

Using non-structural mitigation measures to maintain business continuity: a multi-stakeholder engagement strategy

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Abstract

Encouraging property owners and individuals to adopt mitigation measures to improve the resilience of their buildings and equipments to seismic hazard has been a major challenge in many earthquake-prone countries. Few business leaders are aware of the fragility of their supply chains or other critical systems due to earthquake hazard. Bridging the gap between research production and research use is another crucial challenge for the earthquake risk research process.

The KnowRISK project outcome is aimed at encouraging the proactive engagement of multi-stakeholders (community at large, schools, business community and local government groups) undertaking non-structural mitigation measures that will minimize earthquake losses to individuals and communities. Engaging stakeholders, taking into account their needs and inputs to maintain critical and urgent business activities, can contribute to the research findings and ensure that our data collection is thorough and complete. Engagement with stakeholders, during the whole process can lead to improved outcomes and for the development of viable solutions, for business and society, because of stakeholder's role and influence within the organizations.

Keywords: Business Continuity; earthquake; resilience; non-structural elements; critical infrastructures.

This paper gives a brief overview, tools and ways to communicate and interact with multi-stakeholders throughout the stages of the research process: problem formulation, knowledge generation and communication of results.

1. Introduction

“Earthquakes do not kill people, buildings do” is often heard and we have learned this the hard way. Many citizens are largely unaware that buildings may sustain structural damage but are designed to remain standing after an earthquake. New buildings can be constructed to withstand tremors caused by an earthquake of a certain magnitude. Older structures can be retrofitted to make them earthquake resistant up to a certain extent. In both cases such buildings may develop cracks when shaken by an earthquake, but would not collapse or fall apart. However, it is important to notice that the damage of building contents and non-structural elements (NSE) are responsible for 60-70% of injuries occurring in earthquakes. Earthquake risk can be associated both with the structures as well as with non-structural elements, once structural deformation and acceleration are responsible for triggering non-structural damage. Damage to NSE constitutes a large portion of loss due to earthquakes, and the loss can be up to 85% of total construction cost of commercial buildings [Sankaranarayanan, 2007]. Recent earthquake losses from damage to NSE in countries having codified seismic design provisions have far exceeded losses from structural damage [Filiatrault and Sullivan, 2014].

A good performance of NSE during earthquakes is imperative, to save lives and reduce material losses, and to keep buildings functional after an earthquake; it relies on well-managed processes during the design, procurement and construction project phases.

In order to achieve this goal, it is important to:

- a) identify what sorts of information and knowledge on non-structural risk that different stakeholders and companies need;
- b) provide an accurate measure of vulnerability, since a group’s perceptions of their own vulnerability might be inaccurate and,
- c) provide information and tools tailored in such a way as to meet stakeholders needs.

The KnowRISK project (Know your city, Reduce seismic risk through non-structural elements), co-funded by the European Commission, was implemented in three different countries (Portugal, Italy and Iceland), with different seismic risks, and different people’s earthquake risk perception and preparedness. In Lisbon (Portugal), for example, there is a substantial skepticism about earthquake risk (and the known risks - to life, property and overall economy). The common belief is that earthquakes will occur many years in the future, because these events do not happen very often. Part of the danger comes from the types of buildings that are old and built before modern building codes that may make them a hazard today. In Portugal, citizens and the business leaders are not aware of the earthquake risk and its serious consequences. In Italy, the situation is different in the level of earthquake hazard and awareness towards risk. In Iceland the situation is even more different as, even though the hazard is not low, the risk is low due to a great deal of awareness and preventive policies and practices.

Under KnowRISK, formulated and implemented stakeholder engagement framework was devised to enhance knowledge of target groups; to learn about their needs, concerns, and beliefs regarding non-structural seismic preparedness and mitigation; to provide information on how damages to NSE will affect the operation of their facilities, and to develop non-structural mitigation measures to protect business continuity.

