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structural awareness for seismic safety

handbook

AMERİKAN BORD HEYETİ

Lutheran World Relief
To others, through others.

B.U. KANDILLI OBSERVATORY AND EARTHQUAKE RESEARCH INSTITUTE
DISASTER PREPAREDNESS EDUCATION PROJECT

Structural Awareness for Seismic Safety Handbook

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This project was funded under the auspices of the American Board with funding through Lutheran World Relief with generous support from Boğaziçi University, Disaster Preparedness Education Project, Kandilli Observatory and Earthquake Research Institute, and the Center for Disaster Management. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of American Board and Lutheran World Relief.

This publication was made possible through the support provided by the Office of Foreign Disaster Assistance, U.S. Agency for International Development, under the terms of Award No. AOT-G-00-00-00235-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

Turkish edition published by Beyaz Gemi Publishers.

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PREFACE

Buildings that are damaged in earthquakes can create devastating tragedies for a community, including loss of life, injuries, loss of homes and work. A small percentage of the buildings that were damaged in the 1999 İzmit and Düzce earthquakes were not **life safe**. They collapsed causing loss of life and serious injuries. This was even more devastating because many of the building collapses could have been prevented with better design, construction and maintenance. If we design, construct, and maintain earthquake resistant buildings we will still see some building damage in large earthquakes, but we will create communities with buildings that are **life safe** and see less economic hardship after the ground shakes.

1999 İzmit and Düzce Earthquakes

Approximately 52,000 buildings were damaged. Of these:

70% were moderately to lightly damaged
25% were heavily damaged
5% totally pancake collapsed

Of the damaged buildings, 45% were later condemned.

Erdik, Mustafa. 2000. Report on 1999 Kocaeli and Düzce Earthquakes. www. koeri.boun.edu.tr

Creating a community of safer buildings is not something that can happen overnight. It will take time and effort. Habits, priorities and laws will need to be changed. Unsafe buildings will need to be retrofitted or replaced. Every building from the smallest to the largest will need to be built with earthquakes in mind. We all will need to work on making sure that our buildings are as earthquake resistant as possible from their design and construction to their maintenance and repair.

Our mission is:

- To raise awareness regarding what makes buildings earthquake resistant.
- To show how the actions of building designers, builders, and users can affect earthquake safety.
- To encourage everyone to become advocates for better buildings and building maintenance.

If we all work together, we can save lives, avoid injuries, avoid the devastating economic effects of building damage and make our communities more resilient, for ourselves and future generations.

This education program was compiled 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). It is designed for the general public in order to create awareness about earthquake resistant structures. It is not in any way a replacement for study in earthquake design, detailed earthquake building courses, or builder’s manuals.

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sass BUILDING IN EARTHQUAKE REGIONS

IDENTIFYING EARTHQUAKE REGIONS

The earth's surface is made up of many different parts called **tectonic plates.** These plates are always moving a little bit, at about the same rate that our fingernails grow. As they move, they push against each other and build up pressure. Eventually this pressure causes them to slip and the ground shakes; we call this an **earthquake**. It is similar to when you snap your fingers. When you first push your fingers together, nothing happens. But then, the force is built up and "snap." However, unlike your fingers an entire tectonic plate doesn't slip at once. Sections of the plate slip separately when enough pressure has been created.

The places where plates slip past each other are called **fault lines**. We know about some fault lines because they have left evidence on the surface that we can see. We know about others because we have recorded and mapped where earthquakes occur. However, there are still some faults that have not been discovered or that have yet to be created.

Earthquake Region Maps in Turkey show different earthquake risk zones and classify them from 1 to 5. These numbers identify how close a zone is to a known earthquake fault line and therefore how much the ground is likely to shake. Zone maps are modified as new fault lines are found and earthquake predictions are revised. Zone 5 is thought to be far from a fault line; where as, Zone 1 is thought to be very close. When building construction standards are being established these maps are used to decide how much the ground is likely to shake. This can help us design and build buildings to withstand the type of shaking they are likely to feel. Buildings in each zone must be built to a particular standard. However, discovering what zone you live in cannot tell you how safe your building is. You need to know how it was built, what materials were used and how it has been maintained. Buildings in all earthquake zones can be earthquake resistant if they are built well.

Earthquake Facts:

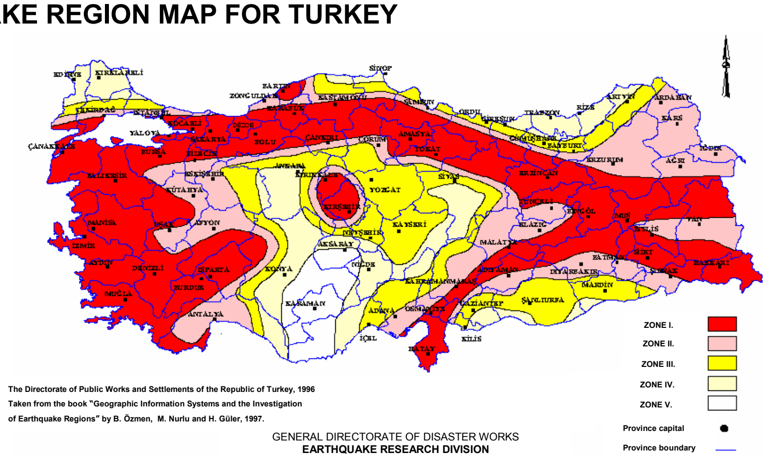
It is estimated that there are 500,000 detectable earthquakes in the world each year. 100,000 of these can be felt; 100 of them cause damage.

The largest earthquake ever recorded was 9.5 (Mw) and occurred in Chile in 1960.

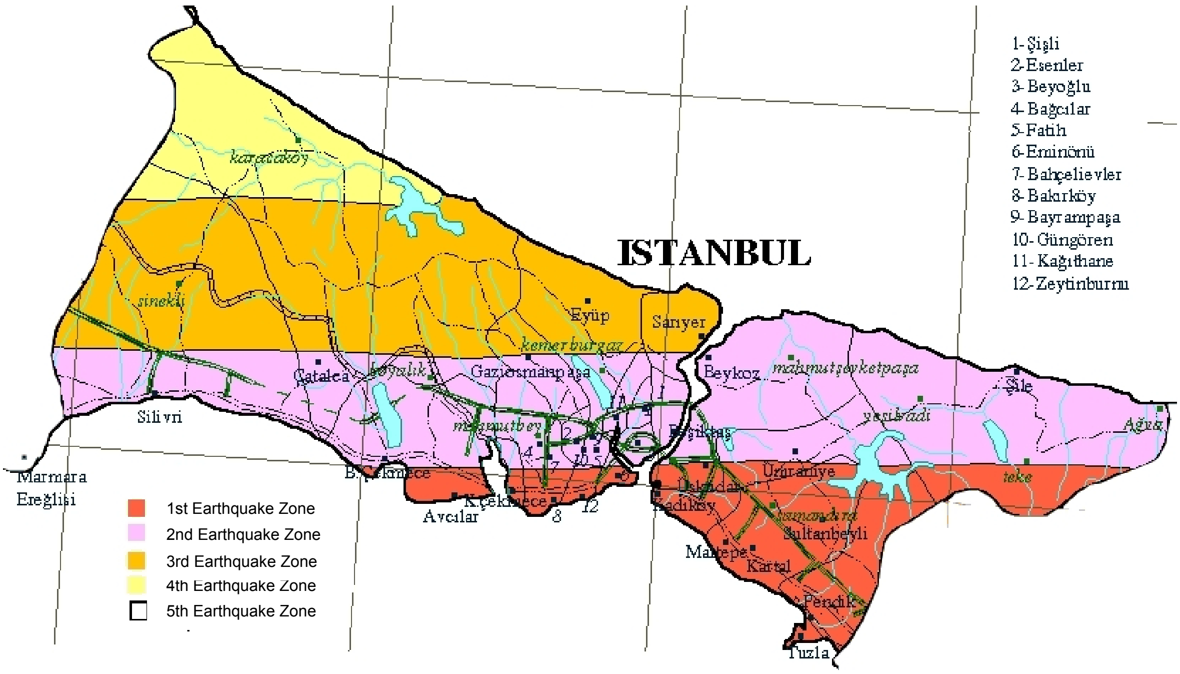
The earliest recorded evidence of an earthquake has been traced back to 1831 BCE in the Shandong province of China.

Source: USGS www.usgs.gov

THE EARTHQUAKE REGION MAP FOR TURKEY

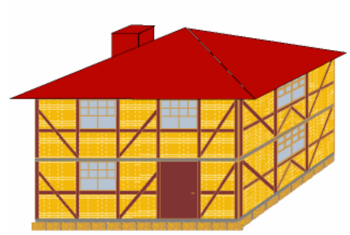


THE EARTHQUAKE REGION MAP FOR ISTANBUL

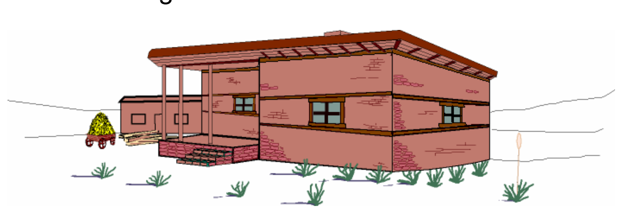


For more information regarding earthquake region maps, you can refer to the website **www.deprem.gov.tr.**

BUILDINGS IN TURKEY THROUGH THE AGES



Earthquakes have occurred in Turkey for a long time, and for almost as long people have been working on ways to build structures so that they will stay standing when the ground shakes. For instance, at one point in Istanbul's history everyone was required to build houses from wood, because they were found to be more flexible during earthquakes and less likely to fall then brick or stone. In many regions of Turkey, traditional building styles have also had elements that make them more earthquake resistant. *Hımış* buildings, traditional houses made from timber frames and infilled masonry walls, have traditionally used X and V patterned wood braces in their construction. This **bracing** helps keep the walls from tipping sideways when the ground shakes. In traditional stone construction in Southern Turkey horizontal wood timbers called **ring beams** are placed in between the layers of stone. This can help keep the stone wall from crumbling when the ground shakes. Engineers and builders use some of the same principles behind these traditional techniques in newer structures that are built today. They are also developing new building techniques to help keep modern concrete and steel structures from being heavily damaged during earthquakes.



