

# Causes and effects of earthquakes engineering essay



**ASSIGN  
BUSTER**

Earthquakes are one of the most destructive mother-nature disasters in the world. An earthquake is defined as quake or tremor which there will be a slipping or movement of earth's crust as a result of a sudden release of energy, accompanied and followed by a series of vibration on the ground that causing damages. The series of vibrations is known as seismic waves and can be measured using seismometer, a device which also records the seismic waves known as seismograph. This disaster may happen naturally or caused by human activities and very difficult to predict (Wikipedia, 2009).

Earthquake can be grouped into three categories based on the depth of their foci that are shallow focus (<70 km depth), intermediate focus (70-300 km depth) and deep focus (> 300 km) Geological faults, volcanic activity, landslides, mine blasts and nuclear experiments will caused an earthquake. Strong earthquakes can cause severe damages and great loss of life in several ways, including fault rupture, tremors flood caused by tsunami and landslides. Earthquakes are generated by either tectonic activity, the movement of large rock plates which underlay the earth's surface, or volcanic activity (GEO. 101-02, 2006).

The areas that experienced the most active seismic are related with the plate tectonics that located on the ground. When the plate tectonics tend to moved, there will be faults that may be detectable on the ground surface, but they are often out of sight below layers of soil deposits. There is about 90 percent of the earthquakes case worldwide which occur at faults along the boundaries of earth's major crustal plates. Deformation will occurred which resulted from the movement of tectonic plate. The type of deformation

that takes place during earthquake generally occurs along zones where rocks fracture to produce faults that cause tremors (Stephen A. N, 2010).

The faults will cause a stresses that form a movements of adjacent plates therefore energy will released. Within the earth rocks are constantly subjected to forces that end to bend, twist, or to fracture them. When rocks bend, twist or fracture they said to be deformed or strain. This deformations are the energy that been released from the fracture. The energy released in the form of ground shaking will result of tremors and trembling of the ground (NAHB Research Center, 1994). Figure 2. 1 shows the location of earthquakes with different magnitude and depth.

Figure 2. 1 Locations of Earthquakes

## **2. 2 Causes of Earthquake**

Earthquakes are caused by the sudden release of energy along faults plane. The strain that builds up in the rock will ruptures when the elastic limit of the rock is exceeded thus released the elastic energy as seismic waves. The greater released energy, the greater strain that stored in the rock. A sort of the energy that released by and earthquake will travels through the earth`s crust which caused damages to life and structures. The earthquakes can be even smaller and even larger (W. Spence, S. A. Sipkin, & George L. C, 1989).

Earthquakes are three dimensional events which the waves will move outwards, horizontal and vertical plains. This condition produces three different types of waves which can be defined through its distinct behavior and some of this wave only travel through certain stratums within the earth.

The three forms of these shockwaves that cause an earthquake are (Geography Sites, 2006):

P-Waves - produces quite small displacement in the ground. It can pass through solids and liquids medium with high frequency, short wavelength and longitudinal waves.

Figure 2. 2 Particles are compressed and expanded in the P-waves direction.

S-Waves - travel more slowly and move in all directions but the speed is depends upon the density of the rocks through which they are moving. S-waves cannot move through liquids.

Figure 2. 3: S-waves move particles at 90° to the wave's direction

L-Waves - majority of the damages on the building causes by this waves because they travel close to the epicenter and through the outer part of the crust. This wave caused the landslides, fires and tsunami that account so much loss.

Figure 2. 4: L-waves move particles in a circular path.

## **2. 3 Measuring the Size of an Earthquake**

Earthquakes range roughly in size and commonly expressed in two ways which is magnitude and intensity. Magnitude is a measure of the total energy released during an earthquake. It is determined from the seismogram, which plots the ground motion that produced by seismic waves. The magnitude scale allows us to compare the earthquakes in relative terms as devised by C. F Richter in 1935 (Ammon, 2008).

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

The key thing to remember about magnitude is that the scale is logarithmic, means that each step in magnitude represents a tenfold increase in amplitude of wave motion. Therefore an earthquake of magnitude 6.0 has ten times the wave amplitude of an earthquake of magnitude 5.0, a hundred times the wave amplitude of a magnitude 4.0 earthquakes and one thousand times the wave amplitude of a magnitude 3.0 earthquakes (Disaster Recovery Journal, 1999).

