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THE KNOWRISK PROJECT: OBJECTIVES AND ACHIEVEMENTS

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ABSTRACT

The KnowRISK Project, an European Commission (Humanitarian Aid & Civil//Protection) ECHO granted project, was developed in the period 2016 – 2017 with the participation of IST (Portugal), LNEC (Portugal), INGV (Italy) and EERC (Iceland) to help European citizens and institutions to deal with the problem of performance of non-structural elements under seismic loads.
These are responsible for a large part of damage occurring during moderate magnitude events which are very frequent in Europe, especially in southern countries. Besides the understanding of these problems and the presentation of simple practical measures to mitigate them, the KnowRISK project aimed at to find better ways to communicate the risk to different sectors of society, namely the population in general, groups of students and selected stakeholders related to the main economic life of a region. Many contacts with media and interventions in TV, radio, newspapers, etc., were made.
The main achievements of KnowRISK to convey this message include the production of several media tools: a Practical Guide, with a few simple measures to be used by the public; a Student Short Guide aimed at first grade students; a Portfolio of Solutions with a more extensive set of measures to be used, not only by the general public but also by the practitioners (designers, contractors, etc.); and short Videos based on shaking table experiments on a model room with furniture and household objects equipped with and without preventive measures.

Keywords: KnowRISK, non-structural elements, public awareness media tools

1. INTRODUCTION

The KnowRISK Project (KnowRisk EU paper (Know your city, Reduce seISmic risK through non-structural elements), an European Commission (Humanitarian Aid & Civil//Protection) ECHO granted project, was developed in the period 2016 – 2017 with the participation of IST (Instituto Superior Técnico, Portugal), which coordinates, LNEC (Laboratório Nacional de Engenharia Civil, Portugal), INGV (Istituto Nazional de Geofísica i Volcanologia, Italy) and EERC (Earthquake Engineering Research Centre, Iceland) to help European citizens and institutions to deal with the problem of performance of non-structural elements under seismic loads (website: https://knowriskproject.com).
The non-structural elements (NSE), in which we include the building contents (furniture, shelves, TV

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monitors, computers, kitchen components, etc.), the architectonic parts (non-structural infill panels, decorative elements, suspended ceilings, small chimneys, veneers, appendages, canopies) and the mechanical, electrical and plumbing (MEP) elements (elevators, AVAC´S, solar panels, generators, transformers, etc.), are responsible for a large part of damage occurring during moderate magnitude events. Depending on the typology and function of construction under consideration, and on the level of ground motion affecting that construction, the percent in terms of total losses that can be attributed directly to non-structural elements are over 60% to 75%. NSE´s are of particular importance for the regions of low to moderate seismicity, and may be of great concern in Southern Europe where moderate magnitude earthquakes are frequent.
Until recent years almost no attention was given to NSE, but now society cannot ignore this reality (Fig. 1). NSE besides being responsible for causing large percent of losses they can cause loss of life, loss of function of many systems and reduce the access to emergency safety exit. On the other hand the cost to implement solutions may be almost null, as it is the case of several contents in our homes, or modest costs of interventions when made by specialized teams.

Figure 1. Non-structural effects inside our houses. (fall of objects from shelves and blockage of exits) (Norcia, 2016)

The present paper aims at presenting the main objectives of KnowRISK project, describes in a brief way the tasks to attain those objectives, and presents the main achievements obtained.
Besides the understanding of the problems presented by the NSE and the enumeration of simple practical measures to mitigate them, the KnowRISK project aimed at to find better ways to communicate the risk to different sectors of society, namely the population in general, groups of students and selected stakeholders related to the main economic life of a region. Many contacts with media and interventions in TV, radio, newspapers, etc., were a significant part of the development of the KnowRISK project, because they forced the merging of the more methodological knowledge of the project participants with the reality of the community interests. To be more effective in its goals, the KnowRISK needed to be very creative in the way to communicate with all the end-users, and several products were developed to meet those goals.
Field missions (at three different times) were organized with members of the KnowRISK team to the

territories between Amatrice and Norcia (Goretti et al., 2018) hit by a seismic sequence that took place in August 2016 to January 2017 and caused extensive structural damage, building collapse and in which several hundred people died. In areas far from the epicenters we could observe non-structural damage and understand needs and relevance the population had towards their vulnerability reduction.

2. OBJECTIVES OF KNOWRISK

The principal objectives of the project can be summarized in the following items:

2.1 Task B - RiskMAP

Task B contains a detailed literature survey on the behavior of building contents during earthquakes
From that analysis together with theoretical modelling and shake table tests (Task C3) of a single rigid block it was possible to obtain a first estimative of a fragility curve for the overturn of these blocks placed at different heights of a building. Theoretical studies try to estimate the level of action along the height of a building in order to understand the frequency changes and amplification of the ground motion at the foundation. This action is then applied to the base of the rigid block to understand its overturning conditions.
This Task also comprised the production of seismic scenarios and risk maps focused on non-structural damage to be used as supporting tools in risk communication activities in the three pilot areas, namely i) Lisbon in Portugal, ii) Etna and Northern Regions in Italy, and iii) the South Iceland Seismic Zone.

