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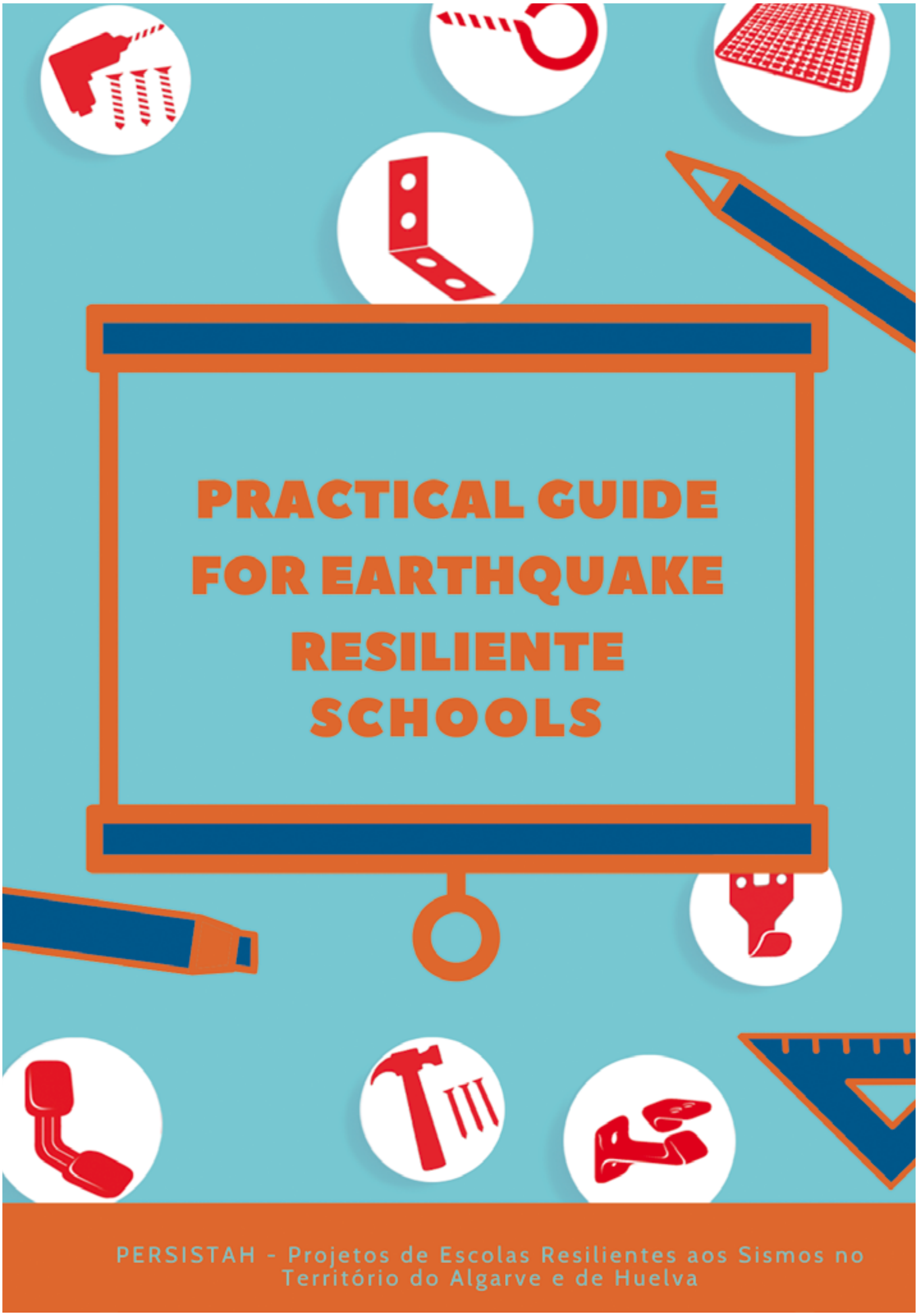

BOOK REVIEW

Editorial Universidad de Sevilla

SUMARY

Mónica Amaral Ferreira
Beatriz Zapico Blanco (coords.)

PRACTICAL GUIDE FOR EARTHQUAKE RESILIENT SCHOOLS

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PRACTICAL GUIDE FOR EARTHQUAKE RESILIENT SCHOOLS

PERSISTAH Project
(Projetos de Escolas Resilientes aos SISmos no Território do Algarve e de Huelva)

Mónica Amaral Ferreira

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Editorial Universidad de Sevilla

Sevilla 2020

SUMARY

Mónica Amaral Ferreira
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PRACTICAL GUIDE FOR EARTHQUAKE RESILIENT SCHOOLS

Series Ediciones especiales

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SUMARY

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Chapter 1. Why is this guide necessary?

In the Iberian Peninsula, around 10 million students attend school every day. Of this total, more than 30 000 students do so at schools in the Algarve region in Portugal, and 50 000 in Huelva, Spain.

Given that in these regions the seismic risk is real and inevitable, it is of vital importance that the **educational community** learns to live with this risk and that it is **resilient** to it.

Educational community is understood not just as the teaching staff but also as the students, families or guardians, school staff, local authorities, and the central and regional administration services.

The resilience of a community may be understood as the capacity of this group to recover from adversity and move forward. Specifically, when the community is faced with an event such as an earthquake, their resilience consists of:

- their capacity to absorb the destructive forces of the event through resistance or adaptation,
- their capacity to manage or maintain certain basic functions and structures during the event,
- their capacity to recover after an event has occurred.

This guide is intended to be a resource, and not a manual, for increasing the resilience of an educational community, by showing the community what they can do on their own account and how they can strengthen their ability to handle seismic risk (for example, being informed and familiarised with the characteristics that affect the vulnerability of an area in the event of an earthquake, and prepared to protect the students under their tutelage before the earth shakes).

This "Practical Guide for Earthquake Resilient Schools" therefore has a dual aim:

1. To provide a tool that allows the school community to identify, assess, mitigate and monitor the risks and adverse effects that they may face in the event of an earthquake, both on and off school grounds. The guide focuses particularly on the effects caused by the non-structural elements that are one of the main causes of the property, human and functional losses during an earthquake, which occasionally prevent classes from starting again for an indefinite period of time.
2. To draw up an intervention model (mitigation plan) that can be applied to all educational levels, increasing the seismic resilience of the school community.

This guide allows the teaching staff and management team of schools to play an active role in managing risks in their schools, promoting and strengthening the long-term and effective participation of the entire educational community.

Chapter 2. Context

The PERSISTAH project (*Projectos de Escolas Resilientes aos SIsmos no Território do Algarve e de Huelva*, in Portuguese), framed within the INTERREG-POCTEP Spain-Portugal programme of the European Regional Development Fund (ERDF) aims to:

i) assess the seismic safety of primary schools located in the Algarve and Huelva regions;
ii) study the seismic retrofitting measures for common existing school buildings in these regions, and to outline these in a retrofit guide;
iii) develop this Practical Guide for Earthquake Resilient Schools; and
iv) create resources and activities in order to raise the educational community's awareness of seismic risk, and train the community in how to reduce it, as set out in the educational guide "Why does the ground move?".

The Iberian Peninsula is characterised by having a moderate level of seismic activity compared to other parts of the world. However, in the south of the peninsula, there is a significant level of seismic activity. This is due to the convergence of the Eurasian and African tectonic plates, which extend throughout the Mediterranean region and the Strait of Gibraltar, reaching the Azores islands. Because of this convergence, the Iberian Peninsula has experienced numerous high-magnitude earthquakes that had disastrous consequences. Among these, the 1755 ($M_w = 8{,}7$) and 1969 ($M_w = 8$) earthquakes stand out.

The Algarve-Huelva region, to the southwest of the peninsula, is known for its high-magnitude earthquakes ($M_w \geq 6$) and long return periods (Morales-Esteban *et al.*, 2014). This is due to its closeness to the Azores-Gibraltar fault zone. Recent studies have also identified fault zones in the southwest region of the Algarve, such as the Marqués de Pombal fault or the San Vicente fault. The latter fault was where the 1969 earthquake and the Lisbon earthquakes originated. Despite the high magnitude of the earthquakes in this area, the inhabitants are not aware of the local high seismic hazard due to the long return periods.

Tsunamis generally tend to be associated with earthquakes, despite the fact that volcanic eruptions and submarine landslides can also trigger them. In the area that concerns us here, tsunamis are also a real threat.

