

## **KNOWRISK TOOLS FOR PREPAREDNESS AND COMMUNITY RESILIENCE: PRACTICAL GUIDE, STUDENTS SHORT GUIDE, PORTFOLIO AND VIDEO**

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### **ABSTRACT**

This paper summarizes the main products resulting from KnowRISK EU Project in what concerns the tools for preparedness and community resilience in the framework of non-structural elements. Namely, these tools are a Practical Guide, a Short Guide for Students (Students Short Guide), a Portfolio and a movie. Contrarily to structural damage, which depends on both the structural vulnerability of the construction and the level of seismic action, non-structural damage may occur even for low magnitude events in low vulnerability buildings. Thus they apply to many more people than those potentially prone to strong earthquakes.

In particular, the Practical and Students Guide provide an overview of the simplest retrofitting actions that can be carried out by the public while for the demanding provisions to be carried out by professional and critical stakeholders are described in the Portfolio. The material developed in the Portfolio resulted in the detailed analysis of various works available in the literature and on the experience gathered through individual contacts with stakeholders that express their concerns about needs, solutions and priority actions. Finally, a movie comparing consequences of retrofitted and non-retrofitted environments made using a shaking table test was also produced for presentation in diverse forum.

*Keywords: Non-structural elements, Earthquake protection, Practical Guide, Portfolio of Solutions, Risk communication tools*

### **1. INTRODUCTION**

Among the experts, it is well known that a great part of the losses in an earthquake are due to non-structural failures, i.e. 60%-70% (65% to 78% in Puebla Mexican Earthquake, EERI, 2017). The non-

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structural elements of a building include every part of the building and all its contents with the exception of the structure. In other words, everything except the columns, floors and roof slabs, beams, etc. Common non-structural elements are divided in three main categories: i) building contents (office equipment; computers; inventory stored on shelves; file cabinets, furnishings; lights; etc.); ii) architectural components (ceilings; windows; veneers, chimney (< 6 m)) and iii) mechanical, electrical and plumbing (MEP) elements (heating, ventilating, and air conditioning equipment; electrical equipment) (FEMA, 2005 and 2012).

On the contrary to structural damage, which depends on both the structural vulnerability of the construction and the level of seismic action, non-structural damage may occur even for low magnitude events in low vulnerability buildings. Thus they apply to many more people than those potentially prone to strong earthquakes. Taking into account these losses, the act to implement effective measures to reduce the non-structural hazards becomes crucial to ensure safety even in low seismic hazardous areas. Unfortunately, the public is not adequately informed about this kind of damage and especially ignore that most of the non-structural failures can be avoided adopting simple safety measures. These range from non-costly actions like moving or anchoring the furniture, which may avoid the blockage of the “way out” in case of an earthquake, to “Do It Yourself” (DIY thereafter) fixing up, to more expensive resorting by professionals.

One of the objectives of The European project KnowRISK (Know your city, Reduce seISMic risk through non-structural components) is to fill this gap of knowledge and foster, in the citizens of the three countries involved in the project (Portugal, Italy and Iceland), actions to decrease the non-structural losses.

In particular, the KnowRISK project aims not only at letting people recognize non-structural elements and understand their vulnerability but especially urging the public and stakeholders to undertake measures to avoid non-structural damage. To achieve this target, among many others activities, some outcomes have been programmed. They are meant to be delivered to the public in order to enlarge the audience beyond the people directly involved in the educative initiatives. This means that, conversely to other projects with a similar scope, the KnowRISK deliverables could be used as standalone tools by the public that is without any further assistance from the research community.

Namely, these tools are a Practical Guide, a Short Guide for Students (Students Short Guide), a Portfolio and a movie. Tools produced are available on the project website [www.knowriskproject.com](http://www.knowriskproject.com). In particular, the Practical and Students Guide provide an overview of the simplest retrofitting actions that can be carried out by the public while for the demanding provisions to be carried out by professional are described in the Portfolio. Finally, a movie comparing consequences of retrofitted and non-retrofitted environments made using a shaking table is also distributed.