Non-structural components addressed in this project include both (i) elements and parts attached to the structure, but don't carry load of the structure, and (ii) contents of the building. Contents of the building are sensitive to floor motion (floor acceleration, for example). Elements such as piping networks, non-structural walls, windowpanes, etc., damage is mainly related to relative deformation between adjacent floors of a building. For such elements, inter-story drift demands become relevant intensity measures. An efficient definition of inter-story drift spectra, as well as its modelling and computational steps are provided in Miranda and Akkar (2006). This model uses a combination of continuous shear and flexible beams to model buildings, which are characterized by a certain height, and a dimensionless parameter α that controls the degree of overall flexural and overall shear deformation in the structure. A value of this parameter equal to 0 represents a pure flexure mode, while a very large value (more than about 650) represents a pure shear model. Structures with lateral resisting system consisting only of structural walls may be approximated by using values of α between 0 and 2. If both moment resisting frames and structural walls are present, the values of α is typically between 1.5 and 6. For buildings with moment resisting frames only, the values of α are typically between 5 and 20. Drift spectra were computed in the study areas in Iceland and Mt. Etna using some ground motion time series that are representative of hazard in these areas. The results showed that for the most critical structures in Selfoss (study area in Iceland) are brittle components attached to the structure.

2.2 Task C - Non-structural seismic risk reduction

Task C started by making a research of most important documents related to NSE´s, in a more descriptive format, with more theoretical oriented approach, or in the form of code. A detailed analysis of pictures from earthquakes with NSE´s was made. The earthquakes of Iceland (2002 and 2008), Faial (Azores 1998), Lisbon (1969), Molise (2002), St Venerina (2002), L'Aquila (2009), Emilia-Romagna (2012) and Amatrice (2016) were the main sources of information.
The purpose of this Task is to develop a set of disaster risk reduction procedures for NSE's that are specifically designed for the needs of different building-related stakeholders. Different stakeholders have different daily objectives and therefore different interests in the various NSE, and furthermore, have different control over them. In order to identify gaps and areas in need of improvement with regards to compliance to the relevant topic "non-structural seismic risk reduction" was performed:

i) literature review, ii) shake table tests where with different types of non-structural components in order to assess their seismic performance, with and without preventative solutions for reduction of NSE vulnerability (Fig. 2); iii) a list with most NSE´s compiled in the international literature sources was prepared and then, an adaptation to the uses and practices in the 3 participant countries took place, iv) the indications given by different stakeholders was very important to complete this list and finally, v) a hierarchy was established based on importance of each NSE to the overall behavior of the structure.
The stakeholders engagement were very important to design a preliminary draft of the KnowRISK Portfolio of Solutions.

Figure 2. Simple measures to mitigate NSE´s losses (from video – "move large pieces down")

2.3 Task D - Going into target-communities

Seismic hazard is different in Portugal, Italy and Iceland in terms of the frequency of earthquakes, the time span from last damaging event, type of damage, level of implementation of protective measures, cultural attitudes towards prevention and previous actions to raise awareness that needed to be taken into account in setting up a communication strategy. Part of Task D was essentially a research to prepare tools that could quantify the efficacy of KnowRISK risk communication strategy in each country (Task E3). This was done for the schools, being the students those to which KnowRISK devoted the most efforts. Surveys specifically built for the Lisbon city and northern Italy pilot areas were submitted to school-boards participating to the KnowRISK communication action during the first year of project. The results of these surveys were compared, their performance was assessed and a common tool questionnaire that took the best from the two was prepared. The common questionnaire is build upon three dimensions: **K**nowledge as the understanding on earthquake and the associated risks, **A**ttitude as the feelings and preconceived ideas towards it and **P**ractice as the ways in which communities demonstrate their knowledge and attitudes through their actions (KAP-NSET, 2017). Measuring changes of KAP from before the communication was performed in schools, at T_0, to one month after, at T_1, it was concluded is devised as an evidence of efficacy. The research was conducted having a control group defined as a class-group that compiled the questionnaire with the same rules of the others but without having the KnowRISK communication action.
Because the Common Questionnaire was prepared within the middle of the school year and during the second year of project it could only be tested with a few classes. In Italy it was submitted at T_0 and at T_1 to two schools, 6 classes located in the Northern Italy pilot area, in Laveno Mombello where seismic hazard is moderate (PGA<0.05 g, return period of 475yr), and in the Mt Etna pilot area, in Catania with high seismic hazard (0.15<PGA<0.25, return period 475yr).
Results on the dimension Practice shows that up to 40% of the students after the KnowRISK intervention consider important to very important to undertake simple actions to reduce NSE vulnerability in a moderate seismic zone while up to 20% in a high seismic zone (Fig. 3).