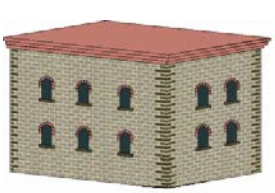
LEARNING HOW TO MAKE BUILDINGS EARTHQUAKE RESISTANT

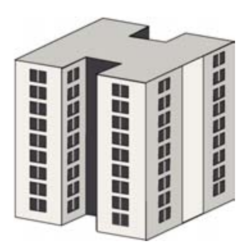
As much as we know about building earthquake resistant structures, there is still a lot that we are discovering. Unfortunately, we learn the most about how to keep buildings earthquake resistant by watching them become damaged. When the Saint Sophia was built in 537, it was a masterful feat in both engineering and architecture. However, it has needed to be repaired and redesigned as problems have appeared. In fact, earthquakes in 558, 986, and 1346 are thought to have caused the large dome to collapse three different times. After each earthquake the Saint Sophia was strengthened and made more earthquake resistant. In 1573, over 1,000 years after it was built, the great Ottoman architect Sinan worked on strengthening it even more by adding buttresses to help keep the walls from falling outward during an earthquake. In 1847 modern engineers examined the building once more and strengthened it further. More recently earthquake engineers recommended proactive strengthening of certain exterior elements to avoid damages in future earthquake. We are constantly learning new ways to make buildings perform better in earthquakes.

Large earthquakes have incredibly strong forces and when they occur we expect that even well built buildings will see some damage, for instance small cracks in the beams and columns. However, urban centers near fault lines are growing denser every day and earthquakes in cities affect enormous numbers of people. Poorly built medium and high-rise buildings with large numbers of residents are now more prevalent and when they are damaged during earthquakes can become lethal. These injuries and deaths could often have been prevented through better construction and knowledge. We need to learn what makes buildings earthquake resistant in order to help ensure that we are safe in our homes, work places and schools. This knowledge will also help us reduce costly damage. By doing this we can make our communities safer and more resilient in the face of earthquakes.

Q: It is the job of engineers, builders, and architects to make buildings earthquake resistant. What good will this information do me?

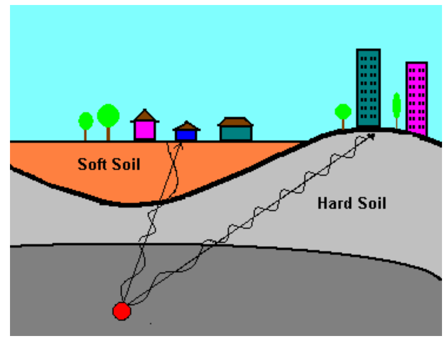
A: Yes, engineers and builders need to know how to make buildings earthquake resistant. However, ordinary citizens purchase, renovate and live in these buildings. In order to drive a car you do not need to know how to change the oil, but you need to know that it is necessary to change the oil or the engine will be ruined. In the same way, as owners and renters of homes in an earthquake region we all need to know how to maintain our buildings and how to tell when an engineer should be consulted so that our buildings remain earthquake resistant .



THE GROUND WE BUILD ON

SOILS DURING EARTHQUAKES



By learning how buildings have been affected by earthquakes in the past and trying to predict how they will be affected in the future, architects and engineers try to create buildings that are earthquake resistant. They use earthquake region maps as a starting point to anticipate how buildings will behave during future earthquakes. They also try to estimate how earthquakes will affect buildings by learning the particular type of soil they will be built on.

When earthquake waves travel from the **hypocenter**, the place where the energy is being released, they pass through many different types of soils. Depending on the strength of the earthquake, different soils may amplify earthquake waves. However, not all soils amplify earthquake waves in the same way. If you are standing on hard rock when an earthquake occurs, you are likely to feel the ground rattling. However, if you are standing on mud flats when the same earthquake occurs, you are likely to feel the ground rolling beneath you in large waves. This is because hard soils cause the earthquake waves that are close together, the **short period waves**, to be amplified, whereas, soft soils cause the earthquake waves that are farther apart, the **long period waves**, to be amplified.

LOCALIZED GEOLOGICAL MAPS

If the type of shaking that will occur under a building is known, it helps it to be built with materials and techniques that are best for this type of shaking. For this reason many cities in earthquake regions have **geological maps** that show what different types of soils are located in different parts of their cities. Looking at a seismic soil map tells the general soil type in an area, but drilling is used to determine the exact soil that exists at a building sight. Through earthquake microzonation studies, soil maps can be used to regulate land use. For instance, regional planners may decide to restrict building in places that are especially difficult to build earthquake resistant buildings, such as right next to a known earthquake fault or on very steep slopes where earthquakes may start landslides. They might also restrict the types of buildings on very soft and wet soils where liquefaction could occur, making the ground unstable during an earthquake. Although engineers use geological maps and soil samples to decide what type of foundation and structure should be built, knowing what your soil type is will not tell you how safe your building is. In order to discover whether your building is earthquake resistant, you need to know how it was built.

For more information regarding geological maps of Turkey, see **www.ibb.gov.tr**.

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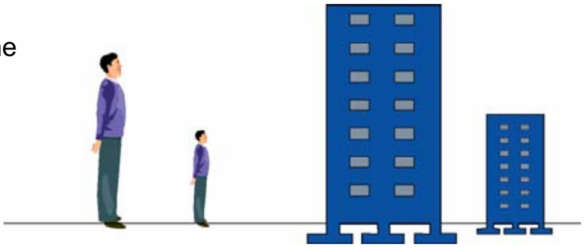
Q: Isn't it better to live on rock than soft soil?

A: When buildings are built according to current earthquake regulations, they are no safer on rock than on soft soil. However, buildings must be built according to the characteristics of each type of soil.

FOUNDATIONS

The foundations of buildings are like the feet on a person. Larger buildings need larger foundations in the same way that larger people need larger feet to help them stand up.

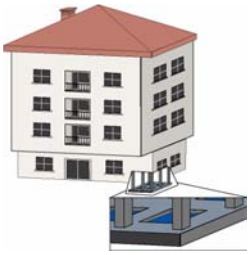


When buildings are built on softer soil it is like a person walking on snow. People wear snow shoes to keep them from sinking in snow. Buildings use wider foundations to help to keep them from sinking in soft soil.

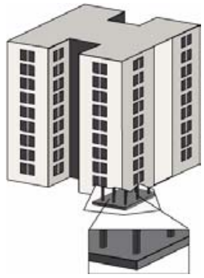
Modern concrete and steel buildings use different types of foundations based on the type of soil that they are on and the size of the building.

Spread footing with tie beam or **baseboard footing** foundations are used when the soil is firm.

When the soil is a little softer, **continuous** or **continuous and tie beam** foundations are used. During an earthquakes, the tie beams help the foundation work together and help keep the building even and well supported. For this reason, it is important to use tie beams in buildings that have spread and continuous footing foundations.



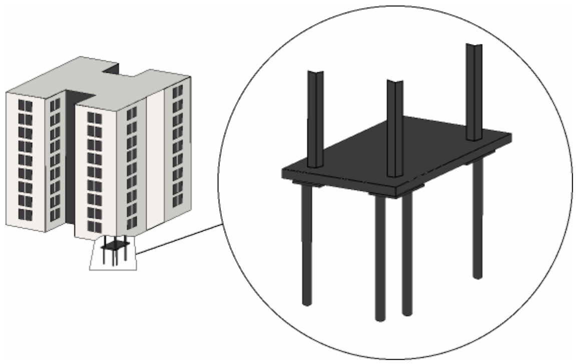
When the soil is even softer **mat** foundations are used.



Q: I have heard that mat foundations are better during earthquakes. Is this true?

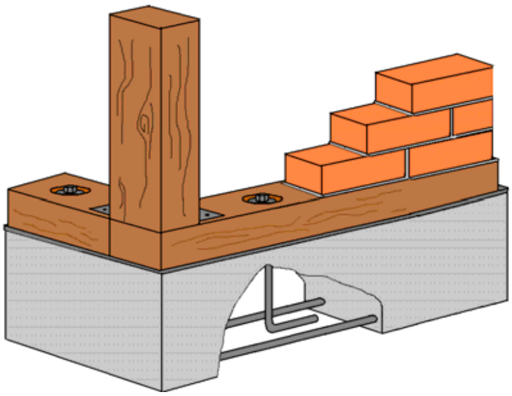
A: Sometimes engineering calculations and the earthquake design code require that buildings be built with mat foundations to make them safe in earthquakes. Using mat foundations when they are not necessary does not make a building any safer and could make it cost more money unnecessarily.