Science can show us where earthquakes or tsunamis are most likely to occur, but it cannot predict when they will occur. This means that there will be no warning before a seismic event, but we can reduce the effects and damage that it has if we know what to do before, during and after it occurs when we are at home, at school or out on the street.

Table 1. Average occupancy density according to use and timetable

Building use	No. people/100 m^2	
	At 3 pm	At 3 am
Residential	1,2	3,1
School	20,0	0,5
Administrative	4,0	0,0
Public safety (firemen, police)	3,0	0,0
Health (hospitals)	5,0	2,0

Furthermore, schools are the places where children spend most of their day. Table 1 shows the average occupancy of buildings according to their use for different timetables (Safina, 2002). In the table we can also see the high occupancy density recorded for school premises, particularly during the day. An unsafe school gives rise to a community with low resilience.

As it is framed in the PERSISTAH project, this guide focuses on the Algarve and Huelva regions. Nonetheless, the recommendations that are outlined may also help educational communities of other regions of seismic risk to be more aware of the dangers they face and of everything they can do to be prepared.

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Chapter 3.
What to do before an earthquake?

Earthquakes are unpredictable, so being prepared and knowing what to do can reduce the amount of damage and losses involved. If schools are adequately equipped with risk mitigation strategies, action plans, and informed and trained teaching staff, non-teaching staff and students, then they are in a better position to quickly regain the continuity of teaching.

In order to carry out effective risk management, it is essential to know which factors increase or reduce the capacity of an educational community to resist the effects of an earthquake, as well as to identify the potential actions needed to mitigate the level of vulnerability (of buildings and individuals).

The following aspects give rise to greater vulnerability:

- i) the lack of conformity of the infrastructures with the building laws and the lack of applying such laws to these infrastructures,
- ii) bad territorial planning and organisation,
- iii) building on high-risk sites (soft ground, near cliffs, embankments, flood-prone areas, etc.),
- iv) the lack of security or inadequate seismic retrofitting during the design or construction of critical infrastructures that must operate immediately after an earthquake (schools, hospitals, operations centres, telecommunication centres),
- v) the use of inadequate non-structural measures for protecting the content and facilities of the buildings, and
- vi) the disorganised response or lack of response when faced with a seismic event.

In the case of already existing buildings, as is the case that concerns us in this guide, the aforementioned points that can be acted upon are i), iv), v) and vi).

It is particularly important that the relevant authorities (the local authorities and the central and regional administration services qualified in the field of education) regularly check the state of school buildings (or their level of vulnerability) in order to ensure that the building is in good condition and can withstand an earthquake.

A building consists of **structural** elements, such as pillars, beams, foundations, slabs, stairs, roofs, etc. and **non-structural** elements, among which we can highlight suspended ceilings, partitions, tiles, chimneys, cabinets, etc.

Structural elements *vs.* Non-structural

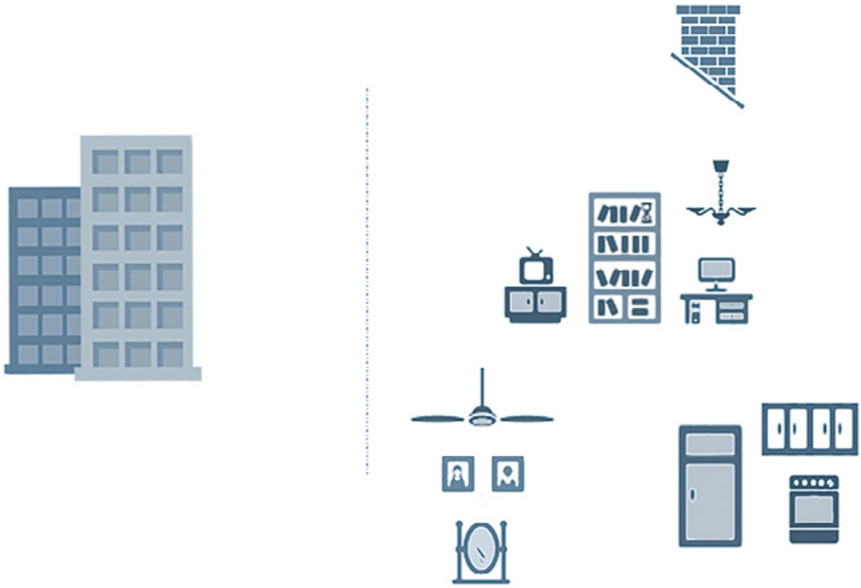

Figure 1. Structural elements (left) and non-structural elements (right) that make up a building (source: <http://knowriskproject.com>).

During an earthquake, non-structural elements may move around or fall, sometimes causing very serious accidents or blocking exit routes. It has been proven that between 60% and 70% of injuries and hospitalisations in the event of an earthquake are caused by objects, furniture or other non-structural elements.

There are simple preventive measures that the whole educational community (students, families, teaching staff, school staff, local authorities and central and regional administration services) can take to reduce the non-structural risk, such as MOVE, PROTECT AND SECURE (see 3.2):

— MOVE heavy objects (books, plants) from the highest shelves to the lowest ones;
— PROTECT valuable items so that they don't fall;
— SECURE shelves, cabinets, mirrors, etc. to the walls.

3.1. IDENTIFYING NON-STRUCTURAL RISKS AT SCHOOL

The Practical Guide for Earthquake Resilient Schools aims to help the educational community to identify which non-structural elements in a school building affect its vulnerability in the event of an earthquake, these elements being able to cause damage, injuries or loss of functioning if they are not adequately dealt with (see Figure 2 to Figure 8).

Below, an overview is provided of the different areas that can be found in a school, describing the potential non-structural risks of each of them. The list is not intended to be exhaustive, but an exemplification of common situations.

3.1.1. Classrooms

Paintings, suspended ceilings, light fixtures, projectors, clocks and any other hanging item, if not properly secured, may fall or become detached, causing injuries and blocking the entry or exit routes to and from the classroom.

Figure 2. Examples of hanging items (source: <http://knowriskproject.com>).

The glass in windows may break and pieces of glass may reach the school desks if these are near to the windows. Blinds may also fall and cause damage or injuries.

Electronic equipment such as computers, screens, printers or photocopiers may fall or move around, which could lead to them being damaged or causing injuries.

Figure 3. Windows and electronic equipment (source: <http://knowriskproject.com>).

3.1.2. Corridors

Cabinets and lockers may fall, causing injuries and blocking the emergency exits in the event of evacuating the building, as well as blocking access to emergency equipment.

Figure 4. Lockers (source: <http://knowriskproject.com>).

3.1.3. Libraries and study rooms

Tall shelves, heavy and loose objects, hanging items and free-standing furniture may cause harm to people and block the way.

Figure 5. Shelves and free-standing furniture in libraries (source: <http://knowriskproject.com>).

3.1.4. Laboratories and activity rooms

The heavy objects and equipment that are usually found in laboratories may fall, harm people and cause severe property losses. Chemical products may spill out, react and cause additional hazards, such as the release of toxic substances or fires.

Figure 6a. Hazardous furniture, equipment and substances in laboratories (source: <http://knowriskproject.com>).

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Figure 6b. Hazardous furniture, equipment and substances in laboratories (source: <http://knowriskproject.com>).

3.1.5. Gyms

Gym equipment such as lockers may fall or move around, causing harm and blocking the way. The use of equipment with wheels, which is common in gyms, increases the risk of the equipment moving around.

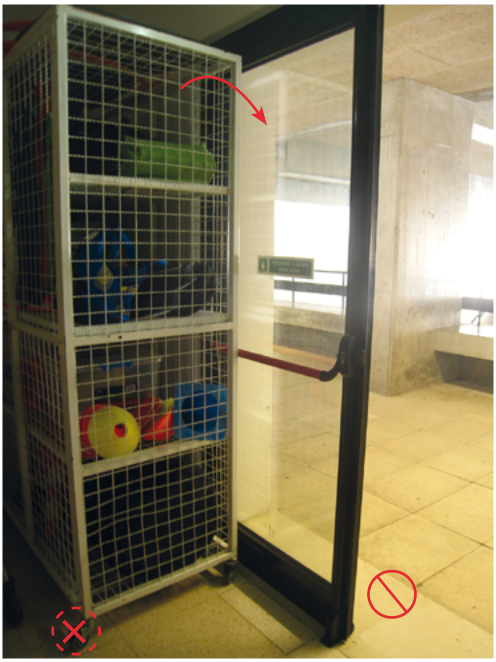

Figure 7. Gym equipment (source: <http://knowriskproject.com>).