In more detail, the Practical Guide (O’Neill et al., 2017) has been designed to inform householders about likely dangers in their homes and foster their preparedness by describing simple and inexpensive to onerous actions to increase safety; most of these solutions have been tested in “ad hoc” experiments on a shaking table by comparing the results of two sessions, one without and one with precautions. The tests have been filmed and the movie is made available to the public with the aim to show how rewarding is to adopt proper measures to avoid non-structural damage.

While the Practical Guide is a sort of how-to instruction manual, the Students Guide is more a reminder to students to watch around in their classroom in search for potential vulnerable items. The suggestions on how to render classrooms and school laboratories more secure are limited to general rules, the application of which depend more on school stakeholders. Finally, the Portfolio is a technical document for professionals to extensively and quantitatively describe most of the retrofitting actions listed in the Practical Guide, from those that are economically feasible and easy to implement, to the more complex solutions related with architectural or electrical/mechanical components, the application of which is not recommended to non-experts. The three deliverables are meant to supply solutions to a wide audience, with only a little overlapping among them.

These tools are the results of a thorough review carried out within the project to find the most effective way to forward the main message, that is seismic risk can be decreased by adopting adequate measures. Many documents addressing the topic of non-structural elements in its form of communication were consulted, such as Petal (2003), Earthquake Commission (2012), FEMA (2012) and FLASH (2017). The main message consists in four steps: get aware of the seismic hazard of your country and your place, estimate your risk due to non-structural failures in your environment (home or school), act and retrofit.

In this paper we describe the KnowRISK tools under the light of a critical analysis of their pros and cons. We also discuss on the effectiveness of these initiatives. Finally, since the tools are designed to take into account the cultural peculiarities of the three countries involved in the project, we also discuss on how they can be exported to other European countries.

## **2. KNOWRISK TOOLS FOR PREPAREDNESS AND COMMUNITY RESILIENCE**

### ***2.1 Practical Guide***

The Practical Guide aims to assist homeowners to locate non-structural issues in their homes and possibly fix them. It is a foldable printed brochure (Figure 1), an always-at-hand guide that can be distributed in strategic communication actions to reach the widest audience. The display of the practical solutions occupies the central focus of the leaflet. It has to be adaptable to different degrees of motivation, from passive interest toward active engagement. For this purpose, a detailed description of the problems and solutions using symbols and images for various specifications unfolds in the length of a polyptych with 8 panels.

The solutions have been grouped into categories representing a path, in four steps, from passive interest toward active engagement, to reflect the varied range of motivations found in public audiences and face the challenges of the resistance from the most suspicious. Each category has an associated colour, ranging from danger to safety such as Red, Orange, Yellow and Green, representing the shift in urgency

**If you live in an area prone to EARTHQUAKES**

**If you live in a seismic hazard prone area, whether you are at home, work or school, you are exposed to injuries, damage and long-term financial consequences.**

European Seismic Hazard map:

Source: European Seismological Commission, 2013

Be safer by taking measures before an earthquake occurs. Earthquakes cannot be prevented, but the damage and number of victims can be greatly reduced.

**How to prepare YOUR HOUSE**

**Damage occurs even when a building does not collapse**

Falling building components, heavy furniture or equipment, cause most of the damage, losses and injuries, during and after an earthquake.

**This guide shows you easy steps you can take for a safer house**

Starting at no cost and without any expertise

The following 4 steps provide progressive solutions that prioritize affordability and life safety.

1. Move
2. Protect
3. Secure
4. Retrofit

**YOU NEED** cost expertise

**1. MOVE your furniture**

Start by moving furniture. You can greatly increase your chances of safety and survival at no cost and with no expertise needed.

physical strength

- Avoid placing heavy objects above beds.
- Move beds away from windows and keep exit passages free.
- Always move heavy or fragile objects to lower shelves or low closed cabinets.
- Avoid sitting plants on top of tall furniture.

**YOU NEED** cost expertise

**3. SECURE tall furniture & heavy objects**

Identify large or heavy items that can pose serious danger when loose. What you need to secure them is available at most hardware stores.

- Picture hooks
- Hammer & nails
- Wall brackets
- Wall anchors
- Shelf holder
- Shelf edge
- Card edge

Use picture hooks, close after hanging. Heavy mirrors or pictures may need screw-eyes or chains.

