *Seismic vulnerability of low-rise residential buildings based on damage data from three earthquakes (Mw 6.5, 6.5, 6.3).* Engineering Structures, 111:64-79.

Rupakhety R., Olafsson S., Sigbjörnsson R., (2016). *Damage to residential buildings in Hveragerði during the 2008 Ölfus Earthquake: simulated and surveyed results*. Bulletin of Earthquake Engineering, 14(7):1945-1955.

Seismic Scenarios Relevant for Non-Strucural Damage. First Results for Mt. Etna and Southern Iceland Pilot Areas

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The EU - project KnowRISK (Know your city, Reduce seISmic risK through non-structural elements) focuses on reduction of damage caused by non-structural elements failure during an earthquake. They involve failure or loss of functionality of non-load bearing elements of a building and its contents, that aside economic of issues, poses risk of severe, sometimes fatal injury to building occupants and other people in the surroundings. Disruption of lifelines, such as heating and ventilation system, water and sanitary systems, etc, are critical aspects as well.
Relevant to nonstructural damage is the definition of the seismic input, in terms free-field ground motion caused by small earthquakes and by larger events at large distance.
Here, we present the preliminary results for the pilot areas of Mt Etna and South Iceland (see Fig. 1), two areas for which a large amount of seismic recorded and macroseismic data is available, thus allowing a comparison of theoretical simulations to observed relevant seismic scenarios with both structural and nonstructural damage.

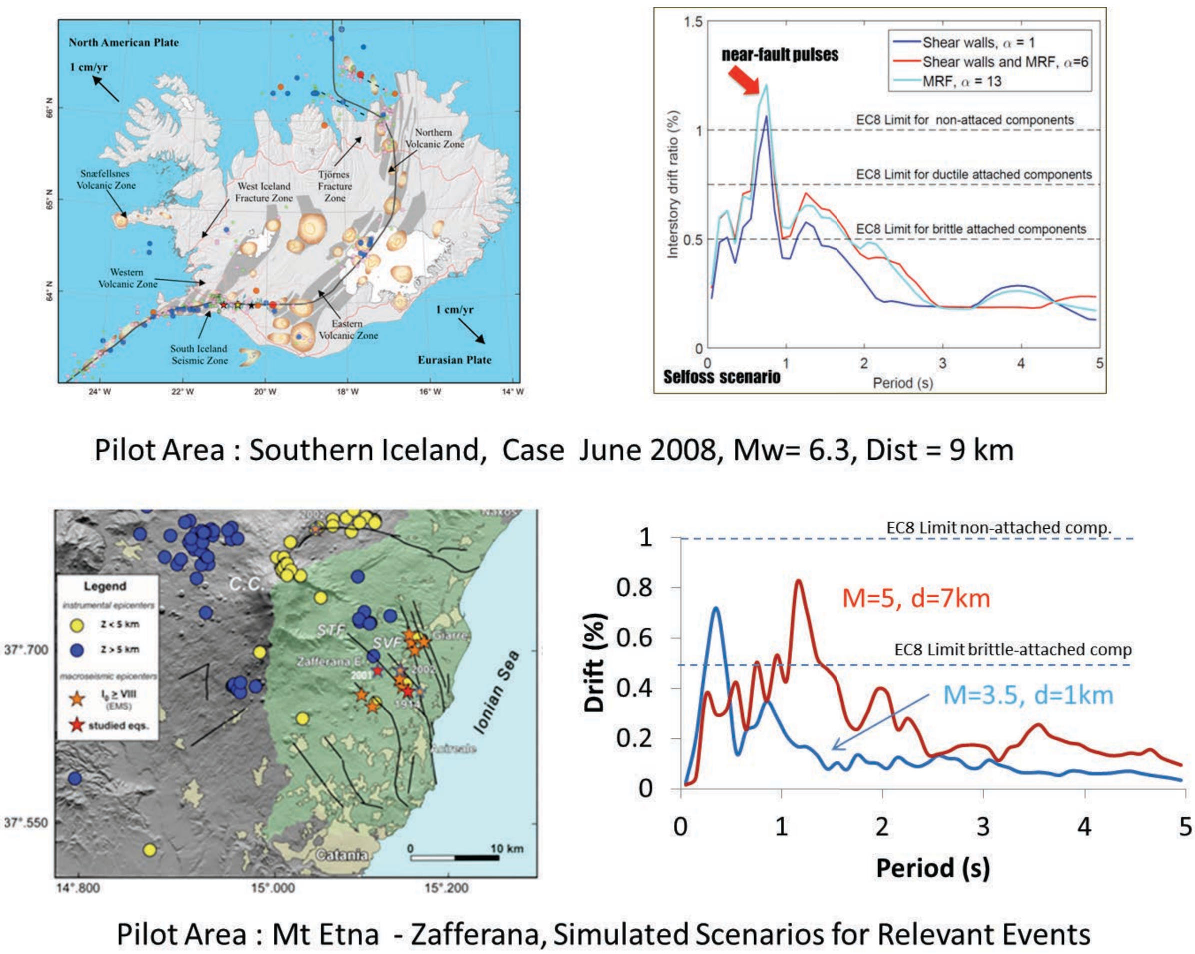

Figure 1. Drift spectra for earthquake scenarios in Southern Iceland and Mt Etna (Italy).

The two pilot areas have fairly different features. In the Etna-pilot area earthquakes causing frequently structural and nonstructural damage occur at shallow depth and have 3.5< M<5. In South Iceland, given the lower vulnerability, much higher magnitudes (Mw= 6.3) have been taken into account. We used seismic action coupled with building response to derive those scenarios that might trigger non-structural components damage. We have studied scenarios taking into account the magnitude and epicentral distance at which nonstructural failure may occur. We consider both instrumental records as well as synthetic simulations incorporating site effects and building response. Besides conventional response spectra we model the building response calculating the interstory drift spectrum [Miranda et al., 2006] that provides an estimate of maximum interstory drift in multistory buildings, and is based on a model that consists of a combination of a flexural beam and a shear beam.

References

Miranda E., Akkar S., (2006). *Generalized Interstory Drift Spectrum*. Journal of Struct. Eng., 840-852 DOI 10.1061/ASCE0733-94452006132:6840.

Identification of the most vulnerable non-structural components. The Italian case: Mt. Etna pilot area

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In Italy, recent earthquakes have shown that damage caused by nonstructural failures can be relevant. In the Mt. Etna pilot area we carried out a quantitative analysis on non-structural damage caused by recent earthquakes with associate moderate shaking. We used AeDES forms, a checklist to assess usability of damaged buildings in the post-earthquake, safety and short-term countermeasures. Based on a retrospective analysis of these forms we intend to extrapolate relationships between non-structural and structural-damage, typology and related vulnerability of building stock.

AeDES data for 23 municipalities of the Mt. Etna pilot area were prepared in digital form. They are representative for local building tradition and furnishing and privilege housing buildings.

One advantage of AeDES form permits to assess building damage and vulnerability in one single survey and gives a better estimate of seismic risk. Information includes building identification, position, structural typology, damage to structural and non-structural elements due to the latest event, as well as pre-existent damage. The analysis of these data allows infer relations between structural and non- structural damage of residential buildings.

The sections of AeDES form to collect damage data are two and consisting on:

- the structural damage information -in terms of level and extension- on five different structural elements making up the building, together with eventual pre-existent damage (section 4);
- ii) typical damage of non-structural components (section 5) which are divided in two groups: (1) possible falling and separation of different components (plasters, coatings, stuccos, false ceilings, infill panels, non-structural roof components, covering, eaves and parapets); (2) damage to building systems.

The structural damage class of a building is assigned according to the rules presented in Pinho (2015, modified from S.A., 2014), passing through a first setting of the synthetic damage for each of the five structural components, and finally assessing the global damage index of the structure with a weighting summation of the five synthetic damage, using different coefficients for masonry and reinforced concrete structures.

A number of 5136 AeDES forms from the Pilot area were processed, 3333 of which are masonry and 1803 are R.C. buildings. For both building typologies, the most common level of structural damage is D1, with a percentage of about 75%.

In every AeDES form, more than a single type of non-structural damage can be detected; so, a number of 7781 non-structural damage have been surveyed in the previous 5136 forms. In the attached figure, their percentage distribution shows that the most recurring damage concerns the falling of plaster, covering and false-ceiling.

Successively, a comparison among the distribution of non-structural damage, the distribution of structural damage and the vulnerability class of the buildings will be carry on trying to find useful correlations.

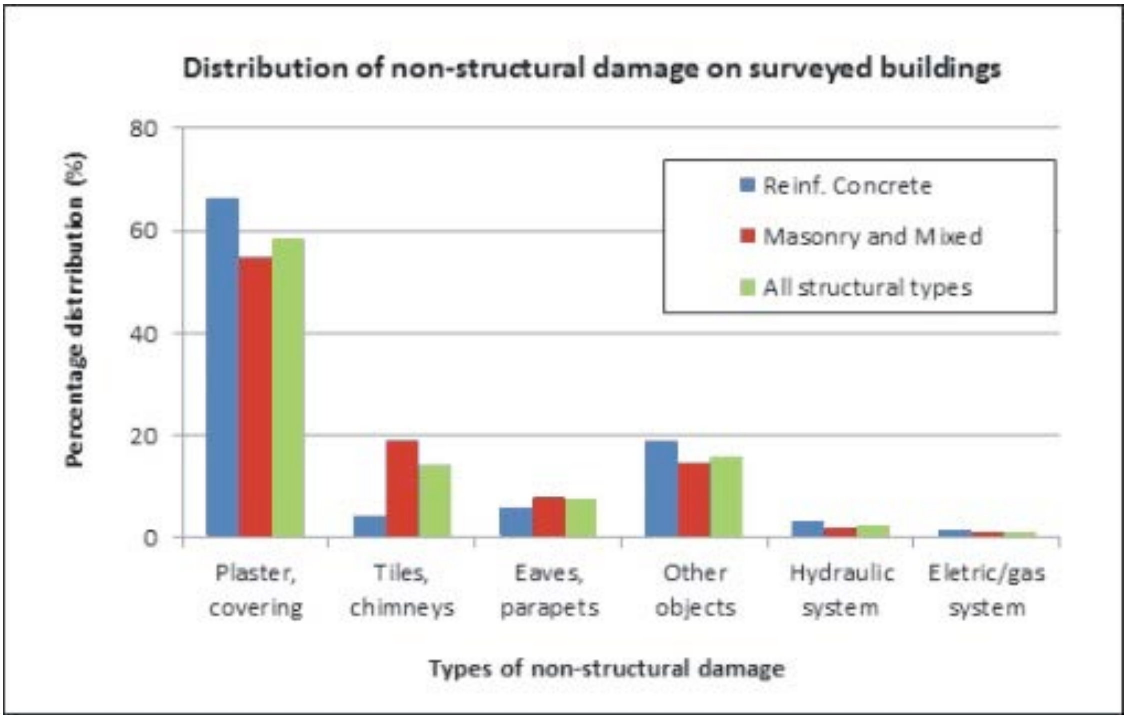

Figure 1. The percentage distribution of collected data for each type of non-structural damage.