There are some places where the soil is so soft that even mat foundations do not work effectively. For soft soils like this there are several solutions. Special machines can be used to vibrate the soil and compact them. Alternatively, special construction equipment can inject a watery cement mixture into the ground to make it stronger. Another alternative is to use a special foundation designed for extremely soft soils called a **pile foundation**. The long piles in this type of foundations pass through the soft soil to harder soil that can support the building weight. The friction between the piles and the soft soil can also greatly help support the building.



Traditional structures need good foundations as well. Rather than being built on spread footings, they are usually built on continuous foundations that are made from stone or concrete. Because traditional structures are generally made from materials that can be damaged by water, their foundations should be covered with an impervious material called a **damp proof course**. This helps prevent the rest of the building from deteriorating from the moisture in the ground.

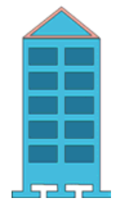
When timber structures are built in earthquake regions they need to be secured to the foundation with hooked anchors so that the rest of the structure and the building will move together during an earthquake. While Turkish *hımış* buildings have not had this traditionally, some newly constructed *hımış* buildings in Turkey now include foundation anchors to make them more earthquake resistant.



EARTHQUAKE FORCES AND OTHER BUILDING LOADS

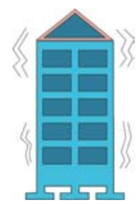
The parts of a building that carry its weight and other loads are called the **structural system**. Foundations are just one element in this system. Together all the elements create a system that is strong and flexible enough to support loads such as:

- The building weight, **dead load**,



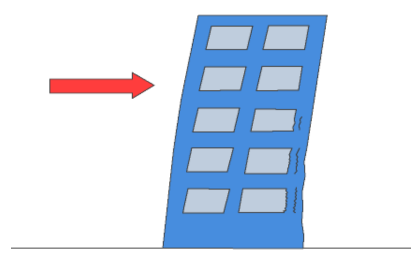
- Mobile loads that occur during the use of the building, such as the people inside, furniture, and some interior walls, **live loads**,

- **External loads** like earthquakes, wind, and snow.



Most of these loads are caused by gravity and are **vertical loads**. They pull vertically on the building. However, some loads like earthquakes and wind, are not only vertical loads, but are strong **horizontal loads** as well. When the ground beneath a building moves, it carries the bottom of the building with it. However, the top of the building does not move as quickly and lags behind. This means that the top and bottom of the columns can be pulled in different directions. It can also cause the building to bend sideways and the higher floors to move more than the lower ones. This movement puts a horizontal load on the building.

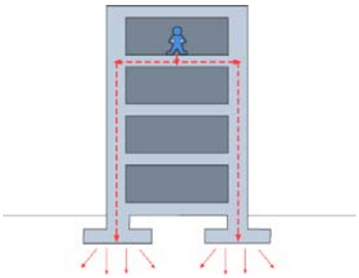
Because earthquake waves can come from many horizontal directions, in one instant a column may be pushed into the ground and in the next instant pulled upward or sway from side to side. For this reason, it is important that the building is strong enough to carry loads in all directions.



LOAD PATHS

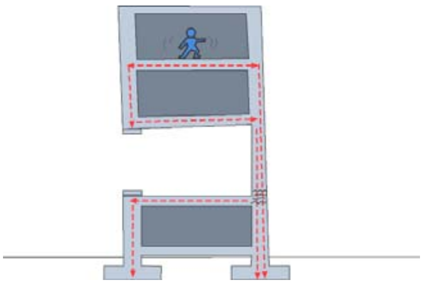
The structural system of a building must transfer all loads down to the soil. This path that loads are carried through is called the load path. For example, the weight of a person standing in the middle of a room is distributed by the floor to the nearest beams. The beams divide the loads that come to them between the columns to which they are attached. The columns carry this weight down the height of the building to the foundation, which sends it to the soil.

In order for the weight of a person to be transferred to the soil, it needs a continuous path all the way down to the ground. A good structural system is one that has a **continuous load path**.



Continuous Load Path

If a load path is **discontinuous**, the loads will not be able to travel straight down to the ground. Instead, they will need to find another path to the soil. This causes some parts of the structure to carry a great amount of weight and others to carry very little. If the load on some structural elements is great enough they may break.



Discontinuous Load Path

Whether the load is the weight of a person or an earthquake, it still needs to follow a load path through the building down to the ground. Buildings made from different materials use different **structural systems** to create this load path.

MOMENT FRAMES

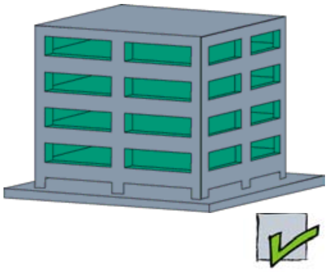
Short and mid-sized steel and reinforced concrete buildings often use what is called a **moment frame system** to carry loads. The structural elements of buildings with this system are:

- Foundation
- Columns
- Beams
- Floors
- Roof

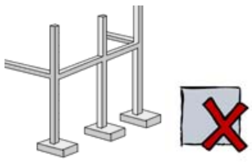
When earthquake waves cause buildings with moment frame systems to lean, the beams and columns resist being pushed over and keep the building from collapsing through rigid connections between them. This is done with well-placed steel reinforcement in reinforced concrete buildings and strong welds and bolts in steel structures.

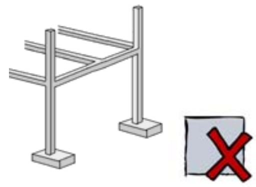
A good horizontal load carrying system in a reinforced concrete or steel building with a moment frame needs to be:

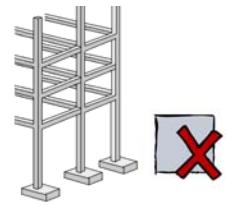
- Continuous
- Evenly distributed
- Well-connected
- Flexible and strong



In order for moment frame systems to carry loads to the soil, the columns and beams need to be continuous throughout the building. Evenly distributed columns and beams need to be as symmetrical as possible. When they are symmetrical, they share the load evenly and can easily carry it to the foundation.







A good moment frame system should also be well connected to carry horizontal earthquake loads. This means that columns should be located at the intersection of all beams and there should be at least two perpendicular beams where columns and beams meet. Having columns and beams at these locations allows loads to reach the ground through the most direct path possible and avoids creating weak points that might be damaged during an earthquake.

When all the parts of a moment frame are continuous, evenly distributed and well connected, the building is able to evenly sway in an earthquake. When this happens, the probability of a building being damaged is reduced. However, when one part of the building is more stiff or more rigid than another part, the stiff part of the building will experience more damage. One of the main ways that this can happen is when one column is shorter than other columns in the same area. This type of column is called a **short column**.

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Q: Are all buildings that have unevenly distributed columns and beams going to be heavily damaged in the next large earthquake?

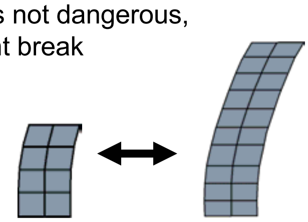
A: No, not all unevenly distributed load systems are unsafe for earthquakes. Engineers can use computers to carefully design buildings so that uneven design systems carry earthquake loads effectively. However, some uneven designs have not been built with earthquakes in mind and are likely to be damaged in the next earthquake.

There are a few reasons that a column that appears to be the same height as other columns may be considered shorter:

- When a beam is connected to a column between floor levels (stair landings, mezzanine floors etc),
- When infill walls do not reach the full height of the columns (window bands).

Short columns are more rigid than long and flexible columns. It is harder for them to bend in an earthquake. During an earthquake, all short columns are more easily damaged.

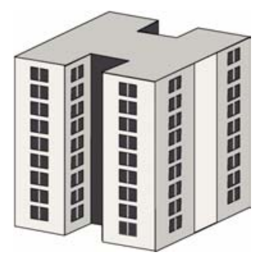
In shorter and smaller buildings, it is easy to make concrete columns and beams and their connections strong and flexible enough to resist earthquake forces. Their bases move with the ground and their tops are not very far behind. Because of this, the columns and beams need to only move a small amount. In taller and heavier buildings, earthquake forces cause the building to sway a lot. This swaying means that the columns and beams must deform or move a lot, and while swaying itself is not dangerous, it may have unintended consequences. Too much swaying and bending might break the exterior parts of a building or cause the walls to crack. Other times, too much swaying might put the building in danger of tipping over, or cause it to hit an adjacent building. By using another method, called a shear wall system, the amount a building sways and the chance of these things happening can be reduced.



SHEAR WALLS

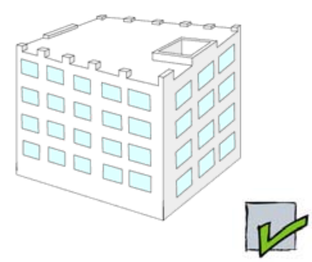
Because tall buildings sway more than short ones, tall reinforced concrete buildings often use **shear wall systems**. Shear walls are similar to reinforced concrete columns, but their shape is long and narrow like a wall. In fact, shear walls are always at least 7 times as wide as they are deep. Shear walls are not much stronger than normal columns when carrying everyday gravitational forces. However, because of their shape, shear walls do not bend as easily. During an earthquake, they can help to keep a building from swaying and deforming as much, especially if the building is tall or heavy. The structural elements of buildings with shear wall systems are:

- Foundation
- Beams
- Columns
- Shear Walls
- Floors
- Roof



A good concrete shear wall system must have shear walls that are:

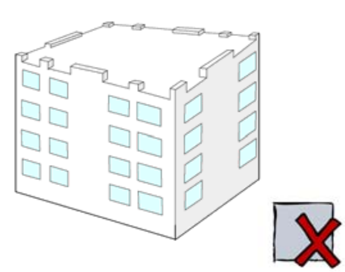
- Continuous
- Evenly distributed
    - Different walls facing different directions
    - Shear walls distributed equally to all parts of the building
- Well-connected



Most often it is only necessary to place shear walls in a few locations where columns would be located. In the other places, regular columns are used. Just like columns in reinforced concrete frame systems, shear walls need to be continuous from the top of the building to the foundation to be effective. Most importantly, shear walls should always be well-distributed throughout the building. This ensures that the horizontal load path will allow the forces to be distributed down to the ground during an earthquake. When shear walls are only located around elevator shafts or stairways, the buildings may sway unevenly and twist during an earthquake. Shear walls should also be well-connected to the beams and floors with strong connection joints.

