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Effects on Earthquakes Resistant Buildings and the Environment

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Abstract----* Earthquakes are one of the most devastating natural disasters that cause the earth's surface to shake suddenly. It not only damages other structures but also affects the surrounding environment building and our way of life. Earthquakes are an exception in this case, although they are understood in advance in the case of other natural disasters. This catastrophe happened in a very short time making it impossible to take precautions. This also causes more damage than other natural disasters. Why do earthquakes happen? According to experts, the whole surface is divided into several levels. Again each layer is divided into multiple plates. The bottom of the earth shakes when these huge tectonic plates collide with each other. Earthquakes cause rocks to rise above each other. And the resulting energy shakes the ground. Basically, this energy is the cause of vibration. This vibration wave-measuring instrument is called a seismometer and a network of these instruments is used to measure earthquakes. Seismograph record a zigzag chart on paper showing how the ground beneath the instrument vibrates. And we feel earthquakes on the surface of the earth. Before the construction of earthquake resistant buildings, earthquake-resistance structure has to be made. Earthquakes can trigger many changes in the environment that can be classified as primary effects (Erosion, Surface defects) and secondary effects (Displaced rocks, Tsunamis, Ground cracks, Liquids, Landslides). These effects are known as earthquake environmental effects [EEE].

Keywords : Earthquake Environmental Effects [EEE], Earthquake Resistance Building, Seismograph, Seismometer, Primary and Secondary Effects of Earthquake.

1 INTRODUCTION

The epicenter was reported below the ground just above the epicenter. The epicenter was reported below the ground. The environment is known as an earthquake environment effect (EEE) [1]. We have witnessed several terrible earthquakes that destroyed the whole city and wreaked havoc on a massive scale [2]. The earthquake takes about 10 to 30 seconds [3]. The quake caused loss of life and property, social and economic damage, or degradation of the environment. But strong and devastating earthquakes caused extensive damage to homes and property and caused countless casualties.The Severity of ground shaking at a given location during an earthquake can be minor, moderate, and strong [4]. Relatively speaking, minor shaking occurs frequently, moderate shaking occasionally, and strong shaking rarely. Soil behavior varies at different levels. Moreover, some special phenomena can be seen in the soil field. For example, Sudden and temporary vibrations occur on the surface of the earth. The magnitude of these vibrations caused by the sudden release of energy stored in the earth's crust can range from mild vibration to strong rotation. Earthquakes are a type of wave motion force that occurs in a limited range and spreads in all directions from the source of the event [3,4]. Earthquakes usually last from a few seconds to a minute. The point in the ground where the wave of an earthquake is signaled is called the center and vibrations from this center. However, the process of building earthquake resistance buildings can also have both positive and negative effects on the environment. On the one hand, these structures can reduce the release of hazardous materials and pollutants that can result from building collapses during earthquakes [4]. On the other hand, The construction process itself can have negative environmental impacts, such as the destruction of natural habitats and the use of energy-intensive materials[4].

During this process, the soil behaves like a liquid. If the properties of the soil are not last. Then the structure made on the ground will collapse. So first of all we have to design earthquake resistance scare. The earthquake resistance structure can be built [5]. For example, an average of 5.0 - 5.9 magnitude is about 800 earthquakes. Occur in the world while the number is only about 18 for magnitude 7.0 - 7.9. Earthquakes are defined as shallow centers (0 - 60km), medium center (60 - 300km) and deep centers (300km) based on the depth of the epicenter. The most common measure of the magnitude of an earthquake is the 'Richter Value'. The seismograph uses the difference between the maximum surface wave amplitude and the time it takes to reach the primary (P) and secondary (S) waves to determine the intensity on the 'Richter scale'. The magnitude of the earthquake is 1 - 10 on this scale. The higher the Richter scale, the greater the loss. First, it is felt on the surface of the earth along the point just above the center which is called the epicenter. The first tremor was felt in this epicenter. A magnitude 7.8 earthquake shook the region of 'Tangshan' in China in 1976. It killed 242,000 people. And there was also a 9.0 magnitude earthquake in Indonesia in 2001. It killed 226,898 people [6].

