non-structural risk mitigation

handbook
**Non-Structural Risk Mitigation Handbook**

This project was funded by American Red Cross with generous support from Boğaziçi University, Disaster Preparedness Education Project, Kandilli Observatory and Earthquake Research Institute, Boğaziçi University Center for Disaster Management, and Turkish Red Crescent. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the American Red Cross.

**What is your wall or structural element type?**

<table>
<thead>
<tr>
<th>Brick Masonry</th>
<th>Concrete</th>
<th>Aircrete</th>
<th>Gypsum Board</th>
<th>Timber</th>
</tr>
</thead>
</table>

**How heavy is your furniture?**

<table>
<thead>
<tr>
<th>0-5 kg.</th>
<th>5-50 kg.</th>
<th>50-150 kg.</th>
<th>150 kg. +</th>
</tr>
</thead>
<tbody>
<tr>
<td>For light objects use size 6 Standard Wall Plugs</td>
<td>Size 6</td>
<td>Size 8</td>
<td>To secure very heavy items, consult an engineer or professional for proper installation.</td>
</tr>
<tr>
<td>Size 10</td>
<td>Size 7</td>
<td>Size 8</td>
<td>Leave a 16 cm. space between expansion bolts</td>
</tr>
<tr>
<td>Size 2</td>
<td>Size 6</td>
<td>Size 8</td>
<td>Leave a 15 cm. space between aircrete wall plugs</td>
</tr>
<tr>
<td>4 mm. x 60 mm.</td>
<td>4 mm. x 60 mm.</td>
<td>6 mm. x 80 mm.</td>
<td>Size 2: 10 mm. board</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Size 3: 12 mm. board</td>
</tr>
</tbody>
</table>

**NOTES:**

- It is best if plastic masonry wall plugs are long enough to pass through 2 holes in the clay tile in order to hold more securely.
- Leave a 16 cm. space between expansion bolts.
- Leave a 15 cm. space between aircrete wall plugs.

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© 2003 American Red Cross, Boğaziçi University, Disaster Preparedness Education Project, Kandilli Observatory and Earthquake Research Institute, and the Center for Disaster Management.
The methods suggested in this education for reducing non-structural risk were based upon 8 months of research, testing, and calculations. This was done by a team of researchers at Boğaziçi University, Disaster Preparedness Education Project (DPEP), Kandilli Observatory and Earthquake Research Institute (KOERI), and the Center for Disaster Management (CENDIM).

Research:
Many of the suggestions in this education are based upon reports from past earthquake experiences and recommendations from governmental agencies in earthquake regions around the globe. Local industrial specialists were also consulted. In addition, countless people were interviewed regarding what they had done to reduce their risk. Their ideas were considered and their questions and concerns were taken into account.

Laboratory Tests:
Electronic equipment, white appliances, and large furniture items were attached to wall materials on a shake table using a variety of fastener types and installation methods. Effective and ineffective attachment methods were learned through hundreds of tests.

Calculations:
When there were no tests or past research, engineering calculations were used. Recommendations for the size and number of attachments, wall plugs, and screws are based upon the International Building Code as well as manufacturer’s guidelines.
Research regarding non-structural damage in earthquakes is a new field. Even newer are the ideas for reducing these risks. While people all over the world have found simple and innovative ways for reducing their risk, there are still many unanswered questions and puzzling problems. Everyone can play a part in finding solutions for these problems. Citizens should reduce the risks in their own surroundings. After an earthquake, they can also investigate how non-structural mitigation worked in homes, schools, and work places. Scientists and engineers can do further research and calculations. Technicians, entrepreneurs, handymen and even ordinary citizens can think of new earthquake safety products. It is only by working together that we can make our surroundings and communities safer and more resilient in the face of earthquakes.

GOALS

Major earthquakes can create devastating tragedies for a community including loss of life, injuries, loss of homes, work and community. However, we have learned from past earthquakes all over the world that much of this can be prevented. Many injuries, economic losses and even deaths can be avoided by simply making the items in our buildings safer during earthquakes.

Our mission is:

• To raise awareness regarding the risks that exist from non-structural items.

• To show how these risks can be identified.

• To encourage everyone to take simple steps to reduce these risks.