Shear walls are different from columns. Most columns have the same strength whether they are bent from side to side or front to back. However, because shear walls are not square or circular like columns, they are only strong when earthquake waves come towards their long dimension. When earthquake waves come towards their short dimension they easily bend. This is like a person standing with their legs apart. They are able to withstand being pushed from the side (their long dimension), but can easily be pushed over from behind.

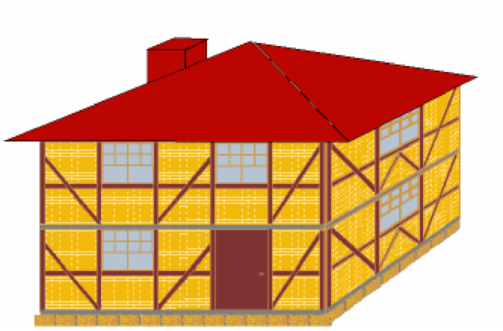
Because an earthquake might come from any direction, it is important to place about half of the shear walls with their long dimensions facing one direction and half with their long dimensions facing the other. When shear walls are placed in this manner, a building will be able to resist earthquake waves that come from any direction.



BRACES

A third type of load carrying system is a **brace system.** Braces are often used in steel buildings and are also an important part of some traditional buildings like *hımış* houses in Turkey. In steel buildings braces are made of steel and in *hımış* buildings, where a timber frame is filled with bricks, adobe or rubble stone, braces are made from timber. The structural elements of buildings with brace systems are:

- Foundation
- Columns
- Beams
- Braces
- Floors
- Roof



When a wall or part of a building has bracing in it, it acts like a shear wall. Just like shear walls, braced walls need to be:

- Continuous
- Evenly distributed
  - Different walls facing different directions
  - Braced walls distributed equally to all parts of the building
- Well-connected

Q: Are traditional houses weaker or stronger than concrete buildings?

A: In the most recent earthquakes such as the 1999 Izmit earthquake, many large concrete buildings were heavily damaged while nearby traditional buildings were only slightly damaged. This may make it seem like traditional houses are stronger. What is more likely is that the tall concrete buildings were built poorly. Both small traditional houses and tall concrete buildings can be resistant to earthquakes if constructed properly.

LOAD BEARING WALLS

Masonry buildings, whether they are made from solid brick, hollow clay brick, stone, or adobe brick, contain load bearing walls. This means that the load-carrying system in these buildings is the walls themselves. The structural elements of buildings with **load bearing wall systems** are:

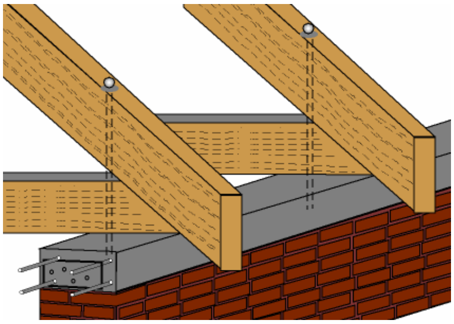
- Foundation
- Walls
- Floors
- Roof
- Earthquake tie beams

When masonry walls are under too much load, they crack, bend and crumble. However, by incorporating some simple techniques, masonry buildings can also be made more earthquake resistant. Load bearing walls need to be:

- Continuous
- Evenly distributed
    - Different walls facing different directions
    - Load bearing walls distributed equally to all parts of the building
- Well-connected

In order for masonry walls to distribute loads to the soil, they need to be continuous, evenly distributed and well-connected. This means that walls need to be symmetrical and should not have large openings in them. When large holes are created in load bearing walls, it reduces their ability to withstand earthquakes and other forces. When windows and doors are kept as small as possible and placed **at least 1.5 meters** from the corner of masonry buildings, the building is more earthquake resistant. Thick walls can also help a building resist earthquakes and for this reason it is necessary to make adobe walls at least 30 cm. thick, and stone walls at least 50 cm. thick in earthquake regions.

Load bearing walls, like shear walls, are much stronger in one direction. They should be placed symmetrically in both directions and have as many cross walls as possible. Small buildings with smaller rooms have more cross walls and are generally more earthquake resistant.

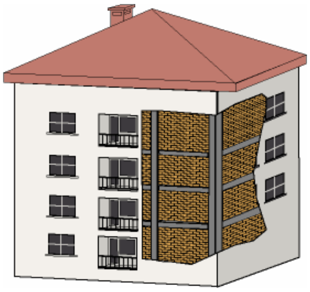


One of the most effective ways to make masonry buildings more earthquake resistant is to place an **earthquake ring beam** (also called a tie beam) on the top of all exterior walls. The beam should be continuous all the way around the outside of the building and is most effective when placed right above the top of doors and windows. In this way the walls are well-connected and able to sway together during an earthquake.

OTHER IMPORTANT FACTORS AFFECTING EARTHQUAKE PERFORMANCE

INFILL WALLS

While the structural elements of buildings are important, other elements can also play a part in how well buildings perform during earthquakes. **Masonry infill walls** are generally made from hollow clay tiles and create the exterior and interior walls in many reinforced concrete buildings. Masonry infill walls are not built to carry the load of the structure and other forces and are therefore considered a **non-structural element**. However, it has recently been learned that when these walls are placed between columns and beams in reinforced concrete buildings, they act similar to weak shear walls. For this reason, where and how infill walls are placed in concrete moment frame buildings is very important. For buildings with masonry infill walls to perform better during earthquakes, the infill walls should be:

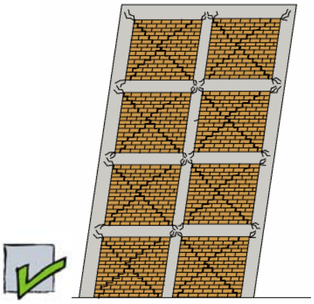


- Continuous from the roof to the foundation,
- Evenly distributed.

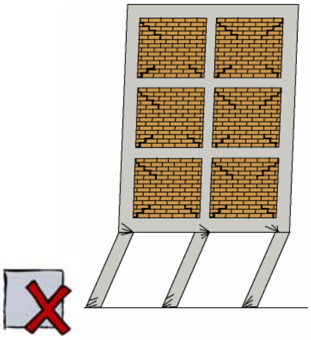
When infill walls are constructed between columns, these walls need to be built on every floor from the top to the bottom and placed as symmetrically as possible.

When infill walls act like weak shear walls they can carry a lot of load from earthquakes and may start to crack in large X patterns and break apart. In some situations, this can be beneficial. Infill walls can actually share some of the earthquake force up until they break apart and can reduced how much the columns and beams need to carry. This can sometimes mean that they crack and break instead of the columns and beams. Badly damaged infill walls can be easier and less costly to replace after an earthquake than badly damaged columns and beams. However, falling infill bricks were the largest cause of injury in the 1999 İzmit earthquake, and being near an outside infill wall during an earthquake was found to be particularly hazardous.

The 1975 Earthquake Design Code in Turkey did not address infill walls, however, recent codes do consider infill walls to some extent. Nevertheless, in the İzmit region most buildings were constructed using the assumption that infill walls were non-structural elements and would not help carry loads during earthquakes. During the 1999 earthquake some buildings were less badly damaged because of the added stiffness of their infill walls. Other buildings were made too stiff by infill walls and were damaged because they could not sway with the earthquake. More importantly, many buildings collapsed or were badly damaged because their infill walls were not continuous throughout the entire building.



When buildings do not have columns, shear walls, load bearing walls, or infill walls that are continuous from the top of the building to the foundation, the floor that is often damaged the most is the floor where they are missing. This floor is called a **soft storey**. If a structure does not have a soft storey, every floor will bend equally during an earthquake. For instance, in a four-storey building all four stories will bend 1/4th of the total amount. However, in a building with a soft first storey, the soft storey is more flexible and will bend almost the entire amount, while the other floors will hardly bend at all. This floor may be heavily damaged or even collapse.



Engineers and researchers are working to find different solutions for how and when infill walls should be used. Here are a few solutions that have been considered:

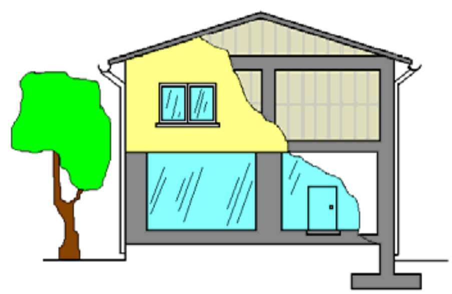
SOLUTION 1: CONTINUE TO USE MASONRY INFILL WALLS, BUT BE CAREFUL TO CONSTRUCT THEM SO THEY ARE CONTINUOUS FROM THE TOP TO THE BOTTOM OF A BUILDING.

Positive + No new materials or construction techniques are necessary. Easy to implement.