A framework synthesis and the results of risk communication with business stakeholders (suppliers and vendors) are presented in the present paper. The risk communication methodology involved interviews with KnowRISK stakeholders and focus groups. This approach was useful for various aspects of the project such as conducting needs assessments, preparing and validating risk communication tools and mitigation strategies. Although not suitable for generalization, the methods and results of this engagement can provide valuable insights into “giving voice” to the stakeholders, in terms of giving importance to their feedbacks, and involving them in increasing awareness, risk communication and mitigation actions.

2. Methodologie

The risk communication methodology followed under KnowRISK project comprehends: (i) the selection and diagnosis of pilot-areas in terms of seismic history, level of hazard, its prevalence and the related vulnerability and, (ii) the selection of relevant stakeholders with different backgrounds and experiences. The assessment of needs-

obstacles-priorities of local communities and selected stakeholders followed a qualitative action-research strategy. This is a type of strategy that puts emphasis on dialogue [Bryman, 2004] and is adopted when the researcher has great interest in understanding the interviewee's point of view. Compared to quantitative inquiry techniques, qualitative techniques are more flexible. For example, individual or group interviews provide more opportunities for the researcher to go deeper on certain subjects or to introduce new questions that follow up interviewee's replies [Bryman, 2004]. Although the methodology is based on dialogue, its form and platform were different in the diverse pilot areas. In Portugal, stakeholders' point of view was approached through individual semi-structured interviews. Italy adopted a mix of individuals' interviewing techniques and focus groups. In Iceland, the dialogue was organized in the form of a session of interaction among experts and stakeholders.

The KnowRISK main objectives of an interactive communication with stakeholders are:

- a) to know the views and concerns of a variety of stakeholders, from all sectors and elements of the community, about earthquake risk and non-structural vulnerability that might cause injury and temporarily affect the use of buildings and infrastructures, resulting in a loss of function;
- b) to prepare and validate KnowRISK supportive risk communication materials considering stakeholders' opinions, issues of interest and strategies to minimize damage and business interruption;
- c) to foster knowledge and awareness about non-structural risk mitigation.

The KnowRISK research team designed and used different tools [Ferreira et al., 2018a; Solarino et al., this issue], which were essential to share information with the stakeholders and contribute to the success of the project. It is important to recognize that different types of communication are necessary and, choosing the right tool for each type ensures that the information exchange happens as smoothly as possible. The first tool developed was the Practical Guide (PG) prepared for citizens, and the second one the KnowRISK Portfolio of Solutions prepared for business communities. This paper describes the contribution of stakeholders for these communication tools.

Stakeholders were selected on the basis of purposive sampling procedures¹. This is a common strategy in qualitative action-research approaches where the researcher proceeds with a selection of people to interview on the basis of research aims and questions. In this type of procedure statistical representativeness and generalization are clearly impossible. As such, it is not even an issue since what the researcher looks for is to create opportunities to go deeper on a certain topic with interviewees and become aware of all the details and personal views independently of the number of times they are referred by the researcher.

In the following sections, a brief characterization of KnowRISK pilot-areas will be pursued jointly with a more detailed description of the adopted qualitative interviewing techniques and contributions to the tools development.

2.1 An overview of KnowRISK pilot areas

The project actions were implemented in three countries: Portugal, Italy and Iceland. The city of Lisbon in Portugal, villages around Mt Etna Volcano and other localities in northern Italy, and South Iceland Lowland are the pilot areas of KnowRISK project.

The pilot areas differ in terms of earthquake recurrence, exposure to hazard, experience from recent earthquakes, and vulnerability of citizens and infrastructure. They have distinct histories of disaster experience and what stands out is the contrast between the Portuguese case, where disaster experience is remote, and Italian and Icelandic cases, where disaster experience has been recurrent in the past decade.

In Continental Portugal, the latest seismic experience dates back to the 1969 M_w 7.5 earthquake that occurred along the Azores-Gibraltar fracture zone, about 230 km SW of Lisbon. There were very few victims and most of the economic losses in Lisbon were due to non-structural damage.