We would like to thank the Turkish Red Crescent Society and American Red Cross for seeing the value of this material and aiding in the development and dissemination of this education. This education program would not have been possible without the assistance of many people. We would especially like to thank the producers of non-structural mitigation products for sharing their experience and donating their products.

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İnteryör
Kaya Yapı San. Ve Tic. Ltd. Şti.
TNT İmalat ve Ticaret

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DISCLAIMER:

Boğaziçi University, Kandilli Observatory and Earthquake Research Institute, and the Disaster Preparedness Education Project have tried to ensure the accuracy of this publication. However, earthquake engineering remains a new science and there is not enough information to fully predict the performance of non-structural items in future earthquakes, even if these guidelines are followed. Individual situations vary and it is the responsibility of the reader to carefully consider how to apply these recommendations to their own situation, and to seek expert guidance when in doubt. All parties assume no responsibility for the losses that may occur in an earthquake or as a result of applying these recommendations.
This handbook includes information about basic non-structural mitigation. You can find out more information from your instructor, www.iiahep.org or www.kizilay.org.tr about the following items:

- Water Heaters
- Stoves and Heaters
- Signs, Air Conditioners, and Satellite Dishes
- Suspended Ceilings
- Pipes and Ducts
- Masonry Walls
- Chimneys
- Non-structural Exteriors
- Elevators, Escalators, and Moving Walks
- Large and Sensitive Equipment

RESOURCES

This book is designed to help identify non-structural hazards in our homes, schools, work places, and public spaces and show how these hazards can be reduced. Non-structural elements are all the parts of a building, its furnishings and contents, except the structure itself. In other words, they are everything but the columns, beams, floors, load-bearing walls, roof and foundation.

“What’s the point of worrying about non-structural risk, don’t most buildings completely collapse anyway?”

The best way to find out if your home will be strong in an earthquake is by having an engineer inspect your building. However, it is important to realize that only 5% of the damaged buildings in the 1999 Izmit and Duzce Earthquakes totally pancake collapsed. In many heavily and moderately damaged buildings and even in some slightly damaged buildings, non-structural hazards accounted for serious injuries and huge economic losses.

Of the 1,500,000 people directly affected by these earthquakes, 1% lost their lives. While losing these people was an incredible tragedy, the remaining 99% of residents were left to try to resume living after the earthquake.

Taking precautions like those suggested in this handbook is one way that we can prepare for the next earthquake. These precautions will help make resuming life afterwards easier and quicker and will reduce economic loss. More importantly, they will reduce the number of lives lost. Even preventing small injuries allows priority to be given to those that are life threatening and helps to save lives.

NSM is still a new subject and new things are learned every day all over the world. This learning process has already started in Turkey. People who see the importance of NSM have begun mitigating hospitals, museums and their own homes and workplaces. These pioneers have not only learned ways to improve NSM, they have also learned the importance of maintaining their work and making NSM a way of life.

As problems occur, they should be seen as clues to better solutions, rather than as failures.

• When plastic clip and strap fasteners first started being used in Turkey, it was found that they were easy to leave open. Because of this, an improved locking fastener was produced.
• After seeing that suspended ceilings broke apart and fell during earthquakes in the United States of America, it was clear that the methods used for attaching them were not sufficient. These methods have also been improved and tested through a series of earthquakes.
• Self-adhesive fasteners have come unattached after use and wear. This has made everyone more aware of the importance of inspection and maintenance.

In everything we do, we need to continue to ask how we can improve.

In order for NSM to be successful, everyone must be educated and part of the process. The measures taken will become ineffective and quickly fall into disuse if they are considered to be a hindrance to the flow of daily life. The responsibility for addressing this issue falls upon the installers of NSM. It is very important to explain how and why measures can help protect our lives and include everyone in the decision making process during installation. This will create users that become advocates for their permanence.

Everyone who learns about this topic realizes that their job is not finished after simply doing NSM. We recognize that this will become a part of our lives. At regular intervals we will need to check our fasteners. When rearranging or buying furniture we will need to consider how we will secure it and buy the necessary materials. While these new habits may come with difficulty at first, with time we will become accustomed to them and making things safer will become automatic. As we share this knowledge and expertise with those around us and our information increases, even more attractive and easy solutions will emerge.