Seismic scenario for non-strucural damage studies on Mt. Etna's Eastern flank

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Earthquakes are by far the most important source of hazard for the densely urbanized areas of Mt. Etna. Despite its low energy (ML< 5.2), volcano-tectonic seismicity is capable of producing severe damage and even destruction, due to the shallow nature of hypocenters.
Studies aimed at assessing seismic hazard at Mt. Etna have been undertaken in the last years by means of a probabilistic approach based on the use of macroseismic data – "site approach" whose computational procedure was implemented in the SASHA code.
In the framework of the KnowRISK project, aimed to reduce seismic risk through non-structural elements, a seismic scenario for moderate earthquake was prepared.
Seismic hazard maps calculated for an exposure time of 30 years (Figure 1a) show that settlements located in the eastern flank of Mt. Etna have high probability (<80%) of undergoing shaking capable of producing slight non-structural damage (at least VI EMS), while the probability of large non-structural damage (at least VII EMS) is greater than 50%. For shorter exposure time (10 years), the probability decreases to about 50% and 10% for VII and VI EMS, respectively.
The high seismic hazard of the volcano's eastern flank is hence confirmed not only for destructive events but also for moderate energy earthquakes. Among the villages of the eastern flank of the volcano, Zafferana Etnea has a probability greater than 50% to be shaken with an intensity at least of VII EMS in 30 years. This result is in agreement with the maximum observed intensity (IMAX = VII EMS) for this locality, as reported in the Macroseismic Catalogue of Mt. Etna Earthquakes (CMTE, http://www.ct.ingv.it/macro).
A disaggregation analysis was performed to determine the most representative earthquakes that contribute to the hazard for this village. Since the events are characterized in terms of magnitude and epicentral location, it is possible to identify the most significant magnitude/distance bins, namely the "design earthquake". The results show that hazard related to VII EMS for Zafferana Etnea is mainly due to small earthquakes (Magnitude 4.0-4.3) very close to the site (up to 6 kilometres away). Conversely, stronger earthquakes of the lower eastern flank contribute less to the hazard assessment.
The seismic scenario, in terms of expected intensity EMS, was calculated using the parameters of the 1984 Zafferana Etnea earthquake, according to the results of the disaggregation analysis. The moment magnitude MW used for the scenario is 4.2, which is equivalent to an epicentral intensity I0 = VII EMS.
To calculate the scenario, the intensity at site IS, and correspondingly, the decay I = I0 - IS, are considered as binomial distributed random variables of a Bayesian model. The mode of the smoothed binomial distribution is taken as an estimate of the intensity at site IS. A detailed description of the method used is reported in Rotondi et al. [2016].
Figure 1b shows the macroseismic intensities observed at sites for the 1984, October 19th earthquake (left), compared with the intensities calculated for the synthetic scenario (right). The scenario represents the observed data well, especially for higher EMS values. Major variability concerns the extension of IV degree, which can be explained taking into account that in a macroseismic survey the elements to assess lower degrees are more subjective. Moreover, it should be noted that IV EMS does not imply the presence of damage.

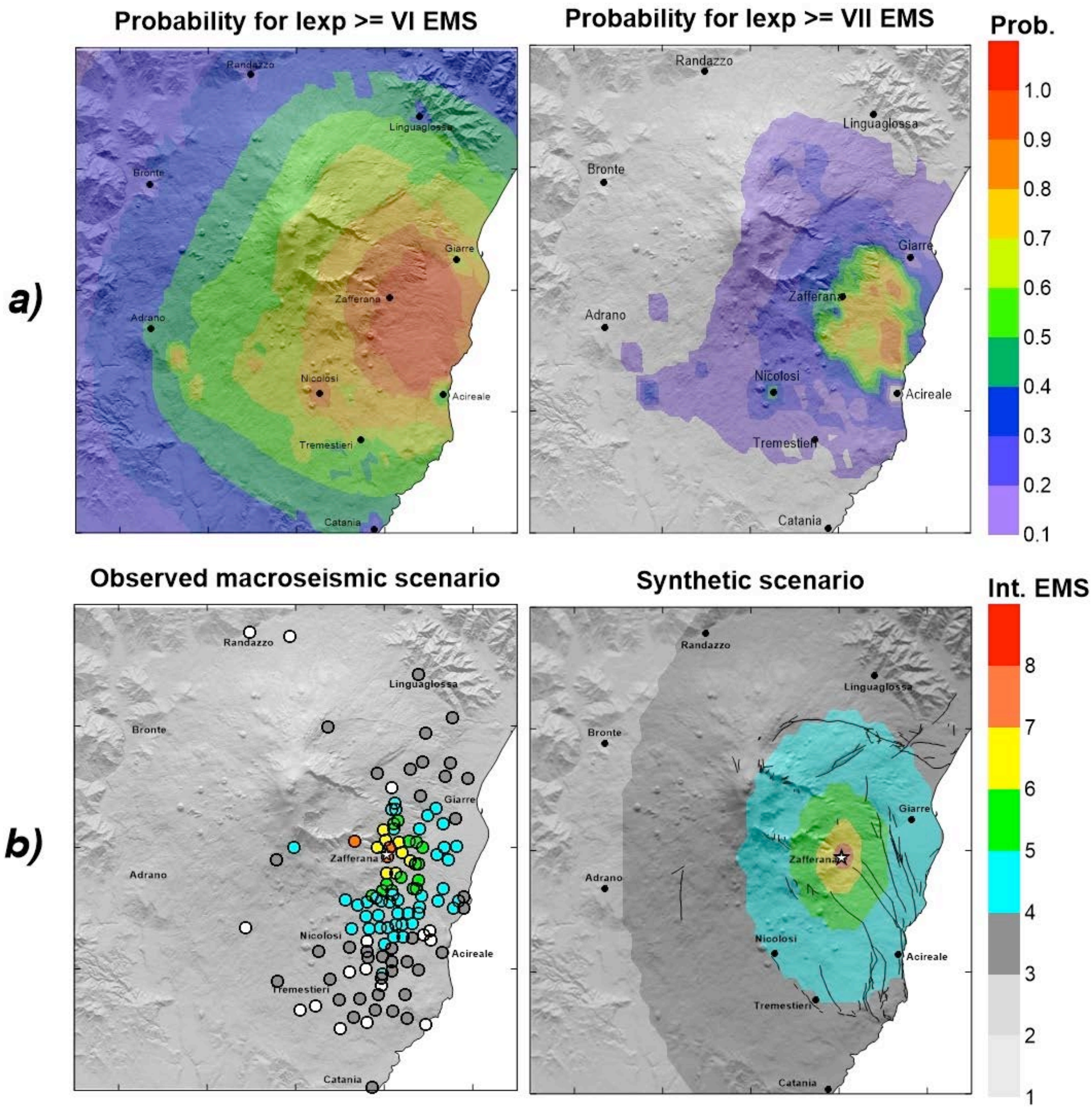

Figure 1. a) Maps of the occurrence probability for expected intensity Iexp VI and VII, calculated for the exposure times of 30 years. b) Maps of the intensities distribution for the 1984, October 19th earthquake; left: observed data; right: synthetic data calculated for the scenario. Faults in figure b) right from Azzaro et al., [2012]).

References

Azzaro R., Branca S., Gwinner K., Coltelli M., (2012). *The volcano-tectonic map of Etna volcano, 1:100.000 scale: morphotectonic analysis from high-resolution DEM integrated with geologic, active faulting and seismotectonic data.* Italian Journal of Geoscience (Boll. Soc. Geol. It.), Vol. 13, N. 1, p.p. 153-170, doi:10.3301/IJG.2011.29.

Rotondi R., Varini E., Brambilla C., (2016). *Probabilistic modelling of macroseismic attenuation and forecast of damage scenarios.* Bulletin of Earthquake Engineering, Vol. 14, N. 7, p.p. 1777-1796, doi:10.1007/s10518-015-9781-7.

Mapping the risk in the Mt. Etna pilot area

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The Italian case study comprises the Mt. Etna area, which was studied in the previous UPStrat-MAFA project (No. 23031/2011/613486/SUB/A5). The lower eastern flank of the volcano has been considered, because of the high degree of risk arising by the dense urbanisation of 28 municipalities in this area, with a total population of about 400,000 inhabitants and the presence of relevant infrastructure and lifelines. The information on vulnerability is an element that together with shaking ground-motion parameters, has been used for the identification of risk. The study of the seismic vulnerability of an urban region follows two main steps:
(i) the exposure geo-referenced inventory and the vulnerability classification of assets at risk;
(ii) the vulnerability characterisation according to damage models.

The Italian National Institute of Statistics (ISTAT) census data on residential buildings, disaggregated by census sections, has been used as a survey of the exposed elements at seismic risk, as already prepared during the past UPStrat-MAFA project. The census which has been taken into consideration is that one of 1991, being the data of 2001 and 2011 unusable. Strict legal rules on confidentiality of information, in force of 1996, impose data providing in the aggregate form only, with no chance to intersect multiple independent variables at least at municipality level. This limitation does not allow an information crossing on the typological characteristics, critical in the procedure for seismic vulnerability evaluation. During these first months of the KnowRisk project the 1991 census data have been updated, by upgrading all the necessary information for vulnerability assessments and comparing the same census variables in the following surveys. In this way it was possible to extrapolate the same categories of information reported by the 1991 census, but updated at the most recent survey (2011). The last step of this analysis was the classification of residential buildings in 6 vulnerability classes of the EMS98 scale (A to F). Finally, by means of the macroseismic damage model proposed by Lagomarsino and Giovinazzi [2006], a classification of the building stock, given their vulnerability, was made. According to the physical structures exposed to the earthquake impact can be organized in different estimated levels of damage severity classified in 5 growing levels. The results point out on the grade D2 (moderate damage) and the grade D3 (substantial to heavy damage) of the EMS-98 scale where non-structural damages are concentrated.
As an example of the expected results is shown the geographical distribution of the mean vulnerability index for residential buildings evaluated in each census section (Figure 1), obtained from the 1991 ISTAT data (a, left map) and from its update at the census of the year 2011 (b, right map).

References

Lagomarsino S. & Giovinazzi S., (2006). *Macroseismic and mechanical models for the vulnerability and damage assessment of current buildings.* Bull Earthquake Eng 4: 415. doi:10.1007/s10518-006-9024-z.