Secure hanging items with slack cables. Provide space to swing freely, at least 45°.

Use pot holders or strap to the wall.

Fix tall wardrobes and bunk beds to the walls with brackets. Strutch cards in front of heavy books or other loose items on open shelves. Use resistant fasteners in drawers and cabinet doors.

**YOU NEED** cost expertise

**4. RETROFIT your house**

If you live in a high hazard area, retrofit critical elements. Consult a certified architect or engineer. The possible savings or pay-back are considerable.

For more details, consult the KnowRisk Solutions Portfolio: [www.knowriskproject.com](http://www.knowriskproject.com)

- Inspect gas lines, water plumbing and electrical systems.
- Verify balconies and chimneys for degradation signs.
- Opt for tempered or laminated glass.

**YOU NEED** cost expertise

**2. PROTECT your valuables**

Take further precaution by protecting valuables fragile or expensive enough to be a significant loss if it falls, with inexpensive and easy to use materials.

- Sliding film
- Shelves
- Restraint straps
- Shelving
- Self-stick mat

For lower heavier objects, use anti-slip mats.

Use adhesive pads or paste for fragile objects.

Install drapes or heavy blinds or apply safety glazing film to windows.

Fasten appliances with restraint straps. Opt for a TV monitor with mounting brackets.

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Seismic risk (having victims and material losses) in an area is the product of seismic hazard, the vulnerability of our buildings and respective contents, and the exposure (people and buildings).

Measures provided in this guide alone do not constitute a guarantee against any losses that may occur in future earthquakes and may not be applicable in all situations. Consult a specialist whenever necessary. You can find more information in the KnowRisk Solutions Portfolio and in the Short Guide for Students.

[www.knowriskproject.com](http://www.knowriskproject.com)

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**PREPARE YOUR HOUSE FOR AN EARTHQUAKE**

**PRACTICAL GUIDE**

Figure 1: Practical Guide inner side page (top), outer side page (bottom). Available at <https://knowriskproject.com/practical-guide/>

and risk. These are the colors often used for weather alarms and resemble those used in traffic lights; the public is already familiar with them and can intuitively estimate what level of safety has been reached. Thus, the Guide provides different levels of interventions to fix the potential non-structural dangers.

The basic stage of engagement of the public into preparedness is to suggest solutions that can be carried out by anyone at any time (red part of the polyptych). Some of the provisions do not even need hardware tools to be carried out. They consist in moving or rearrange furniture that may cause wounds or block the way out, and moving heavy or large items to the floor or low shelves. These are solutions that in fact can be executed by the residents, with minimal skills at almost no cost.

Then, in an ascending order of skill required and costs to be sustained, (orange and yellow areas of the guide), measures to fix, anchor, protect valuables and furniture are described. Icons intuitively show what kind of hardware is needed. They can be carried out by people with an average DIY skill level in fixing; most of the hardware needed is very easy to find and cheap. These suggestions are a collection of protective measures as results of the KnowRISK project or selected from guides and reports about earthquake safety, worldwide (Petal, 2003; Earthquake Commission, 2012). It also lists solutions conceived specifically taking into account the local culture and needs of each of the participating countries. Most of these solutions have been tested in the shaking table at LNEC - Laboratório Nacional de Engenharia Civil, in Lisbon. These tests have been filmed and made available to the public to give emphasis to the safety provisions.

Finally, for a complete safety especially in the areas where seismic hazard is high, more demanding retrofitting are also proposed (green area of the guide). They apply to electrical systems, gas lines, water plumbing and internal and external decorations. For these, seeking the help of a professional is recommended together with the reference to the Portfolio (described later in this paper), where more technical suggestions are collected and published.

The Guide is distributed to a varied and basically skeptical public, thus great care has been devoted to communication style since people act only if they had acquaintance with the potential dangers of their living place. In particular, the Practical Guide and the Students Short Guide make extensive use of visual content in order to reduce the text and capture the attention of the reader. To foster prevention, it is then necessary to provide basic information about the natural phenomenon and the associated hazard: some folds of the guide are devoted to education, information and additional support. In particular, the Initial front page has a cover image that quickly represents the concept – “discover, move, fix”. The text is limited to a slogan. An introduction gives a general overview and explanation of the guide and risk assessment. A hazard map, designed specifically for the public, helps people. Finally, the Acknowledgement and a disclaimer section displays the logos of the institutions and the list of collaborators and sources, the address of the web page, the name of the authors. The disclaimer reminds that applying the measures illustrated within the guide may not be enough to gain absolute safety. Given the cultural differences of each country, that in turn reflect in different lifestyles and customs, the disclaimer is a necessary reminder.