2 EARTHQUAKE ENVIRONMENT EFFECTS (EEES)

The effects of an earthquake on the nearby and adjacent environment it is called earthquake environmental effect

[EEE]. Two things are involved with earthquakes. One is the center and the other is the epicenter [7]. Earthquake environmental effects [EEE] can be categorized into two types primary and secondary. Cause of earthquake scientists have been experimenting for many years to identify the causes of earthquakes. Among the causes are landslides, groundwater vapor, avalanches, heat radiation, loss of groundwater pressure, volcanic eruptions, glacier effects, cracks, and fissures, sea level changes, river diversion, folding, landslides and glaciers. [EEEs] are increasingly being used as equipment for measuring the intensity of an earthquake[8, 2]. But in relatively developed counties the effects of earthquakes are not seen. The reason is their improved quality construction methods and plans. But then from fear. As much a magnitude 6.3 earthquake shook New Zealand on 22 February 2011 and killed at least 185 people [9]. It is the magnitude of the earthquake in 8.5 - 9. It will have a serious impact on the environment.

2.1 PRIMARY EFFECTS

The first (P) wave to reach the seismic device from the epicenter is called the primary (P) wave. It travels straight through the soil and it proportional to the velocity of the wave. The surface velocity of the continental crust is 6.1km/s, its velocity at the bottom of the continental crust is 6.9km/s and the speed of the marine crust is 8km/s. The primary effects move the object through contraction and expansion and change the position of the rock slightly. The Primary effects of earthquakes include tremors, building collapses, landslides, bridge collapses, and injuries to people. Tectonic disasters are caused by the movement of tectonic plates on the earth's surface such as earthquakes and volcanoes. The initial effects occur as a direct result of the movement. For example, the ground shakes or lava flows. Observation means that after an earthquake the soil is reduced by the fluidity of the sand. In 1964 the Niigata earthquake a region of about 0.64 km in length. It's impact was diminished liquidity. This area has gone under about 600mm of water. For one month due to flooding by tsunami [10]. There have been many terrible earthquakes in the past as there are knows. According to the theory of history, the Crete island civilization was wiped out by an earthquake in 1900 [11].

On January 17, 1995, a major earthquake struck near the city of Kobe, Japan [12]. The earthquake was of magnitude 7.3 on the surface wave magnitude scale (Ms). And its durability was the 20s. The earthquake had devastating effects on urban infrastructure - 215,000 residential structures collapsed, burned, or sustained severe damage [12, 13]. The intensity value assigned by MM (moment magnitude scale) was lower than that assessed by JMA (Japan meteorological agency) scale.

TABLE 1. COMPARISON OF INTENSITY VALUE ASSIGNED BY MM SCALE AND JMA SCALE FOR THE EARTHQUAKE [13]

Location	**Intensity (in MM scale)**	**Intensity (in JMA) scale**
Kobe	VI	VII

In 1737 Kolkata, India an earthquake was severe. An earthquake in Assam in 1950 changed the course of the Brahmaputra River. The January 26, 2001 earthquake in Gujarat, India was the second worst earthquake in India. The buildings built in this earthquake collapsed like a house of cards [14]. On October 7, 2005, the whole of Kashmir, Pakistan, Afghanistan, and vast areas of northern India were shaken. The maximum magnitude f the tremor was 7.5 on the Richter scale. In 1894 Greece was known to have the Gulf of Atlantis coastal configurations cause big changes like big arrows thunderstorms, tsunami-driven floods, and coastal erosion [15].

2.2 SECONDARY EFFECTS

Secondary effects can occur a few hours after the initial earthquake. The primary effects are know as secondary effects. The short wave is called S wave. After the initial wave, the second wave travels from the epicenter to the Seismometer [16]. The difference from the initial wave is that it is slower than the initial wave and it cannot pass through the medium [17]. The S wave waves the object back causes the most damage to the structure of the building.

2.2.1 Liquefaction

Vibration or water pressure in large parts of the soil can cause soil particles to lose contact with each other when fluidity occurs. As a result, the soil behaves like a liquid, cannot support weight, and can flow very slowly. This condition is usually temporary and estimated for non - overlapping windows 10 min of the recorded ambient seismic vibrations and is often caused by seismic water - saturated fillings or unresolved soils [18].

2.2.2 Seismic conditions

Earthquake or artificially generated earth vibrations are related to or related to earthquakes. The distance of a certain area from the epicenter of the earthquake affects the intensity of the ground motion of the earthquake. After an earthquake in a certain area, it is reduced by the fluidity of the soil and sand.

2.2.3 Pressure on Soil

The process of soil compaction is due to the release of water from the soil due to the long - term fixed quality load action on the soil. Surface soil contains soil particles as well as water and air. The pressure exerted on the soil by high force exerted on the soil for long period of time reduces the volume by expelling air and water from the soil [19].