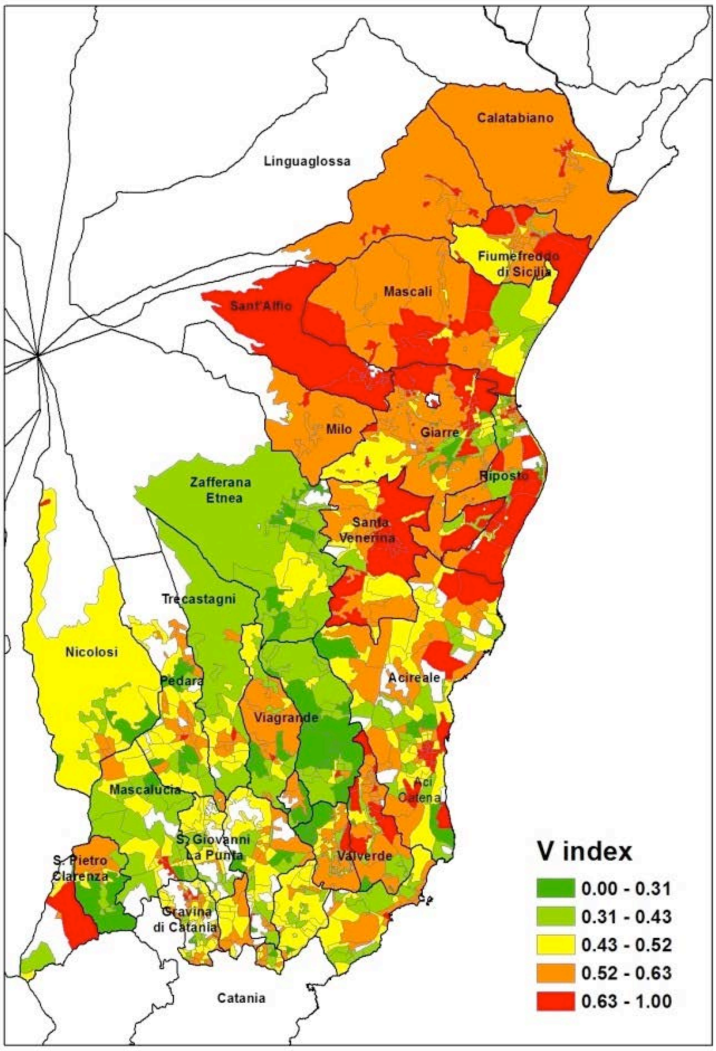

Figure 1. The mean vulnerability index calculated for each census sections of the municipality in the zone of analysis (Mt. Etna area) updated at the year 1991 (a) and the year 2011 (b).

Stakeholder-Specific, Non-Structural Damage Classification Systems for Disaster Risk Reduction Planning

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The purpose of task C1 is to develop a set of disaster-risk reduction procedures for non-structural components (NSC) that are specifically designed for the needs of different building-related stakeholders. The stakeholders in question are: Building owners, occupants, facility managers, local building and safety staff members, and post-earthquake damage inspectors. These stakeholders have different daily objectives and therefore different interests in the various NSC, and furthermore, have different control over them. For example, facility managers have control over the mechanical systems, but might not have control over building content, which the user will control. A post-earthquake inspector has control over neither, but needs to be able to assess damages to NSC. Therefore DRR guidelines are more affective if they are written with specific stakeholders in mind. The effectiveness of DRR procedures can also be improved by developing procedures for specific facilities.

This presentation presents a new method for developing such stakeholder specific DRR procedure. The method is in seven steps. The presentation will explain each step and the methodology behind them. The study places a specific focus on housing, hospital and school facilities.

A short description of the each step is a follows:

1. A literature survey of existing classification systems for NSC damages.
2. A general stakeholder analysis will be performed to obtain a general idea of the normal day-today objectives of each stakeholder, their legal responsibility towards NSC, and financial aspects, in order to gauge their ability and responsibility to perform DRR activities.
3. Step 1 and 2 are used in step 3 to develop basic stakeholder-specific classification systems for each stakeholder type, and to identify gaps in existing systems. Step 3 is currently a filing system (a place-holder) to depict the information needed for the data collection.
4. Research on NSC damages from other countries (in particular New Zealand, Japan, USA, and Europe) is used to fill in gaps and expand the systems developed in step 3. The research focuses on gaining an understanding of the following
    - NSC damages type and characteristics.
    - The source of NCS damages.
    - How the damages affect the functionality of the buildings that they are in.
    - How changes in building functionality affects occupants and their ability to function.
    - Are new demands placed on stakeholders in how they act or function?
5. The fifth step presents the improved stakeholder specific classifications systems. This section will be developed based on the results of steps 3 and 4.
6. The DRR methodology used in this study is based on disaster-function management (Thorvaldsdóttir 2016), which provides an overall goal for disaster-related activities, specific disaster-related objectives, and offers a list of basis activities associated with each objective. The three disaster-related objectives that need to be addressed prior to a disaster are to understand risk, to measurably reducing known risk, and to prepare for residual risk.
7. The final step is to outline DRR procedures for each stakeholder and facilities in this study. The DRR procedures are intended to reach three objectives, to understand risk, to measurable reduce risk and to prepare for residual risk.

The presentation will conclude with outlining what has been completed so far towards task C1 and the remaining tasks to finish the task.

The results of the study of the current literature set will result in identifying any gaps needed to complete the development of the systems. Identified gaps will lead to a secondary literature survey. If such a survey does not help to fill gaps, then a discussion on research agendas to be able to complete the stakeholder-specific NSC classification system and DRR procedures will be provided.

Strategies of risk-communication in the KnowRISK project: the Italian case

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Expert knowledge on seismic protection needs to penetrate into communities' routines in order to become valuable in terms of disaster risk reduction. The strategy implemented by Task E belongs to the Action For Prevention part of the KnowRISK project and stands on the understanding of local communities fragility and on their direct engagement. In each country participating to the KnowRISK project Pilot Areas were chosen and studied trying to stick to a holistic approach to vulnerability. The level of relevance of seismic compared to other hazards, the understanding, the memory are all indicators that can affect the way a risk is perceived and preventive measures are taken. The level of education, wealth, exposure to other, social, risks need to be taken into account as aggravation parameters in risk computation and in strategies for communication. All these indicators (Fig. 1) were addressed to draw a general picture of the pilot areas and the target societal groups, which were chosen to be students and citizen living in historical downtowns. Risk perception assessment relied on a quantitative approach and was pursued with a questionnaire (Action D.3).
In general terms the case of Italy is that of a country with recurrent earthquakes and yet low level of prevention. Two pilot-areas -Mt Etna volcano region and Northern Italy- restrict the portion of territory where research and strategies for prevention are implemented. They were selected based on two criteria:

i) areas affected by the most common non-structural vulnerability, on the basis of information gathered under Action C.2;
ii) ii) areas where it was possible to have a high range of target public.

In Mt Etna pilot area we have considered the lower eastern flank of the Volcano where recent earthquakes with associate moderate shaking had caused non-structural damage that is studied under Action C.2. The Northern Italy Pilot area was chosen to implement communication in regions where PGA was expected to be lower than 0.15g (G.U. n.108 del 11/05/2006), being these seismic zones where strong earthquakes might rarely occur or where earthquakes are rare at all. Risk communication main sites are the cities La Spezia, Laveno Mombello, a small town in the Varese province, and Ferrara. Societal groups we address are schools and citizen living in historical downtowns.
The most relevant achievements we gained in Task E refer to:
(1) risk communication in schools;
(2) citizen's science activities;
(3) tools for dissemination and learning;
(4) engagement of citizen's in risk prevention.

In Italy we could profit from an already established a network of schools to which INGV devoted science outreach activities in the past. We implemented and tested risk communication strategy in schools (Action E.3) to be shared and used in the other participating countries, Portugal and Iceland, after being reshaped and adapted to local needs. We prepared a brochure for students with the intent to provide a tool that results into an immersive learning stratagem. High school students were engaged in citizen's science activities to map non-structural elements in schools and in their environments. The activities are collected and presented in a video that highlights the power of education in raising awareness.
Tools to promote efficient dissemination of information were the targets of Action E.4. Here Augmented Reality techniques were used to build talking posters that were presented to the public during science outreach events.
In the Ferrara site we could profit from a peculiar experience of citizens' engagement in seismic prevention after the 2012 Emilia sequence that could be renewed thanks to the KnowRISK project. Here we will also involve key-stakeholders in implementing a shared strategy to reduce risk caused by failure of non-structural elements, and test the KnowRISK Practical Guide.