## ***2.2 Students Short Guide***

The second deliverable that we describe in this paper is the practical guide for the schools, namely a Students Short Guide (SSG). The main users of this tool are the students, however the suggestions contained in it aim at increasing, in a more general view, the safety in the households and school building, at least from the point of view of damage to non-structural elements. This is achieved through the education of the students as “observers” and the actions of both the students and the personnel working in the school through retrofitting operations at different levels. Sadly, it must be remarked that in some European countries school buildings are not completely safe; in some cases they are very old; they are often located in constructions built with a different intended use (buildings, monasteries, factories); in some cases the emergency facilities or those for the disabled have been added only when the laws make them mandatory; in some extreme cases, many of these buildings would not resist to a major earthquake. The SSG has a double task, being at the same time a reminder about the likely dangers and an interactive

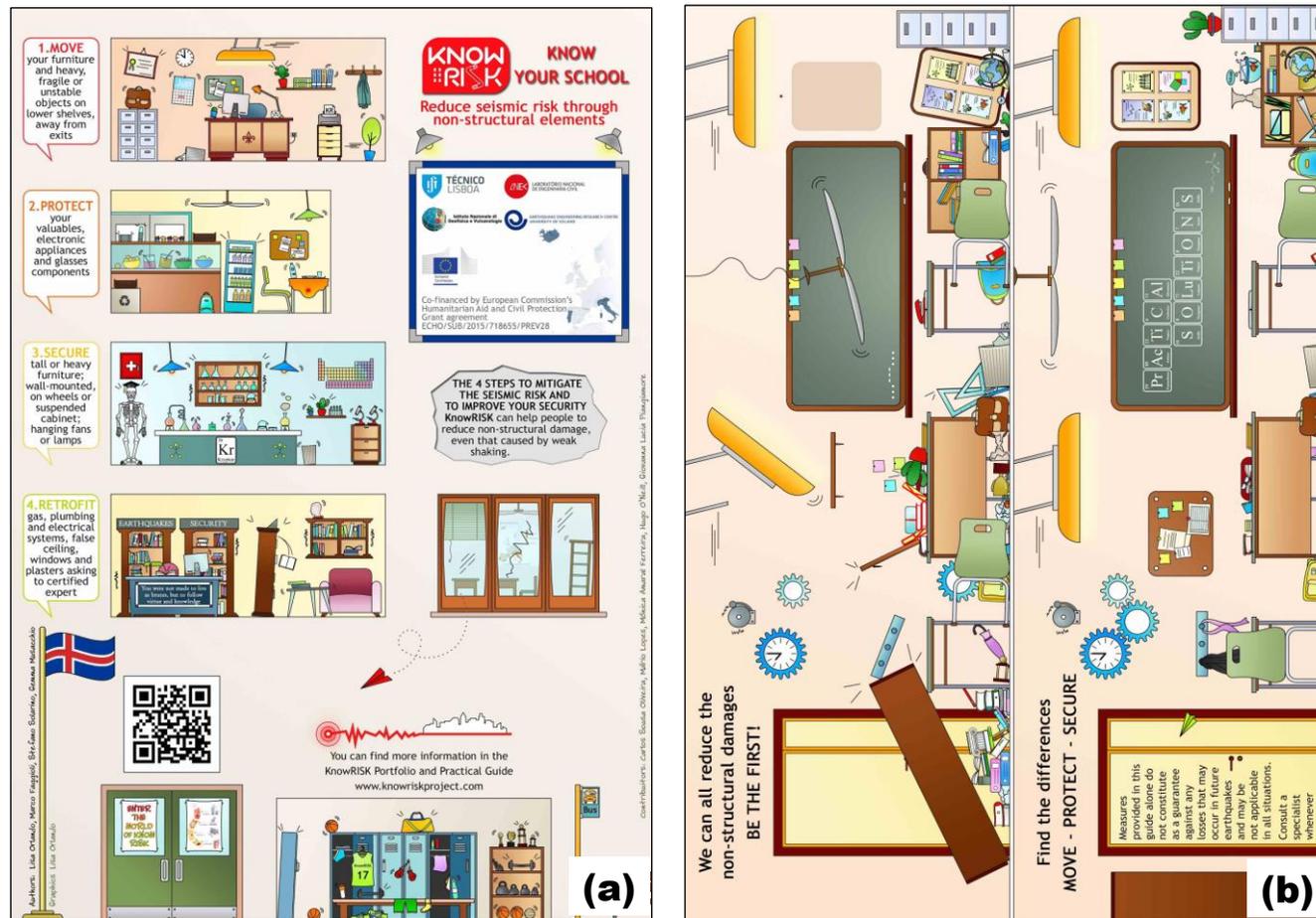


Figure 2: Students Short Guide: front page (left), rear page (right). Available at <https://knowriskproject.com/students-short-guide/>

game where the students can raise their awareness on possible non-structural elements failures during earthquakes.

The guide is printed on an A4 sheet and it consists of two situations: one specific for the house and another for the school. The house SSG consists on a front page with some of the environments that can catch students' attention: a living room, a balcony, a bathroom, a kitchen and a garage. The non-structural vulnerabilities "in actions" (meaning while the shaking strikes) recall familiar situations in a students' household. The other side of the page shows a teenager bedroom in two different frames, before and after simple mitigation solutions to non-structural vulnerabilities have been applied.

The school SSG has printed on one side typical environments of a school (the office of the dean, the canteen, the chemistry lab, the library and the gym) and on the other side a classroom (Figure 2). For each room some likely situations of non-structural vulnerabilities are shown, while text boxes describe what can be done, in general terms, to reduce them. This part of the guide aims at informing about threats especially those people that have an active role (school masters, teachers, janitors) in the school. Most of the suggestions to increase safety, in fact, need actions to be carried out by adults. The classroom is shown in two frames: top frame displays severe