Lisbon has 552,700 inhabitants [INE, 2012], which doubles during working hours, distributed in 24 parishes. Many buildings in Lisbon, especially those built before the introduction of the first seismic code in 1958, are seismically vulnerable. Seismic risk is perceived as something distant in Lisbon inhabitants' social memory and has low degree of intrusiveness in their daily lives, in part, due to the infrequent nature of damaging earthquakes.

¹ Purposive sampling, also known as judgmental, selective, or subjective sampling, is a form of non-probabilistic sampling in which researchers rely on their own judgment when choosing members of the population to participate in their study.

In Italy, damaging earthquakes have been frequent in the recent years. The most recent ones are the 2016 Amatrice-Visso-Norcia sequence (M_w 6.0, 5.9, 6.5) in Central Italy and the 2012 Emilia sequence (M_w 5.9 and 5.8) in Northern Italy. In the worst hit areas, building collapse has been common, and structural damage is extensive. The 2012 Emilia earthquakes, however, caused mostly non-structural damage in an area where the population was not aware of seismic risk.

Ferrara is a city of 130,000 inhabitants located in the northern Italy pilot area. It has an urban fabric typical of many ancient Italian cities. It is a UNESCO World Heritage Site. Streets alleys and pedestrian paths date pre-14th century, and non-structural- architectural elements of old buildings pose risk to the citizens. Flood hazard has been of most concern to this city in recent years.

In Iceland, recurring strong earthquakes (since 2000: M_w 6.5, 6.5 and 6.3) have contributed to a high level of awareness in the local communities [Bernharðsdóttir et al., 2015]. Although significant ground shaking occurred in the South Iceland Lowland during these earthquakes, residential buildings had no severe structural damage [Bessason et al., 2016]. Damage was mostly non-structural. During the earthquakes in June 2000, many inhabitants found it difficult or even impossible to move to a safe place inside their dwellings [Sigbjörnsson et al., 2018].

The South Iceland Lowland is the largest agricultural region of the country. It contains many small towns and villages as well as critical infrastructures. In comparison to the other pilot-areas, disaster risk management is more integrated in people's routines. Research on perceived and observed residential safety in the aftermath of recent earthquakes [Akason et al., 2006] reveals high-risk awareness and knowledge on safety procedures among citizens.

Since the three pilot areas differ a lot in terms of both seismicity and socio-cultural aspects and risk communication needs, the methods adopted in these areas had to be diverse. Low intrusiveness of earthquake-related experience in the Portuguese pilot-area required a thorough and longer risk communication protocol, with more encounters between the experts and selected stakeholders. In Italy, the focus was on lessons learned from municipalities that recently experienced essentially non-structural damage. The focus in Iceland was to communicate the upcoming research and products of the KnowRISK project to selected stakeholders, ask for their feedback on these products, and to understand their approach on managing risk.

2.2 Identify the stakeholders

A project is successful when it achieves its objectives and meets or exceeds the expectations of the stakeholders. Stakeholders are all participants (single individuals or organizations) with interests in the topic being considered and those whose jobs or lives might be affected and their input can directly impact the project outcome. It is important to identify the project key participants, to understand their individual characteristics and interests and know how the project will affect their problems and needs. The key business stakeholders who participated in the KnowRISK project are owners, facility and financial managers and professionals. It is important to note that not all stakeholders will be influenced or affected in the same way by future earthquakes, but all of them are concerned with the protection of business services and operations in order to maintain business continuity. It is therefore important to understand their opinions, interests and concerns as well as their willingness to take mitigation actions. Information collected from them was used to prepare the KnowRISK Portfolio of Solutions [Ferreira et al., 2018b].

3. Understand the needs of stakeholders. Engagement process

Understanding the expectations of stakeholders was absolutely critical to the project success. In Portugal face-to-face interviews were conducted during the project with high profile stakeholders, including agents in building industry, as well as owners and operators of critical infrastructures. The outcomes from the interviews and information collected provided an opportunity to build the KnowRISK Portfolio of Solutions (available: <https://knowriskproject.com/portfolio/>). Other stakeholders were the Alvalade and Olivais Parish Councils, representing local authorities.

In the Italian pilot areas, in addition to one-to-one semi-structured interviews, focus groups and checklists were used.