Non-structural mitigation is a shared responsibility. After earthquakes occur, all of our observations and thoughts regarding improvements will help our knowledge to grow. In order to make our communities more resilient in the face of this type of disaster, everyone must play a role.
TANKS AND LIGHTING

Non-structural hazards are the cause of a huge number of avoidable injuries and deaths. They also hinder rescue and aid efforts, cause great economic loss and make resuming everyday life harder.

Did you know?

- 50% of the injuries and 3% of the deaths in the Izmit Earthquake of 1999 were caused solely by non-structural hazards.
- After the Izmit Earthquake of 1999, survivors estimated that 30% of their economic losses were due to loss of furniture, equipment and other valuable non-structural objects.
- Non-structural damage in earthquakes has caused businesses to close, jobs to be lost, and schooling to be interrupted.
- After the United States Northridge Earthquake of 1994, ten essential hospitals with little or no structural damage needed to be evacuated or closed because of non-structural damage. As a result, medical response was severely disrupted.

There are many things that can be done to keep lighting from falling and causing harm during earthquakes:

- Attach lighting to structural elements
- Secure florescent tubes to casings
- Secure hanging lights with safety cables
- Secure heavy hanging lights with locking hooks
- Keep wires and ballasts neatly secured
- Attach floor lamps to the wall
- Secure tabletop lamps with glass shades to tables and shelves
OBJECTS CAN SLIDE AND FALL IN MANY DIRECTIONS

When identifying non-structural hazards, it is important to remember that earthquake forces are different than the gravitational force that we feel every day. When we drop something it falls straight to the ground. The gravitational force of the earth pulls the object down to the ground. However, earthquake waves may come from any direction. It is important to consider all possible directions when looking for items that can topple or slide.

ITEMS THAT WILL TOPPLE EASILY:

1. **Objects that are taller than they are deep or wide:**
   - If the height is MORE than \(1\frac{1}{2}\) times the depth it can easily topple forwards and backwards.
   - If the height is MORE than \(1\frac{1}{2}\) times the width, it can easily topple to the side.

2. **Objects that are top heavy:**
   These objects can easily topple in all directions.

ITEMS THAT WILL SLIDE EASILY:

1. Objects that have wheels
2. Objects that are too low to topple
3. Objects that are on a slippery floors, like tile or wood
4. Objects that are much heavier on the bottom than on the top

GLASS AND EXITS

It is especially important to make sure that glass in crowded public spaces such as shopping areas, large terminals, hospitals, theatres, schools, and places of worship will not pose serious risk.

- Rearrange furniture and hang long curtains
- Use laminated glass
- Use tempered glass
- Install security film

Not all glass furniture is made from the same type of glass. Furniture made from **tempered** or **laminated** glass is safer when it breaks. When purchasing furniture with glass parts it is important to find out what type of glass it is made from.

After an earthquake, people may need to quickly, but calmly exit buildings. Here are several steps that can be done to make exiting easier:

- Keep items that may hinder evacuation away from exit doors
- Install outward opening doors
- Create wide exits
- Ensure that doors open easily
- Install service entrances adjacent to revolving doors
- Use a single secure door instead of an added security gate
- Keep fire exits unlocked and install panic bars
- Place strong levers to use in case of emergency near heavy exit doors and barred windows
- Install back-up systems for electric automatic doors and gates
Some items on shelving are more important to secure than others. Here are some items that may be irreplaceable, cause harm, be hard to reorganize, or be needed immediately following an earthquake:

- Stored museum collections
- Dangerous chemicals
- Files
- Large collections of books
- Emergency equipment
- Medical supplies

- A removable wooden or metal bar can be placed across each shelf at mid-height.
- A metal, plexiglass, or wood “lip” can be screwed to each shelf.
- An elastic band or wire can be added as well.
- Small items and bottles can be secured in larger boxes in a way that they will not hit each other.
- Heavy or dangerous items should be placed on bottom shelves.

Be sure that unsecured heavy objects are placed below the height of the lowest person in your household.

OBJECTS SHOULD BE SECURED TO STRUCTURAL OR SOUND NON-STRUCTURAL ELEMENTS TO PREVENT TOPPLING AND SLIDING

Our objective is to make the objects move with the structure of the building, rather than being thrown about inside it. Sometimes objects can be attached to the structure and other times to strong and secure non-structural elements instead.

