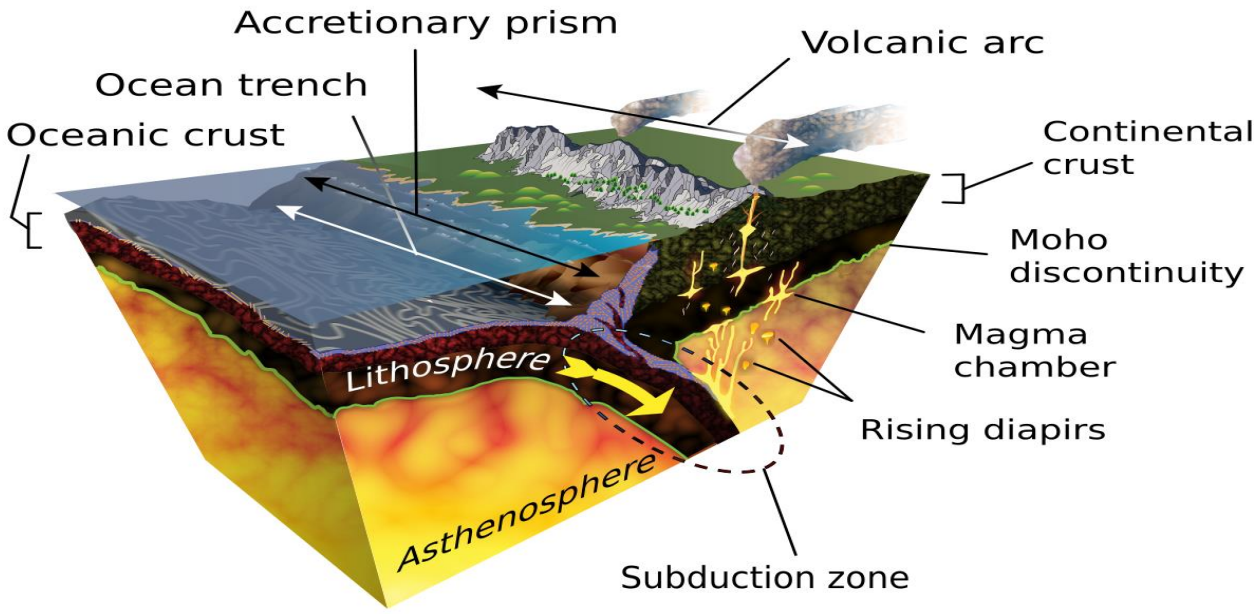


# CHAPTER 2

## Earthquake:
## THE FORCE OF NATURE

An earthquake (also known as a quake, tremor or temblor) is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity.

## PRE-READING

### *Improve Your Reading Skills*

**Intensive Reading**
You need to have your aims clear in mind when undertaking intensive reading. If you need to list the chronology of events in a long passage, you will need to read it intensively. This type of reading has indeed beneficial to language learners as it helps them understand vocabulary by deducing the meaning of words in context. It moreover, helps with retention of information for long periods of time and knowledge resulting from intensive reading persists in your long term memory.

**Extensive Reading**
Extensive reading involves reading for pleasure. Because there is an element of enjoyment in extensive reading it is unlikely that students will undertake extensive reading of a text they do not like. It also requires a fluid decoding and assimilation of the text and content in front of you. If the text is difficult and you stop every few minutes to figure out what is being said or to look up new words in the dictionary, you are breaking your concentration and diverting your thoughts.

## READING

# Top 5 Earthquake Resistant Structures Around the World

Earthquakes are one of the most destructive forces of nature. Structures and infrastructures suffer the most when an earthquake strike a seismically active region in the world. Seismic loadings must, therefore, be taken into account when designing structures especially those that are considered as skyscrapers. Let's roam around the world together and discover the top 5 earthquake-proof structures and learn how buildings can be designed to resist extreme seismic loadings.

**How do earthquakes happen?**

As an engineer, it's important to initially understand what the problem is to make the solving part easy. So, what exactly is an earthquake and how do they happen? Everyone knows about the existence of tectonic plates and how they influence the movement of the Earth's crust. Earthquakes happen when these tectonic plates collide with each other and produce large magnitudes of energy measured using the Richter scale. The movement of these tectonic plates can be attributed to one simple physical phenomenon - convection.

Professor Iain Stewart, a geologist from Plymouth University, argues that having information about how earthquakes happen and how they affect structures might make people, in general, and engineers, in particular, prepared to stand against it. Knowing that

waves radiate from the base of a structure throughout its whole body is essential in designing earthquake-resistant buildings. The below countdown represents five exemplar earthquake resistant structures and buildings across the globe.