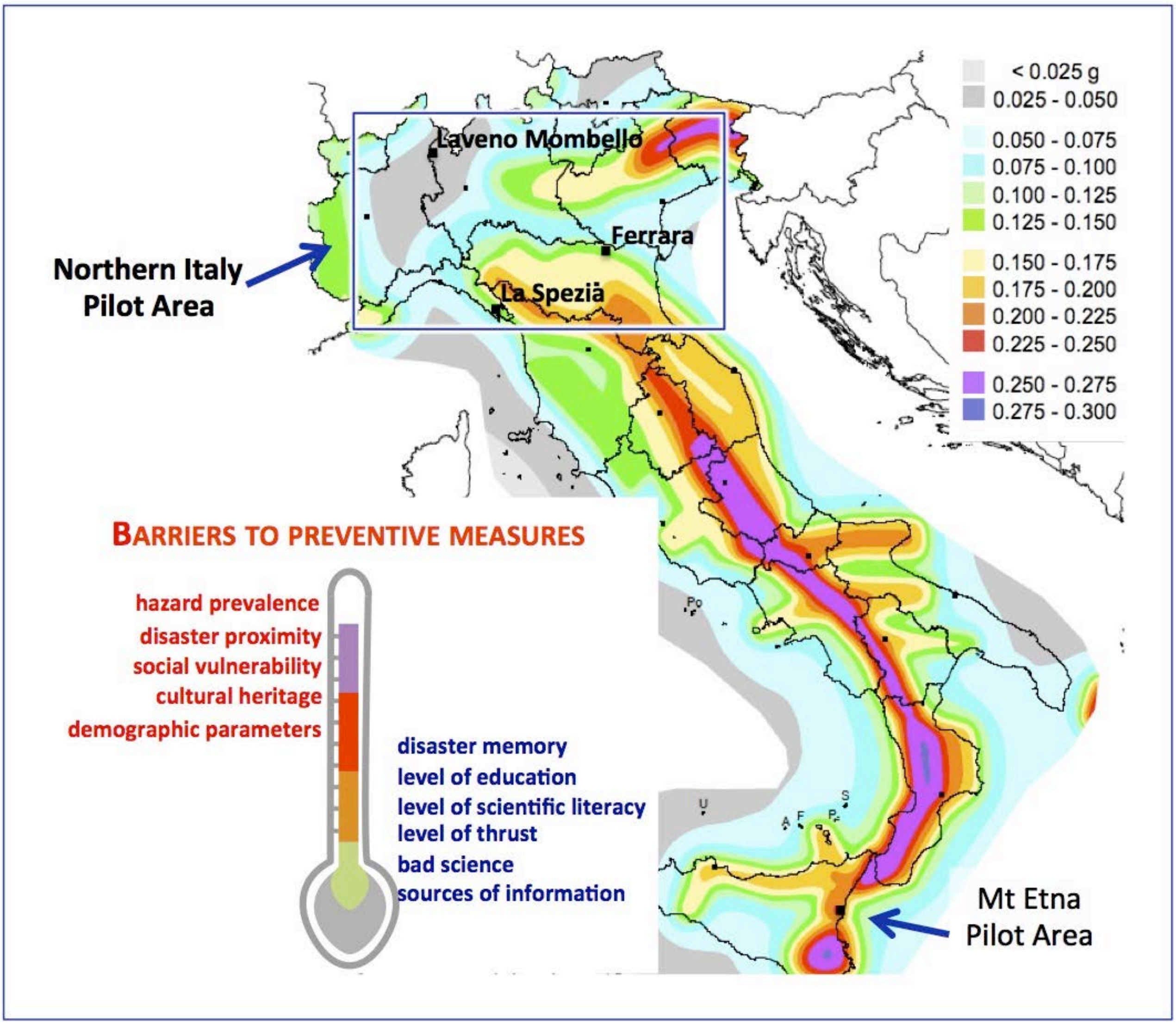

Figure 1. A schematic sketch of indicators to be taken into account to complement physical risk with social vulnerabilities and define a communication strategy. Pilot area are plotted on the seismic hazard map color coded PGA for excedance probability of 10% in 50 years

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Towards a practical guide in nonstructural risk reduction: A tool for the KnowRISK countries

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Nonstructural buildings damages are often considered second order priority issues when modelling an earthquake scenario. While this is reasonable in major earthquakes, where structural damages mask nonstructural failures, it is not such when dealing with moderate earthquakes where, often, the nonstructural damages exceeds losses from structural damages. Nonstructural damages may in fact cause a reduction in the performance of the affected building, which becomes critical in facilities of social relevance like hospitals, schools or fire stations. Moreover, the failure of nonstructural building components can become a safety hazard or can hamper the safe movement of occupants evacuating or of rescue workers entering buildings [Filiatrault, 2016].

Thus, it is critical to raise in the citizens the awareness of potential nonstructural risks, the costly consequences of nonstructural failures, and the opportunities that exist to limit future losses.

The definition of nonstructural components include all of those components that are not part of the structural system; that is, all of the architectural, mechanical, electrical, and plumbing systems, as well as furniture, fixtures, equipment, and contents. Windows, partitions, granite veneer, piping, ceilings, air conditioning ducts and equipment, elevators, computer and hospital equipment, file cabinets, and retail merchandise are all examples of nonstructural components that are vulnerable to earthquake damage [FEMA E-74, 2012]. Most of these components can be easily secured with little money investment and a limited intervention of professionals.

However, in comparison to structural elements and systems, there is relatively limited information on the seismic design of non-structural elements and it is sometime difficult for the public to understand what are the sources of nonstructural earthquake damage and, as a consequence, to act to reduce the potential risks in simple terms.

The action E1 of the KnowRisk project aims at compiling a guide on how to reduce risks from non-structural components failure to be both handed as a printed version and made available on the internet.

The guide shares a few characteristics with those already available for other countries, like the (low) level of expertise of the readers and the facility of the suggested actions to fix potential hazards. Nevertheless it differs in that it is specifically designed on the results of others actions within the project (namely C1: review of non structural damage from past earthquake. C2: Identification of the most vulnerable non-structural components in the pilot study areas. C4: Portfolio: procedures for minimizing the risk of non-structural damages), it takes into account some peculiarities of the participating countries as derived from the inventories provided by task D (Approaching target communities) and, dealing with in-door vulnerability, it aims at mainly inform homeowners. In fact other actions of task E (Tools and strategies of risk communication and learning) take care of the community level (E2, E4, E5) and the schools (E3, E5).

The guide is designed as a handy, multilingual leaflet; great care is devoted to the impact of communication. Too often the messages from the scientific institutions are disregarded because the language is too technical or the communication style is not enough attractive and appealing. In order to improve the impact and the readability of the guide it will be made extensively use of graphics and cartoons. Pictograms proved to engage and be easily understood even by people that does not heed or particularly care about an issue.

The content of the guide is under definition because it finally depends on the availability of the results of the tasks above mentioned, but the skeleton is already defined. In fact the guide must be compiled and distributed soon in order to possibly check its efficacy in the E5 (Ex post survey on risk communication) action.

Each page of the leaflet deals with a different room of the house, the garden and the space outside the house. For each of these environments the weak points of the furniture, equipment or contents will be marked together with a possible solution to avoid damages.

It must be remarked that the safety suggestions must have a different power of education, and therefore of conviction, depending on both the seismic hazard of the area where they are applied and the time spent in

any environment. As an example, the bed room is probably the place where people spend most of their time and it is especially the one where they are more helpless. Actions for risk reduction must be carried out considering that none, or very few, protective actions can be done during the night or in the dark. Moreover, these are the rooms where often students spend most of their time studying or playing.
In bed rooms, potential hazards come by the presence of bookcase units used to divide a space or to create an additional room, shelves above the beds, glass lamps on the night tables, computers or TV on the desk, to cite only a few. These appliances may be easily fixed using Velcro strips, in case of a laptop or a lamp, and damages may be avoided by moving the tower case of a PC on the floor and fixing the monitor. Glass lamps can be substituted with plastic lamps. Bookshelves can be anchored to the wall, and to create a divider a curtain can be used instead of a bookshelf. Generally speaking, drawers are safer than shelves in that, if the dresser falls, the drawer may avoid the content to get out. However the best safety is reached when the dresser is anchored and the drawers are locked (with a key, for example) or using clamps. Of course showing these weak points may be of help also to people that are furnishing rooms by avoiding, if possible, potential failures when designing their space.

References

FEMA E-74 / December 2012. *Reducing the Risks of Nonstructural Earthquake Damage - A Practical Guide*
Filiatrault A., (2016). *Seismic design and analysis of nonstructural components*. http://www.sponse.eu/wp-content/uploads/2016/02/SDNBC-Spring-2016.pdf

Two concepts for Risk communication and Learning

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We have realized two participatory risk communication tools to support dissemination activities of the Task E of the KnowRISK project (Know your city, Reduce seISmic risK through non-structural elements), financed by the European Commission (AGREEMENT NUMBER - ECHO/SUB/2015/718655/PREV28): a brochure for schools inside the Action "Know your school: be safe!" and a promotional video about public engagement initiatives.

BROCHURE: first the imagery!
To communicate risk is never a simple task. Its perception is subjective and the potential damages are often underestimated, as well as the importance of prevention in peacetime. The non-structural seismic risk might seem less significant if compared to the earthquake's violence and the severity of structural damages. Difficulties increase when the communication is addressed to an audience of teenagers (target 12 to 17 years). We have to show them the real implications of the project topic avoiding unnecessary alarm. At the same time, in order to capture and keep their attention, we have to use simple, light and ironic language, paying attention to avoiding banalities. We had also to respect the design restraints. To reach a wider audience, the brochure has also to be available on website and in an easily printable version for everybody.

"I hear and I forget. I see and I remember. I do and I understand"
According to Confucius' aphorism, we have decided to create something more than just a piece of paper. We wanted a gadget, an "interactive" manipulable product, which can be more looked at and discovered than read. We have focused on a surprise effect with a simple but addictive idea. With a 3d use of the paper in mind, we have used a narrative approach close to teens' reality, which "speaks" by himself and stimulates deep reflections. Our training as Architect and Environmental Engineer and the experience of Emilia's Earthquake in 2012 enable us to pay much more attention to, and have a larger vision of the messages to be conveyed. We also wanted to focus attention on risk factors and on the time issue, showing the period before and after a seismic event, even of minor entity. The front-back change of scale is crucial to the development of story-telling and allows to direct the issue of prevention starting from many points of view. Teachers will be able to continue the discussion in the classroom thanks to other various cues (plant safety, statics of buildings, prevention of domestic accidents). At the same time the abundance of details keeps the students' attention so that the message does not end at first glance. The surprise effect is multilevel, to be more careful we have also entered some game/quiz elements: the rebus on the Italian word terremoto (earthquake) literally terre (lands) + moto (motorbike) and a reference in Pictionary style to a known film of the 80s (living-room, above the armchair). Hence the idea of a pop-up DIY and the homely A4 paper size. To print only the black and white outlines and ask students to paint the individual elements gives the opportunity to maximize the attention and find out every detail. On the KnowRISK website we have added the example 3d (image below) as a further supportive element and explanation. The first results obtained in the classes show the success and effectiveness of the graphic as an instant translation tool, also of difficult concepts. The story-telling is the key element to accompany the reflection, increase involvement and encourage personal reworking of contents.

VIDEO: the just swing of communication
The expressive power of the image is further accentuated in the video product that, in order to the promotional intent, was to be particularly dynamic and immediate, both in content and stylistic choices. Studying the project's guidelines, we have individuated the slogan "Research for Action and Action for Prevention", continuing with the same narrative approach. The main aspects to tell were: on a side the dissemination activities, according to different models, on the other side the participation, the enthusiasm and the ideas of the students. So the story has been divided in three chapters: the dissemination activities in the dedicated events and in the individual classes, the time for discussion among adults with the PlayDecide format and, in last but not least, the students' reworks with graphics, texts, videos and handmade 3D models.

The final product is thus at the same time descriptive and promotional and it shows the importance of prevention and information, for all.
Both original-made products are susceptible of implementation and future development, at different levels of complexity, for various audiences and platforms.

Figure 1. Brochure 3D Model

Risk communication impact assessment procedure

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Action D3 aims at assessing the impacts of KnowRISK risk communication strategy in the pilot-areas. This procedure stands on a questionnaire to be applied to a sample of target groups (minimum of 50 individuals) before the start of the participatory process preview (ex ante survey, T0), previewed under Task E, and after its conclusion (ex post survey, T1).

In the first months of the project, we designed a questionnaire to assess the starting point (T0) of students and public in general before of the project actions. Knowledge at T0 is fundamental for the impact of the project and may give important information to improve project actions.

The KnowRISK questionnaire (KR-Q) is built on four areas: Who are you? (WHO); Do you feel safe? (PER); What do you risk? (RIS) What would you do? (DO).