In Iceland pilot-area stakeholders' engagement was organized in a special session of specialized talks from the

KnowRISK researchers, followed by general talks with various stakeholders including local government, school headmaster, building authorities, and consulting engineers.

It is interesting to note that, in general, lack of knowledge (which entails basic knowledge and education) on earthquakes and non-structural problems implies a lack of perception and awareness amongst stakeholders and general public.

3.1 Business groups and preventive measures for business continuity

Every business faces risks that could present threats to its success. Engineers in all locations must be aware of, and comply with, earthquake protection regulations. In critical applications, such as communication or healthcare facilities, NSE must be successfully applied to go beyond surviving an earthquake in order to remain operational after the event is over. For that purpose, the KnowRISK Portfolio of Solutions was developed to alert and provide detailed instructions and guidelines, to building systems designers who do not have a detailed knowledge of seismic engineering, to prevent poor performance of NSE in seismic events.

In the Portuguese pilot-area, the majority of stakeholders involved are key players with important operational and economic activities, representing a significant part of the Portuguese economy. The stakeholders were selected due to the importance of goods and services they provide and the impact that a serious disruption affecting them can cause to the economy and supply of basic goods and services. Table 1 presents a large group of stakeholders in Portugal who were interviewed during this process.

The stakeholder involvement took place through a dedicated meeting made with each stakeholder, with 1-6 representatives of each of these organizations with different fields or expertise. The meetings were in-person interviews, of one-hour duration. For each meeting a roadmap was prepared according to the topics that each stakeholder would probably be more interested in. The KnowRISK project and its products, such as the Practical Guide and Move, Protect and Secure video campaign (Ferreira et al., 2018a) and a preliminary version of the KnowRISK Portfolio of Solutions, were distributed and discussed with them.

For a better understanding of stakeholders' expectations and priorities, potential losses and business interruption due to non-structural damage were presented and a list of questions was used to help to determine the best way to convey information to each group:

- i) What are the main problems/concerns regarding NSE to your company's operations?
- ii) Which NSE's are critical to the continuity of your business?
- iii) What are the interventions available to reduce non-structural risk?

The KnowRISK Portuguese team identified the goals and important factors (Table 1) which help them gauge the level of risk and an interactive process of exchange of information and opinions among experts and business groups was established, through individual interviewing.

Stakeholders were also asked to collaborate, examining a list of 40 NSE classified with a hierarchy based on a Cost-Benefit Approach (CBA) [Mota de Sá, 2017], choosing which elements are more critical to maintaining production continuity, or hazardous if damaged. The stakeholder's 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. Finally, the KnowRISK researchers visited some facilities of these organizations and identified *in-situ* vulnerabilities and good practices.

The expectations and interests of all key stakeholders/interested parties were taken into account and documented. In general, owners and facility managers care very much about their facilities and equipment (protect their investment), service availability and uninterrupted services, job security and recovery capability. The companies that give more importance to people's safety are those which have a large concentration of individuals (customers and employees) or must ensure that the service is guaranteed 24h/24h (e.g. super- and hypermarkets, call centers) [Ferreira et al., 2018b]. Another concern is related with interdependencies; many companies have subcontracted companies for some specialized services. In addition, these are not always obliged to cope with earthquake resilience, as this issue may not be included in the contract specifications. This is often the case of call centers that are subcontracted to specific organizations and are vital to the functioning of the companies. Earthquake resilience measures should be addressed when contracting outsource services.

Although organizations seem to be concerned with the topic and how it could impact on their facilities and business activities, the earthquake risk reduction did not yet become a relevant part of business planning. Unfortunately, not all companies give value to the opportunity to minimize exposure to earthquake risk or to build their businesses more resilient, because mostly don't know how to do so. Today's companies are focus on financial performance management and short-term return, forgetting what is changeable, unpredictable, and improbable, which is critical to their long-term success and recovery after an unanticipated stress. A company must adjust to new realities and seek advantage in promoting resilience in the business strategy and in marketing campaigns ("earthquake-proof" slogan or stamp, for example).