Gypsum board, aircrète and adobe are weak wall materials that need special consideration.

It is important to consider how secure shelves, cabinets, and tables are before securing items to them.

Masonry walls, although they are non-structural elements, can be a good place to attach items when they are made from strong brick and mortar.
When objects are allowed to hit people, each other, or parts of a building they will cause damage and injury. However, where and how we attach these items is also very important. Attaching furniture items incorrectly can make non-structural mitigation less effective or even be of no help at all.

When furniture is secured loosely or with a large space between it and the wall, it can still violently hit the wall during an earthquake. For this reason it is best to attach items as tightly as possible.

If a space remains between the wall and a secured item, placing a bumper in the space can protect both the furniture, the wall and the fastener.

When using nylon straps and plastic clip and strap fasteners, the straps should be tightened so that the secured object does not move around and strike anything.

When we attach non-structural items to structural ones, they are less likely to topple, hurt someone or be damaged. However, where and how we attach these items is also very important. Attaching furniture items incorrectly can make non-structural mitigation less effective or even be of no help at all.

Cabinet doors should be kept from opening and spilling their contents during earthquakes.

- **Mechanical Latches**: It is important to close cupboards containing heavy items with mechanical or child proof latches.
- **Child Proof Safety Latches**: Magnetic and other lightweight latches should only be used for cupboards containing lightweight objects.
- **Magnetic and Click Latches**: Rubberized shelf mat will also help keep low objects inside cabinets from sliding.
- **Earthquake Hold and Rubberized Shelf Mat**: Earthquake hold can be placed on the bottom of fragile items to secure them.

Remember to clean well!
Earthquakes are a risk that we accept by living in an earthquake region. We face many other risks in our lives as well and we take precautions to reduce our losses from them. NSM is a reasonable precaution against earthquake risks from the non-structural elements of buildings. To decide what NSM is necessary, you need to identify what risks exist in your home, school, workplace, and the public spaces that you frequent. This risk varies from situation to situation. It is important to evaluate each situation individually.

**RISK IDENTIFICATION**

**RISK: SERIOUS INJURY OR DEATH**

**RISK: DAMAGE TO BELONGINGS**

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If your lightweight pictures are already hanging on nails in the wall, you can secure them with strong twine without removing the nail.

Secure the bottom edges of pictures and mirrors with earthquake hold to keep them from banging against the wall and breaking.

Carefully choose a location to attach hanging objects like flower pots. This location should not be near windows, walls, or other objects.

Close the opening of the hook with a pair of pliers to prevent the object from jumping off the hook during an earthquake.
DECIDING WHAT TO DO FIRST

1. The first step to reducing non-structural risk can be to rearrange furniture and other items. Think of the places where your family, your students or your co-workers spend the most time.
   - Are there any heavy tall items that you could move to safer locations?
   - Can furniture that people sit in often be moved away from windows?
   - Are there any large items that can be moved to lower shelves?
   - Are there any items that you are no longer using that can be removed?

2. Now, identify the rest of your risks using the hazard hunt.
   In general, items that are taller and heavier, that can fall on us while we sleep or block exits, contain hazardous materials, are important to daily life, or are expensive should be considered first.

3. Reduce all the risks you can by using the simple instructions in this book.

4. Consult a professional to help you reduce any remaining risks.

Securing countertop appliances that may be hot or that are attached to gas lines can help prevent burns, gas leakage and fires.

The angle should be tall enough to come up the side of the appliance and hold it in place. It does not need to be attached to the appliance surface.

L shaped angle can be attached to a well cleaned countertop using any of the following options:

- **Screws**, and if necessary wall plugs, appropriate for your type of counter top.

- Double sided self adhesive tape found in many large hardware and do-it-yourself stores. Look for tape labeled “mirror attachment tape” as it is sufficiently strong.

- Strips of **self-adhesive hook and loop tape**, commonly called self-adhesive Velcro™, found at large hardware and do-it-yourself stores. Stick one side of the hook and loop to the counter and the other to the bottom of the L profile or bracket.
Use plastic clip and strap fasteners only on small white appliances that are **counter height or lower** and weigh **less than 35 kg**. (e.g. dorm size refrigerators, etc).

**ATTACHING TO A BACK WALL**

Be sure to leave about a 2 cm. tail on each end of the strap so that the strap cannot easily be pulled out of the fastener. A 2 cm. tail will also ease tightening.