The KR-Q has been tested on a sample of about 165 students ranging between the ages of 13 and 16. First results showed that the questionnaire uses simple terms and is easy to be filled in. However compilation time seemed to be considered too long by interviewees. We therefore shortened the KR-Q and divided in four sessions to facilitate the compilation. The questionnaire is now available at the web site https://sites.google.com/a/ingv.it/knowrisk/.

Here we describe the four sessions

Who are you? (WHO).

Municipality were the respondent is resident. Age, Gender, Place of Birth, Nationality, Level of Education, Work Activity, Civil Status, Family Unit Composition, Information on the building where the respondent lives.

Do you feel safe? (PER)

Indicators considered in this session regard mainly what interviewee's may image about an earthquake and its effects. The main indicators pertaining to the risk have been tested in previous research [Crescimbene et al. 2013, 2014, 2015]. It is therefore possible derive the risk perceived by using the indicators of Hazard, Exposure and Vulnerability.

For example, to evaluate Hazard perception we use the following ten scales: unexpected-expected; weak-strong; little-big; distant-near (in space); predictable-unpredictable; short-long; moderate-aggressive; slow-fast; innocuous-dangerous; faraway-close (in time). While the others indicators are composed respectively of: Vulnerability (House and School) 6 scales; What will happen into house/school 10 scales; Social preparedness 7 scales; Exposure 7 scales and Phenomenon description 15 scales.

What do you risk? (RIS)

Indicators considered in this session concern knowledge of key concepts on risk. These concepts are fundamental for the success of the KnowRisk project and at the end of the project actions should be known. We ask respondents to rate their level of information about earthquakes and to indicate the sources of this information. We ask also if they participated at risk reduction initiatives, and if so, the level of involvement.

This session includes a comparison between the probabilities of occurrence of an earthquake respect to other natural hazards. In addition to test the level on knowledge we propose a comparison between the magnitude and intensity of an earthquake defined as mild or strong. We ask to respondents where in case of an earthquake, they would feel safer; what are the key concepts to define risk and if they are able to recognize the structural elements/non-structural of buildings. Closes the session a question of what damage they expect due to non-structural elements.

What would you do? (DO)

The session "what would you do?" regards the preventive measures that respondents are willing to take.

In addition they are asked to indicate the possible difficulties in taking and what they think are the basic steps to protect themselves and what might persuade to adopt them.

The questionnaire provides both qualitative and quantitative results that can be compared before and after the project activities, and between different groups (see e.g. Fig. 1).

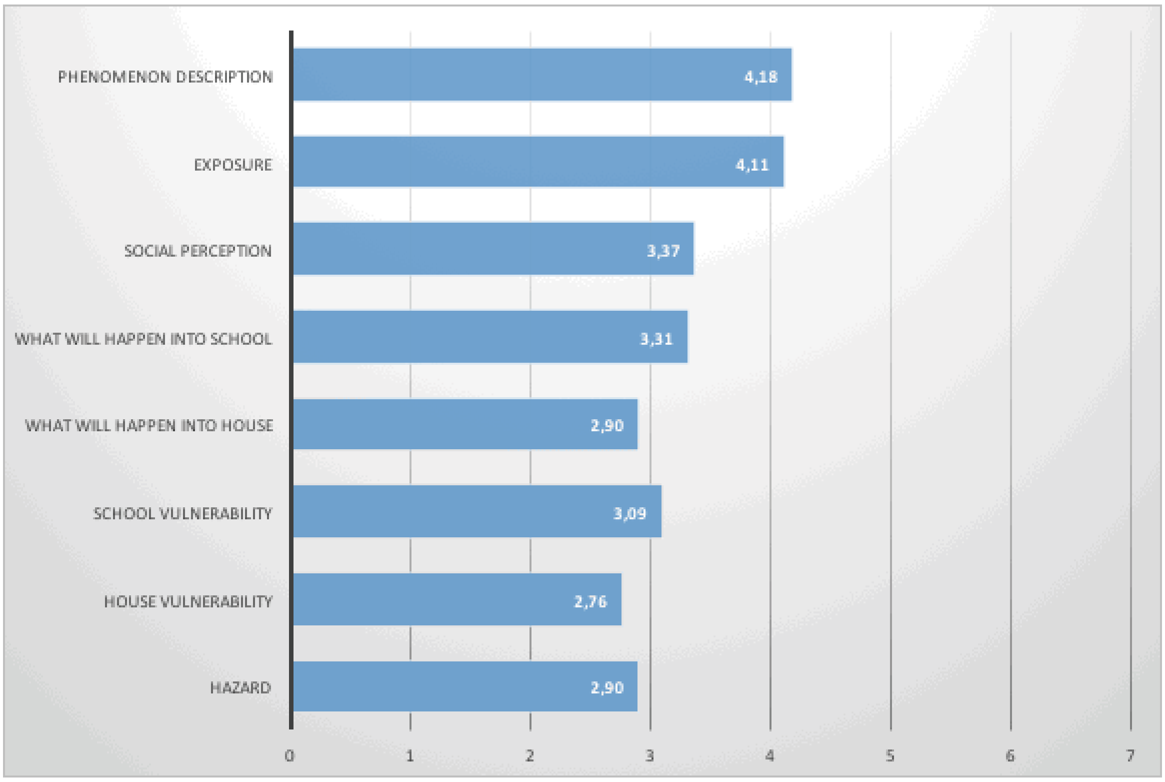

Figure 1. Know-Risk Questionnaire: Average scores of some indicators of the session What do you risk?

Augmented Reality applications as dissemination tools for the mitigation of non-structural damage from earthquakes

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Mt. Etna covers a region prone to earthquakes with low to moderate magnitude in southern Italy. Nevertheless, its seismicity can yield serious non-structural damage due to the superficial seismic foci. For this reason, it is necessary an effective prevention activity of education and preparedness to seismic hazard for the local populations.
One of the fundamental tasks of the European KnowRISK project (Know your city, Reduce seISmic risK through non-structural elements) is the dissemination of information to reduce non-structural damage from earthquakes in three pilot areas (Portugal, Iceland, and Italy). Focusing on tools that can convey such a useful information among laypersons and students, we choose Augmented Reality (AR) for its interactivity, simplicity and efficacy.
AR enhances the user's perception of and interaction with the real world. It has inspired the "Intelligence Amplification" concept [Brooks, 1996] in which computers are tools to make easier human being life. Elements that "increase"; reality are visible using a mobile device, such as a smartphone, through a video camera on board on a tablet, or any new wearable devices.
We tested our first AR application during ScienzAperta in May 2016, an open-door event organized at INGV in Catania, and addressed to pupils and students who live in the Etna region. For that application, we referred to Wikitude ™ framework provided by Wikitude GmbH (www.wikitude.com), under Android OS version 4+. Throughout ScienzAperta, all visitors were astonished by the AR experience, as the majority of them never heard before about AR applications.
What's happened after the *Pokémon Go!* revolution? Actually, the worldwide success of the game makes easy to understand the potential impact of AR, which is not only useful for games. This new video game experience represents indeed a milestone for the future of AR: "the success of AR games such as *Pokémon Go!*, which was downloaded more than 100 million times in its first month, reportedly earning $10m per day at the height of its popularity, has attracted widespread attention and investment" (The Guardian, [2016]).
As mobile devices (like glasses, smartwatches, etc.) will be even wearable in the next future, many important groups among the biggest technology communities are working hard to create some amazing smart devices (Fig. 1). This will increase the great success of AR technology among the "digital native" generation, raising our motivation to use this new way of communication to disseminate a better culture of safety.

Figure 1. Google Glass view example.

References

Brooks F.P. Jr., (1996). *The Computer Scientist as Toolsmith II*. CACM 39, 3, 61-68.

The Guardian, (2016). https://www.theguardian.com/technology/2016/oct/23/augmented-reality-development-future-smartphone.

The talking poster: An example application of Augmented Reality for the mitigation of non-structural damage from earthquakes

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The concept of Augmented Reality (AR) has spread out since the development of the famous game "Pokémon Go!" The game contains all the main features of AR and was downloaded more than 100 million times only in its first month of life [The Guardian, 2016, *https://www.theguardian.com/technology/2016/oct/23/augmented-reality-development-future-smartphone*].
AR is part of the Virtual Reality approach, but creates a new experience around the user's world in real time, adding some useful information based on the pointed target. Elements that "increase" reality can be detected through a mobile device, such as a smartphone, through a video camera on board on a tablet, or any new wearable devices. In addition, mobile on-board sensors, such as GPS, accelerometer, and gyrocompass, are exploited to enrich AR user's experience.
In the framework of the European KnowRISK (Know your city, Reduce seISmic risK through non-structural elements) project, we focus on tools for the dissemination of science education in the field of seismic hazard and, in particular, for the mitigation of the non–structural damage caused by earthquakes. In this light, we develop new dissemination formats using AR features. In this paper, we propose a "talking poster" that deals with seismic hazard, providing useful information to increase common awareness on earthquakes. The poster covers different sections containing static images: they are the "virtual buttons" to start the KnowRisk software application. Based on a Tablet or similar mobile device, it is possible to run a demo scenario that highlights potential non-structural damage inside a house or in public buildings (schools, roads, public workspaces). The tool is developed by using the Wikitude™ framework provided by Wikitude GmbH (www.wikitude.com), under Android OS version 4+.

References

The Guardian, (2016). https://www.theguardian.com/technology/2016/oct/23/augmented-reality-development-future-smartphone.

Building-up AR applications for field survey purposes

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Augmented Reality (AR) is a new way to interact with the world around us by means of the alteration of reality perceived through specific sensors. Virtual elements are indeed overlapped to our visual perception using a video camera or special glasses. In the light of this experience, the AR user will see real images mixed with virtual objects and movies, hear sounds, perceive tactile sensations and, in the next future, have olfactory experiences.

We exploit AR features for dissemination purposes in the field of non-structural damage caused by earthquakes as part of our activities within the European project KnowRISK (Know your city, Reduce selSmic risK through non-structural elements). In this presentation, we propose an AR application that allows the user on the field to access information based on a geo database. Accordingly, the application can work in outdoor guided tours as well as field surveys in the form of a virtual assistant. The application requires a tablet and is developed using the Wikitude™ framework, provided by Wikitude GmbH (www.wikitude.com), under Android OS version 4+. From a technical point of view, it is based on the Wikitude Software Development Kit (SDK), which represents an all-in-one AR solution including image recognition and tracking, video overlay, and location based AR service.