2.2.4 Groundwater level

Groundwater use can be regulated through the groundwater conservation Act [20]. This can lead to dehydration of the soil, which can lead to an increase in the amount of sand in the soil. In all these cases, there is a strong possibility of cracks or collapse of houses in urban areas. Essential elements to increase groundwater supply. Soil porosity results in liquidity [21]. For example, there was an earthquakes on 9 May in Japan. Which resulted in a lot of loss of liquidity.

2.2.5 Tsunami

A tsunami is a tidal wave caused by an earthquake, landslide, or volcanic eruption in an ocean or river, and other body of water. Tsunami causes earthquakes, volcanic eruptions and landslides. Two of them are earthquakes at a depth of 20 - 30 km below sea level and sudden rise and fall of tectonic belly. Deepwater tsunamis can reach speeds of up to 600 miles per hour. In history, there have been major earthquake and tsunamis in Cascadia, Japan including tsunamis [22]. When earthquakes occur in water, they can cause tsunamis. Tsunami waves are usually continuous and can reach a peak of about 100 miles. Wave can hit the ground. For example, A strong earthquake shook Indonesia on 27 May 2006 [23]. The tsunami caused huge sea waves to wreak havoc on the coastal areas. For example, Hilo island in the Hawaiian islands of Japan was devastated by the April 1, 1946 tsunami, The tsunami occurred in the deep sea 70 miles off the Alaska Peninsula.

An earthquake Mw= 9.0 earthquake shook the region of Tohuku in northeastern Japan at 2:47 pm local time on March 11, 2011. The epicenter was reported below the ground at 10 meters (33 feet). The number of injured was 4,878,282 [24].

Fig 1. Japan earthquake and tsunami of March 11, 2011.

Areas that are on the coast and surrounded by forests or plants. And encircled areas that cause even more devastation in the regions [25].

3 EARTHQUAKE RESISTANCE BUILDING

Since the earthquake force is a function of mass, the building shall be as light as possible. A heavier structure means a large inertia force and the collapse of these structures result in heavier damage and loss of lives [26]. Before constructing the building, the soil has to be examined well. There are two types of soil > clay and sand. If there is more sand in the soil, the water at the bottom rises during the earthquake. This process is called liquefaction. If the properties of the soil are not intact, the ghost will not survive. Then the structure made on the ground will collapse so first of all you have to design earthquake - resistance scare. Then an earthquake - resistance structure can be built [27].

To specify the earthquake resistance features in masonry and wooden buildings. The building has been in five categories shown in Table 2.

TABLE 2: BUILDINGS CATEGORIES FOR EARTHQUAKE RESISTING FEATURES.

Category	**Range of ah (Horizontal acceleration coefficient)**
A	0.04 to less than 0.05
B	0.05 to 0.06 (both inclusive)
C	More than 0.06 but less than 0.08
D	0.08 to less than 0.12
E	More than 0.12

The earthquake resistance of a building can be improved by five simple principles of design and good building construction practices. The principles are:

1. *Lightness*
2. *Regularity*
3. *Size of Building*
4. Continuity

3.1 LIGHTNESS

Since the power of earthquakes is a feat for the public. So the building will be as strong as possible. The use of heavy structures and the massive inertia of large sums of money and earthquakes resulted in the collapse of these structures, resulting in many casualties. Thus, the roof of the building and the upper story should be designed as light as possible [28].

3.2 REGULARITY

The building should have a simple rectangular plan. It is seen that simple shapes behave better during earthquakes than complex shapes like L, T, E, H, U ,C ,etc. It is seen that during earthquakes the buildings with re-entrant corners have suffered great damage [29]. Torsional effects of ground motion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times its width (L>3b) [30]. Separation of a large building into several blocks may be required to obtain symmetry and regularity of each block [31].

3.3 SIZE OF BUILDING

Building of great length or planned area may not respond to earthquakes in the way calculated [32]. Buildings that are too long in plan, may be subjected to different earthquake movements simultaneously at the two ends, leading to disastrous results [33, 32]. As an alternative such a building can be broken into several separate square buildings shown below (Fig 2).

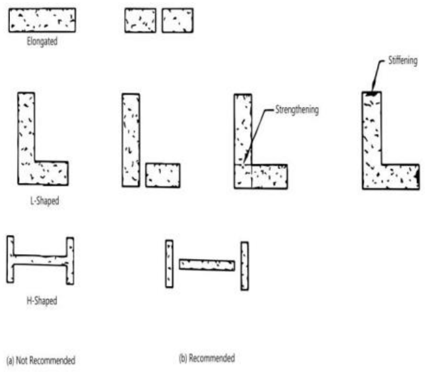

Fig. 2 Broken layout concept.

