Throughout human history, earthquakes have taken the lives of millions. For some of us, earthquakes are regular occurrences, whereas, for others, they may have never experienced an earthquake in their lives. It all depends on where we live.

However, unlike other natural disasters, it is impossible to prevent earthquakes from occurring. Over 500,000 earthquakes occur each year – more than 1,300 each day! Despite that, there are many ways for us to minimise the damages caused and the lives lost.

Today, we will be discussing what earthquakes are, and some of the hazards and impacts involved.

What are Earthquakes?

Earthquakes are seismic activities that cause tectonic hazards, together with volcanic activities and tsunamis. Seismic activities refer to the frequency, size, and type of earthquakes that an area experiences over a certain period. They occur when the lithosphere suddenly releases energy. This creates seismic waves and causes the Earth's surface to shake. Most earthquakes occur along linear chains following plate boundaries.

While we mentioned that there are over 500,000 earthquakes occurring every day, most are weak and we cannot feel them. However, some earthquakes are so violent that they can send people and things into the air, with a number of them even obliterating whole cities. Historical earthquakes that obliterated whole cities include the 1923 Great Kantō earthquake, destroying Tōkyō and Yokohama, and the 1995 Great Hanshin earthquake, destroying Kōbe.

How Earthquakes Work

Strain and stress may accumulate along the joins of tectonic plates when rock masses try to move past one another. When this strain is released, seismic waves are sent in all directions, including to the surface of the Earth. This point on the surface of the Earth is the epicentre of the earthquake.

There are two main types of seismic waves – the primary (P) waves and the secondary (S) waves. The P waves have shorter wavelengths compared to the S waves and reach the surface of the Earth first as they travel through the crust at a fast speed. The S waves then reach the surface seconds later. The S waves often cause more damage than the P waves as they have a velocity of 4 km/s. To put into perspective the strength of the S waves, it only

took the S waves 90 seconds to reach Tōkyō from 373 km away when they were released at the epicentre in the 2011 Tōhoku earthquake.

Measuring Earthquakes

We can measure the magnitudes of earthquakes with two main scales – the Richter scale and the Moment Magnitude scale. The Richter scale estimates the magnitude of an earthquake by using the time that the P and S waves reach the epicentre, together with the S waves' amplitude and distance. On the other hand, the Moment Magnitude scale takes into account the energy released by every shockwave released, and the movement and rupture area. The two scales are logarithmic and there is no big difference between the two scales. However, the Moment Magnitude scale is more accurate when determining the magnitude of major earthquakes.

Distribution of Earthquakes

There are different types of tectonic plates – major, minor, and micro-plates. These tectonic plates are constantly headed in different directions and at different speeds. As such, this creates different plate boundaries, which gives rise to different magnitudes of tectonic activities, including earthquakes.

The majority of major earthquakes occur along the Ring of Fire – countries along the edges of the Pacific Ocean. These countries include Japan, Taiwan, the Philippines, Indonesia, New Zealand, Chile, Mexico, the United States, Canada, and Russia. Major earthquakes that occurred here include the 1960 Valdivia earthquake and the 2011 Tōhoku earthquake. On top of earthquakes, volcanic activities are also prominent in areas along the Ring of Fire.

Earthquakes Hazards

Just like other types of tectonic activities, earthquakes also cause hazards. We can classify these hazards into primary and secondary hazards.

Primary hazards

The first main primary hazard is the shaking of the ground. Even if an area experiences an earthquake with low intensity, it can still result in severe shaking of the ground. This depends on the conditions of the local geology and geomorphology. However, other factors also play a part. We can measure this using ground acceleration.

The second main primary hazard is the faulting of the surface. This occurs when the earthquake displaces the surface of the Earth along the fault's trace. When building major engineering structures such as bridges, dams, and nuclear power stations, we have to check for existing faults that may cause the surface to fault.

Both main primary hazards may result in damage to architectural structures. The effects of earthquakes depend on factors such as the magnitude, the distance from the epicentre, together with the conditions of the local geology.