Finally, these organizations were kept informed of the state of preparation of the relevant guidelines and were invited to participate and present their main concerns in the Final KnowRISK Conference (December 11, 2017). Stakeholders' (EDP, Metro, Siemens, CP and Junta de Freguesia de Alvalade) presentations were an opportunity to voice their concerns, views and perceptions on the topic and possible steps to take forward.

Stakeholder	Sector	Concerns	Feedback
CP Comboios de Portugal	Transportation	CP is concerned with stations, trains and traffic. All placards with information to the public should be functioning in rush hours or when announcements are needed. The access to the platforms to enter the station and the cars is of great concern as well. Another concern is with all the old buildings that still house a great number of services, stores, etc, (architectural elements and building contents).	List of NSE with their prioritization sent to KnowRISK Team.
CTT Correios de Portugal	Postal industry	Lighter piping's coming from the top roof (Solar Tubes), a new technology they are not prepared to deal with in case of shaking.	Used "Move, Protect and Secure campaign" to disseminate internally the main findings of KnowRISK.
EDP - Energias de Portugal	Electricity	Electric substation equipment, power distribution lines and many pieces of lower voltage electrical equipment are of major concern, such as the EDP main building (architectural elements and building contents).	EDP identified the non-structural elements that can cause major damage in its facilities and provided some technical solutions to the problems.
EPAL - Grupo Águas de Portugal	Water	Architectural elements and building contents.	List of NSE with their prioritization sent to KnowRISK Team.
IKEA Portugal	Furniture retailer	Existence of very high shelves (storage racks), full of heavy products and without any seismic restraints, presenting a high risk to the customer and staff. It is of utmost importance to implement products restraint systems.	IKEA Portugal objectives do not contemplate earthquake threat to NSE. Unfortunately, IKEA does not take advantage of their restraint kit and other solutions, in their marketing campaigns, to boost earthquake education and prevention.
IP - Infraestruturas de Portugal	Transportation (roads, railways, bridges, tunnels, as well as trains)	Main concern is the functioning of most arches of their lifelines, ensuring continuity when operations are disrupted. Another concern is related with the system's catenary and breaks in the contact wires.	List of NSE with their prioritization sent to KnowRISK Team.
Jerónimo Martins	Food distribution	The main problem in their stores is related to the shelves, rack storages and suspended ceilings. It is important to secure shelf items and to implement restraining systems to prevent the fall of goods.	Jerónimo Martins applies textile ducts for air conditioning in their supermarkets instead of traditional spiral or rectangular steel ducts, which is a good protective measure.

Metropolitano de Lisboa	Transportation	Metro stations.	Identification of the main NSE that can cause major damage in its facilities and design of significant technical solutions to the problems. Some of these solutions were considered in the KnowRISK Portfolio of Solutions. To celebrate the International Day for Disaster Reduction 2018 (from 12 to 26 October), the Portuguese KnowRISK team and the Metropolitano de Lisboa decided to launch an advertising campaign in subway metro using 350 posters (A3 format).
NOS communications and entertainment group	Communications	Call centers are the major concern.	List of NSE with their prioritization sent to KnowRISK Team.
PT-Altice	Communications	Call center with all facilities, store racks, computer racks, electrical transformers, suspended ceilings, control tables and man-power, all this is inside the same huge room. Large computer screens, table computers, large window panels, etc. complete a short list of important equipments. Outside they need antennas (on top of high buildings or communication towers on the floor) and all systems need a great deal of redundancy.	NSE resilience towards seismic risk has not always been considered a top priority for the company. Nevertheless, a set of good practices are already in place. For example, equipment racks are fixed with screws, electricity transformers have locked wheels and flexible connections are used in pipes.
Siemens	Industry (transformers, gas turbines, control centers, etc.)	Siemens is committed to compliance with seismic regulations.	Information on NSE performance is of most interest for them. Earthquake resilience is considered in their offices and in their products.
SONAE MC	Food distribution	Shelves in their stores are not fixed to the floor or to strong walls. Their policy is to renovate frequently their store layout.	List of NSE with their prioritization sent to KnowRISK Team. SONAE applies textile ducts for air conditioning in their supermarkets instead of traditional spiral or rectangular steel ducts, which is a good protective measure.