Negative - Walls may break apart and fall out causing damage, injury and even death.

Negative - It may be difficult or undesirable to place infill walls on floors with large shops, large windows or big open spaces.

SOLUTION 2: CONSTRUCT INFILL WALLS FROM LIGHT MATERIAL SUCH AS GLASS OR GYPSUM BOARD.



Positive + Infill walls can be placed wherever desired.

Positive + Infill walls will not effect how the building moves in an earthquake.

Negative - New materials like gypsum board may be more expensive.

Negative - When using gypsum board for walls, it is necessary to insulate against sound and heat.

SOLUTION 3:   LEAVE A SMALL SPACE BETWEEN INFILL WALLS AND COLUMNS WHILE CONSTRUCTING THEM.

Positive + Infill walls can be placed wherever desired.

Positive + Infill walls will not effect how the building moves in an earthquake.

Negative - Leaving a space between columns and masonry infill walls requires new construction methods in order to ensure that infill walls do not fall and hurt people.

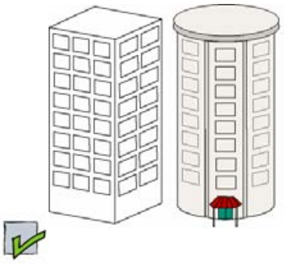
During large earthquakes, infill walls may, in some cases, crack and collapse causing serious injuries. In order to reduce the chance of this occurring, the outside face of hollow clay tile or aircrete infill walls can be covered with wire mesh, FRP (fiber reinforced plastic strips) or similar materials. This will support the walls and help them work the load carrying system, assisting the building throughout the earthquake.

? **Q:** My neighbor is remodeling their apartment and taking out infill walls. Should I be worried?

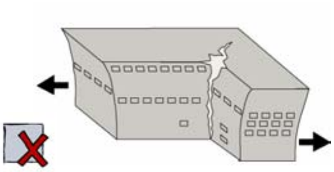
A: Maybe. Changing or taking out infill walls may change how a building behaves in an earthquake. However, it is only when infill walls that are BETWEEN columns are removed that a soft storey may be created. Taking out infill walls that are not between columns, such as some interior walls or the exterior walls of buildings with projections, does not create a problem.

PLAN SHAPE

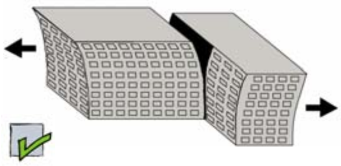
The shape of a building is not important when it is carrying vertical loads such as its own weight and the weight of people or furniture inside. However, plan shape is important when a building is carrying large horizontal loads from earthquakes. During an earthquake, buildings that are square, rectangular, or circular can more easily withstand shaking. Their compact shape ensures that the whole building moves together as one piece and that it can sway back and forth easily.



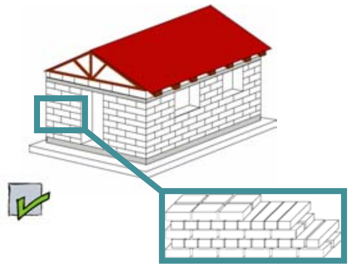
Buildings that have L, H, T or cross shapes are usually more vulnerable when the ground shakes. The projections or wings of the building tend to move separately from each other and move more than the building's inner core, causing the building to crack and tear where the parts connect.



When buildings have been designed with projections, they can be divided into smaller square or rectangular sections and constructed separately. Where the sections connect, a thick rubber bumper called an **expansion joint** can be added. These expansion joints allow each piece of the building to sway and move separately in an earthquake, but from the inside and outside, it looks as though there is only one continuous building.

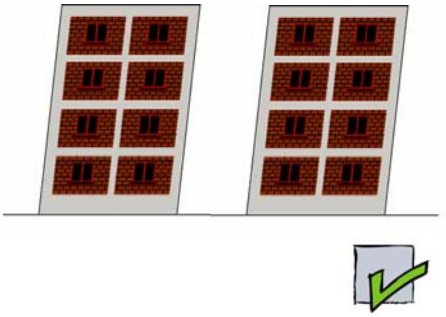


Whenever possible, buildings should be made in compact shapes and projections should be made as small as possible. This is especially important for masonry buildings. Since masonry buildings are made from brittle materials they should only be built one or two floors high and have compact plan shapes.

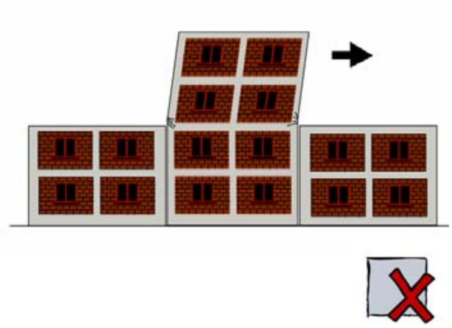


NEIGHBORING BUILDINGS

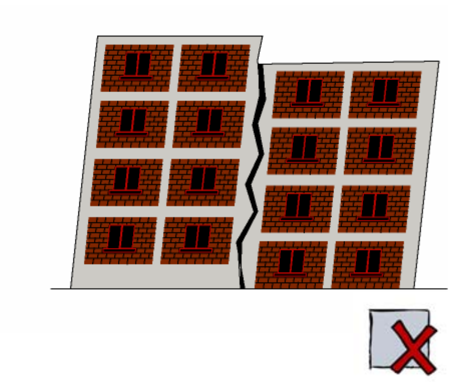
Buildings that do well in earthquakes are flexible, they bend and sway rather than breaking. How much a building sways or drifts from side to side is related to its design, dimensions and size. Taller buildings sway more or have larger **horizontal drift** than shorter buildings.



If a shorter building is touching a taller building, the tall building may act like two separate buildings. The bottom storeys will move like a short stiff building, while the upper stories will remain a tall flexible building. During an earthquake, if the two parts of the building move differently there is a greater likelihood of damage where they meet. If this problem is considered during the design of the building, engineers can design this location of the building differently so that it can carry these extra loads.



When floors of neighboring buildings are at different heights, the floor of one building may meet the middle of a column of the neighboring building. If the floor of one building hits the middle of a column in the adjacent building, it will act like a giant battering ram. It may cause the column to crack, buckle and even break.



When enough space is left between buildings these problems can be reduced or eliminated.

sass

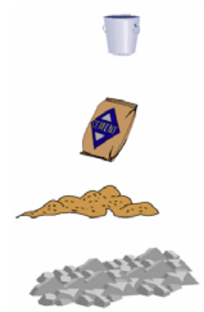
GOOD MATERIAL AND CONSTRUCTION

The materials that are used and the way that a building is constructed are just as important to its safety as the structural system, plan shape, infill walls and neighboring buildings. Here are a few common examples of the types of things that can be done to make buildings earthquake resistant.

REINFORCED CONCRETE

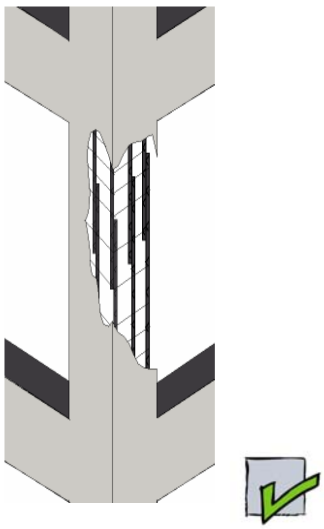
Reinforced concrete is a new material that has been developed in the last century. It combines the strength of concrete and the flexibility of steel to create a very strong and flexible material that can withstand the back and forth swaying caused by earthquakes. However, not all concrete and steel are the same. Good quality concrete and steel must be used in order for reinforced concrete to perform well.

Each material that makes up concrete performs a special function. Similar to a cake, it is important to mix concrete together with the right amounts and with good quality ingredients. When concrete is made well it forms a very strong material, but when it is made poorly it can be very weak. Good quality concrete has:



- **Clean water:** Dirty water that has chemicals in it can damage or stop the chemical reaction of the cement. Sea water has salt in it and can cause corrosion of the steel that will be put inside the concrete.
- **Quality cement**
- **Clean sand and rocks:** Sand and rocks that are dirty can hinder the cement from sticking to the rocks. Also if sea sand is used, the sea salt can cause the reinforcing steel to quickly corrode and dramatically weaken the entire building.

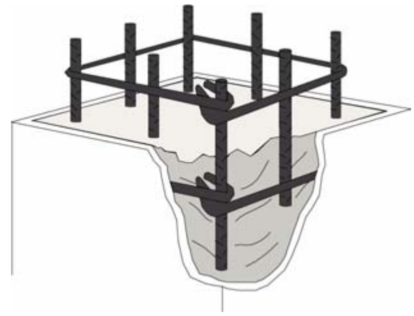
Because good concrete needs to have very little water in its mixture, mixing it by hand can be difficult and very labor intensive. Concrete that has had extra water added to make it easier to mix or has not been mixed thoroughly is quite weak. For these reasons, building codes often state that it is necessary to use **pre-mixed concrete** that has been mixed at a cement factory and then brought to the construction site by truck.



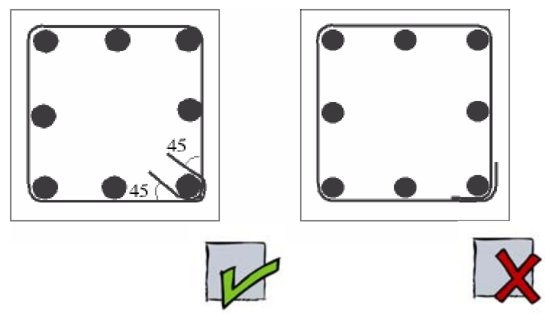
Quality reinforcing steel comes in many varieties. In order for it to attach to the concrete properly, **ridged reinforcing steel** rather than smooth steel should be used. These ridges help the concrete grip the reinforcing tightly and hold it in place, something that is especially important in an earthquake.