non-structural component damages after an earthquake shaking when no actions has been undertaken to increase safety; the bottom frame displays a safe classroom, where simple and careful actions for prevention have been applied and shaking causes only slight damage. Students are supposed to compare the two drawings and spot what measures have been undertaken to render the classroom safe. To cite just a few examples, the cabinet has been fixed to the wall to prevent falling and to avoid to block the exit door and the heavy objects have been placed on the lower shelves to refrain from breakage and cause wounds to the students in the room. The students can then discuss their solutions with the teacher or a researcher, motivating their choices. The philosophy behind this guide and the related activity is similar to the "learn by doing" approach, where taking decisions or making actions help to better understand and remember rules and suggestions. Although in this case the students do not make real actions but they only seek how to proceed, however we are confident that this kind of approach develops a critical vision of the environments where the students study or live, that is where they spend most of their time. This Student Short Guide as well as the Practical Guide are available in English, Italian and Portuguese at the KnowRISK website ([www.knowriskproject.com](http://www.knowriskproject.com)).

### ***2.3 KnowRISK Portfolio of Solutions for the reduction of seismic risk through non-structural elements***

KnowRISK Portfolio of Solutions aims at to alert building owners and occupants, engineers, designers, architects and other parties to the need to prevent poor performance of non-structural elements in earthquakes. This will help architects and MEP (mechanical, electrical and plumbing) engineers know which are the MEP elements requiring seismic design and some form of limitation of uses.

KnowRISK Portfolio of Solutions is a comprehensive publication which identifies potential earthquake hazards associated with non-structural elements of various types of stakeholders, namely, residential buildings, workplaces or schools, and a few common problems existing in critical structures. It further 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.

This Portfolio 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 et al. (2014), guides, reports, periodicals, and other sources dealing with reduction of seismic risk through non-structural elements. The non-structural elements is nowadays a topic of great relevance and continuous upgrading, and solutions for solving problems are coming from many sources and many enterprises are putting a great effort on solutions with the new materials and new technologies.