Table 1. List of Portuguese stakeholders, their concerns and feedback.

3.1.1 Stakeholders contributions to the KnowRISK Portfolio of Solutions

The main goal of KnowRISK Portfolio of Solutions is to help architects and MEP (mechanical, electrical and plumbing) engineers know which elements require design and seismic restraint. These seismic restrains requirements can apply to almost any building regardless of occupancy type, particularly buildings that provide essential services in case of disasters.

The KnowRISK Portfolio of Solutions is based on a rational classification of NSE elements (architectural elements, building contents and MEP elements), which considers performance and consequences of damage. Information from several sources [FEMA 2005, 2012; Porter et al., 2014, including stakeholders' opinions] was collected and a list of 120 NSE was compiled. Each one of the NSE was then ranked in terms of their relevance in

categories, such as Life Safety, Property Loss, Functional Loss, Expertise needed for risk mitigation, and potential financial cost of mitigation (Figure 1). Level of expertise was classified as DIY (Do It Yourself), non-engineered solution implemented by a tradesman, and engineered solution. Stakeholders (association of engineers in Sicily, Italy, and the 12 companies in Portugal) were asked to rank the NSE included in the portfolio. In detail, in Italy this procedure was entrusted to “Officine Ingegneri Catania”, a free association of structural engineers based in Catania (Sicily, Italy) who were asked to fill in the rightmost column in Annex 1. The Italian stakeholders are represented by a skilled feedback group of experts: they were asked to rank the proposed NSE list in terms of priority, following their own field experience. Their survey also refers to current Italian laws.

A cost-benefit analysis (CBA) was performed to rank technical solutions to reduce seismic risk, considering “cost of intervention” and “impact on risk reduction” [Philips and Bana e Costa, 2007]. This procedure helped in ranking risk mitigation of NSE in residential buildings, workplaces and classrooms: the 47 most important NSE elements were included in the KnowRISK Portfolio of Solutions. Knowing which NSE are most important or present a potential risk to each stakeholder involved in the project, was relevant to identify and define the various solutions suggested. Figure 1 illustrates the general page layout of each NSE and the preventive measures to reduce seismic risk in an A4-size.

All the solutions are available at <https://knowriskproject.com/portfolio/>.

Figure 2 shows a part of the list of 47 NSE ranked by the stakeholders in Italy and Portugal. The priorities are ranked as High (H), Medium (M) or Low (L). The “KnowRISK Priority ex-ante” is based on CBA. The results show that different stakeholders have different priorities. For example, engineers (Italian case study) are more concerned with Life safety, but assign Medium priority of intervention to non-life-threatening elements such as “large computers equipment, data centers, computer rooms”. The stakeholders from Portugal, being owners and operators of businesses and critical services, assign high priorities to these elements. Physical damage to servers and IT equipment will likely result in loss of business and serious disruption of public services, as correctly identified by the stakeholders. The same reasoning applies to computer access floors. It is important for business owners and operators but not for homeowners and schools.

It should be emphasized that non-structural seismic hazard mitigation solutions can only be effective if the building itself is relatively damage-resistant during earthquakes. If a building, however important to the community, is highly vulnerable (may get significant damage or collapse in earthquakes), undertaking non-structural mitigation solutions for the building will most likely not be viable or cost-effective. Bolting a bookcase to the wall, for example, is not worthwhile if the building collapses.

The Icelandic stakeholders’ feedback was of most value not only to test the Practical Guide, but also allows to include stakeholders’ concerns and needs in the KnowRISK Portfolio of Solutions, which was finalized in March 2018.