The Richter magnitudes are based on a logarithmic scale (base 10). The measurements of earthquakes by C. F. Richter are classified into categories that ranging from minor to great, depending on their magnitude. Table 2.1 below shows the earthquake magnitude classes.

## **CLASS**

### **MAGNITUDE**

Great

8 or more

Major

7.0 -7.9

Strong

6.0 -6.9

Moderate

5.0 -5.9

Light

4. 0 -4. 9

Minor

3. 0 -3. 9

Table 2. 1: Earthquake magnitude classes proposed by R. C Richter.

Another way to measure the strength of an earthquake is to use the Mercalli scale. This scale is the most widely used intensity scale which divided into 12 degrees, each identified by a Roman numeral. The relationship between Modified Mercalli intensity and Richter magnitude is as follows (B. Haneberg, 2007):

## **Modified Mercalli**

## **Ritcher Magnitudes**

## **Description**

## **Earthquake Effects**

MMI

0. 00 - 2. 17

Micro

Not felt or rarely felt under favorable circumstances

MMII

2. 18 - 2. 78

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

Minor

Felt indoors by a few persons, especially

MMIII

2. 79 - 3. 38

Minor

Motion is usually a rapid vibration, and sometimes vibrations are not at first recognized as an earthquake

MMIV

3. 39 - 4. 00

Minor

All people are frightened and run outdoors, general alarm.

MMV

4. 01 - 4. 62

Light

Buildings tremble; dishes and glassware break; small or unstable objects overturn.

MMVI

4. 63 - 5. 20

Light

Felt by all people indoors and outdoors. People move unsteadily; some plaster cracks

MMVII

5. 21 - 5. 81

Light

Many people find it difficult to stand loosened bricks and tiles fall

MMVIII

5. 82 - 6. 42

Strong

Trees shake strongly and branches break off

MMIX

6. 43 - 7. 04

Strong

Ground cracks conspicuously, large parts of masonry buildings collapse.

MMX

7. 05 - 7. 64



### Major

Numerous landslides occur on river banks and steep coasts, structures are seriously damaged.

### MMXI

7. 65 - 8. 23

### Great

Few masonry structures remain standing; large, well-built bridges are destroyed.

### MMXII

8. 24 - up

### Epic

Damage is total and works of construction are greatly damaged or destroyed.

Table 2. 2: The relationships of measurement the earthquakes between Modified Mercalli and Richter scale.

## **2. 4 Earthquake Analysis in Sumatra, Indonesia**

Sumatra is one of the islands in Indonesia that experienced earthquakes frequently and there will be major damages each year because of this earthquake. Sumatra`s earthquakes record that almost 1000 events occurred during the year 1900 to 2002 (USGSNEIC) with the magnitudes over

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

5.0 Richter scale. The great earthquakes were recorded in December 26, 2004 and March 28, 2005 with Richter scale of 9.0 and 8.7 respectively struck off Sumatra which triggered a destructive tsunami which left about 300,000 people dead or missing in Africa and Southeast Asia.

On September 12, 2007, once again Sumatra was attacked by the earthquakes with magnitudes 8.4 and 7.8 on the southern Sumatra which occurred as the result of slip faulting on the plate boundary between Australia and Sunda plates. This magnitude of 8.4 is the fourth earthquake of magnitude greater than 7.9 over the past decade. Figure 2.5 shows the USGS map of past earthquakes in the Sumatra Region.

Figure 2.5: Location of past earthquakes in Sumatra, Indonesia.

Indonesia's active earthquake zones located only 523 km distance to Malaysia. They are the Sumatran subduction zone and the Sumatran fault zone. Table 2.3 below shows some of the recorded earthquakes in these zones between years 2004 to 2010.