**5. Sabiha Gökçen International Airport / Turkey**

Sabiha Gökçen is one of the two international airports in Istanbul, Turkey, which is located near the North Anatolian fault. It was designed by the engineering firm Ove Arup to have 300 base isolator systems that can withstand up to a maximum of 8.0 Moment Magnitude (Mw) earthquake. The base isolators can reduce lateral seismic loadings by 80% which makes it one of the largest seismically isolated structure in the world.

**4. Transamerica Pyramid**

The Transamerica Pyramid is an iconic 1970s structure hosted by the Californian city of San Francisco which sits closely beside the San Andreas and Hayward faults. In 1989, the Loma Prieta earthquake struck the structure at a magnitude of 6.9 Mw which caused the top story to sway, by almost one foot from side to side, for more than a minute but the building stood tall and undamaged.

This earthquake resistance feat can be attributed to the 52-foot-deep steel and concrete foundation that is designed to freely move with seismic loadings. Vertical and horizontal loadings are supported by a unique truss system above the first level with interior frames extending up to the 45th level. The complex combination of these structural systems makes the building resistant to torsional movements and allows large horizontal base shear forces to be absorbed.

**3. Burj Khalifa**

I don't think this skyscraper requires any introduction. Burj Khalifa is simply one of the most iconic supertall structures in the world. And wait, it's also earthquake resistant! The structure is composed of mechanical floors where outrigger walls connect the perimeter columns to the interior walling. By doing this, the perimeter columns are able to contribute support for the lateral resistance of the structure and the verticality of the columns also help with carrying the gravity loads.

As a result, Burj Khalifa is exceptionally stiff in both lateral and torsional directions. A complex system of base and foundation design was derived by conducting extensive seismic and geotechnical studies which gave the skyscraper stringent structural measures against earthquakes.

**2. Taipei 101**

Taipei 101 is perhaps one of the most mesmerizing supertall skyscrapers in the world. The architectural exterior design, by C.Y. Lee, was inspired by the Asian mentality "we climb in order to see further". Putting aside the architecture, the mind-blowing fact about Taipei 101 is that it houses the biggest tuned mass damper (TMD) in the world! It's basically a gigantic metal ball that counteracts big transient loadings like wind and earthquake to reduce the sway of the supertall tower.

The TMD is supported by hydraulic viscous damper arms and bumper system which function in the same way as a car's shock absorber. When large forces act upon the tower the TMD sway in the opposite direction bringing the entire building in equilibrium by damping out the transient forces using the ball's mass. It is amazing to know that this earthquake damper system is located between the 87$^{th}$ floor up until the 92$^{nd}$ one.

**1. Philippine Arena**

The Philippine Arena is the world's largest domed arena and is the most amazing earthquake-proof structure. The arena was designed by the Australian architecture firm Populous and the elite engineering firm Buro Happold. You can appreciate the greatness of this structure by its susceptibility to earthquakes and how it was designed to resist large seismic loadings.

The Philippine plate sits along the Pacific ring of fire, the world's most notorious and active chain of earthquake fault lines. Previous earthquakes in the country has surmounted up to 8.2 Mw and have claimed thousands of lives where the epicenters originate and the seismic activities were also responsible for igniting volcanic eruptions and tsunamis. Philippine Arena's vast stadium roof, spanning 165m in the shortest direction, was engineered to withstand severe transient loadings such as earthquakes, winds, and typhoons.

Buro Happold cleverly responded with an independent base design for the entire structure which means that the main structural body of the arena is isolated from its base and foundation. The gap between the main structure and base foundation system is composed of lead rubber bearings (LRB) which are a flexible arrangement of materials with high energy dissipation properties. This allows the base and foundation system to freely move with the earthquake force while the top structure remains stationary during dynamic actions.

## POST-READING

***Recalling Information.*** *Decide if the following sentences are True (T) or False (F). Correct the false statements to make them true.*

…… 1. When designing structures, engineers need to pay special attention to seismic loadings.

…… 2. Earth's plates play almost no role in the occurrence of the earthquakes across the globe.

…… 3. Convection is argued to be the push behind the movement of the tectonic plates.

…… 4. To make the buildings earthquake resistant, it is essential to know the base of the structures and their bodies.

…… 5. Located near the North Anatolian plateau, Sabiha Gökçen is one of the two active faults in Turkey.

…… 6. As an iconic structure, the Transamerica Pyramid hosts the Californian beside the San Andreas and Hayward faults.

…… 7. Due to the high-tech designing, Burj Khalifa is argued to be extremely firm in both lateral and torsional directions

***Text Comprehension.*** *Provide the following questions with appropriate answers from the text.*

1. Sabiha International Airport is one of the largest seismically isolated structure in the world as .....
   a. its base isolators can reduce lateral seismic loadings by 80 percent.
   b. it was designed to hold few base isolator systems to resist maximum earthquakes.
   c. the structure strikes the earthquake at a great magnitude causing it to sway.
   d. the unique truss system of which is located above the first level with central frames.