Long straight ridged bars of reinforcing are placed inside of concrete columns and beams to help them resist earthquake forces. The amount of steel that is placed inside concrete columns, where it is placed, and how it is connected together is also very important. When two pieces of steel are connected together to make a longer piece, this connection must have a long area of overlap in order to remain strong in an earthquake. Creating this overlap is called **lap splicing** and the length of lap splice necessary is related to the size of the reinforcing steel. The larger the size of the reinforcing steel, the longer the lap splice must be.

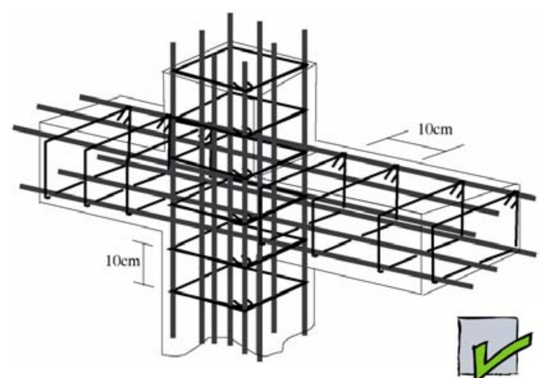
Shorter steel bars are also used to wrap around the long steel bars inside the concrete and hold the concrete in place during an earthquake. These wrapping pieces are called **shear ties** or **transverse reinforcing.** In regions where earthquakes occur, shear ties are very important and need to be constructed in a special way. For this reason, they are often called **earthquake ties** instead. Earthquake ties wrap around the steel bars, like a piece of string around a box and hold them in place. This helps the long bars inside the beams and columns from bending too much and collapsing. It also helps hold the concrete together, so that when it cracks, it does not fall out of the columns in chunks.



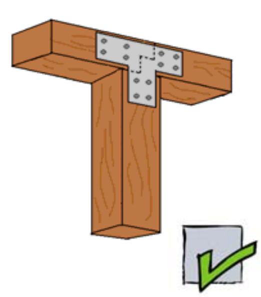
Earthquake tie ends need to be **bent to 135 degrees** so that the tails stick into the center of the column. These tails must be long enough for the concrete to surround and grip them tightly. When ties are not bent correctly, they may spring open during an earthquake and cause the column to break apart.

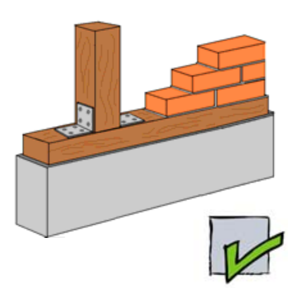


Because the connections between columns and beams feel the most force from earthquakes, they need to have more earthquake ties than the remaining sections of the column and beam. It is necessary to place earthquake ties **10 cm. apart** or closer near the connections. These closely spaced earthquake ties are the only way to keep reinforced concrete joints flexible and strong enough to resist the large earthquake loads they must carry.



TRADITIONAL TIMBER CONSTRUCTION TYPES: HIMIŞ AND BAĞDADİ





Good strong materials and quality construction are also important for wood and masonry buildings. Timber needs to be free of bugs, charred areas, and rotten sections. The **diagonal bracing** in timber buildings needs to be strong and concentrated in areas where the forces are the greatest, around the windows, doors and corners.

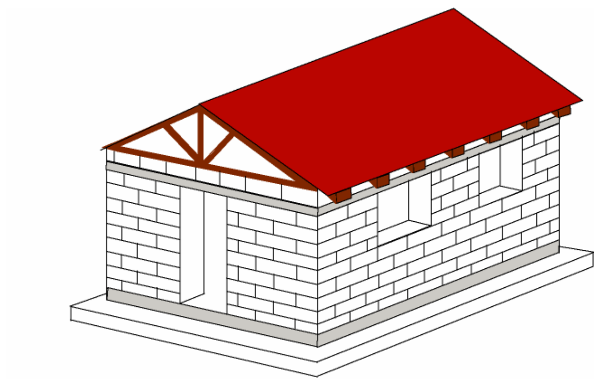
Strong connections between wooden structural members can be made by using connection plates and by notching the two sections before attaching them together. This helps to hold the joint together as it rocks back and forth in an earthquake. **Connection plates**, a simple plate made from painted or non-corrosive metal, can be made in different shapes and sizes to connect columns, beams, braces, foundations and roofs.

MASONRY AND ADOBE

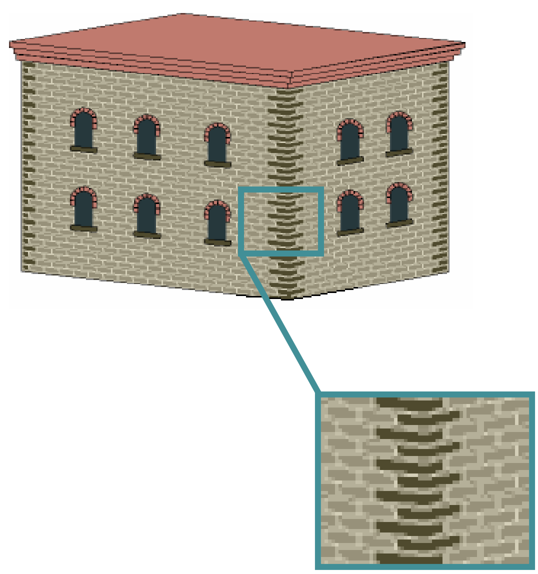
There are several types of bricks that can be used in masonry construction. However, no matter what type of brick is used, good quality materials are important to the strength of the building.

Adobe bricks should be air dried for 10-15 days before use and made from soil that is 15% clay. When the clay content of the soil is too high the bricks crack much easier. To prevent this from happening, sand or straw is often added to soil with high clay content.

Hollow fired bricks that have thicker walls and smaller holes are generally stronger than ones with larger holes or thinner walls. Strong fired bricks do not break when dropped.



When constructing masonry walls mortar needs to be applied properly. It should be applied to the entire surface of all bricks. Care should also be taken to make sure that the brick is the right wetness so that the mortar can dry properly. Bricks that are too wet will cause the mortar to slide off and not stick. Bricks that are too dry will remove the moisture from the mortar, causing it to be weak and crumble when it dries. It is best if the bricks are damp on the inside and dry to the touch on the outside. This means that in hot dry weather, wetting the bricks may be necessary. Whereas, in very damp climates, keeping the bricks dry is important.



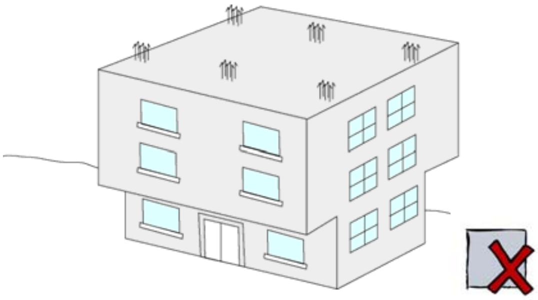
Corners where walls meet are one of the weakest points of masonry buildings. They should be tightly joined together using reinforcing or by constructing the bricks in an interlocking pattern rather than completing one wall before starting the next one. This will help keep the walls from separating, and instead help them move together during earthquakes.

MAINTAINING LOADS

Buildings can be built to be very strong, flexible and earthquake resistant. However, in order for them to remain strong they need to be maintained. One of the most important ways you can help maintain a building is by NOT adding extra weight. When a building is built, the number of floors the building will have, the number of people that will be in the building, and how much heavy equipment will be placed on the roof and other areas is estimated. This weight is used to calculate how big the structural elements must be and what elements are necessary to make the building strong and flexible during large earthquakes.

Not increasing the load on a building means:

- Keeping the same number of floors in a building as were originally constructed.
- Keeping the use of the building the same.
- Keeping the weight and location of machinery and large equipment the same.



If an apartment building or office building were to be used as a hospital, school, warehouse, library or gymnasium, it would have to carry many more machines and people than it was originally designed to hold. Even if this load does not harm a building while it is carrying everyday vertical loads, it may cause it to be severely damaged when it is carrying earthquake loads as well. It is important to remember that even if the building use has not changed, adding very heavy tanks, large factory machinery, elevators or extra floors may weaken a building if it was not built to carry them. In all cases, it is important to make sure that the original design of the building is taken into account when deciding whether extra weight can be added.

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Q: Can we ever add extra weight to our buildings?

A: Yes, adding small items like furniture and household machines doesn't hurt a building. It is only when large changes are made that a building is made less earthquake resistant. Someone who knows about earthquake forces need to be consulted before these large extra loads are added. Sometimes, buildings are strong enough or can be strengthened so that changes can be made. However, there are some buildings that cannot have extra weight added no matter what is done.

KEEPING STRUCTURAL ELEMENTS INTACT

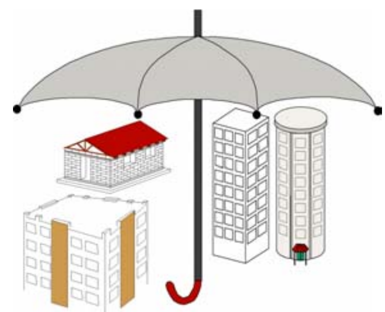
Another important part of maintaining buildings is making sure that the structural load carrying system remains continuous, evenly distributed, and well-connected.