## **Date**

## **Location**

## **Richter Magnitude Scale**

February 5, 2004

Irian Jaya, Indonesia

7.0

November 11, 2004

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

Kepulauan Alor, Indonesia

7. 5

December 26, 2004

Sumatra-Andaman Islands

9. 1

January 1, 2005

Off the west coast of Northern Sumatra

6. 7

March 2, 2005

Banda Sea

7. 1

March 28, 2005

Northern Sumatra, Indonesia

8. 6

May 19, 2005

Nias Region, Indonesia

6. 9

January 27, 2006

Banda Sea, Indonesia

7. 6

May 26, 2006

Java, Indonesia

6. 3

July 17, 2006

South of Java, Indonesia

7. 7

January 21, 2007

Molluca Sea

7. 5

September 12, 2007

Southern Sumatra, Indonesia

8. 5

November 25, 2007

Sumbawa Region, Indonesia

6. 5

February 20, 2008

Simeulu, Indonesia

7. 4

February 25, 2008

Kepulauan Mentawi Region, Indonesia

7. 2

November 16, 2008

Minahasa, Sulawesi, Indonesia

7. 4

January 3, 2009

Near the North Coast of Papua, Indonesia

7. 7

February 11, 2009

Kepulauan Talaud, Indonesia

7. 2

September 2, 2009

Java, Indonesia

7.0

May 9, 2010

Northern, Indonesia

7.2

(USGS 2010)

Table 2. 3: Earthquakes in Sumatran Subduction and Fault Zones (2004 to 2010)

On the report, a great earthquake kill 25 people, 161 injured, 52, 522 building destroyed and road damages in Bengkulu and Sumatra Barat. At Padang, a tsunami with a wave height about 90 km was measured. This earthquake disturbs the connection of power and telephone. Tremors can felt by people in high-rise buildings at Jakarta, Malaysia, Singapore and Thailand.

### **2. 4. 1 Effects of Sumatra Earthquake to Malaysia**

After the tsunami occurred on 26 December 2004, Malaysia began worried and realized that in the future, Malaysia will experienced earthquakes that arising from the Sumatra since its location is only about 530 km from Sumatera. This country is surrounded by the two most seismically active plate boundaries which is Australian Plate and Eurasian Plate in the west of Peninsular Malaysia and Philippine Sea Plate and Eurasian Plate in the East of Malaysia.

Recent earthquakes that occurred in Sumatera on year 2000 and 2005 causing East Malaysia also affected by low magnitude earthquake that measured below 4.0 on Richter scale. These earthquakes causing ground acceleration intensity below 0.15g as recorded by the accelerograph. Recently, a 4.0 magnitude of earthquake occurred in the north of Lahad Datu, Sabah. The quakes have caused weak tremors in Lahad Datu region (Bernama News, Aug 22, 2010).

Therefore, it seems necessary to take the seismic effects into consideration in designing the multi-storey building in Malaysia since it is potentially hazard and caused severe damages. Although it might be impossible to design a building without significant damages but in it can be reduce by early detection and doing some improvement in structures stability. Consideration on seismic effects on high or low rise building have not been practiced in Malaysia, even though there are design guidelines on seismic action of building due to assumption that Malaysia will never severe to earthquakes.

Figure 2.6: Indonesia's active earthquake zones located only 523 km distance to Peninsular Malaysia.

## **2.5 Effects of Earthquake on Buildings**

The level of damage done to buildings depends on the amplitude and the duration of the earthquakes. Generally the size of earthquake would be increases as the amplitude and the duration increases. This is because larger the quakes longer the shake as they rupture larger areas. Building will respond to the accelerations that transmitted from the ground to the

building's foundation during the shaking. The building tends to hold its inertia that causing shearing of the structure which the weak walls or joints experience stresses resulting damages or perhaps will collapse (Ammon, 2001).

The most important cause of earthquake that induced damage to buildings is the dynamic response of the building to earthquake ground motion. When the ground shakes, building responds to the accelerations that been transmitted from the ground through the foundation on the structure. The inertia of the building which the building tends to stay at rest cause shearing of the structure which can concentrate stresses on the weak walls or joints in the structure resulting in failure or perhaps total collapse. The type of shaking depends on the type of structure (MCEER, 2010).

Figure 2. 7: Movement caused by the Ground Acceleration

Some observations of earthquake damage to buildings indicate that in most cases, regular buildings perform better than irregular buildings. This is because regular or symmetry (in mass distribution, strength and ductility) is adequate to torsional effects. Thus, regular and symmetrical structures exhibit more favorable and predictable seismic response characteristics than irregular structures. Hence, the use of irregular structures in seismic zones should be avoided if possible (W. G. Godden, 1997).