Different stakeholder groups have intrinsic different motivations, influence or interest (e.g., investment risk, operational risks, and market risks) for decisions relative to catastrophic hazard mitigation. The KnowRISK Portfolio of Solutions chooses two groups of stakeholders: "Owners and Facility Managers" and "Homeowners".

“Owners and Facility Managers” have a vision of the non-structural risks, in the perspective of an activity of support and management of spaces, administrative buildings and of operational efficiency through their customer services and contact center operations. Customer expectations are high, and they are less tolerant or patient with companies for dealing with problems. So, it was important in our in-person interviews to evaluate the stakeholder expectations and to know what information each stakeholder needs, which helps determine the best way to convey information to each group.

A total of 15-20 stakeholders contributed to this study. After a dedicated meeting made with each stakeholder, they were asked to collaborate, examining a list of main non-structural elements (about 50 elements) (Mota de Sá, 2017), choose which elements are more critical to maintaining production continuity, or hazardous if damaged. Their feedback was very helpful to balance and refine our approach and it includes the completion of the initial list of elements and the characterization of priorities on individual interventions.

### *2.3.1. KnowRISK Portfolio essential information*

A successful user portfolio of solutions provides users with quick answers to the questions that they might have about a particular problem/solution. Users searching for information don't want to know about the latest and greatest features of a product. Users want to know how to complete tasks. Here you will find a brief overview of the KnowRISK Portfolio of Solution contents. The emphasis is on providing short and practical advice - what the construction need to reduce or eliminate exposure to earthquake loss - but also interested in some details, that will especially be of use to homeowners, but to some extent also to architects and MEP engineers.

It is important to notice that for some facilities, the cost of anchoring, bracing or securing every piece of equipment can be high. In such cases, homeowners and facility managers should prioritize the need for protective measures based on whether shaking would result in significant damage, critical to maintaining production continuity, or hazardous if damaged.

The KnowRISK Portfolio of Solution is organized in a way that the user find it most beneficial.

The first section includes general information about earthquakes, presents the basic concepts related to this natural phenomenon, along with the manner in which the potential hazard in our surroundings behaves during an earthquake. This section is meant to use very simple language but with accuracy in the presentation of concepts. Links to more mathematical oriented explanations are given along the text. The second section refers to protection measures. It provides just enough information so that the user can complete a task or understand a concept, and a list of the main non-structural elements is provided. Each non-structural element has a separate A4 page (Figure 3) with the following structure: i) name of non-structural element; ii) typical causes of damage, which may include a picture taken from an earthquake event; iii) technical solutions to reduce seismic risk; iv) 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. These icons are placed at the beginning of the sheet where the user will see them right away. This will help the reader for an easy access of information and help in taking printouts.

2. Hazardous materials storage such as chemicals (labs, pharmacies, schools)			
Stakeholder	Life safety	Property loss	Functional loss
			
Solution/ Expertise	Repair time	Costs of strengthen	
			

#### Typical causes of damages

Unsecured or improperly stored hazardous materials resulting in a release may close businesses located in an otherwise undamaged building. It poses health and safety risks to students, school employees and the environment.

#### Recommended methods

Secure furniture to walls using L-brackets.

Chemical storage shelving must have shelf lips or other restraining devices (e.g. lip, wire or bungee cord along edge) or front panel plates and vertical spacers installed to prevent chemicals from falling.

Seismic netting holds small, light-weight items.

To prevent accidental mixing of chemicals, incompatible materials must be segregated properly. Relocate heavy items or volatile chemicals to floor mounted cabinets.

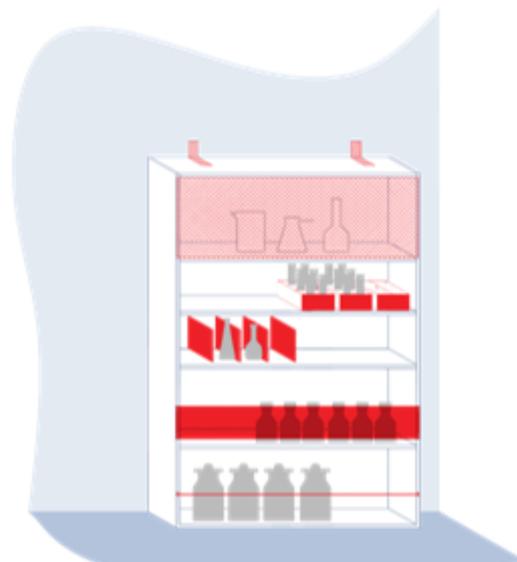


Figure 3: KnowRISK Portfolio snapshot. Available at <https://knowriskproject.com/portfolio/>