In tall buildings with large height - to - base size ratio (slenderness ration > 4). The horizontal movement of the floors during ground shaking is large.

Earthquake resistance building will not happen without proper structural design.The columns of the building should be placed parallel to each other [34].The pressure carrying capacity of concrete can't be reduced below 3000 PSI under any circumstances [35.] High power rods should be used. So that it can be carrying power close to 60 thousand PSI [36]. The plan and elevation of the building are balanced on both sides. The expansion gap should be kept as per the building code.The amount of seismic strength should be increased by placing the concrete walls in the right place.

3.4 CONTINUITY

The seismic forces developed at different floor levels of a building need to be lowered to the ground by the shortest path; any deviation or pause in this load transfer path leads to poor building performance [37] .The risk could be greatly reduced if a proper foundation was laid through proper piling.

constructing a building by following the code and building construction rules properly [38].

Buildings with columns that hang or float on beams at an intermediate story and do not go all the way to the foundation have discontinuities in the load transfer path (Fig. 3 (a)) [39,40]. Building on the sloping ground has unequal height columns along the slope, which causes ill effects like twisting and damage in shorter columns (Fig 4 (b)). [41] Five different cases of (G+3) building on varying slope angles are designed 0, 15, 30, 45 and 60. Successive floors of such building step back towards the hill slope ,and sometimes the building also setbacks. The stepping back of the building towards the hill slope results in unequal column height in the same story, which causes severe stiffness irregularities in along-and-cross-slope directions.

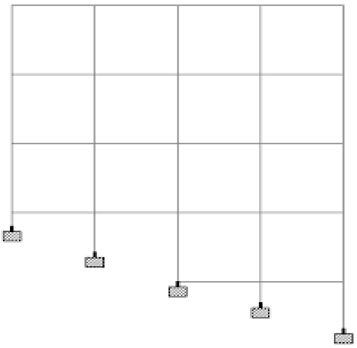

Fig. 3: Elevation of a sloping ground (15 Degrees) [42]

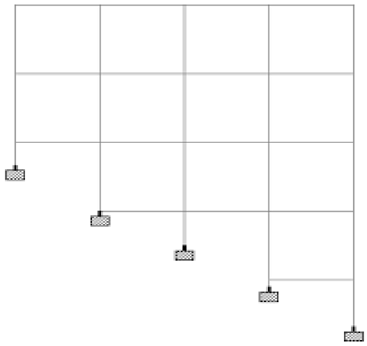

Fig. 4: Elevation of a sloping ground (30 degrees) [43]

Consider the layout of the structural framing system (weight-bearing infrastructure system) with special attention to the addition of lateral resistance and the design of the general design and consider the intersections with heavy weight with the provision of reinforcement as required [44].

The structure should not be fragile and should not be accidentally destroyed. Rather they should be strong and should have sufficient capacity for deformation and deflection. Resistant parts like walls must be given evenly throughout the building from one side to the other and from top to bottom. Nowadays, rapid construction is taking in hilly areas due to the scarcity of plain ground. As a result, the hilly areas have a marked effect on the buildings in terms of style, material, and method of construction leading to the popularity of structures in hilly regions. Due to the sloping profile, the various levels of such structures step back towards the hill slope and may have setback also at the same time.

4 EARTHQUAKE RESISTANCE BUILDING MODEL

A FRICTION DAMPER is a specialized component designed to control unwanted vibrations in structures such as bridges, buildings, or towers. It operates by converting the kinetic energy of these vibrations into heat energy through friction. By doing so, the friction damper helps to stabilize the structure and enhance it's safety against dynamic loads such as wind, gusts or earthquakes [45]. In essence, it acts as a shock absorber, mitigating the impact of the vibrations and keeping the structure in a stable state. FDs are primarily concerned with reducing vibration [46,47]. Focused on improving their efficiency and effectiveness.

- ***Magnetic Friction Damper:*** These are magnetic forces in addition to friction to achieve better damping performance.
- ***Hybrid Friction Damper:*** These combine different damping mechanisms, Such as magnetic and hydraulic, to improve their performance in a wider range of frequencies and amplitudes.
- ***Smart Friction Damper:*** These are sensors and control systems to adjust the damping force in real time, allowing for improved control optimization of the damping performance.
- ***Tunable Friction Damper:*** These allow for the adjustable friction force, allowing for fine-tuning of the damping performance to meet specific requirements.