We developed our prototype application as field trip experience of the town of Noto (Italy), destroyed by an earthquake in 1693. In the middle Ages, the old town of Noto was an important and rich stronghold chosen by Arabs as chief town of one of the three districts (Val di Noto) in which Sicily was divided. Houses, churches, convents and monasteries in Noto were totally destroyed by earthquakes with intensity I=X-XI MCS between 1542 and 1693. The victims were 3,000 out of a total population of 12,000 inhabitants.

Our AR application provides historical information on Noto along images and seismic data. Building-up similar tools can be useful not only for laypersons, but also for professionals in support to their field surveys.

Assessing risk communication impacts: the Portuguese case

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This communication aims at presenting the procedure designed to assess the impacts of seismic risk communication strategy that is presently undergoing in Lisbon pilot-area. This procedure stands in a multi-method approach where quantitative data collection techniques will be complemented by qualitative techniques.

Before all, risk communication expected goals should be reminded. These are as follows: i) to foster knowledge about the seismic risk problem and about the protective measures the individuals can adopt to increase their safety; ii) to stimulate the creation of seismic protection beliefs; iii) to encourage the development of protective behaviour intents. It should be emphasised that it is unrealistic to expect behavioural an alteration of individuals' behaviour as an impact. Social contexts, as is the case of Lisbon, marked by low intrusiveness of earthquake risk in people's daily lives are particularly resistant to change. Besides, target-groups are teenagers, with ages between the 12 and 15 years old. Much of the non-structural earthquake protection measures do not fall within their scope of action. Consequently, the aim of the intervention is to stimulate the creation of beliefs favorable to earthquake protection.

The assessment of risk communication impacts stands in the stage-theory proposed by Weinstein, [1988] named "Precaution Adoption Process". According to this model, the adoption of protective behaviours is not an issue of "yes or no"; it is rather a cognitive process by which individuals occupy different stages. The methodological procedure design to assess the impacts of risk communication aims at allowing the identification of the stage that individuals occupy at the beginning of the intervention and their evolution by the end of the intervention.

References

Weinstein N.D., (1988). *The precaution adoption process*. Health Psychology, 7(4), 355-386.

Risk communication pilot-intervention in Portuguese schools

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This communication aims at giving an overview of the of a pilot experience of risk communication in two Portuguese schools which is being set up under the EU project KnowRISK (Know your city, Reduce seISmic risK through non-structural elements).
The efficacy of education for seismic safety is often inhibited by an incomplete understanding of the process by which individuals decide to protect themselves from harm [Becker et al., 2012]. Given this, the first step for the design of a risk communication process was to systematically explore previous research on protective adoption process. Based on this literature revision, it was made the option by standing risk communication procedure on Becker et al., [2012] model which conceives protection adoption process has composed by a series of stages, respectively: knowledge and awareness, thinking and talking, understand the consequences, develop skills. Individuals pass through a serious of stages until they decide to act protectively. Target-groups must first learn that earthquake exists and, also, that there are a series of alternatives of protection.
Along with actions of raising awareness and knowledge, the intervention was designed to stimulate dialogue with experts, to assist in understanding the personal consequences of an earthquake as well as the benefits of protection and, finally, to stimulate the development of protection oriented skills.

References

Becker J.S., Paton D., Johnston D.M., Ronan K.R., (2012). *A model of household preparedness for earthquakes: how individuals make meaning of earthquake information and how this influences preparedness.* Nat Hazards, 64: 107. doi:10.1007/s11069-012-0238-x.

Earthquake hazards: integrated marketing campaign

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"The purpose of (risk) communication is to assist people to obtain the information they need to make informed choices about the possible risk they face" [Wade et al.,1992].
Earthquakes are an example of a risk that most non-experts would see as unlikely to have an impact on their lives. However earthquakes are one of most costly natural disasters in the world.
People usually underestimate risks because they would rather believe they are safe, free to live their lives without the responsibility of feeling vulnerable and obliged to make difficult or unpopular decisions that would affect their lifestyle [O'Neill, 1994]. Research suggests that when people feel threatened when confronted with health and safety messages, they become defensive and believe that it won't affect them.
What approach should we take in encouraging safety preparation for disasters?
In Lisbon contacts have been established with one school of Arts, Technology and Creativity (Restart) to develop a risk communication action an integrated marketing communication campaign.
Our goal is to raise awareness in earthquake protection of non-structural elements to the public, decision makers, stakeholders, typically whom have much less experience with earthquakes compared to other disasters, as large earthquakes in Portugal are relatively rare.
During two months, two groups of students developed two campaigns (Figure 1): "Know Risk" and "It's time to fix", both structured to be employed in outdoor, print, digital and social. In these campaigns, the community is seen as an active participant in its own safety, rather than a passive recipient of services, altering the traditional top-down, 'command and control' relationship with the community.
By integrating tools such as advertising or social media, you provide clarity, consistency and maximum communications impact. By repeating the headlines, key phrases and images in each communication, you ensure that people receive consistent messages each time they see one of the elements of the campaign.

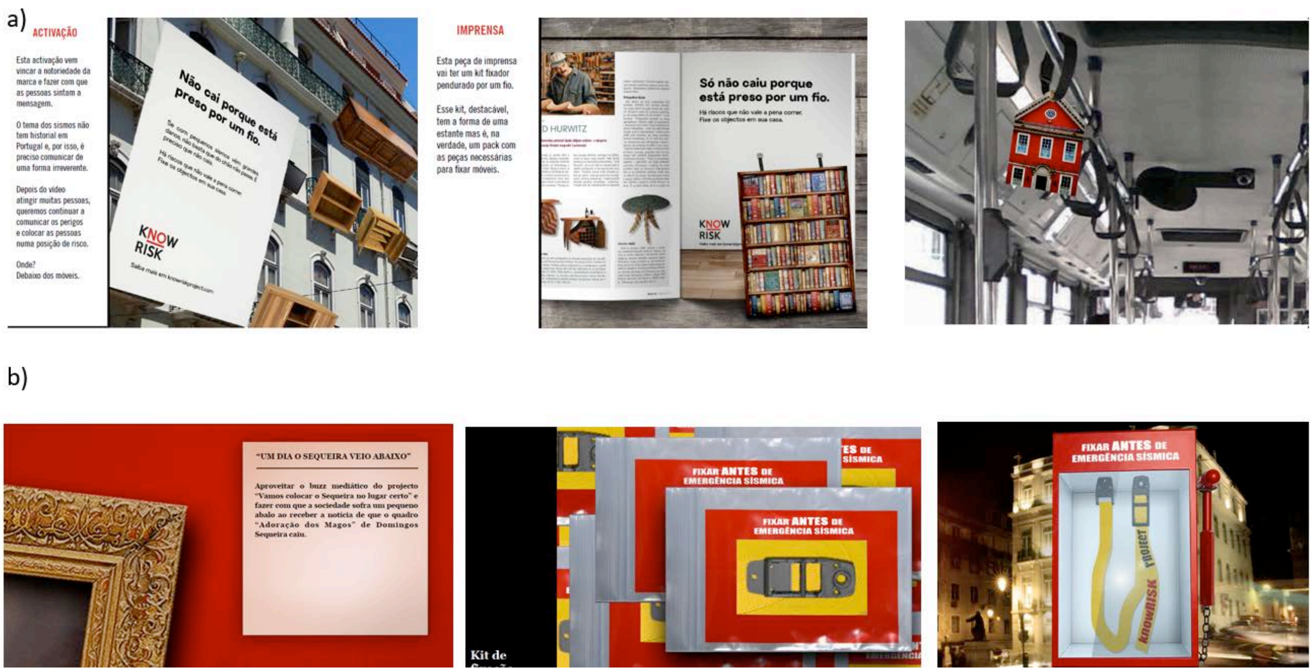

Figure 1. a) Know Risk campaign. b) It's time to fix campaign.

References

O'Neill P., (1994). *Developing a risk communication model to encourage community safety from Natural Hazards*. State Emergency Service (SES).

Wade C.R., Molony S.T., Durbin M.E., Klein S.H. and Wahl L.E., (1992). *Communicating with the Public about Risk*. U. S. Department of Energy, Los Alamos.

Know your school: be safe! - where students become active part of the KnowRISK project

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Seismic risk mitigation is less effective without a culture of prevention and preparedness, the pillar of which lays on education.

Non-structural elements are often neglected even in seismic risk assessment. Yet they may cause relevant economic losses and injuries and act over resilience of population. A large part of non-structural elements belong those aspects of daily lives on which people feel to have full control. Among these, in-door furniture of residential building, offices, schoolrooms, and partially laboratories, are all elements upon which it takes little effort to take decisions that improve safety. It might be just a matter of education.

"Know your school: be safe!" is the participatory risk communication action of the KnowRISK project (Know your city, Reduce seISmic risK through non-structural elements), financed by the European Commission (AGREEMENT NUMBER - ECHO/SUB/2015/718655/PREV28) that starts with schools to implement strategies to reduce non-structural damage in urban areas. The action aims at raising awareness of school communities (e.g. students, teachers and school managers) in the pilot-areas within the three European participating countries, namely Portugal, Iceland and Italy. Although being the starting point, students are not our final targets: their interaction with families and their surrounding is bound to enlarge the audience.

In the Northern Italy pilot area the 4 middle- and 2 high-schools involved are listed here:

Middle schools (13 years old students - III classes): "Jean Piaget" in La Spezia: 5 classes (about 103 students), "U. Mazzini" in La Spezia: 4 classes (about 96 students), ISA 10 Lerici ("F. Poggi" in LERICI and "P. Mantegazza" in SAN TERENZO): 3 classes (about 66 students), "G.B. Monteggia" in Laveno Mombello: 6 classes (about 130 students).

Secondary schools: Scientific Liceum "A. Pacinotti" in La Spezia: 4 classes, 17 years old students (about 81 students - IV classes), Scientific Liceum "T. Parentuccelli" in Sarzana: 5 classes, 14 years old students (about 130 students - I classes).

The activity started in La Spezia, one of the cities involved in the project in the Northern Italy pilot area and it resulted into a new experience of risk education and communication tools self-implemented directly by the students. The results will be exported to the other participating countries, after an assessment on the effectiveness of the approach.

Our challenge is to actively involve schools in strategies to reduce non-structural elements that may strongly affect lives while being highly underestimated by formal education.

The approach is that of natural hazard active learning in a "Smart School". By learning know what, know how, know why in the innovative approach Search-Show-Share, schools are directly involved in a participatory process based on Understanding, Observation and Reflection to foster the culture of securing non-structural elements and save lives and properties.

The method is based on Situated Learning Episode, EAS, (Episodio di Apprendimento Situato; Rivoltella, 2014) where active learning strategies are used to enhance knowledge, skills and attitudes. The learning is flipped-up: homework for learning and skills; classwork for reworking and understanding.