## **2. 6 Regular and Irregular Buildings.**

Structures are designated as structurally regular or irregular. Regular structure has no significant discontinuities in plan, vertical configurations, or lateral force resisting systems. On other hand, irregular structure has <https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>



significant discontinuities in its horizontal and vertical plan. This research only focused on the vertical irregularity. Vertical irregularities are characterized by its vertical discontinuities in the distribution of mass, stiffness and strength. There are five types of vertical irregularity on buildings listed as shown in the Figure 2. 8 below (D. P. Soni & Bharat B. Mistry, 2006):

Stiffness irregularity (soft-story)

Mass irregularity

Vertical geometric irregularity (set-back)

In-plane discontinuity in lateral-force-resisting vertical elements

Discontinuity in capacity (weak story)

Figure 2. 8: (a) Soft-story irregularity; (b) Mass irregularity; (c) Set-back irregularity;

(d) In-plane discontinuity in lateral-force-resisting vertical elements.

### **2. 6. 1 Stiffness Irregularity (Soft-story)**

This research only focused on the stiffness irregularity as also known as soft-story. Stiffness irregularity exists on the buildings having a soft-story if any story is less than 70% of the stiffness of the story above it, or less than 80% as stiff as the average stiffness of the three floors above it. The building with soft-story level is dangerous in earthquake, because the soft floor level susceptible with the lateral forces caused by swaying of the building during quake. In a moderate to severe earthquake cases, the soft-story buildings

are vulnerable to collapse and this phenomenon known as soft story collapse (S. E Smith, 2003).

The characteristic of soft-story buildings is the building with the lower level has a lot of open space or floors with a lot of windows. Whereby, this open space is used to be parking garages or commercial spaces. Since the soft-story is unobstructed space designed purposely for commercial space or parking lot, therefore this level is less opportunity to install shear wall as demands in every designed of structures as this special walls can distribute lateral forces so that building can cope with the swaying during the earthquake (COG, 2006).

Past earthquake`s experiences record that many cases of building collapse are related to soft-story floor on the building. During the 1989 Loma Prieta earthquake, soft-story collapse killed about 63 people and left 7, 700 housing units tumbledown. The 1994 Northridge earthquake shows a visual image of whole apartments buildings collapsed onto the cars parked on the ground floor. Also in San Luis Obispo record 6. 5 Richter scale earthquake in December 2003 ripped apart the country`s buildings and most of them soft-story (Gregory J. McFann, 1998).

Therefore it is necessary to carry out a research on the building with soft-story level. Figures 2. 9 and 2. 10 shows the effect of earthquake to the soft-story building which always result in collapse and serious structural damages.

Figure 2. 9: Collapsed apartment building during the Northridge earthquake.

Figure 2. 10: Soft story partial collapse due to inadequate shear strength at ground level, Loma Prieta earthquake.

## **2. 7 Mechanism of the Earthquakes to the Reinforced Concrete Buildings**

A usual Reinforced concrete building consists of horizontal members (beams and slabs) and vertical members (columns and walls) and at the bottom is the foundation which supports the building to rest on the ground. Once the earthquakes shake and generate a movement on the ground, buildings will tend to create inertia forces which proportional to the building mass as intend in Newton`s First Law Motion which stated that the building has a tendency to stay in its original position. In view of the fact that most of the building mass is currently present at the floor levels, the inertia forces will developed on floors.

Figure 2. 11: Inertial forces that acting in the building.

As these forces travel downward which will pass through the slabs and beams to columns and walls, finally to the foundations. The columns and walls at lower storey will experience higher earthquake as the inertia forces being transfer from the top of building to the bottom. Therefore it is necessary to build the columns to be stronger than the beams, and foundations to be stronger than the columns in order for a building to remain safe and stiff during the shaking. The columns suffer severe damages if it is made weaker than beams. It results in building total collapse.

## **2. 8 Earthquake Resistant Design Philosophy**

In order to design structures to resist earthquake loading, some general philosophy of earthquake resistant building design are indicated as the following:

For minor earthquakes there should be no damage

For moderate earthquakes there may be minor, repairable, structural and some nonstructural damage.

For major earthquakes there may be major, un-repairable, structural and nonstructural damage but without collapse of the building.

Earthquake resistant design mindedly concerned about to make the building less severe to be damaged during earthquakes. In order to save the building from collapse, some pre-determined parts to undergo the acceptable type and level of damage should be designed and understand by the designer. The main element in designing the earthquake resistant buildings is needed to be built with ductility in them. Therefore, during an earthquake, the buildings have the ability to sway back-and-forth in order to withstand the earthquake effects with some damage, but without collapse.