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3.1.6. Canteens and cafeterias

Vending machines are very heavy items and if they fall, they can cause serious injuries to people and block exits.

Figure 8. Vending machines (source: <http://knowriskproject.com>).

3.1.7. Checklist | Non-structural elements

The following checklist can be used as a basic guideline for carrying out a visual inspection with the aim of assessing the presence and safety level of non-structural elements in the school. This sheet can also be used as guidance when teaching students about some of the non-structural risks at school, allowing them to apply this at home too (bedrooms, living room, study and kitchen) in collaboration with their families.

Interreg España - Portugal PERSISTAH PROJECT

NON-STRUCTURAL ELEMENTS CHECKLIST

School	
Building	Date
Classroom	

Ceilings and loads	Are there any?	
	Yes	No
Ceiling lamps, fluorescent lights		
Suspended ceiling		
Air conditioning equipment / heaters mounted on the ceiling		
Hanging objects (lamps, vases, plants, etc.)		
Decorative ceiling mouldings		
Pipes / ducts		
Tiles (exterior)		
Balconies		
Chimneys		
Canopies		

SUMARY

Interreg España - Portugal PERSISTAH PROJECT

NON-STRUCTURAL ELEMENTS CHECKLIST

Elements secured to the walls	Are there any?		Are they well-secured?	
	Yes	No	Yes	No
Shelves				
Cabinets, lockers (> 1m)				
Televisions, projectors, microphones, speakers				
Paintings, wall lamps, clocks				
Fire extinguishers				
Decorative elements (statues, sculptures)				
Tempered glass windows				
Shutters / awnings				
Glass doors				

Interreg España - Portugal PERSISTAH PROJECT

NON-STRUCTURAL ELEMENTS CHECKLIST

Furniture and equipment	Are there any?		Are they well-secured?	
	Yes	No	Yes	No
Filing cabinets (> 1m)				
Shelves				
Computers, printers, photocopiers				
Projectors				
Furniture / equipment with wheels				
Works of art				
Plant pots in upper reaches				
Fish tanks				
Wardrobes (> 1m)				
Fans / air conditioning / heaters				
Cabinet doors with security locks				
Lab equipment with hazardous chemical products				
Gym equipment				
Kitchen equipment (oven, stoves, extractor hood, fridge/freezer, dishwasher)				
Kitchen cabinet doors with security locks				
Vending machines				

3.2. REDUCING NON-STRUCTURAL RISK AT SCHOOL

The protection measures for reducing non-structural risks are, for the most part, of a low cost (or zero cost!) and are easy to apply. Not to mention, and most importantly, their impact is huge as they can save lives and prevent injuries and property losses.

Protecting the non-structural elements and the content of the building improves the safety of the school facilities during a seismic emergency in the following way:

i) reducing the amount of injuries and fatalities;
ii) helping to keep entrances and exits unblocked and safe for the evacuation of and access to the building;
iii) reducing the spillages of chemical products and fires;
iv) protecting school equipment and materials;
v) increasing the community's capacity to keep the school in operation in the event of a disaster and
vi) allowing the children to go back to school sooner and limiting the interruption of classes.

There are small gestures that make all the difference. Move, protect and secure are measures that can be implemented to reduce the risk of non-structural elements falling or slipping, causing damage, injuries or blocking exit routes.

There are measures that the whole educational community (students, families, teaching staff, school staff, local authorities and central and regional administration services) can take to reduce the non-structural risk, such as Move, Protect and Secure:

— Move heavy objects from the highest shelves to the lowest ones.
— Protect the most fragile and/or valuable goods. For example, the use of double-sided tape prevents objects from slipping or being knocked over. Hanging curtains on the windows prevents broken glass from causing damage or cuts, which makes it a good solution to apply in order to protect.
— Secure large non-structural elements to the walls, such as bookshelves, cabinets and lockers, which can move around, tip over and block traffic areas. Properly secure fans, paintings, mirrors, computers, furniture with wheels, electrical equipment and hanging light fixtures.

The solutions presented (Move, Protect and Secure) prevent property losses (Figure 9). They can also prevent a moderate earthquake from causing the deterioration or loss of functioning of critical buildings and infrastructures such as schools, hospitals, operations centres and telecommunication centres, which must operate immediately after an earthquake.

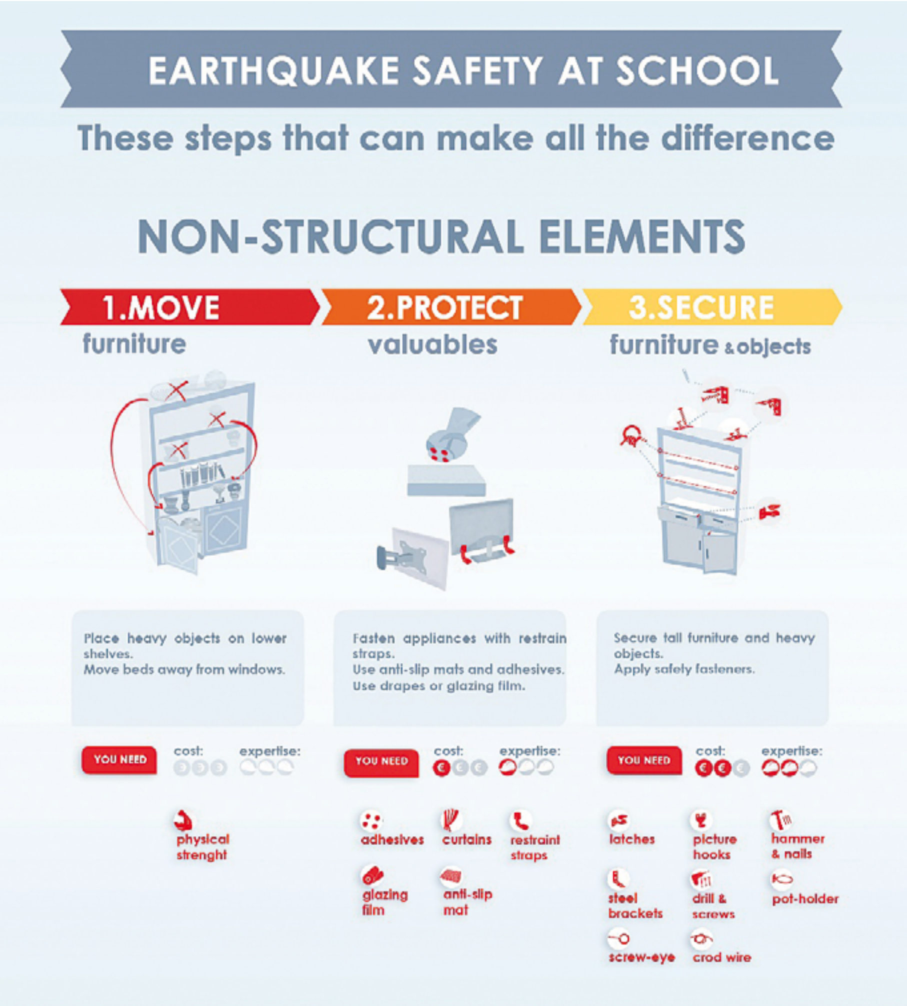

Figure 9. Move, Protect and Secure (adapted from KnowRISK, <https://knowriskproject.com/practical-guide/>).

The Move, Protect and Secure campaign was developed in the framework of the KnowRISK (2017) project which aims to raise awareness of communities towards scientific knowledge on protection against non-structural seismic risk. Various resources have been developed in this frame for raising awareness and risk communication, some of which are mentioned and used in this educational guide.

The European project KnowRISK (2017), pioneer in the dissemination of scientific information on the protection against non-structural seismic risk, allowed for the collection of information regarding the dangerousness of non-structural elements in different settings (bedrooms, schools and companies) and their subsequent analysis for the identification of self-protection measures. The results were used for the creation and subsequent sharing of outreach materials, such as the KnowRISK Practical Guide and the KnowRISK Portfolio/Manual of Solutions (Ferreira *et al.*, 2017, 2018a, b) (Figure 10).