**ATTACHING IN A CORNER**

**ATTACHING IN A NICHE**

Do not forget to use padding when necessary!

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**EARTHQUAKE HAZARD HUNT**

The Earthquake Hazard Hunt should begin at home, with all family members participating. Imagination, and common sense are all that are needed as you go from room to room and think about what will happen when the earth starts shaking. Check for objects that may slide, fall, and fly where people spend the most time - where they sleep, eat, work and play. Do some detective work! Make a list of what needs to be done and tackle it one by one until it’s finished!

As you tackle what needs to be done, prioritize the items as follows:

1. **Secure life threatening items first** (eg. wardrobes in bedroom or things blocking exit)
2. **Secure those things that would entail significant economic loss** (eg. computer, a/v equipment)
3. **Secure those items that will let you live more comfortably** (eg. family heirlooms, breakables)
   - Move heavy items below the head level of the shortest family member.
   - Tightly secure furniture to walls (including kitchen cabinets).
   - Make sure white appliances and hot water heaters are secure.
   - Fasten LPG tanks and other gas cylinders to the wall.
   - Make glass that may break into large shards less dangerous (hang long curtains, rearrange furniture, install strengthened glass.)
   - Secure heavy and important electronic items.
   - Secure light fixtures to the ceiling.
   - Fasten pictures on closed hooks.
   - Check for any hazardous materials (poisons, flammable materials); make sure they are secure.
   - Consider replacing kitchen cabinet latches with ones that will hold shut during a quake.

**Hazards we found:**

______________________________  **Date corrected:**

______________________________

______________________________

______________________________

______________________________
BEFORE MITIGATION

STEP 1.
ESTIMATE WEIGHT

STEP 2.
CHOOSE FASTENER TYPE AND NUMBER

STEP 3.
DECIDE WHERE TO FASTEN

STEP 4.
CHOOSE HARDWARE FOR ATTACHING TO WALLS AND STRUCTURAL ELEMENTS

STEP 5.
DECIDE HOW TO ATTACH FASTENERS TO FURNITURE

Nylon Straps
After 24 hours, tighten all straps!
Remember to clean well!

ATTACHING TO A BACK WALL
Items up to 130 kg. or WITH WHEELS
Low Items up to 65 kg. WITHOUT WHEELS

ATTACHING IN A NICHE
Items up to 120 kg. or WITHOUT WHEELS

ATTACHING IN A CORNER
Items up to 120 kg. or WITHOUT WHEELS

Nylon straps should be attached to the wall behind appliances at least 20 cm. from their edge. This will help ensure that the hook and loop attachment will not come undone when the appliance is shaking during an earthquake.

Do not forget to use padding when necessary!
**ELECTRONICS AND OTHER ELECTRIC EQUIPMENT**

Self-adhesive hook and loop tape can be used for **light** equipment that is **low and will slide**, but will not tip over during an earthquake.

Attach one strip on each side of the bottom of the equipment.

To temporarily remove electronics attached to surfaces with self-adhesive hook and loop tape, gently but firmly pull up on a single corner of the equipment.

Wait at least 24 hours before first removing the equipment in order to allow the self-adhesive to completely set.

If using self-adhesive hook and loop tape is not possible, placing a large piece of non-slip material underneath the entire under surface of the equipment can help reduce the amount it will slide.

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**STEP 1. ESTIMATE WEIGHT**

The pictures below may be helpful when estimating weight.

- **Approx. 200 kg.**
  - Large office equipment 150-175 kg.

- **Approx. 150 kg.**
  - Large refrigerator 100-150 kg.
  - Large furniture 100-200 kg.

- **Approx. 100 kg.**
  - 135 mm television 100 kg.
  - Midsize refrigerator 90-120 kg.

- **Approx. 50 kg.**
  - Washing machine 50-75 kg.
  - Mini Oven 30-40 kg.

- **Approx. 25 kg.**
  - 55 mm television 25 kg.
  - Small furniture under 25 kg.

Do NOT use self-adhesive hook and loop tape on large televisions or other equipment that can topple.