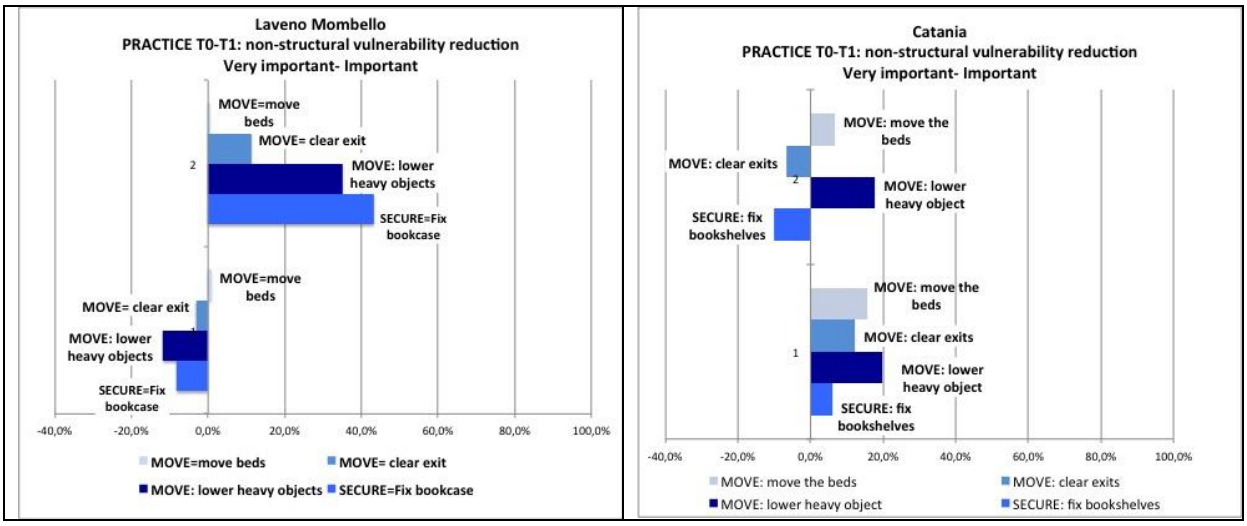

Figure 3. Results from the assessment of communication efficacy in the schools in Italy. Questions concerning the dimension Practice is shown. The level of importance (only important-to-very important are shown) students from a moderate hazard zone (left) and from a high hazard zone (right) judge measures to reduce NSE vulnerability.

In the three participant countries different type of stakeholders such as engineers, architects, facility managers, historical downtown citizens, civil protection officers, have given their contribution to the project in different ways. In several initiatives such as dedicated meetings, talks and workshops they shared their knowledge gaps, needs and priorities and this was vital to develop communication techniques and tools to communicate this topic to them.

2.4 Task E - Tools and strategies of risk communication and learning

The purpose of this task is to reach and inform the communities and relevant stakeholders about non-structural vulnerability as well to improve individual's capacity to adopt protective behaviors.
All materials developed under this project such as RiskMAP's (Task B.3), the Practical Guide (Task E.1), the Augmented Reality tool (Task E.4) and the KnowRISK Portfolio of Solutions (Task C.4) (in progress) have been used in actions and initiatives with communities (available at www.knowriskproject.com).

Part of Task E was essentially directed to school students, which are the social group that more easily can take the knowledge about disaster culture. The action was extensive as it involved 12 schools and 45 classes for about 962 students and was based on local community's needs (Musacchio et al., 2018). Actions and protocols for communication were based on different theoretical frameworks and stood on school board engagement. They were all based on the dialogue between experts and students that was performed either as a debate session or as a real focus group that allowed to go deep into preconceived ideas that were at the base of a miss-perceived risks. Students became prevention promoters and prepared themselves communication products (videos, music, cartoons, and comics) that may be used to disseminate best practice among teenagers and were uploaded to the project website.

Tools that make use of Augmented Reality were specifically developed to communicate with young people, the so-called digital native generation. Also the use of simple gadgets such as small shaking tables, house models, etc., were very important to explain some basic concepts of structural dynamics and overturn of objects (Fig. 4).