Some self-protection measures that can be applied to the common non-structural elements in schools are shown below. The details of the strengthening procedures of these elements are based on a set of measures taken from FEMA E-74 (FEMA 2012) and Ferreira *et al.*, 2018 a, b.

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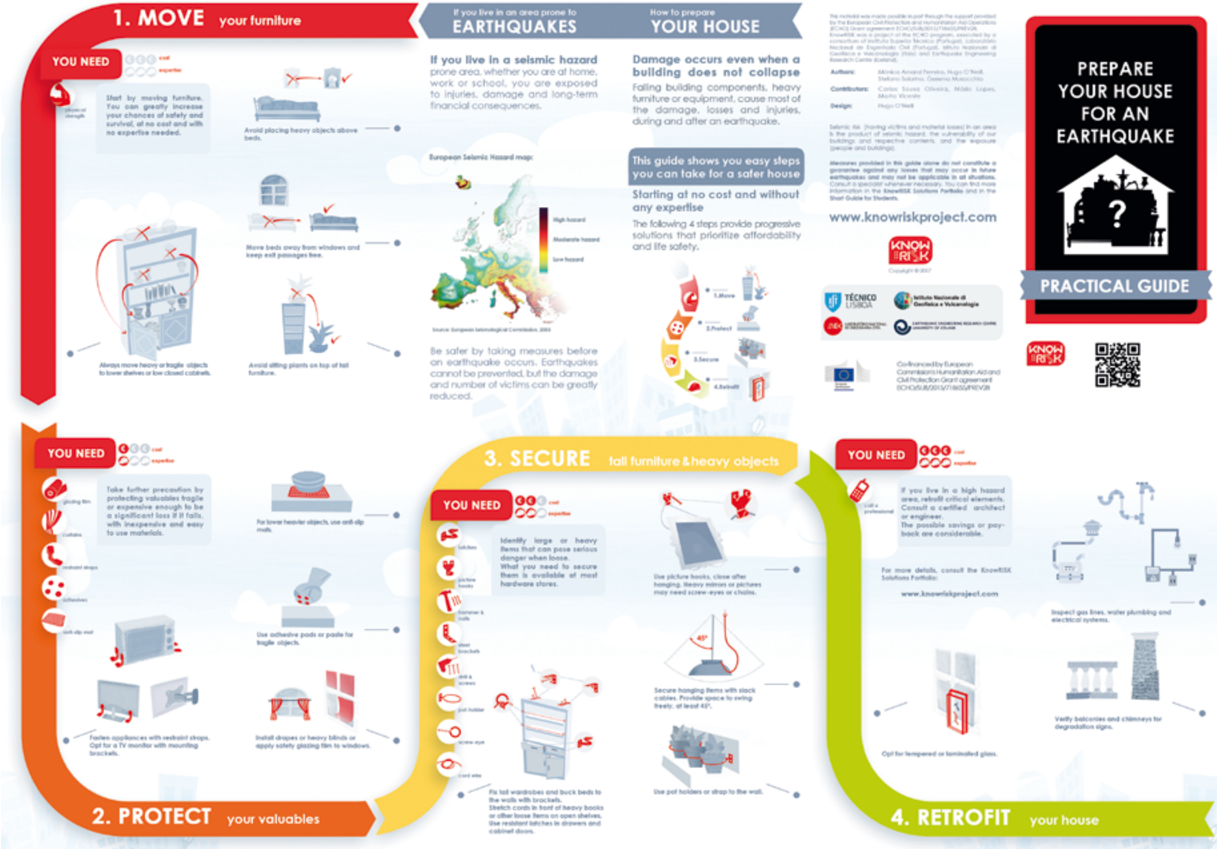


Figure 10. *KnowRISK Practical Guide* (source: <knowriskproject.com>).

SUMARY

3.2.1. Tall shelves and cabinets

Problem: tall or thin shelves and cabinets may fall or slide, and their content may fall out and become damaged, causing fatalities and / or blocking doors or exits. **Good practices:** shelves and cabinets must be secured to a wall (except plasterboard walls) using corner profiles (perforated or angle bracket). These must be placed on the upper or side part of the furniture or, if you prefer, you can place screws on the back of the furniture, thus securing it to the wall.

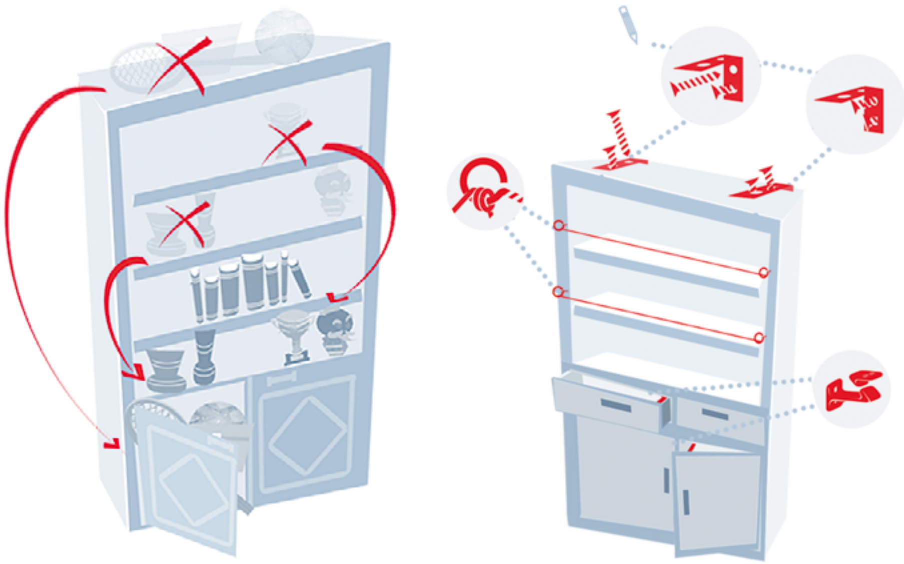


Figure 11. Tall shelves and cabinets (source: *KnowRISK Practical Guide*, Ferreira *et al.*, 2017).

When you cannot secure them to the wall, secure them to the ceiling or minimise the space between the ceiling and the furniture using height-adjustable storage units.

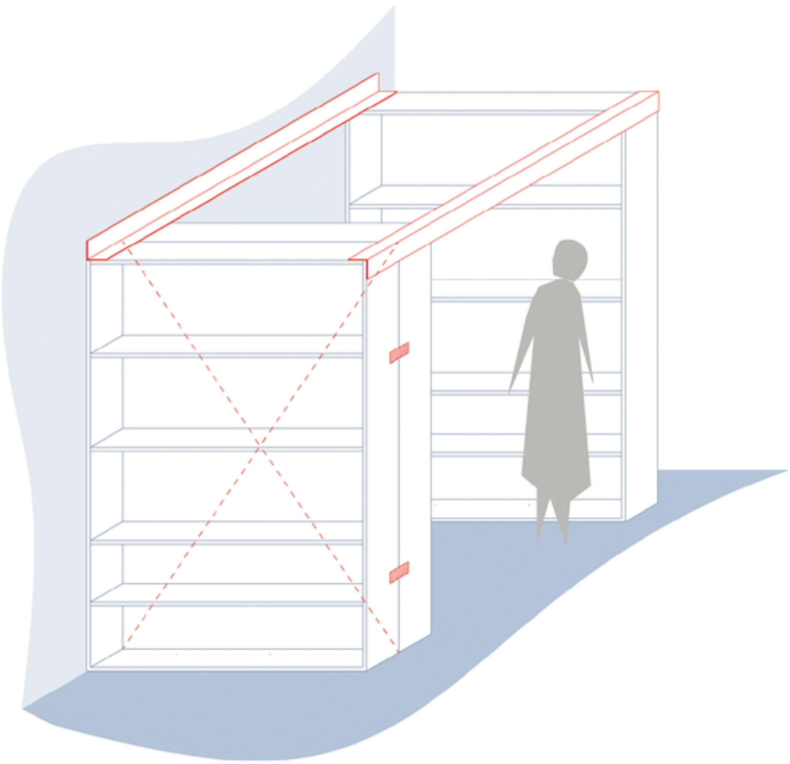


Figure 12. Libraries (source: *KnowRISK Portfolio of Solutions*, Ferreira *et al.*, 2018b).

Shelves or cabinets that are over 90cm high must be reorganised, in rooms and libraries, so that they are attached to each other, thus creating a broader and more stable base, as shown in figure 12.