Even the buildings that have been designed using the earthquake resistant code, the building still have severe damages during the strong earthquake. Thus, safety of people and contents is secure in earthquake-resistant buildings, and in that way a disaster is avoided. This is a main purpose of seismic design codes all over the world. To understand the earthquake-

resistant buildings, the engineer should carry out research to understand the earthquake effects on building from times to times.

## **2. 9 Reinforced Concrete Frame Building**

Concrete is the material that widely been used in construction of many structures such as buildings, dams also in road pavement. In 19th century, the uses of concrete became popular after the invention of Portland cement. However its weakness in term of limited tension resistance prevented its wide use in building construction.

A solution to this problem can be solved by using the steel bars embedded in concrete to form a composite material known as reinforced concrete.

Reinforced concrete is one of the most materials that widely used in modern building construction. Recently, reinforced concrete frame building commonly used in modern building construction particularly in urban areas. It is consist essentially of horizontal and vertical elements formerly known as beams and columns respectively (Ahmed Yakult, 2009).

These two elements are connected by rigid joints. Most cases, beams and columns are cast in a single operation during the construction in order to act in unison (EERI, 2006). The connection action between beams, columns and slabs provides resistance both in gravity and lateral loads through the bending in beams and columns. There are several subtypes of RC frame construction:

Nonductile RC frames with/without infill walls

Nonductile RC frames with reinforced infill walls

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

## Ductile RC frames with/without infill walls

There are thousands of older reinforced concrete frame buildings are considered to be at risk since the design of structures in term of seismic requirements code did not applied in the detailing during the construction. Until the early 1970`s when several earthquakes show that the need for more ductile design of structures to resist the quake that caused severe damages and perhaps to collapsed.

The 1964 Anchorage, Alaska, the 1971 San Fernando, California, and the 1994 Northridge, California earthquakes revealed the vulnerability of reinforced concrete frame buildings and impelled the development of modern seismic resistance technologies (Faison, Comartin & Elwood, 2004). Ductility of buildings is the most requirements features that desirable in seismic behavior. This requirement defined as the ability of a material to deform significantly before failure.

## **2. 10 Factors Affecting the Earthquakes Performance of Reinforced Concrete Structures.**

Generally, the poor performance of buildings is due to combinations of inadequate strength and stiffness of the overall seismic resisting system. Also from the poor distribution of strength and stiffness over successive stories which leads to soft story formation. Other than that, lack of provision of an adequate load path through the structure leads to partial or complete failure of the structure. Various types of non-ductile failures can be found resulting from a poor detailing of joints and connection on the structure elements (Sanders, 1995).

An effective design criteria should be carried out which the correlation between damage and drift must be calibrated against the performance of structures in actual earthquakes. The factors that influenced the earthquakes performances of reinforced concrete structures are:

Ductility capacity

Effect of drift

P-delta effect

Effect of strong beams and weak columns

Ductility Capacity - Ductility in structural design is used to describe the ability of a structure to undergo large inelastic deformations in the post-elastic range without substantial reduction in strength. Under severe earthquake excitation, ductility is an important design requirement for a structure to behave adequately due to strong ground motion. Depending on the structural materials, ductility is under demand of the structure due to seismic loading. Ductility factors have been commonly expressed in terms of the various parameters related to deformations i. e. displacements, rotations, curvatures and strains.

Effects of drift - In flexible buildings, there can be relatively large lateral movements between consecutive stories, which called the inter-storey drift. Unacceptable damage to the cladding and non-structural elements is result from the damage of the structure because of the inter-storey drift. This effect can be controlled with careful design and detailing. The control of the

estimated lateral drift is one of the design aspects which have an important effect on the seismic performance on structures.

P-Delta effect - This effect can reduce the seismic performance because the effective lateral loads are increased as lateral displacements increase. P-delta effect then further increase the lateral displacement thus placing higher demand on the structural system. This effect is refers to the abrupt changes in ground shear, overturning moment and axial force distribution. Damage will therefore occur sooner than the similar systems without significant P-delta effect. Due to the high weight of RC structures in comparison with steel structures this effect is quite significant.