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STEP 2. CHOOSE FASTENER NUMBER AND TYPE

STANDARD AND SPECIALITY L BRACKETS

1. Weight of furniture:
   - 0-50 kg. – small L brackets
   - 50-100 kg. – medium L brackets
   - 100-150 kg. – large L brackets

2. Space between wall and furniture:
   If there is a space between the wall and the furniture, you may need to choose a larger bracket so that the holes on the furniture side are usable.

3. Width of bracket:
   Choose wide L brackets with more than one row of holes. When screws are placed in the holes closest to the bend and in a diagonal pattern they work best.

NYLON STRAPS

When you use nylon straps with hook and loop tape (Velcro™), it is important to make sure that the pad that you are attaching with is big enough for the weight of your object.

- **0-50 kg.** - small nylon straps
  Each strap you use should have at least 25cm² industrial strength Velcro™ or similar hook and loop products

- **50-100 kg.** - large nylon straps
  Each strap you use should have at least 50cm² industrial strength Velcro™ or similar hook and loop products

- **televisions**
- **monitors**
- **small office equipment**
- **small copy machines**
- **small laboratory equipment**

- **white appliances**
- **large screen televisions**
- **copy machines**
- **workplace equipment**
- **equipment on wheels which must be moved**

ELECTRONICS AND OTHER ELECTRIC EQUIPMENT

- **37 mm. screen** televisions or electronic equipment up to 20 kg.
  - 2 or 3 plastic clip and strap fasteners

- **55 mm. screen** televisions or electronic equipment up to 40 kg.
  - 4 plastic clip and strap fasteners

STACKED EQUIPMENT

When attaching the base item to the table, be sure to use sufficient number of fasteners for the **combined weight** of all the items stacked together.

Be sure to leave about a 2 cm. tail on each end of the strap so that the strap cannot easily be pulled out of the fastener. A 2 cm. tail will also ease tightening.
ELECTRONICS AND OTHER ELECTRIC EQUIPMENT

- 35 kg. or lighter
- counter top height or lower
- small and medium electronics
- computers, fax machines, printers, and similar equipment
- countertop appliances
- mini (dorm size) refrigerators and freezers
- countertop laboratory equipment

Large home improvement stores:
- L brackets, cabinet latches, hooks, non-slip material, nylon webbing for straps, metal angle, self-adhesive hook and loop tape, and plastic clip and strap fasteners (at some locations)

Small hardware stores:
- L brackets, cabinet latches, hooks, rubber shelf mats, and metal angle

Boating stores:
- Nylon webbing for straps, fishing line, and cabinet latches

Specialty earthquake safety product distributors:
- Plastic clip and strap fasteners, small and large nylon straps, specialty L brackets, and picture hangers

WHERE TO FIND NSM SUPPLIES

This handbook will tell you which fasteners are appropriate for particular items and how many of them you will need. You can use this information to easily determine what supplies are necessary to purchase.

For big screen televisions and other large electronic equipment, see the section on white appliances for proper fasteners and attachment methods.

Remember to clean well!

After 24 hours, tighten all straps!
### Step 3. Decide Where to Fasten

**Desktops, Tables and Workspaces**

**Walls**

**Columns, Beams and Floors**

**Wall Bridges**

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### Wall Types Not Strong Enough for Securing Non-structural Items

<table>
<thead>
<tr>
<th>Wall Types</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum Board</td>
<td>Attach directly to the studs or make a wall bridge between the wood studs or timber framing members.</td>
</tr>
<tr>
<td>Traditional infill walls (bagdadi and himiş)</td>
<td>Make a wall bridge between columns, also attaching the wall bridge to the wall at 15 cm. spacing. Alternatively, secure items to structural elements.</td>
</tr>
<tr>
<td>Aircrète</td>
<td>Make a wall bridge between columns, also attaching the wall bridge to the wall at 15 cm. spacing. Alternatively, secure items to structural elements.</td>
</tr>
<tr>
<td>Adobe</td>
<td>Attach to wood structural members in the floor and ceiling.</td>
</tr>
<tr>
<td>Rubble stone</td>
<td></td>
</tr>
</tbody>
</table>

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### Furniture

When items must remain free-standing, or the space between the their top and the ceiling is small, the methods show below can help reduce the risk of them toppling or sliding.

Row shelving can be secured by using steel L angle to secure the tops of the shelves together. The steel L angle must then be securely fastened to the wall.