It is necessary to use security locks on drawers and cabinet doors, and to attach straps to shelves with books or other loose objects. Both solutions are affordable, easy to implement and prevent objects from falling.

The heaviest and most fragile objects must be kept on the lowest shelves, or in tightly closed compartments.

3.2.2. Computers, televisions, printers, photocopiers, scanners

Problem: computers and monitors may fall, screens may break, and hard disks may be damaged, which can lead to the loss of stored information.
Good practices: secure monitors to the walls, desks or tables. Place computers and printers at a sufficient distance from the edges of tables and desks in order to prevent them from falling in the event of an earthquake. Anti-slip mats can also be placed under equipment to stop it from moving around.

If a television or monitor has a base or mount, this can be secured using tape or a chain to hold the rear part of the monitor to the base of the table. For various monitors, you can opt for fixing brackets as shown in the following figure.

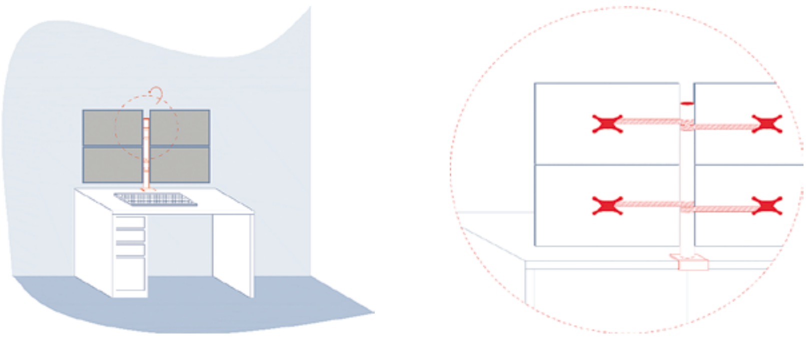


Figure 13. Monitors (source: *KnowRISK Portfolio of Solutions*, Ferreira *et al.*, 2018b).

For monitors or televisions secured to the wall, it is essential to know the type of wall material (brick, plasterboard, wood or other) and the weight of the monitor in order to select an appropriate clamping element.

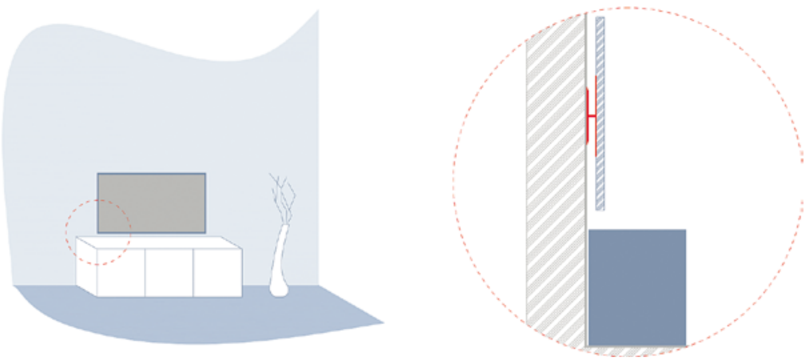


Figure 14. Televisions (source: *KnowRISK Portfolio of Solutions*, Ferreira *et al.*, 2018b).

SUMARY

3.2.3. Paintings, frames and mirrors

Problem: heavy objects such as paintings or mirrors may fall and the glass in them may cause injuries.
Good practices: Hang only light objects near to desks, tables and chairs, such as posters without a frame.

Wall-mounted mirrors, figures, paintings and other hanging objects (that weigh less than 2,5 kg) must be secured using brackets for picture frames (do not use hooks or similar items), the edges of which must be semi-closed so that the object does not come loose with the vibration.

Figure 15. Paintings and frames (source: *KnowRISK Practical Guide*, Ferreira *et al.*, 2017).

3.2.4. Furniture and equipment on wheels (pianos, chairs, desks, vending machines)

Problem: with the vibration of the earthquake, furniture and equipment may slide or tip over.
Good practices: always keep the wheels on any large mobile device blocked in order to prevent it from moving around due to the vibration. Secure the largest objects to the floor and/or walls as shown in the following figure.

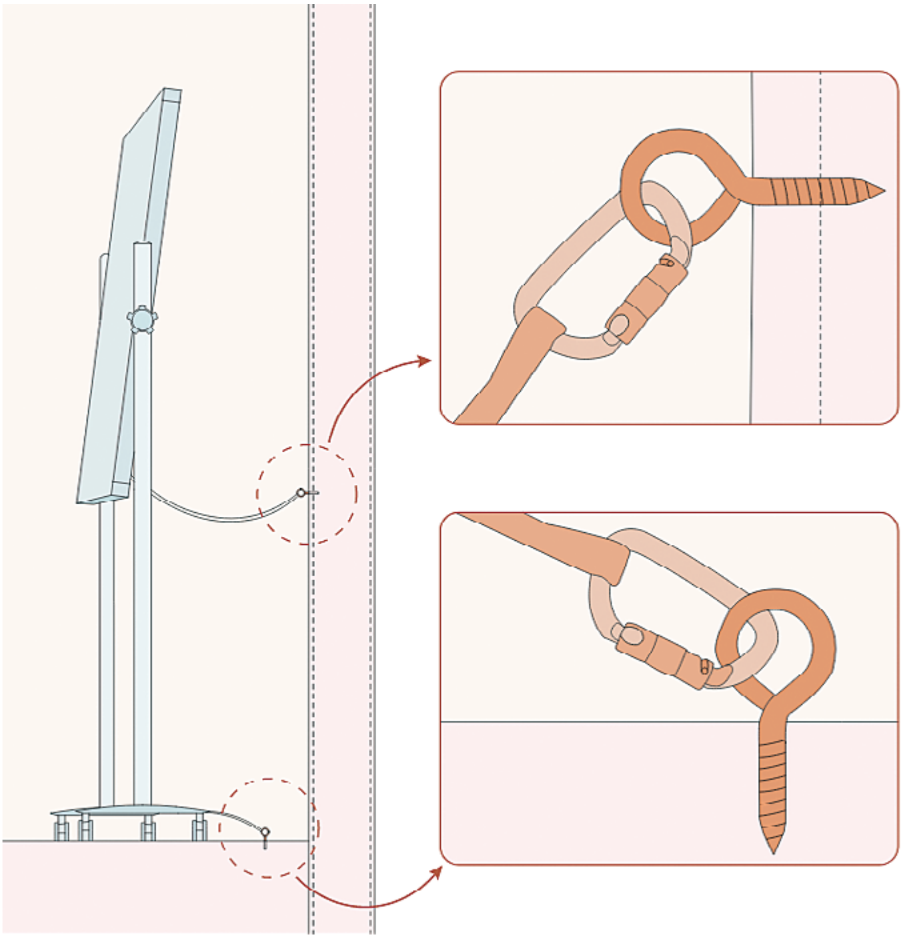


Figure 16. On wheels (source: Earthquake Country Alliance).

3.2.5. Ceiling lamps and fans, plant pots and others hanging objets

Problem: hanging objects may break when they collide with other items during the vibration and their remains may cause injuries. Hanging light fixtures with chains may fall if they or their wall hooks and/or anchors break.
Good practices: Secure lamps or hanging objects with safety cables. Leave space for the object to swing 45° without it crashing into other items in the event of an earthquake.

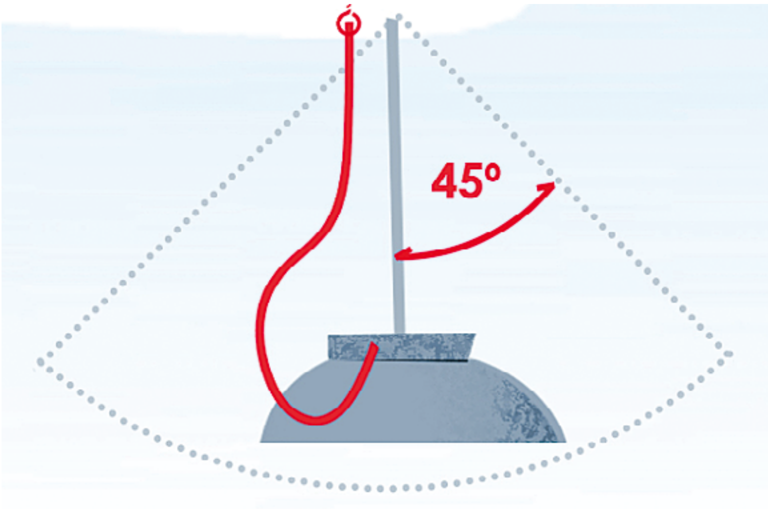


Figure 17. Lamps (source: *KnowRISK Practical Guide*, Ferreira *et al.*, 2017).