Columns, important infill walls, beams, and shear walls should NOT be removed or added without redesigning the entire structural system. Removing or adding structural elements may weaken the structural system and could have disastrous results during an earthquake.

Sometimes holes are created in walls to make or enlarge doorways and windows. The walls of stone, masonry and adobe buildings are a major part of their structural system. Making windows or doorways bigger in these types of buildings means that the structural system has been made weaker as well. For the same reason, infill walls between columns should not be removed.

Buildings can also be weakened if holes are made in structural elements. While a building is being built, workers often drill holes in reinforced concrete, steel, or wooden columns and beams to place pipes, wire and ducts. If these holes have been considered during the design phase, the building will still be able to easily withstand earthquake forces. When extra holes that were not considered in the design are made in structural columns, beams, and floors, during or after construction, these parts of the structure are weakened. Furthermore, the holes expose the reinforcing steel to air and moisture, allowing it to begin rusting.

PROTECTING BUILDINGS FROM MOISTURE



Keeping buildings dry is another important part of building maintenance. Many types of materials become weak if they are exposed to wet weather over a long period of time.

- Wood **rots**.
- Metal building parts **rust**.
- Adobe bricks **become soft** and lose their strength.
- Reinforcing inside concrete **rusts**.
- Water in masonry walls **freezes** and causes damage.

There is no way to keep rain from falling, but we can help protect our buildings from water by maintaining them.

Roofs should be well maintained and promptly repaired to keep water from running into the building from the roof. Gutters should be kept unclogged and well maintained. The exit ends and any other discharge pipes should be located away from the edge of the building. Large overhangs can also prevent water from pooling right next to buildings.

Basements should be kept dry. When basements are continuously damp or have standing water, this moisture can more easily seep into the structural elements of a building and weaken them. If a water problem does exist, a pump can be used to keep water out of the basement, rocks can be put around the foundation and drainage paths can be created to direct water away from the building.

Wood and masonry buildings that have an outer coating of stucco, plaster or paint should have their exteriors maintained regularly. Some types of brick are painted with a moisture resistant coating during building construction, because they are of a soft variety that cannot withstand wind and water on their own. This coating needs to be maintained in order for the building to remain strong.

Reinforced concrete needs to be carefully protected in order to slow the concrete disintegration process and to keep the reinforcing steel inside from rusting. The best way to do this is to make sure that a good thick layer of concrete covers the outside of the bars. This covering should be 3-5 cm. thick and should be maintained throughout the life of the building. This protective covering needs to be even thicker in the building foundation. You should not be able to see any reinforcing steel.

Rusting occurs when:

- Reinforcing steel is not covered by a protective layer of concrete
- Reinforcing bars are left sticking up in the air on the tops of buildings with the hopes that a new floor will be able to be added in the future. When this steel rusts it can spread to the whole building, weakening the entire structure.

REPLACING DAMAGED ELEMENTS

Even if buildings are well built and maintained, their structural parts will not last forever. These parts, no matter what they are made from, slowly wear out when they are exposed to weather and use. Damaged or worn structural parts do not perform as well during earthquakes; by replacing these parts, we can help our buildings remain strong and flexible. At some point, with the exception of buildings of special historic importance, the cost of maintaining a building may exceed the cost of replacement. When structural parts can no longer be repaired or rebuilt, entire buildings must be replaced. Most buildings in modern mega-cities are replaced every 40-50 years.

TIMBER

Any wooden structural members or wood non-structural parts that are connected to the structure, or in close vicinity, must be quickly replaced when damage occurs from water, insects or fire. It is important to cut away not only the problem areas, but also nearby apparently undamaged pieces to make sure that the problem does not spread.

Making it an annual habit to carefully check all the wood members of a building, especially under eaves, windows, and around the foundation can help ensure that small unnoticed problems do not become large ones.

MASONRY

It is important to repair or replace the mortar in masonry buildings regularly in order for the bricks to be able to stay together when earthquakes occur. This means scraping out any cracked or broken mortar and repointing it. When doing repair and repointing of mortar, it is important to use the same type of mortar as was originally used. It is also important to replace damaged bricks with the same type of brick. If components are replaced with stronger ones, they will act more rigid and weaken the rest of the building. Mixing mortars and brick types can also create moisture problems that will weaken the building. For instance, when cement plasters and mortars are used on adobe structures they often trap moisture, which creates unseen problems and weakens the entire structure. Instead a mixture of soil and water is the best mortar for use with adobe structures.

CONCRETE

Reinforced concrete buildings usually start to wear out as a whole system instead of one structural element at a time, though much of this is not usually noticeable with the naked eye. Concrete is a material that changes over time. When it is first mixed it is wet, but it quickly hardens by chemical reactions between the cement, other chemicals and water. These reactions continue over time, even after the building has been completed. Concrete continues to get harder and to slowly shrink. At the same time it loses its alkalinity, a property that helps protect the internal reinforcing steel. Unlike other building materials, such as wood and masonry, a concrete building can last a long time without repair; however, 4-5 decades after a building has been completed, the concrete can no longer protect the steel and it starts to lose its strength. This usually means replacing the whole building when it is about 50 years old.

THE DESIGN PROCESS IN TURKEY

If a person or company wants to construct an earthquake resistant building on a deeded piece of land, there are several requirements that need to be followed. When the design process is done correctly, the necessary checks and inspections will be made as the structure passes through the building process. This will help ensure that it will have been built according to earthquake resistant standards. The following are a few of the requirements in Turkey regarding the safety of new buildings:

- The design of the building needs to be done by a competent architect according to the unique characteristics of the plot of land and local regional plans.
- Before the detailed design begins, it is necessary to apply to the Chamber of Geological Engineers in order to have soil testing done on the proposed building site – an engineer will then use this information to do a detailed engineering design of the foundation.
- The owner must also hire a construction inspection company in order to have them check that the correct amount and quality of material is used and that these materials are applied according to the design plans throughout the entire building process. This company is required to inspect the building site during the construction of every floor, when masonry walls are laid, when the roof is done, etc. They are also responsible for taking samples of the concrete for laboratory testing during the pouring of concrete on every floor. At the completion of every stage, the company must apply to the municipality for payment. The municipality then sends an inspector to the construction site and makes sure that the stage has been completed according to plans. If everything has been completed properly, the municipality gives the private inspection company permission to withdraw their payment from a public bank.

There are three permits that need to be obtained in order for buildings to be constructed and inhabited. In order to receive these permits, the design and construction must be done correctly and have been properly inspected:

- Before starting construction, it is necessary to receive a **construction permit** from the concerned municipality, greater municipality, or if outside municipality boundaries from the provincial Directorate of the Ministry of Public Works.
- When the building foundation has been completed up to the height of **flooding level**, and the private inspection company has inspected it, an application can be submitted to the municipality or provincial Directorate of the Ministry of Public Works for an **above foundation permit**. The municipality inspectors will come, check that the project is going according to plan and give permission for the construction to continue.
- When construction has been completed it is necessary to receive a **dwelling permit**. This is done by the architect and owner applying together to the municipality or provincial Directorate of the Ministry of Public Works, and must be done after the private inspection company has completed inspections. A representative of the municipality will return once more to the project site to ensure that health conditions are up to standards and if all is in order, the dwelling permit process begins. Until permission is received, there is little use in working on or installing electric, water and sewage lines. If the building does not meet the design or health requirements, these lines cannot be opened.

The appropriate associations for applying for permits are the municipality when inside those boundaries, or the provincial Directorate of the Ministry of Public Works, when outside municipality boundaries. Within Istanbul, buildings inside the region governed by skyline restrictions from the Bosphorous Straits, must obtain permission from the Bosphorous Planning Department, connected to the Greater Municipality of Istanbul.

Buildings for special uses and in rural areas may not require building permits, however it is necessary to receive permission to build from the local **headman** to ensure that the building does not violate physical or health laws.

If alterations are being done on a building, it can have an unintended effect upon the structural system and the way loads are distributed. During an earthquake the most important factor in a building staying standing is its load carrying system being able to work properly. For this reason, when any alteration work is desired, it is important to consult with a qualified architect or engineer as well as apply to and receive permission from the municipality concerned.

If the area where a new building will be constructed is a historic site, it is necessary to receive permission from the Commission for the Protection of Cultural and Natural Heritage as well. This commission was established to ensure the protection of historic items.

You can find more information at the web site: **www.bayindirlik.gov.tr**.

INVESTIGATING THE EARTHQUAKE SAFETY OF EXISTING BUILDINGS

Whether a building is earthquake resistant cannot be understood simply by observation. In order to clearly understand whether a building will withstand earthquake forces, it is necessary to closely examine the building and take samples of its materials to send for laboratory testing. This investigation should be done by authorized establishments. The establishments that can be consulted are:

- The Society of Civil Engineers
- Civil or Earthquake Engineering Faculties in Universities
- Engineers Certified by the Ministry of Public Works

To decide to what extent a building is earthquake resistant, whether the stipulations detailed in the existing "Earthquake Code" have been implemented is measured. The Earthquake Code was most recently updated in 1998. However, buildings built according to the 1975 code are also more earthquake resistant than those of previous codes.