### 2.4 KnowRISK Video Awareness Campaign: “Move, Protect & Secure”

A series of earthquake simulations were performed in a 3D shake table at LNEC – Laboratório Nacional de Engenharia Civil, in Lisbon (Candeias et al, 2017). The simulations were performed in a full scale bedroom and used signal data collected from real earthquakes that took place in Iceland.

The tests were recorded on camera, and the footage was used for a video awareness campaign aimed at to improve knowledge and behavior related to non-structural risks and to motivate preparedness actions.

Most shake table tests available to the public in film have an obvious appearance of a staged set, building distance between the viewer’s own reality and that of scientific testing. To portrait a reality recognizable by anyone as their own accommodation and housing, a typical teenage-bedroom was recreated in detail, filled with objects serving both as potential falling elements and as metaphors for the typical stages of anyone’s lifetime of dreams, hopes and responsibilities.

#### 2.4.1 Move, Protect & Secure – teasers spots

The video format was taken advantage of, as an effective medium for easy sharing and viral spreading, fitting to an awareness campaign.

The campaign is composed by a main short length film, accompanied by four teaser-spots.

The main focus of the message in the campaign is to acknowledge seismic risk and that just by taking simple and inexpensive measures you can reduce non-structural damages.

The teasers try to convey this message to the slogan “Move, Protect & Secure”, making it easy to remember and share (Figure 4). The spots length is around 30-40 seconds, fitting into the short span attention of passive viewers, increasing the chances to reach a broad audience, and capture the interest to view the main film.

The “Move, Protect & Secure” motto, is based on 3 of the main steps defined in the Practical Guide, those that require the least effort and cost. The steps are a direct echo of what was captured in film during the shake tests, the comparison of consequent damages in furniture during an earthquake, when retrofitted and non-retrofitted. One of the spots presents the full range of the three protective measures, and the other three present them in separate. The messages are in Portuguese and were translated into the two official languages of the project: English and Italian.

These four-videos were placed on several online platforms and partner websites (schools, key government officials and business leaders).



Figure 4: “Move, Protect & Secure” video screenshot  
(<https://www.youtube.com/channel/UCQng71zMIJE0PeVHP9ktWlIQ/videos>)

#### 2.4.2 Move, Protect & Secure – General

A short length documentary (15 min) was produced and focuses on the need of reducing disaster risks. It presents the scientific and educational aspects of the shake table experiences, through interviews with KnowRISK experts who are familiar with the subject, as they explain the importance to reduce seismic risk through non-structural elements, expand about the test findings, and give details about the advised protective materials, where to find them and the importance of regular checking. The testimonies are interweaved with behind the scenes images documenting the whole process of the filmmaking.

To refine and finalize the intervention, it could be interesting to test the videos campaign effectiveness.

### 3. DISCUSSION AND CONCLUSIONS

KnowRISK project is always looking at different ways to significantly increase resiliency of communities. All the tools described in this paper (Practical Guide, Students Short Guide, Portfolio of Solutions and Videos) had been used during KnowRISK interventions (interactive discussion groups or teaching) and appeared to be promising methods to increase knowledge and risk communication among various stakeholders. We should emphasize the importance of the Practical Guide and the Students Short Guide, which are already finalized products, for their impact in society and the remarkable way they were received by many stakeholders. The other products (Portfolio of Solutions and part of Videos) are still under preparation and we cannot tell which will be their impact, even though many stakeholders are placing great expectations on them. They are all products that answer to needs of having clear

distinctions between what is non-structural and what is structural as well as a indications on when people can rely on their abilities to improve safety (i.e. Move-Protect-Secure) and when people need intervention of an expert (i.e. Retrofit). These were the major demands from our stakeholders.

#### 4. ACKNOWLEDGMENTS

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