3.2.6. Built-in hanging light fixtures

Problem: any damage to lighting equipment is directly related to the installation method. In some cases, they break due to weak connections or inadequate fixtures to the ceiling. The panels, substructure, steel cases, protective grids and globes may fall from fluorescent and incandescent light fixtures during an earthquake, mainly due to insufficient and badly designed mounting systems (clamps) (A Homeowner's Guide, 1999).
Good practices: when installing built-in lighting systems, it is necessary to use diagonal cables / wires in each corner, connecting them to the structure (for example, the concrete slab). These security cables must support the total weight of each item. Each cable must stay loose, without supporting the weight of the

item in normal conditions (see the figures below). For more information see Ferreira *et al.*, 2018b (<https://knowriskproject.com/portfolio>).

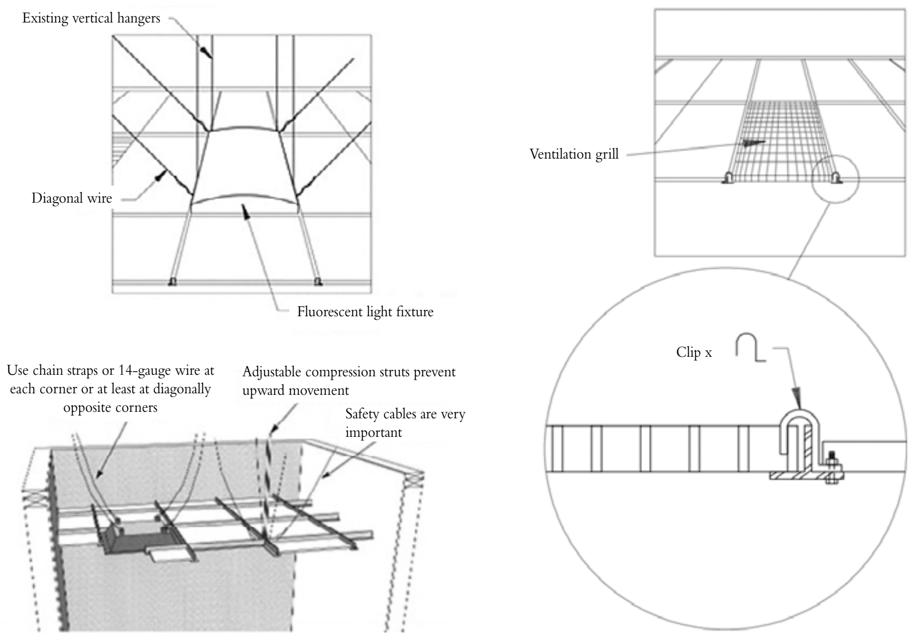


Figure 18. Built-in hanging light fixtures (source: A Homeowner's Guide, 1999; Earthquake Country Alliance).

3.2.7. Suspended ceilings

Problem: when suspended ceilings fall during an earthquake, this can lead to significant damage, and is mainly due to the suspension system not having the capacity to withstand the lateral forces.

Good practices: in order to keep the suspended ceiling horizontal, the plates can be secured to the existing ceiling on both sides of the perimeter. The areas of the ceiling that are greater than 200 m² must have seismic separation joints, closure angles and horizontal restraints. A suspended ceiling must not be used to support fittings that weigh more than 10 kg. When a suspended ceiling is used to support equipment, it must be directly secured to the suspension system of the ceiling, and not to the plates of the suspended ceiling. For more information see Ferreira *et al.*, 2018b (<https://knowriskproject.com/suspended-ceiling>).

3.2.8. Glass partitions and windows

Problem: the glass in windows and partitions generally tend to be damaged due to the deformation of the window frame or base and the small clearances between the window and the base.
Good practices: ensure that furnishings, such as tables or chairs, are not located near to the windows. The use of blinds or curtains (Figure 19) can provide additional protection, as it makes it more difficult for the pieces of glass to fall inside the room, preventing injuries.

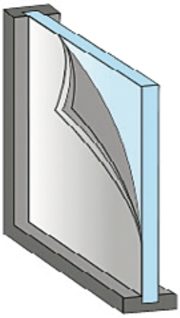
Figure 19. Blinds and curtains (source: *KnowRISK Practical Guide*, Ferreira *et al.*, 2017).

Security window film can also be placed (polyester film placed with special adhesives, Figure 20) which helps to hold in the pieces of glass. Typical solar film is not suitable for this purpose.

Replacing normal glass with tempered glass is also a solution, as the latter breaks into small pieces that do not pose any kind of danger. It is not advisable to use tempered glass for balconies. In these cases, preference is given to the use of film or laminated or glass.

The use of laminated glass is another option, particularly for façades or windows. Laminated glass is made up of two or more layers of glass bonded between one or more plastic films (Polyvinyl butyral (PVB) is the most common), using heat and pressure. Laminated glass is considered a type of safety glass because even when shattered, the pieces stay stuck to the window film that bonds them.

Technical advice must always be sought on the details and specifications of the project in question.



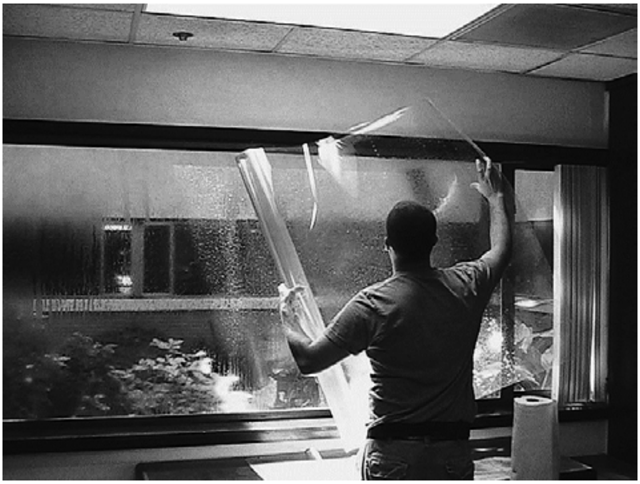


Figure 20. Security window film being installed (source: 3M™ Safety & Security Window Films).

For glass partitions (open spaces), it is advisable to strengthen the support structure to reduce the damage caused by the earthquake. Bracing involves inserting steel rods and anchoring them in the corners of the window structure (Figure 21, on the left). Another method consists of using larger profiles that include a flexible rubber or plastic frame (compressible material) in order to prevent contact between the profile and the glass panel, reducing the chance of it breaking (Figure 21, on the right).

For cantilevered partitions with glazing elements (only attached to the floor) it is necessary to ensure that they are well-secured to the structure (slab).

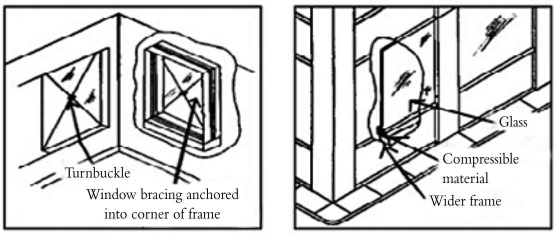


Figure 21. Strengthening of a window structure (source: FEMA, 2004).

3.2.9. Hazardous substances

Problem: during an earthquake, even a moderate one, if containers holding chemical products are not protected or properly stored, they may release toxic substances. This puts the health and safety of both the educational community and the environment at risk.

Good practices: various solutions can be applied. For example, the cabinets used for storing these products can be adequately secured to the walls using L-shaped profiles (see section 3.2.1).

Measures must be taken to ensure that, in the event of an earthquake, fragile glass containers do not fall to the ground or knock against each other. To achieve this, cabinets for storing chemical products must be protected or have clamping devices (for example, elastic cord or cord along the edges), front panels or vertical separators to prevent stored chemical products from falling. Also, in certain cases, a net can be used to stop small and light items from falling.