Figure 4. Use of simple gadgets in class to explain dynamic behavior (small shake table; house model)

3. COMMUNICATING EARTHQUAKE RISK AND KNOWLEDGE TRANSFER

The form to communicate seismic risk to different receivers such as professional users (engineers, architects, managers, etc.) and unprofessional users (general public, mass media, students, teachers) is very difficult and depends on the frequency and degree of damage inflicted by earthquakes and on the perception conveyed by the specialists. As the three participating countries (Continental Portugal, Italy and Iceland) have completely different seismological frameworks, efforts to minimize problems of communication and of information dissemination were emphasized.
The KnowRISK project poses two challenges. One is a need to translate scientific information in a usable format and language that can be understood by different audiences through appropriate channels. The other challenge is that we need to ensure that the information is available to all of those who need but don't recognize that they need it. This is a particular challenge, given the profound lack of perception and information that characterize the Portuguese society regarding earthquake risk.

The KnowRISK objectives focus on two broad strategies and groups of audiences.

3.1 Practical Guide, Student Short Guide and Portfolio of Solutions.
Three main products were developed in the course of KnowRISK (Ferreira et al. 2018).
The Practical Guide is a leaflet that addresses to citizens and meant to help distinguish what is structural from what is non-structural and when they can act on a Do-It-Yourself base from when they need an engineer. It prompts suggestions to improve security of their homes taking simple steps, from the low-cost and low-level of expertise to the more expensive and for which a professional is demanded. "Move-protect-secure and retrofit" are the keywords of the Practical Guide and they have been used as a slogan for short-videos that were clipped from shake table tests movies.
Since students have been major target of the project, we have prepared a Students Short Guide (for home and for school) that had a specifically built layout and was recalling familiar environments in order to make teenagers aware of the vulnerable situations they might be surrounded by.
KnowRISK Portfolio of Solutions is addressed to building owners and occupants, engineers, designers, architects and other parties and point out to the need to prevent poor performance of non-structural elements in earthquakes. It identifies potential vulnerabilities associated with non-structural elements provides detailed instructions (sketches of many simple, practical details for a range of common items) and guidelines for mitigating those hazards, considering the stakeholder group perspective.
It is a highly selective list of non-structural elements, and all the technical solutions are the result of an extensive research and compilation of relevant safety standards performed by KnowRISK team, from multiple studies (FEMA 2005, 2012), Porter (2005), guides, reports, periodicals, and other sources dealing with reduction of seismic risk through non-structural elements.
Each non-structural element has the following information: typical causes of damage, which may include a picture taken from an earthquake event; technical solutions to reduce seismic risk; icons that provide information about: type of stakeholder, skills needed (ER: Engineering Required; NE: Non-

Engineered Required; DIY: Do-it-Yourself), life safety concerns, property losses, functional losses, repair time and costs involved.

3.2 Shake table tests and movies for the general public.
A thorough series of tests were performed in a large shaking table (Candeias et al. 2017), where a room to represent a youngster place was built. Two types of ground motion to simulate a room in the lower and upper apartments of a building were used. Techniques to fix the objects to the walls were implemented and tested under various seismic input levels.

3.3 Interviews to the media
Many interventions in TV (newsroom, talks, commentary, entertaining), radio stations, newspapers, YouTube, Noite dos Cientistas (Sciencia Aberta) took place.

With the occurrence of Amatrice and Norcia events (Goretti et al., 2018), direct intervention in TV were made as well as a series of talks in several Academic Forum, where interested researchers and academicians participated.

All products generated within KnowRISK (Practical Guide, Portfolio of Solutions, Videos, public campaigns, webpage, etc.) were always prepared by graphic professionals for better images and communication. Texts were revised in many ways to make them appealing, simple, but nevertheless accurate. (available at www.knowriskproject.com).

4. FINAL CONSIDERATION AND FURTHER STUDIES

The main achievements of KnowRISK were as follows:

i) Understand the role on NSE´s in the structural and earthquake engineering contexts.
ii) Development of a series of tools to identify the main NSE´s and solutions to mitigate their potential losses. Among them we should refer a Practical Guide, Students Short Guide, KnowRISK Portfolio of Solutions and KnowRISK Video campaign.
iii) Communicate the earthquake risk to students, stakeholders and the population in general, through a number of initiatives which can be replicated in other regions with minimum adaptation.
iv) A Common Questionnaire to be used in different groups of students and population was envisaged. Results and interpretation should be pursued.

Future activities should include polishing the Portfolio of Solutions to be appellative to the various audiences interested in the topic of NSE´s, setting a group of instructions for the behaviour of population function of the typology of the construction and their state of vulnerability.
A campaign designed in schools to attain a much larger audience of student population should be prepared. The use of webcast and other new communication technologies could be a solution. Also the inclusion of several texts produced in KnowRISK could be included in the Curriculum of the school system, and teachers should undergo a campaign to become familiar with these new concepts.
The Common Questionnaire could be extended to many different forum to understand the level of awareness of the population at large and the degree of acceptance of the population to cope with the instructions to reduce the NSE´s vulnerability.
Further discussion should be engaged in which ways to present the seismic risk to the population. Is it possible to envisage a minimum consensus to be settled?

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