For large free standing shelving, consult an engineer to determine appropriate size steel angle, bolt sizing, and connection placement.

Shelf bottoms should also be attached directly to the floor using expansion bolts or L angle.
**STEP 4. CHOOSE HARDWARE FOR ATTACHING TO WALLS**

Wall plugs, expansion bolts, and screws are designed and manufactured to work best when used with the correct material. Use the table below to determine the size wall plug, lag screw or expansion bolt you will need. You can figure out how many you will need by looking at the instructions for your type of furniture.

**What is your wall or structural element type?**

<table>
<thead>
<tr>
<th>Brick Masonry</th>
<th>Concrete</th>
<th>Aircrete</th>
<th>Gypsum Board</th>
<th>Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Masonry Wall Plugs</td>
<td>Standard Wall Plugs</td>
<td>Steel Expansion Bolts</td>
<td>Plastic Aircrete Wall Plugs</td>
<td>Gypsum Wall Plugs</td>
</tr>
</tbody>
</table>

**How heavy is your furniture?**

<table>
<thead>
<tr>
<th>0 - 5 kg.</th>
<th>5 - 50 kg.</th>
<th>50 - 150 kg.</th>
<th>150 kg. +</th>
</tr>
</thead>
<tbody>
<tr>
<td>For light objects use size 6 Standard Wall Plugs</td>
<td>Size 6</td>
<td>Size 8</td>
<td>To secure very heavy items, consult an engineer or professional for proper installation.</td>
</tr>
<tr>
<td>Size 10</td>
<td>Size 7</td>
<td>Size 8</td>
<td></td>
</tr>
<tr>
<td>Size 2</td>
<td>Size 6</td>
<td>4 mm. x 60 mm.</td>
<td></td>
</tr>
<tr>
<td>4 mm. x 60 mm.</td>
<td>6 mm. x 80 mm.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

- It is best if plastic masonry wall plugs are long enough to pass through 2 holes in the clay tile in order to hold more securely.
- Leave a 16 cm. space between expansion bolts.
- Leave a 15 cm. space between aircrete wall plugs.
- Size 2: 10 mm. board
- Size 3: 12 mm. board

Open shelving must be braced before it can be secured to walls and floors. This bracing will ensure that the shelving cannot easily sway from side to side and collapse.

When you attach furniture together you create one object that is wider or deeper than the original individual objects. This can make the items more stable and less likely to tip over during an earthquake.

Once furniture has been attached together, you need to check whether its height is 1 1/2 times its new width and depth. If it can still topple, securing it to a wall, floor or ceiling is necessary.

Flexible bracing

Rigid bracing

M8 bolts and oversized washers -or- furniture attachment bolts

Metal plate connected with 4 5 mm. or larger diameter screws -or- 2 M8 or larger diameter bolts and oversized washers.

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STEP 5. DECIDE HOW TO ATTACH FASTENERS TO FURNITURE

FURNITURE SCREWS
Always use at least two screws per fastener when attaching a fastener to a piece of furniture. Use more for heavy items or consider using bolts.

Solid Wood Screws
In order to avoid causing wood material to break or crack, drill pilot holes when using screws over 4 mm. in diameter or 45 mm. in length. Use a drill bit half the diameter of the screw when making the pilot hole.

Plywood, Pressboard and MDF Screws

Sheet Metal Screws
Metal screws need to be selected based upon the thickness of the metal to which the screw will be attached. The teeth of the metal screw should be wider than the thickness of the metal.

FASTENERS WITH SELF-ADHESIVE
It is always stronger to attach an item with screws. However, there are times when items cannot be screwed into. In these instances self-adhesive pads are often used. When using fasteners with self-adhesive attachments, it is very important that surfaces be clean and completely dry.

Cleaning products:
• Special surface primer sold by manufacturers of self-adhesive is the best possible cleaning solution.
• Isopropyl alcohol found at local pharmacies is also recommended by manufacturers.
• Alcohol based window cleaner purchased at your local grocery store is also a good alternative and is easy to use.

ATTACHING TO A WALL
Some furniture can be secured by screwing the back directly into the wall.
• The back panel of the furniture must be thick and strong.
• Distribute the attachments evenly across the back panel.
• Spaces between attachments should be no more than 1.25 meters in each direction.

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Do not forget to use padding when necessary!