In order to prevent chemical products from accidentally mixing, incompatible chemical substances must be separated in boxes with compartments according to the diameter of the containers and at a safe distance. Heavy items or volatile chemical products must be placed in the lowest part of the cabinets.

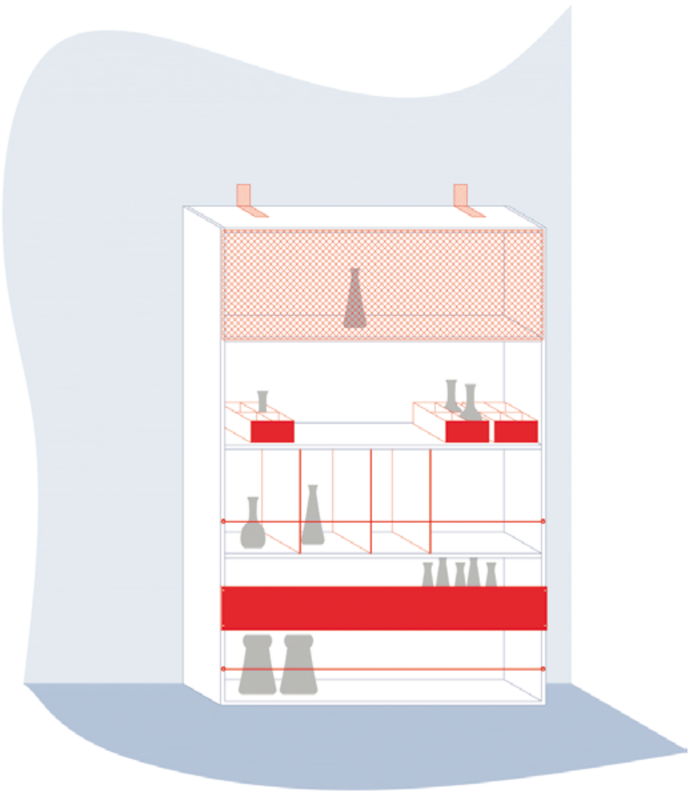


Figure 22. Hazarddous substances (source: *Set of KnowRISK Solutions*, Ferreira *et al.*, 2018b).

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3.2.10. Vases and plant pots

Problem: plant pots resting on window sills or balconies may fall and cause serious injuries. Pieces of plant pots that have fallen may pose a threat, blocking emergency exits, for example.

Good practices: do not place vases (or other heavy items) on top of tall pieces of furniture. Place them at ground level or at a low height to avoid them breaking.

Plant pots can be anchored to the wall using pot holders to stop them from tipping over and causing damage or injuries.

Figure 23. Plant pots (source: left: *KnowRISK Practical Guide*, Ferreira *et al.*, 2017; right: <http://plantaredecorar.blogspot.com/>).

3.2.11. Parapets, ledges and decorative elements

Problem: parapets, decorative elements such as ledges and corbels, and other architectural elements are common among old unreinforced masonry buildings. These elements generally tend to be made of stone or other heavy and fragile materials, and when an earthquake occurs, they can fall due to the lack of anchoring or support.

Good practices: elements can be tied up to the structural support system using mechanical anchors.

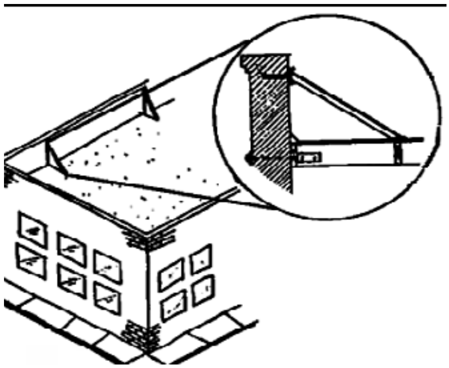

Figure 24. Parapets and ledges (source: FEMA 2004).

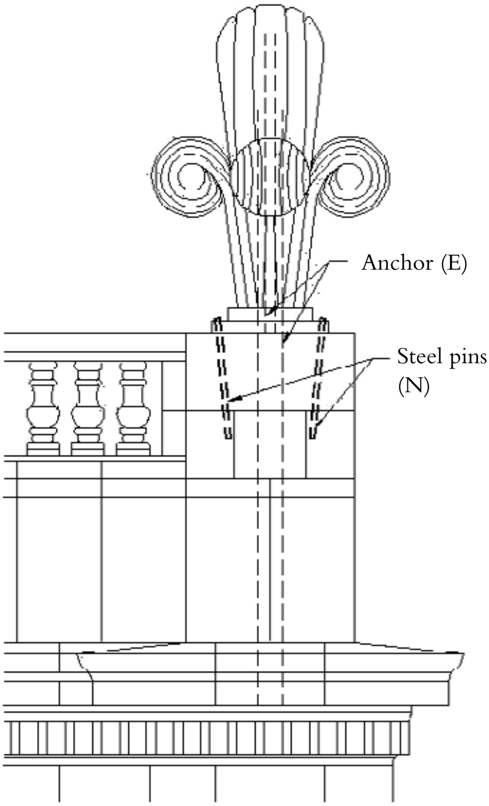

Figure 25. Exterior decorative elements (source: FEMA 2004).

3.2.12. Chimneys

Problem: chimneys are subject to the effects of earthquakes, even moderate ones. Such is the case of the earthquake that occurred on 28th February 1969, during which numerous chimneys were damaged and even collapsed in buildings located in the Algarve and Lisbon. If the chimney collapses and falls onto the public highway, not only can it damage the building, but it can also cause property losses and fatalities.
Good practices: if the chimney stands at over 1,5 m above the rooftop, it can be anchored to the buildings with metal parts placed at multiple points.

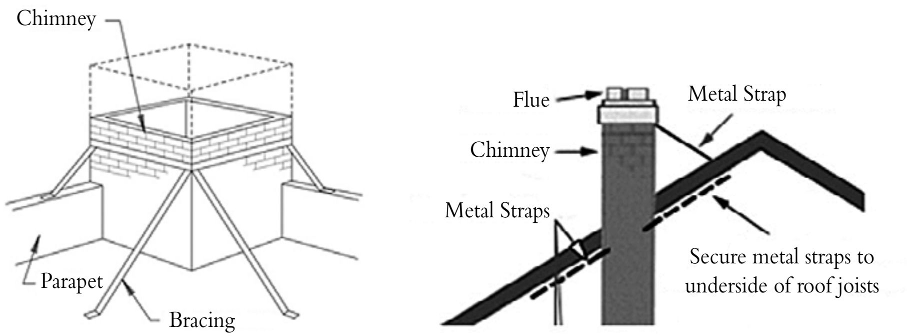

Figure 26. Chimneys (source: Earthquake Country Alliance).

3.2.13. Tiles

Problem: tiles are heavy items and, when the vibration of an earthquake occurs, they may become loose and fall, causing injuries to the people that may be found below them.
Good practices: tiles must be correctly secured to the support structure to stop them from moving around. It must be borne in mind that the structure of the roof is subject to both deformations due to lateral loads (horizontal loads on the building) and high vertical seismic accelerations.

It is advisable for one of every two tiles (or better yet, every tile) to be attached to the support structure with wire, metal clips, nails or screws.

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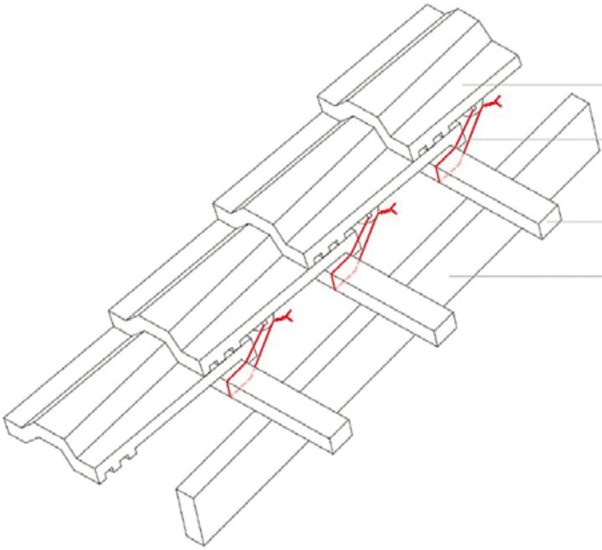

Figure 27. Tiles.

Chapter 4. What to do during an earthquake?