Examining the earthquake resistance of concrete buildings includes the following steps:

1. The building's project construction drawings are investigated by an engineer and the application of the earthquake code on the project is also examined. If project drawings cannot be found, the existing conditions of the building are drawn by measuring the elements of the building's structural system.
2. Engineers go to the building and check whether it was constructed according to the construction plans. In order to decide this:
    - The size of building elements is examined.
    - The type of reinforcing used in the structural system, its size, placement and the amount of corrosion present is investigated by removing the plaster and concrete cover from concrete structural elements. (After this investigation, the areas where the coverage was removed are properly covered with chemical reparative mortar.)
3. In order to measure the quality of the building's existing concrete, concrete coring samples are taken of the structural elements in order to send them to be tested in a laboratory. These

cores are carefully taken from several different locations that are considered suitable in a way that avoids hitting any reinforcing steel . The holes in the structural system where these samples have been taken are then properly filled with high strength, low shrinkage chemical mortar.

Sometimes hammer readings are taken in areas of the building where core samples are not possible. However, hammer readings alone are insufficient to determine concrete strength.

4. The building's structural characteristics and characteristics of the soil under the building are considered and analyzed on a computer. The load carrying capacity is then examined according to the applicable regulations.

EARTHQUAKE INSURANCE IN TURKEY

According to a decision passed after the 1999 Kocaeli earthquake, earthquake insurance has become mandatory. Mandatory earthquake insurance, DASK, can be obtained at insurance companies licensed to give out these policies. Premiums paid are collected by the Natural Disaster Insurance Council. In order to take out an insurance policy the following information is necessary.

- Title deed information (name, parcel, page number)
- The year of building construction and building construction/material type
- Total number of floors
- Any existing damage to the building
- Total square meterage
- Use of the space

The value of the building to be insured is calculated by multiplying the total meterage of the dwelling with standard worth of that meterage according to the building's type. The premiums are then calculated by taking this value and multiplying it by a set value according to the earthquake zone in which the building is found.

In 2003, 40 million Turkish Lira (approximately $25,000) is the most that will be awarded, regardless of house type. Insurance policies must be renewed yearly.

Individuals and agencies not licensed by the Natural Disaster Insurance Council cannot give out mandatory earthquake insurance policies. If the cost of the building to be insured is more than the maximum amount that can be awarded under this program, the remaining amount can be covered under a traditional Need Based Earthquake Insurance policy. This extra insurance must be taken out from the same firm used for the Mandatory Earthquake Insurance policy.

Buildings not used for residence, such as commercial buildings, are not included in mandatory earthquake insurance. Most importantly, buildings built after December 27, 1999, that were not done according to applicable laws and those who do not have legal title deeds cannot be insured. In fact, owners that weaken their buildings or change them from their original design will lose any amount linked to damage or increased damage considered to be a result of these changes. For this reason, when making changes to a building, it is important to work with engineers and architects in order to ensure that the changes follow local provisions.

All materials and interior contents are not covered under Mandatory Earthquake Insurance policies.

After an earthquake the following steps are taken:

- Within 15 days it is necessary to contact the firm from which the mandatory earthquake insurance policy has been taken.
- A NDEC member or authorized expert must come and appraise the building.
- When the value of the damage has been established, this amount must be paid to the policy holder within one month.

It is important to remember that in the future, the government will not give new homes to those whose buildings are destroyed or damaged. It is the responsibility of all homeowners who want to protect their homes to take out an earthquake insurance policy.

You can find more information at the web site: **www.dask.com.tr**.

PREPARING OURSELVES

Having earthquake resistant buildings is very important. However, we need to prepare our families, students and colleagues for earthquakes as well. Of the 1,500,000 people affected by the 1999 İzmit and Düzce 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. Avoiding injury and permanent disability are very important. Storing food, water and emergency supplies and creating disaster plans can reduce the chaos that will occur when the ground shakes and afterward.

We need to make sure that the items inside our buildings are earthquake safe too. Buildings that are built to resist earthquakes still **move** during them. This causes wardrobes, refrigerators, and bookshelves to fall, televisions and glass objects to fly, and windows to break. By rearranging our furniture, securing it to the wall and taking other small steps, we can reduce our risk of injury and economic loss in future earthquakes.

We should be ready to help when tragedy occurs. When streets are blocked and damage occurs, it is the people that are nearest that can be of the most help. Taking first aid classes and learning how to help after a disaster is another way that we all can prepare for earthquakes.

More information on how you can prepare yourself through Basic Disaster Awareness, Non-structural Mitigation, and Community – Emergency Response can be found at **www.iahep.org**.

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FAMILY DISASTER PREPAREDNESS PLAN

Enter date of completion:

- ☐ We held a family meeting to discuss our Family Disaster Plan.
- ☐ We identified the safest places in the house, and in each room. (Away from windows, large and heavy objects that can fall, and objects like heaters that can cause fire.)
- ☐ We identified exits and alternative exits from our house and building.
- ☐ We considered the special provisions we need for pets, people who don't speak the language of the country, elderly, disabled, and small children.
- ☐ We have enough water to last us a week (4 liters per person per day), and food for 3 days.
- ☐ We know how to turn off our electricity, water and gas.
- ☐ We know our out-of-area contact person(s) and phone number(s):

  It's: ____

- ☐ We know where we would reunite

  Inside the house:____

  Outside the house:____

  Outside the neighborhood:__________________________________

- ☐ We know how to use a fire extinguishers.
- ☐ We keep shoes and flashlights by our beds.
- ☐ We have a good first aid kit.
- ☐ We collected our survival supplies, and made up our earthquake bags. (Flashlight, batteries, radio, first aid kit, change of clothes, cash, whistle, matches, 1 week prescription medication, paper and pencil, important phone numbers.)
- ☐ We made our copies of important documents, and key addresses and phone numbers, and keep them in our earthquake bag or with our out-of-area contact.
- ☐ We know never to light a match, lighter, or any other flame after an earthquake until we are sure there is no danger of escaping gas anywhere around.
- ☐ We're starting to spread the word to everyone we know.
- ☐ We know that we will only use the telephone in an emergency after an earthquake, so that the lines will be there for those who need them most. We will get our information from TV and radio.
- ☐ We have completed our Earthquake Hazard Hunt and have taken measures to protect ourselves.
- ☐ We plan to review our plan again every 6 months.

name ____

address ____

____________________________ e-mail ____________________________

telephone ____________________________ date ____________________________

sass 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!

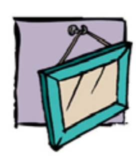
As you tackle what needs to be done, prioritize the items as follows:

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 lighting fixtures to ceiling.
- Fasten pictures on closed hooks.
- Check for any hazardous materials (poisons, flammable materials); make sure they are secure.
- Consider replacing kitchen cabinets latches with ones that will hold shut during a quake.





Hazards we found: **Date corrected:**

sass BUILDING HAZARD HUNT

Buildings carefully designed and constructed according to the 1975 and 1998 Earthquake Design Code are sufficiently strong enough to be life safe and will not collapse during an earthquake. For buildings that were not carefully designed according to this code, the following **Building Hazard Hunt** is intended to help you understand their potential risks. If your building has high risk in any catagory, consider having your building further invesigated by a qualified professional.

1. RISKS RELATED TO SOIL

What is the location of your building like?

High Risk
- Stream bed or fill soil
- Marshy soil
- Very steep slope
- On the edges of a cliff
- Right on top or next to fault line

2. RISKS RELATED TO AGE

If your building is reinforced concrete, how old is it?

High Risk
- 28+ years old
- Any age building not built according to Earthquake Building Codes

3. RISK RELATED TO LOAD CARRYING SYSTEM

What is your building type?

High Risk
- Reinforced concrete building with discontinuous, uneven, or poorly connected moment frame
- Masonry, stone, and adobe without an earthquake tie beam

4. BUILDING HEIGHT RISKS

How many storeys high not including the ground floor?

High Risk
- 4+ storey poorly constructed reinforced concrete
- 2+ storey unreinforced masonry

5. SOFT STOREY RISK

What is the ground floor like?

High Risk
- Same as other floors but without walls
- Higher than other floors and without walls

6. RISKS RELATED TO THE SHAPE OF THE BUILDING

What is the shape of your building?

High Risk
- Very long and narrow rectangular building
- L, H, T, or cross shaped building without isolation joints

7. RISKS FROM NEIGHBORING BUILDINGS

What type of neighboring buildings are there?

High Risk

- Row housing with same floor heights but different overall height from neighboring buildings
- Row housing with differing floor heights from neighboring buildings

8. RISK RELATED TO WATER DAMAGE

Can you find any water damage or water present in your building?

High Risk

- Dampness during winter months
- Localized visible water damage: rusting reinforcing showing through, rotting wood, erroding brick
- Always damp
- Dripping water

9. RISKS RELATED TO POOR QUALITY MATERIALS IN REINFORCED CONCRETE BUILDINGS

What does your reinforced concrete look like?

High Risk

- Sea shells noticable in the concrete
- Transverse reinforcing missing or spaced at over 10 cm in columns near joints
- Transverse reinforcing with only 90 degree rather than 135 degree bend
- Very large rocks, trash, or wood in concrete
- Moderate damage, especially from previous earthquake, that has remained unrepaired

10. RISKS RELATED TO CHANGES IN HOW THE BUILDING IS USED

Has your building ever been changed?

High Risk

- Building constructed for housing, but now used as a workshop with large equipment or for storage space
- Open balconies or terrace floors that have been closed in with heavy building materials
- Heavy equipment added to the roof
- Building built for housing, but now used as a school, gym, hospital or another place where many people congregate
- Extra floor added after construction

This building hazard hunt is intended to help you identify areas that may be of potential risk for your building during an earthquake and review the concepts covered in the Structural Awareness for Seismic Safety Education Program. It is NOT a replacement for an engineering assessment of your building.

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