The action "Know your school: be safe!" is a particular EAS experiment which starts and ends with two different focus groups where students and teachers meet researchers and fire brigades to rework and restructure concepts to come up with the appropriate behavior towards non-structural elements. First we ask students to research on a topic regarding seismology and act on problem solving abilities in a learning-by-doing framework; then we encourage a classroom discussion engaging students in solving problems; at the end of the EAS experience we debate with students. We tested the methodology described in the Fig. 1a in La Spezia at the "J. Piaget" institute with 5 classes (more than 100 of 13-year-old students) and in Laveno Mombello (Varese) at "G.B. Monteggia" institute with 3 classes (about 70 students) during the school year 2015-'16.

We first focus on the difference between hazard and risk, which is often not completely clear to them (T0-focus group). Students do not have the knowledge of risks in their school and home environment. We discuss

different scenarios in order to describe the different level of risk for a similar hazard. We then listen from them in order to let them list the weak or dangerous elements in their classroom or bedroom. As a result of this activity, students are asked to make brief video-reports, collect interviews and carry other activities as they please to promote education and prevention (songs, poems, short stories, comics and cartoons, scientific games) (Home-works).In the second Focus Group (T1-focus group) Test age-targeted activities encourage the school community to share the benefits of the project with other citizens and aims to reach ambitious results such as (1) the engagement of students in the discovery of their own environment, its vulnerability and resilience; (2) the dissemination of knowledge on non-structural seismic protection measures.
The best students' products will be made available (some examples in the Fig. 1b) on the KnowRISK website to be used to promote knowledge and best practice.
A Competition about seismic risk will involve schools in preparing original communicative products to promote education and prevention, while increasing resilience in terms of societal capacity to cope with future disasters and to reduce non-structural vulnerability.

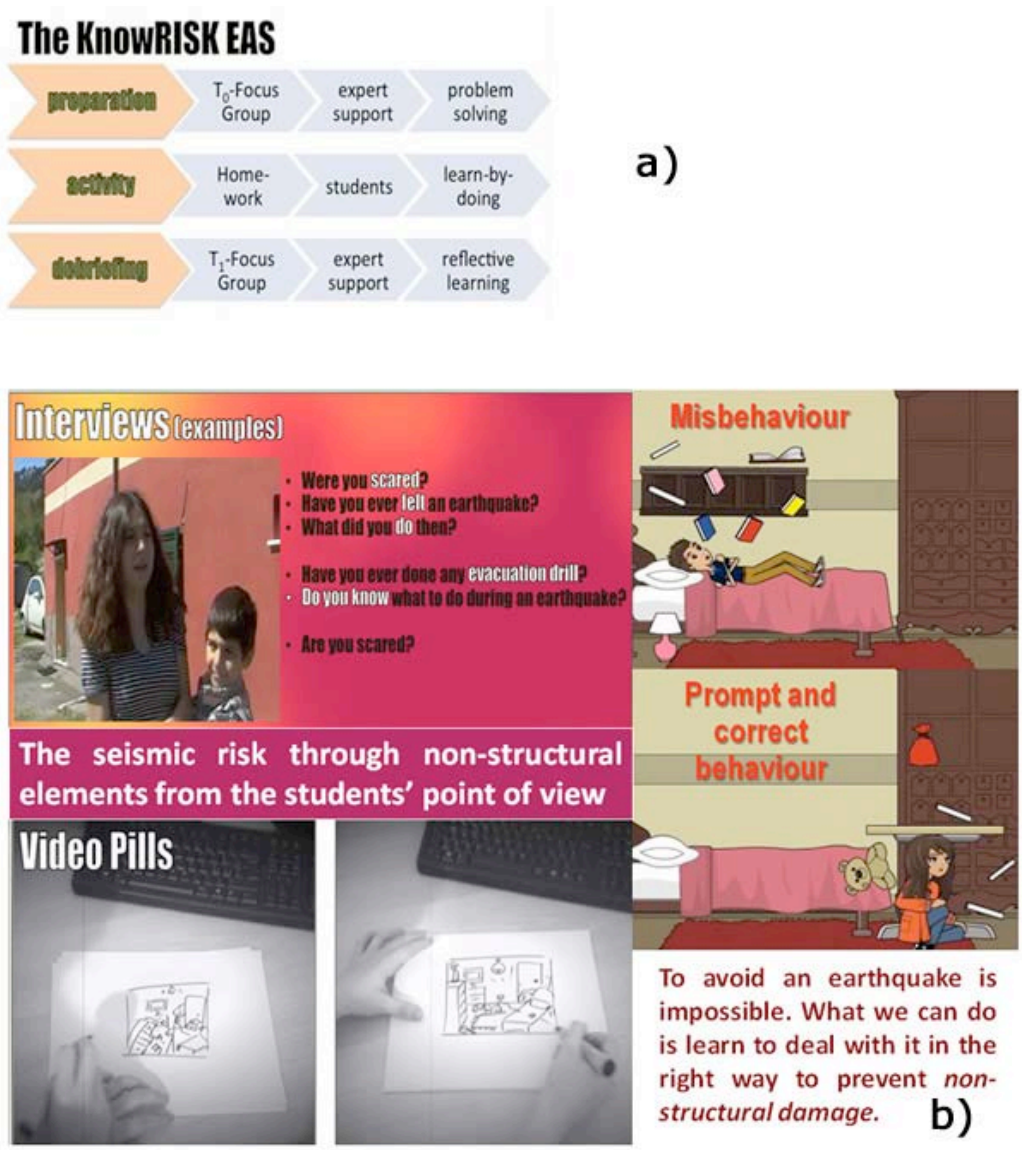

Figure 1. a) Scheme about the methodology of the KnowRisk EAS experiment. b) Examples from students products. Top left is a video clip with an interview "J. Piaget" institute in La Spezia) where some of the major questions are listed; bottom left video pill showing drawings of cartoons on non-structural damage ("J. Piaget" institute in La Spezia); right is an animated cartoon on non-structural damage and appropriate prevention solutions (G.B. Monteggia institute in Laveno Mombello -VA).

References

HAZUS technical manual. National Institute of Building Sciences, Washington, DC.

Mercer J. (2012). *Knowledge and disaster risk reduction.* in The Routledge Handbook of Hazards and Disaster Risk Reduction (B. Wisner, JC Gaillard, I. Kellman ed.). London and New York: Routledge.

Piangiamore G.L., Musacchio G., Devecchi M., (2016). *Situated Learning Episodes: natural hazards active learning in a smart school*. second chapter of Interactive Learning: Strategies, Technologies and Effectiveness, New York, NOVA.

Rivoltella P.C., (2014). *Episodes of Situated Learning. A New Way to Teaching and Learning*. Research on Education and Media, VI, N. 2, 79-87.

Yamori K. (2007). *Disaster risk sense in Japan and gamming approach to risk communication*. International Journal of Mass Emergencies and Disasters, August, vol. 25, N. 2, 101-131.

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How to survive earthquakes: the example of Norcia

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On the 30st October 2016 an earthquake of magnitude 6.5 hit the town of Norcia, in central Italy. Due to the reduced epicentral distance the accelerations in Norcia were extremely high, with a value of the horizontal PGA=0,48g registered at the nearest seismic station (http://shakemap.rm.ingv.it/shake/8863681/stationlist.html#sNRC). This is an extremely high value. Two months before, on 24th August the neighboring village of Amatrice had been shaken by an earthquake slightly less strong. In this earthquake most of the constructions of Amatrice collapsed, the ones that did not collapse were so damaged that were useless, and hundreds of people died. Today it is a dead village, where nobody is allowed to enter freely. How is it possible to explain the differences between Norcia and Amatrice, how is it possible nobody died in Norcia?
The above can be explained by two main factors:
1 – Norcia had already felt the shaking due to the earthquake of Amatrice on 24th August, but was less shaken then Amatrice. The severity of the earthquake in a given location can be measured by the soil accelerations, which is the factor that affects more the constructions. The accelerations on a specific location depend on several factors: the magnitude, the epicentral distance and site effects. Besides Norcia was also shaken 4 days before the main earthquake, by two other earthquakes on 26 October not so strong but that caused some damage. Therefore the population was on alert, and because of that, when the main earthquake took place on 30st October, at 7h 41m am, many people were sleeping on cars and not on their homes.
2 – In Norcia constructions are old, built in periods in which earthquake resistant was not enforced in codes of practice, and therefore it is thought that original constructions were vulnerable. However in Norcia there is a culture of safety in what regards earthquake risk, and due to that the constructions in Norcia were strengthened to provide earthquake resistance during the last 40 years. Priority was given to houses were people live permanently, with second houses receiving a lower priority. The main strengthening techniques used in Norcia were i) the confinement of masonry walls by a layer of mortar with a pre-fabricated steel welded mesh inside, in both face, that were connected by steel bars at a given spacing, and ii) prevent the out-of-plane movement of exterior walls to the outside of the construction, by steel cables connecting parallel walls. These informations were transmitted to a KnowRISK team by the sindaco (mayor) of Nortia in a meeting in the morning of 26th October, a few hours before the earthquakes of that day.
The result was the destruction and dead of Amatrice (at least as it was), and in Norcia, despite damages in many houses and some collapses of historical constructions, as the exterior walls and churches, most of the houses are standing and, above all, nobody died. Figure a) provides a good comparison of the state of both villages after the earthquakes.
At this moment, besides the solidarity and support to the affected populations, it is also importante even though not so urgent, to draw lessons from the comparison between Amatrice and Norcia: the main conclusion is that prevention is worth it. It is important to draw attention to the decision makers and managers of programs of urban rehabilitation in seismic zones, for the importance of seismic strengthening in the rehabilitation of constructions. In seismic zone, improvement of aesthetics and living conditions of old and unsafe houses should always be accompanied by seismic strengthening.
However this is not enough. Even though properly strengthened houses survive strong earthquakes, they vibrate and deform during the earthquakes. These may introduce relevant non-structural damage, part of which can be avoided by appropriate measures taken by common citizens, which is the subject of the KnowRISK project. And reducing non-structural damage reduces the probability of people getting injured by falling objects and reduce economic damage. Note that the reduction of economic damage is also important for the affected populations to recover their way of life back. Figure b) shows a recent example in Italy: during the August earthquake the television fall down and broke. After that a new television was bought to replace the broken one, but was fixed with chains, as shown in Figure b) (photo shot by the KnowRISK team on 28 October). The result was that the television suffered no damage during the 26 October earthquakes. The above example has already been used by the Portuguese team in KnowRISK action in schools.

Figure 1. a) Amatrice and Norcia after the earthquakes. Figure b) Televisions connected by chains to avoid toppling.