Secondary hazards

Some secondary hazards of earthquakes include:

- Soil liquefaction (2011 Christchurch earthquake)
- Landslides and rockfalls
- Debris flow and mud flow
- Tsunamis (2011 Tōhoku earthquake)
- Fires (1923 Great Kantō earthquake)
- Floods

Extent of Damage of Earthquakes

Factors affecting the extent of damage

There are many factors affecting the extent of damage of earthquakes. These include:

- Distance from the epicentre
- Economic developments
- Number of aftershocks
- Population density
- Secondary hazards
- Strength and depth of earthquake
- Time of the day when the earthquake occurs
- Type of buildings
- Type of rocks and sediments

Minimising the extent of damage

We can minimise the extent of damage of earthquakes by implementing forecasting that is

more accurate, together with better warning systems and emergency preparedness.

We can predict the occurrences of earthquakes by checking for:

- Anomalies in the magnetic field of the Earth
- Changes in the concentration of gaseous radon
- Changes in the rocks' electrical resistivity
- Micro-earthquakes
- Small-scale uplift, subsidence, or tilting of the ground
- Stress of rocks

On top of that, we can also make improvements to the design of architectural structures and where their location. Flexible foundations can be used for buildings in earthquake-prone regions, such that only the foundation moves rather than the entire building. We can also implement damping to absorb the shock from the earthquake. Besides, reinforcement of structures and the use of earthquake-resistant materials can minimise the impact of the earthquake on buildings.

One such example of combining prediction of earthquakes and improving the architecture can be seen from the Shinkansen during the 2011 Tōhoku earthquake. With Shinkansens travelling at a top speed of 320 km/h, it is surprising that no passenger Shinkansen services were derailed despite the 9.1 M_W earthquake. This is due to the early warning system that detected the earthquake 12 seconds before it struck the epicentre. The system induced an emergency brake on dozens of Shinkansen services across the Tōhoku and Kantō regions, preventing them from derailing.

Impacts of Earthquakes

Economic impacts

We have been harping on buildings for quite a while now, so it is obvious that the most significant economic impact of earthquakes would be on buildings. Besides, public utilities, such as water, electricity, and gas, may be halted as the earthquake may damage cables and pipes. Fires are also a common sight after earthquakes. This is especially so when gas pipes are damaged, but was historically significant when earthquakes occurred during lunchtime or dinnertime when people were cooking.

While governments usually build dams outside of earthquake-prone areas, some dams may collapse during an earthquake. This causes the water to flood into populated areas. Factories hit by earthquakes may also cause hazardous materials to be accidentally released.

Social impacts

The most prominent social impact of earthquakes is the loss of lives. People are killed both by primary and secondary hazards. Occasionally, more people are killed in the aftermath of the earthquake rather than because of the earthquake. People are also displaced after an earthquake, with the homes of people destroyed, or worse, the complete destruction of entire towns and cities.

On top of that, when sewage systems are damaged or when floods occur, diseases may spread. This includes mosquito-borne diseases such as malaria, or other forms of conditions such as hypothermia.

Recent Major Earthquakes

Earthquake	Magnitude	Deaths
1960 Valdivia earthquake	9.4 to 9.6	1,000 to 6,000
2004 Indian Ocean earthquake and tsunami	9.1 to 9.3	227,898
2011 Tōhoku earthquake and tsunami	9.0 to 9.1	19,747
1952 Severo-Kurilsk earthquake	9.0	2,336
1950 Assam–Tibet earthquake	8.6	4,800
1939 Chillán earthquake	8.3	28,000
1923 Great Kantō earthquake	8.2	142,800
2008 Sichuan earthquake	7.9	87,587
1920 Haiyuan earthquake	7.8	200,000 to 273,400
1976 Tangshan earthquake	7.6	242,419 to 655,000
2005 Kashmir earthquake	7.6	86,000 to 87,531
2010 Haiti earthquake	7.0	100,000 to 316,000

Conclusion

While some of us are fortunate enough to live in places that are not prone to earthquakes, many of us do. We cannot avoid earthquakes, but we can do our best to be prepared when it strikes, both individually and collectively.