The action in Iceland was a panel discussion with stakeholders in the KnowRISK Special Session at the International Conference on Earthquake Engineering and Structural Dynamics, June 2017 (<https://icesd.hi.is/>). A total of six stakeholders were invited to listen to KnowRISK presentations and gave a 5-10 min talk on their perspective of earthquake damages, in particular on non-structural components, under a session called: Discussion with Stakeholders. Upon arrival at the Conference Hall the stakeholders were given a copy of the Practical Guide [Ferreira et al., 2018a]. The stakeholders represented the following institutions and perspectives:

- Mayor of a town in a seismically active area that has been hit by both moderate (between M5 and 6) and strong (between M6 and 7) earthquakes.
- Icelandic Standards (IST), the national standards body of Iceland. It is an independent association whose role, by law, is the publication of Icelandic standards and the representation of Iceland in international and regional standards bodies. The person representing IST at the KnowRISK Conference was a member of the building sector committee that operates under the auspices of Icelandic Standards.
- Iceland Construction Authority. The Iceland Construction Authority is in charge of matters regarding building regulations, fire safety, and electrical safety.
- An Engineering Consultant.
- Head master of a primary and secondary school in a seismically active area that has been hit by significant earthquakes during school time.

1. Heavy flat-screen TV and panels monitor walls

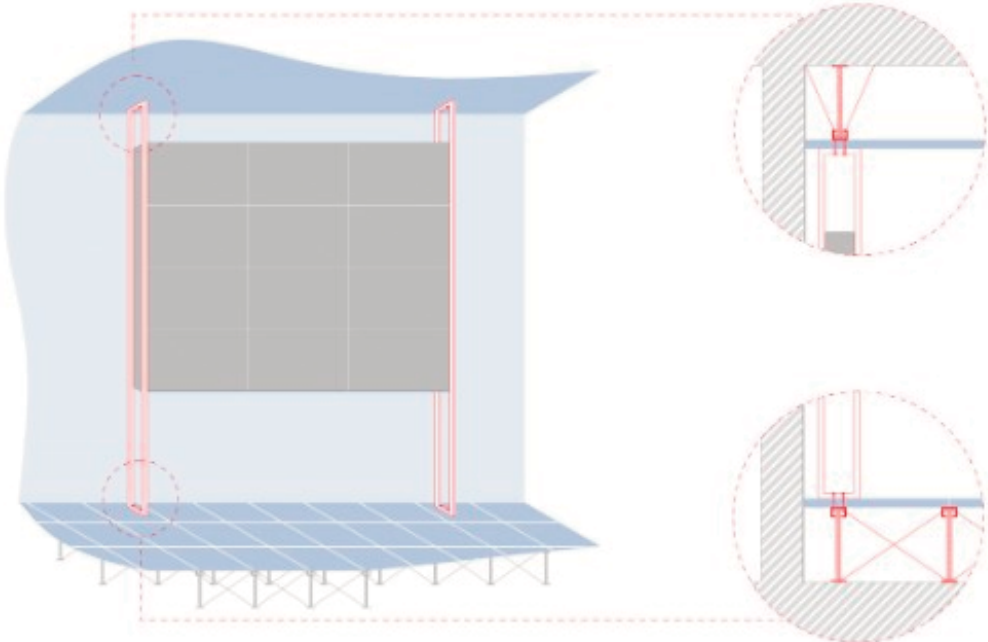
Stakeholder	Life safety	Property loss	Functional loss
			
Solution/ Expertise	Repair time	Costs of strengthen	
			

Typical causes of damages

Flat-screen TV's and monitors, especially large ones, could easily topple during an earthquake, causing a range of injuries. Sometimes injuries are severe enough to be fatal.

Recommended methods

Connect heavy flat-screen and panels monitor walls to the floor and ceiling. Floor slabs and free access floor panels are not connected, so heavy video monitors cannot be secured only to the floor panel. To secure furniture and floor slabs, insert reinforcing materials under floor panels and sandwich the panel using long anchor bolts (see raised access floor).



Technical drawing by M.Vicente

Figure 1. Example of KnowRISK Portfolio of Solutions layout.