Public engagement in seismic prevention: the Ferrara's case study

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The poster "Engaging citizens, preventing risks" presented by the Master in Journalism and Institutional Communication of Science at Ferrara University (MGS) offers an overview of a peculiar experience of citizens' engagement in seismic prevention realized in Ferrara in 2013 and now renewed thanks to the Knowrisk project and a fruitful collaboration with the INGV, project partner. In particular, the research presented in the poster fulfils part of the objectives of Task E "Tools and strategies of risk communication and learning".

Ferrara is a city of 130.000 inhabitants in the Po Valley, who were unconscious of the seismic risks affecting the area until the earthquake happened in 2012 in the Emilia region.

Although hit by earthquakes in the past, the memory of risk has been lost over the decades and centuries and the need to make the citizens active in preventing the damages of possible further earthquakes suddenly became pressing.

Among the other initiatives, the Municipality of Ferrara, with the support of MGS and the participation of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the Ferrarese Naturalists Society, and the Waseda University of Tokio, organized a series of participative events to involve the citizens of the city centre: Laboratories on the prevention of the seismic damage, financed by the Emilia Romagna Region.

The structure of the ancient centre of Ferrara, similar to many other Italian cities and villages under risk, resulted to be a useful example of the necessity of raising participation in order to carry on effective prevention activities.

Main outputs achieved through the initiative were: a series of shared practices to mitigate the non-structural risk, summarized in a booklet called "10 good practices to make our home safer"; a serious game to involve schools goers and citizens, namely the Playdecide "Earthquakes, when and how to communicate an emergency"; a participative proposal, a formal document in which the need to develop strong communication and social cohesion actions by the public administration was declared to the City Council and approved by its members.

With the research-action process presented here, the MGS faces the Ferrara case study along three main steps:

1. analysis of the Participative Laboratories on the Seismic Risk Prevention to evaluate the strengths and weaknesses of the process, define the lesson learned and make them available for the Knowrisk project's further initiatives.
2. involvement of citizens, experts and key-stakeholders in co-designing a common strategy to reduce the seismic risk caused by non-structural elements of buildings (the Knowrisk Practical Guide).
3. organization of Playdecide events with the aim to engage the general public and the school goers on the topic of earthquake communication and risk prevention.

Regarding the methods used and targets involved, a series of focus groups, in-depth interviews and a workshop will be held with:

- Citizens who took part in the Laboratories in 2013.
- Citizens who didn't take part in the Labs and live in the city centre.
- Representatives of the local administration (councillor for urbanistic, technical, civil protection, communication officers) and relevant experts inside and outside academia.

A description of the Participative Laboratories, as well as the full design of the MGS activities and the very first results of the research-action process will be presented in the poster.

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Appendix for the field trip

Earthquakes and ghost towns in eastern Sicily: the case-history of Noto antica

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Evidence of past earthquake effects is generally reported in historical documents and used to reconstruct seismic scenarios. In some regions like Sicily the scars of an earthquake can be still visible in the territory in form of archaeological remnants of towns or villages abandoned following a destructive event. The ghost towns indeed represent places of memory, but they also constitute the most effective warning to local communities about the potential danger impending on their own territory.
The post-conference field trip crosses Eastern Sicily passing through one of the most seismically hazardous districts of Italy, the Val di Noto. The impact of the 1693 earthquakes on this area has been so devastating as to determine the relocation of several towns and villages. At the same time, the catastrophic event at the end of the 17th century represented a chance for social and cultural revival having its unifying element in the famous baroque. The case of the modern Noto is probably the most exemplary.

The 1693 Val di Noto earthquakes
The January 11 earthquake (M = 7.3) produced the largest seismic catastrophe in Eastern Sicily history. It represents the mainshock of a seismic sequence lasting for two years which totally destroyed about forty towns in the area between Catania, Syracuse and Ragusa (Fig. 1) and heavily damaged all the other localities as far as Messina, the inland of Sicily and Malta.

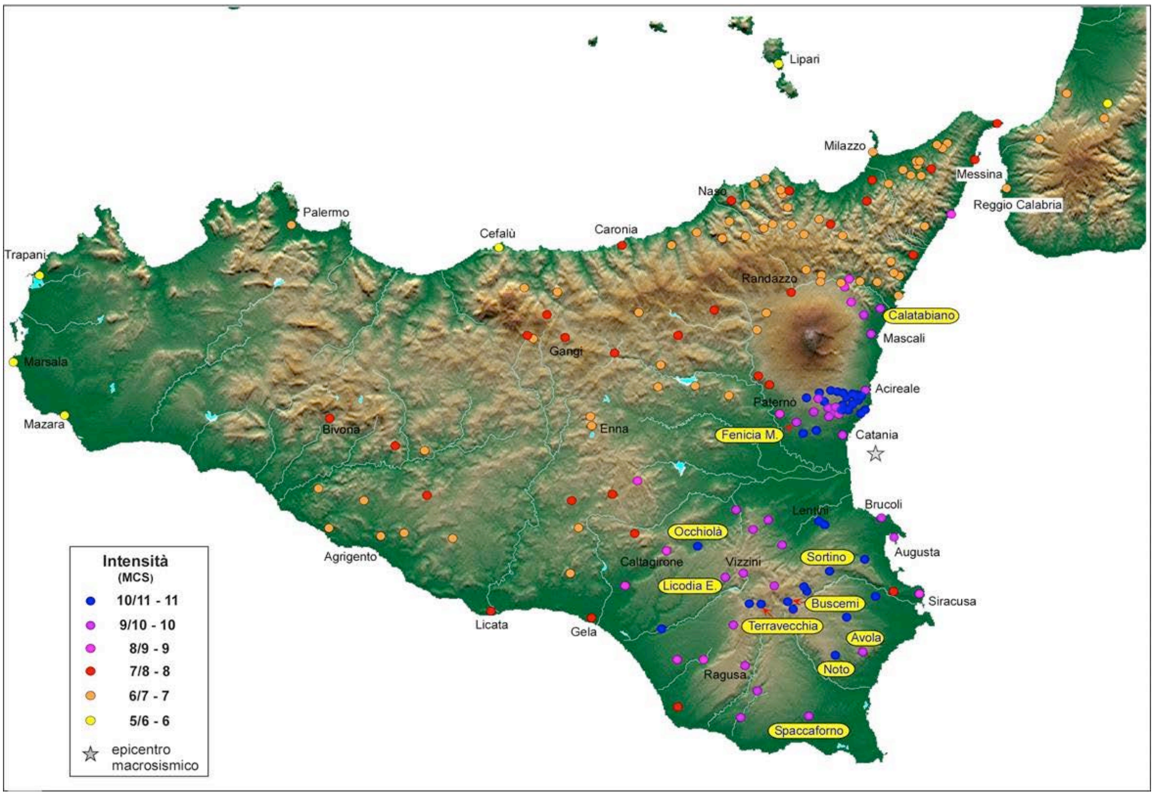

Figure 1. Intensity map of the January 11, 1693 earthquake. The localities reconstructed in a new site are marked in yellow.

In total there were 60,000 victims. The interpretation of this earthquake is problematic because it was preceded by a strong foreshock on January 9 (M = 6.0), which caused heavy damage (I=8-9 MCS) in many localities of southeastern Sicily. On the whole, the severity of damage scenario related to the 1693 events represents the typical example of cumulating effects during a seismic sequence.

Noto Antica
In the Middle Ages the old settlement of Noto was an important and rich stronghold chosen by Arabs as chief town of one of the three districts (Val di Noto) in which Sicily was divided (Fig. 2).

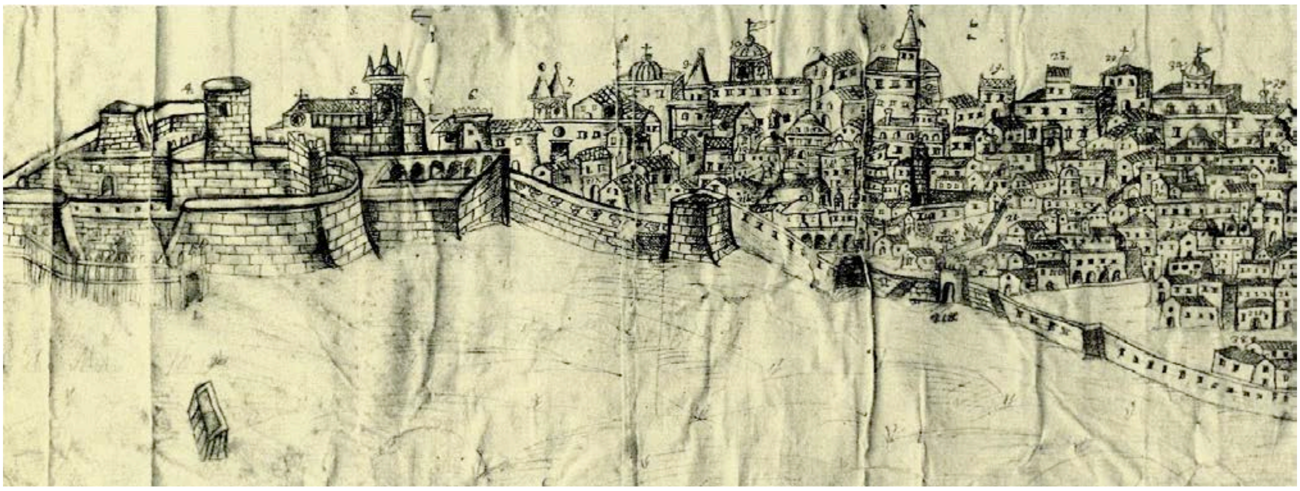

Figure 2. View of Noto Antica before the 1693 earthquakes, considered an "impregnable admirable place ". Detail of the castle and walls seen from the West.

Noto Antica was severely damaged by the 1542 earthquake (I=8 MCS) and almost raised to the ground by the 1693 earthquakes. The January 9 foreshock produced severe effects on the town (I=8-9 MCS), since several edifices were ruined causing 200 victims. Two days later, the January 11 mainshock totally destroyed (I=10-11 MCS) houses, churches, convents and monasteries (Fig. 3); the victims were 3,000 of a total of 12,000 inhabitants.

Figure 3. Noto Antica: left, ruins of the Castle Tower; right, entrance to the town through the Royal Gate.

The modern Noto

The medieval structure and the mountain location of the town forced it to be reconstructed in a different site; from 1694 the first religious buildings were erected in a site more accessible and without fortifications. The old town was definitively abandoned in 1702 for the new settlement reconstructed ten kilometres downhill.
During the second and third decades of the 18^{th} century the monumental buildings became imposing, the domes of the churches were completed and the fronts of houses were raised with upper storeys. The baroque town features a regular urban plan with orthogonal roads; the main road (Cassaro) crosses the town from the royal gate. The modern Noto is on the Unesco Heritage List (Fig. 4).

Figure 4. The modern Noto: night landscape.

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