2. The Transamerica Pyramid is resistant to torsional movements due to the .....
   a. undamaging earthquake forces
   b. use of the complex combination of the structural systems
   c. attributed force of the shear resistance of the steel
   d. free movement of the seismic loadings

3. To what factors can the earthquake resistance feat can be attributed?
   a. structural systems and large horizontal base
   b. free movements and the magnitude of seismic loadings.
   c. The 52-foot-deep steel and concrete foundation
   d. absorbed forces and combined systems

4. ..... and ..... well contribute to the Burj Khalifa to be earthquake resistant.
   a. outrigger walls / interior walling
   b. extensive seismic studies / geotechnical investigations
   c. base design / foundation structure
   d. perimeter columns / the verticality of the columns

5. How does Taipei 101 stand against strong forces of wind and earthquake?
   a. By shaping a ball-like structure
   b. Through counteracting big transient loadings
   c. By means of reducing the height of the supertall tower
   d. Via a simple car's shock absorber metal ball

6. In Taipei 101, when large forces act upon the tower, .....
   a. the ball's mass damps out the equilibrium forces
   b. the bumper system supports the whole hydraulic system
   c. the TMD power in the opposite way keeps the structure in equilibrium
   b. a hydraulic viscous damper arms and bumper system counteract

7. How has Philippine Arena become resistant to earthquakes?
   a. With an independent base design for the entire structure
   b. by isolating the base of the structure and its foundation
   c. Through allowing the base and foundation system to freely independently move
   d. All of the above

## Vocabulary Practice

***A. Matching:*** *Match each of the words given below on the left with a definition on the right.*

| | |
|---|---|
| 1. infrastructure ….. | a. able to keep out something being harmful |
| 2. take into account ….. | b. consider to be the cause of |
| 3. -proof …… | c. gradually diminish or weaken |
| 4. crust …… | d. twisting; reacting torque |
| 5. attribute to …… | e. basic framework; vital resources |
| 6. lateral …… | f. defenselessness; frailty |
| 7. isolate …… | g. separate; quarantine |
| 8. torsional …… | h. located on the side; on the side |
| 9. susceptibility …… | i. the hardened exterior surface |
| 10. damp out …… | j. consider; pay attention to |

***B. Fill in the Blanks.*** *Using the words in part A, fill in the blanks below with correct form of the words.*

1. After the long lasting crisis, all the social and economic …… of the nation were damaged, paralyzing almost all sectors.
2. The volcanic eruption made a big fault in the earth's ……, rendering the whole area uninhabitable.
3. Many view holders believe that the North Pole is a vast area which is …… from the rest of the world due to the extremely harsh conditions.
4. At the end the pipe, there is a filter which is installed by the technicians to …… the poisonous effects of the wastes!
5. While designing and constructing a building, different safety precautions should be …… so that it won't yield easily when a natural force is applied to it.
6. The changes in his behavior are claimed to be …… the recent economic achievements he has made.

7. The stress which is produced when we apply the twisting moment to the end of a shaft and about its axis is known as …… stress.
8. When the seams are all covered with pitch and the cracks are completely soldered in a way that not even a drop can get into, we say that the structure is water ……
9. the plant takes up water not just through its main root but via many tiny …… roots it has at the end.
10. In today's people's lifestyle, lack of exercise and the overuse of junk food increase their …… to mainly heart diseases.

***C. Parts of Speech.*** *Fill in the blanks with the appropriate forms of the words given below.*

| Verb | Noun | Adjective | Adverb |
|---|---|---|---|
| Destroy | Destruction | Destructive | Destructively |
| Isolate | Isolation | Isolated | - |
| Attribute | Attribution | Attributive | Attributively |
| Radiate | Radiation | Radiative | - |

1. The emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which causes ionization is referred to as ……
2. To our surprise, he …… the firm's success to the efforts of the managing director and give no role to the staff!
3. In the chemistry laboratory, the main difficulty will be to safely …… the factors which are most significant from the compound.
4. The physical phenomenon of energy transfer in the form of electromagnetic emission is called …… transfer.
5. The main unreality of this novel is the …… of complicated emotions to their unstable character.
6. A child's …… from his family and friends may also result in different degrees of anxiety.
7. Many viewers argue that the …… criticism raised against the director was not fair.

## Earthquake Fantasy

- ***The ground can open up during an earthquake.*** A popular cinematic and literary device is a fault that opens during an earthquake to swallow up an inconvenient character. But unfortunately for principled writers, gaping faults exist only in movies and novels. The ground on the two sides of the fault slide past each other, they do not pull apart. If the fault could open, there would be no friction. Without friction, there would be no earthquake.
- ***People can stop earthquakes.*** We cannot prevent earthquakes from happening (or stop them once they have started). However, we can significantly mitigate their effects by

characterizing the hazard, building safer structures, and preparing in advance by taking preventative measures and knowing how to respond.