Effects of strong beams and weak columns - The critical bending moments which develop in the vicinity of the frame joints occur under earthquake and gravity loading. Plastic hinges will develop if these moments exceed the limit state capacity of the sections. Mostly, these hinges develop in the structural elements of beams, columns or in a combination of locations. But the most suitable for achieving ductility in concrete frames is the beam hinge because:

A greater number of plastic hinges need to form before collapse mechanism develops leading to smaller inelastic rotations in each hinge.

Beam hinges are more ductile because they carry lower axial loads than column hinges.



## **2. 11 Lateral Load on Building**

### **2. 11. 1 Earthquake Loading**

Earthquake loading is one of the basic criteria in earthquake engineering which consist of the inertial forces of the building mass resulting from the shaking in its foundation by the seismic disturbances. Usually the design criteria of the earthquake resistant focus on the translational inertia forces, whose caused major damages than the vertical or rotational shaking to the structure`s components.

Once earthquakes happen, their intensity is correlated inversely to their frequency of occurrences which are severe earthquake are rare, moderate one occur more often and minor ones occur frequently. It may be probable to design a building to resist the most severe earthquake without major damage but the improbable need for such strength in the lifetime of the building would not rationalize the high additional cost.

The design philosophy of earthquake-resistant design for building is based on the principle that the design should be:

Resist minor earthquakes without damages

Resist moderate earthquakes without structural damage but accepting the probability of nonstructural damage

Resist average earthquakes with the probability of structural as well as nonstructural damage, but without collapse.

The magnitude of earthquake loading is a result of dynamic reaction of the building to the shaking of the ground. There are two general approaches to estimate the seismic loading (Bryan S Smith, 1991), which are:

Equivalent lateral force procedure

This procedure uses a simple estimate of structure's fundamental period and the anticipated maximum ground acceleration, or velocity to determine the maximum base shear.

Modal analysis

This analysis is described the modal frequencies of the structure to be analyzed and then used it in conjunction with earthquake design spectra to estimate the maximum modal responses.

## **2. 12 Seismic Design and Analysis of Structures**

Analysis is performing to find the response of the structures to the seismic excitations. It is required to determine the moments, shears, direct forces and torsions in the member of the structures due to seismic actions. Seismic Analysis is a subset of structural analysis and it can be proceed by calculation of the response of the building to earthquakes. During the seismic analysis, various effects produced by the ground motion caused by the quakes must be taken into account.

Duration, magnitudes and velocity are the important factors of seismic analysis to be considered in structural design. It is the part of the process in structural design in order to understand the effect of the earthquake to the

building as a structural assessment and retrofit in regions where earthquakes are commonly occur. The analysis methods can be separated into the five categories such as list below:

Equivalent static analysis,

Response spectrum analysis,

Linear dynamic analysis,

Non-linear static analysis, and

Non-linear dynamic analysis.

Since early 20th century, building codes have been applied as a requirement for seismic analysis in the areas that subject to earthquakes. Greater understanding of the effects of an earthquake in designing buildings is achieved as these codes and computer program became available. Together with the analysis method, building codes and computer program, it became easier to model the effects of an earthquake and design buildings that could resist the forces involved.

## **2. 12. 1 Equivalent Static Analysis (ESA)**

The equivalent static analysis has been the most important method of analysis for years. This analysis defines a series of forces action on the building which correspond to the effect of earthquake ground motion, usually defined by the seismic design response spectrum. It assumed that the responds of the building is in its fundamental mode. The building must be low-rise and must not twist significantly when the ground moved.

<https://assignbuster.com/causes-and-effects-of-earthquakes-engineering-essay/>

This response can be read from the design response spectrum which given the natural frequency of the building. The ability of this method is comprehensive in many building codes which been applied as a factor to account the high-rise building with some higher modes, and for now level of twisting. Many codes apply modifications factors that reduce the design forces (e. g. force reduction factors) to account the effects due to yielding on the structure.

ESA can be used to determine the displacement demands for structures where a more complicated dynamic analysis will not offer extra insight into behavior. It is the best suitable method for structures or individual frames with well balanced spans and uniformly distributed stiffness where the response can be captured by the predominant translational mode of vibration.

The loading, design standard and codes for buildings permit the great equivalent static force analysis for a greater or lesser range of structures. All these start