No.	NSE Class	KnowRISK Priority ex-ante	Stakeholder Priority (Italy)	Stakeholder Priority (Portugal)
1	Heavy flat-screen TV and panels monitor walls	H	H	H
2	Hazardous materials storage such as chemicals (labs, pharmacies, schools)	H	H	-
3	Large computer equipment, data centers, computer rooms	H	M	H
4	Fire extinguisher and cabinet	H	H	H
5	Air diffusers	H	M	H
6	Tall shelving – typically 150 cm or taller	H	H	H
7	Tall file cabinets and furniture	H	H	H
8	Heavy light fixtures	H	M	H
...
47	Computer access floors and equipment	M	M	H

Figure 2. Ranking of the NSE priority (only a few shown here) by stakeholders in Italy (association of engineers of Sicily) and Portugal (NOS communications and entertainment group, Metro and EDP). (H= High; M=Medium; L=Low).

The Mayor stated that it was reassuring that buildings did not collapse during past strong earthquakes. But since they did not collapse, it has become clear that falling objects are the hazard that people should be focus on. In Iceland, hot water is pumped directly from the ground from geothermal hot water sources. Natural hot water is not potable due to sulphur and other chemicals. During the earthquake, due to damage in the pipelines, hot water got into the cold water system. Bottled cold water was therefore brought to the town and distributed for free at distribution stations.

The Mayor also pointed out that fashion trends in furnishings have shown to influence the level of damage to building content. Nowadays, kitchen cupboards have doors that open out, and pointed out the need for special fasteners to stop them from opening during earthquakes. The Mayor also pointed out the vulnerable practice of fastening heavy furniture to gypsum sheets used for partition walls, many of which failed in the recent earthquakes in South Iceland. The KnowRISK practical guide was very well received by the mayor (available in English, Portuguese, Italian and Icelandic: <https://knowriskproject.com/practical-guide>).

The representative of the IST clarified that the level of precautions taken within the design process depends on the elements at risk. For building contents there are only guidelines, no standards. Standards are created by the industry itself. When stakeholders within the industry believe that there is a need for a standard, they contact the national body, which organizes the work. The people who participate in the development of the standards are offered pro-bono from their employers. Therefore, the cost for the Standards institution is at a minimum.

The Construction Authority has nothing in their standards about how to fasten or deal with non-structural components. However, a conference on the matter, such as the KnowRISK session, was found to be very useful in increasing stakeholder awareness of the importance of non-structural damages during earthquakes, especially when structural integrity is maintained. It was obvious to the representative from the Construction Authority after having attended the KnowRISK session that the Construction Authority should have and apply guidelines for non-structural damages.

Discussion and conclusions

An important strategy for managing risks and exploiting opportunities for building a resilient business involves stakeholder engagement and communication with other players, such as academia/researchers. Engagement and communication are essential; not only to share good practice and showcase successes, to provide technical inputs, but also to understand priorities and shortcomings, and to explore what lessons can be learnt from both. This was the way we were able to re-adapt priorities to different stakeholders and set the KnowRISK Portfolio of Solutions with the minimum number of items deserving attention from the majority of

the consulted stakeholders.

The KnowRISK Portfolio of Solution is an important tool to alert building professionals to the need for a well-planned and coordinated approach to prevent poor performance of NSE in earthquakes.

As part of internal dissemination, most Portuguese stakeholders decided to use internal channels (screens in common areas, webpage, newsletters, etc.) to convey the information to their staff and to intensify the collaboration with the follow up of KnowRISK.

A big challenge that companies and organizations face is to change their attitude towards the unpredictable such as earthquakes or other disasters. We found, after the project conclusion, that in spite of all the information, campaigns and tools developed, that appeal to people's heart and mind, organizations do not give importance to the information, and don't actively mobilize or use these tools as an opportunity to improve performance, decision making and business resilience, unless there is continuity along time of the all process. It isn't easy to change attitudes, or to make a company's leadership or department receptive to the change, even if we are talking about "soft issues" to promote business resilience such as the mitigation of non-structural elements.

It is important to maintain the conversation's with the companies, trying always to evaluate and wage on interventions that would improve their chances of success before a crisis occurs. Moreover, it should be borne in mind that NSE are more fragile than the structure itself and pose safety threat to occupants not to mention bulding functional failure and business disruption.

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