4.1. SELF-PROTECTION MEASURES IN THE EVENT OF AN EARTHQUAKE

DURING AN EARTHQUAKE, try to keep calm, look for a sturdy table or a safe place and protect yourself, as shown in the following figure:

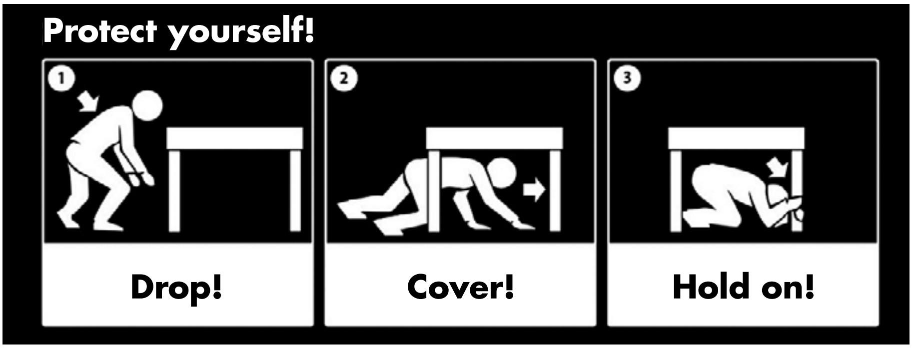

Figure 28. Drop, cover and hold on (source: <redsismica.uprm.edu>).

4.1.1. Know what to do!

Inside a building: *drop, cover, hold on and wait*. If you are standing up, drop onto your hands and knees and take cover under a table or a sturdy desk (cover your head and neck with one hand, whilst using the other hand to hold on to the table leg, as it may move around during the earthquake). Wait until the vibration has stopped. If you are not near to a table or desk, then drop down onto your hands and knees, preferably away from exterior walls, windows, cabinets, mirrors or objects that may fall, and cover your head and neck with both hands. Do not go out onto the street! Do not use lifts. Do not be alarmed if the fire sprinkler or fire alarm system is set off.

If you are using a wheelchair: apply the brakes on the wheels when you find a safe place, away from exterior walls, windows, cabinets, mirrors or objects that may fall. If you cannot move quickly, then stay where you are. Cover your head and neck using your arms.

When outdoors: if you can do so in a safe way, move away from areas near to electricity pylons, traffic lights, street lamps, buildings, vehicles and other hazards.

When driving: move to the side of the road, stop the engine and apply the hand brake. Avoid stopping near to raised floors, bridges, electricity pylons, traffic lights and other hazards. Stay inside the vehicle until the vibration has stopped.

When in a stadium or concert hall: stay in your seat and cover, avoiding panic, your head and neck with your arms. Only leave after the vibration has stopped and stay alert to ensure that nothing falls on top of you in the event that it happens again.

Near to a dam: dams can collapse after a severe earthquake. If you are near to a dam, have an evacuation plan ready.

4.2. SELF-PROTECTION MEASURES IN THE EVENT OF A TSUNAMI

The best signs for identifying the arrival of a tsunami are provided by nature itself: a very strong earthquake near to the coast, an abnormal amount of water suddenly receding from or approaching the coast, and a very loud noise (similar to that of a train) coming from the sea.

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Figure 29. Tsunami: when to evacuate (source: National Geographic Institute, <www.ign.es>).

SUMARY

What to do?

If you are at home, at school or another place near to the coastal area (at risk), take into account that you only have a matter of minutes in which to act.

Evacuate as quickly as possible, **on foot**, after the earthquake has stopped. Remember that you only have a few minutes to get to a higher and safer spot.

Always follow the instructions of the evacuation plans (horizontal / vertical).

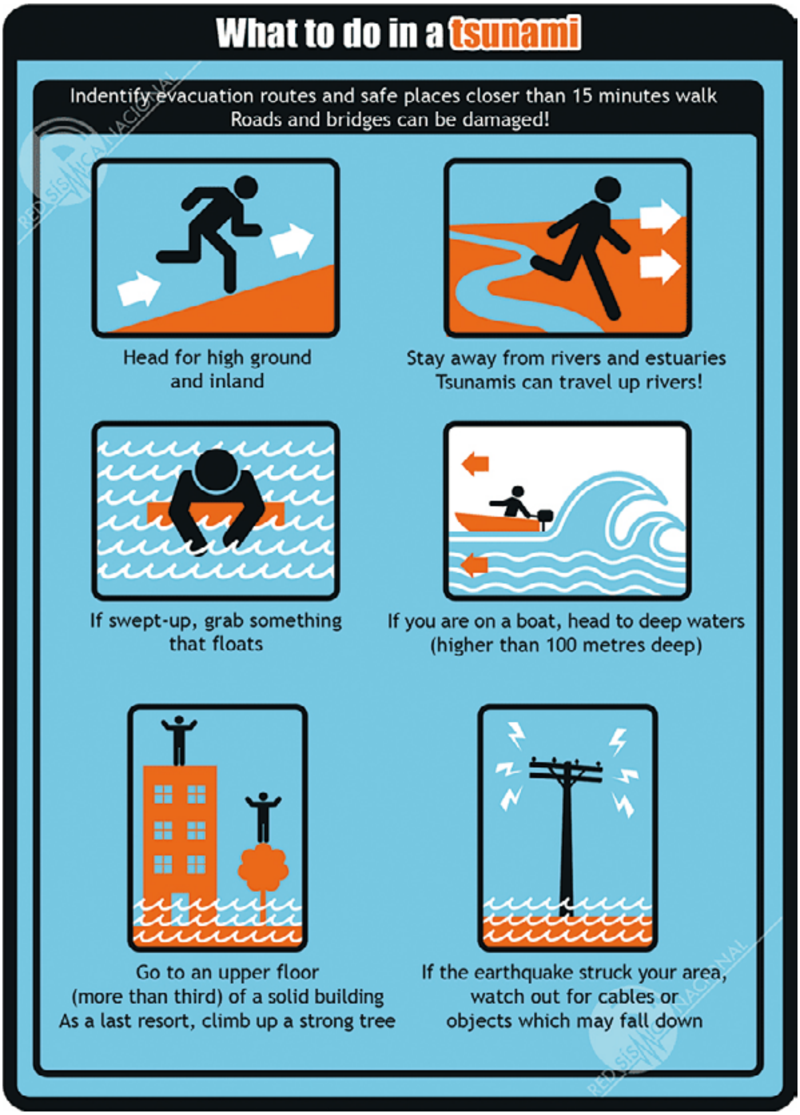

Figure 30. What to do in the event of a tsunami (source: National Geographic Institute <www.ign.es>).

Chapter 5. What to do after an earthquake?

After an earthquake, it is important to carefully assess what is happening around us and ensure not to rush.

- Keep calm and bear in mind that it is possible that it may happen again;
- Do not rush when using stairs or exits. Never use lifts;
- If there are debris, use resistant shoes to protect you;
- Do not smoke or light cigarettes or lighters, as there may be gas leaks;
- Turn off the water, gas and electricity;
- Use battery-powered torches;
- Turn on the radio and follow the guidelines that are being broadcast;
- Immediately clean any flammable products that may have been spilled (alcohol, paint…);
- Avoid entering areas in which there are loose electrical cables;
- Do not use the telephone, except in cases of acute emergency (serious injuries, gas leaks or fires);
- Do not go out onto the street to see what has happened. Keep public roads free so that emergency teams can use them;

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List of Illustrations

SUMARY

This guide is intended to be a resource, and not a manual, for increasing the resilience of an educational community, by showing the community what they can do on their own account and how they can strengthen their ability to handle seismic risk (for example, being informed and familiarised with the characteristics that affect the vulnerability of an area in the event of an earthquake, and prepared to protect the students under their responsability before the earth shakes).

This "Practical Guide for Earthquake Resilient Schools" therefore has a dual aim:

1. To provide a tool that allows the school community to identify, assess, mitigate and monitor the risks and adverse effects that they may face in the event of an earthquake, both on and off school grounds. The guide focuses particularly on the effects caused by the non-structural elements that are one of the main causes of the property, human and functional losses during an earthquake, which occasionally prevent classes from starting again for an indefinite period of time.

2. To draw up an intervention model (mitigation plan) that can be applied to all educational levels, increasing the seismic resilience of the school community.

This guide allows the teaching staff and management team of schools to play an active role in managing risks in their schools, promoting and strengthening the long-term and effective participation of the entire educational community.

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