Dynamic simulation of multi-story buildings with FDs can be challenging due to the sliding-sticking nature of friction forces [47,48]. This results in continuously changing degrees of freedom of the system, making it difficult to accurately model the system behavior and predict its response to seismic excitation. To overcome these challenges, advanced numerical methods, such as multi-point constraints, hybrid and incremental dynamic analysis and other, are used in conjunction with sophisticated computational tools to simulate the behavior of large-scale multi-story buildings with FDs [49].These methods can provide more accurate predictions of the building response and help engineers design more resilient and safer structures.

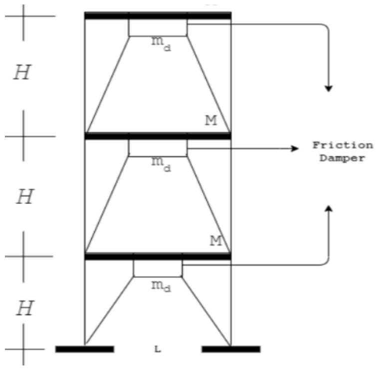

Fig. 5: A three-story building with FDs.

4.1 METHODOLOGIES

In IS method of analysis is followed by using code - IS1893 (Part 1): 2002.

The seismic analysis of buildings connected with and without friction dampers is done by equivalent static analysis, Response spectrum analysis.

TABLE 3: COMBINATIONS OF LOAD AS PER IS 1893-2002 & IS 875(Part-3)-1987.

Combination of loads	**Loads factor**
Equivalent static method (ESM)	1.2 (DL+LL+EQX)
	1.2 (DL+LL+EQY)
	1.5 (DL+EQX)
	1.5 (DL+EQY)
Response spectrum method (RSM)	1.2 (DL+LL+RSX)
	1.2 (DL+LL+RSY)
	1.5 (DL+RSX)
	1.5 (DL+RSY)

4.2 CHARACTERISTICS OF FRICTION DAMPER

If there is no seismic activity, there is no activity of the damper, Which can support its designed static load indefinitely, So there is no problem with wear or fatigue. FDs are designed to protect structures from earthquakes by absorbing energy from seismic forces [49]. They act as fuses, limiting the force that can be imposed on the members they protect. Dampers have a rectangular hysteresis loop, providing maximum energy dissipation for a given force and travel, independent of velocity and frequency. They are manufactured to slip at a specified force and are adjusted by the tension in bolts holding the sliding elements together. The coefficient of friction is about 0.2, but it is not of great importance as the slip force is controlled by bolt tension [50]. Energy dissipation during sliding increases the temperature of the damper but does not affect its performance. The extent of travel in the event of an earthquake will act as a damage indicator, showing whether the main structural frame remained elastic.

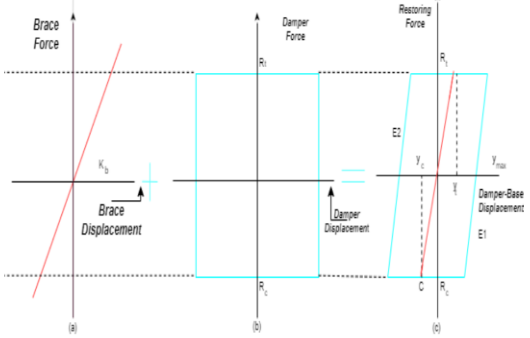

Fig 6: (a) Elastic Behavior of brace, (b) hysteretic loop of FDs, (c) resultant elastoplastic behavior of offriction damper in the brace. [47,50].

5 CONCLUSION

Earthquakes are natural disasters. Resulting in destruction and loss of life. The effects of the earthquake on the nearby and adjacent environment it is called earthquake environmental effect [EEE]. Earthquake environmental effects [EEE] can be categorized into two types primary and secondary. We do not have the experience, training and mentality to face natural disasters like earthquake. Earthquakes are not a mainstream phenomenon. The floods and tsunamis caused by the earthquake and many casualties. Earthquakes sometimes cause parts of the earth's surface to move downward. Again some parts go up. Earthquakes in the form of natural disasters make people helpless. The Richter scale is an instrument that determines the stability of an earthquake. If the magnitude of this scale is more than 5, there is a risk of a catastrophic disaster. The cruelty of the earthquake shook everyone on Earth. Huge buildings are being built without any code. To build an earthquake resistant building an earthquake resistant structure has to be built before that. The earthquake resistance of a building can be improved by five simple principles of design and good building construction practices. These principles are lightness, symmetry, regularity, continuity ,and size of a building.

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