Earth Quake Resistant Building Using SAP

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ABSTRACT

Advances in seismic design technology today enable structural engineers to design buildings with a variety of seismic safety levels corresponding to different demands of the society. However, target of design is basically limited to secure life safety level within relatively short time span, i.e., serviceable life of each building. Aspects of constructing sustainable and resilient cities, which consists of buildings with long life, are not taken into account in general. Strong earthquakes occur at intervals that are longer than life of individual building or people. On the other hand, as life of cities is obviously much longer, the corresponding seismic action is stronger than the design action and may cause serious damage in buildings designed for their life only. Though multi-storeyed buildings with soft storey floor are inherently vulnerable to collapse due to earthquake, their construction is still widespread in the developing like India. Functional and Social need to provide car parking space at ground level and for offices open stories at different level of structure far out-weighs the warning against such buildings from engineering community. With the availability of fast computers, so that software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects.

Keywords: Earth Quake Resistant, Building, Seismic Design SAP

1. INTRODUCTION

An earthquake (also known as a quake, tremor or temblor) is the perceptible shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's crust that creates seismic waves. Earthquakes can be violent enough to toss people around and destroy whole cities. The seismicity, seismism or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter magnitude scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitude 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.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.

1.1. Naturally Occurring Earthquakes

Tectonic earthquakes occur anywhere in the earth where there is sufficient stored elastic strain energy to drive fracture propagation along a fault plane. The sides of a fault move past each other smoothly and a seismically only if there are no irregularities or asperities along the fault surface that increase the frictional resistance. Most fault surfaces do have such asperities and this leads to a form of stick-slip behavior. Once the fault has locked, continued relative motion between the plates leads to increasing stress and therefore, stored strain energy in the volume around the fault surface. This continues until the stress has risen sufficiently to break through the asperity, suddenly allowing sliding over the locked portion of the fault, releasing the stored energy. This energy is released as a combination of radiated elastic strain seismic waves, frictional heating of the fault surface, and cracking of the rock, thus causing an earthquake. This process of gradual build-up of strain and stress punctuated by occasional sudden earthquake failure is referred to as the elastic-rebound theory. It is estimated that only 10 percent or less of an earthquake's total energy is radiated as seismic energy. Most of the earthquake's energy is used to power the earthquake fracture growth or is converted into heat generated by friction.

Due to increasing population since the past few years so that car parking space for residential apartments in populated cities is a matter of major problem. So that constructions of multi-storeyed buildings with open first storey is a common practice in all world. Hence the trend has been to utilize the ground storey of the building itself for parking or reception lobbies in the first storey. These types of buildings having no infill masonry walls in ground storey, but all upper storeys in filled in masonry walls are called „soft first storey or open ground storey building. Experience of different nations with the poor and devastating performance of such buildings during earthquakes always seriously discouraged construction of such a building with a soft ground floor. This storey known as weak storey because this storey stiffness is lower compare to above storey. So that easily collapses by earthquake. Due to wrong construction practices and ignorance for earthquake resistant design of buildings in our country, most of the existing buildings are vulnerable to future earthquakes. So, prime importance to be given for the earthquake resistant design.(Figure.1)

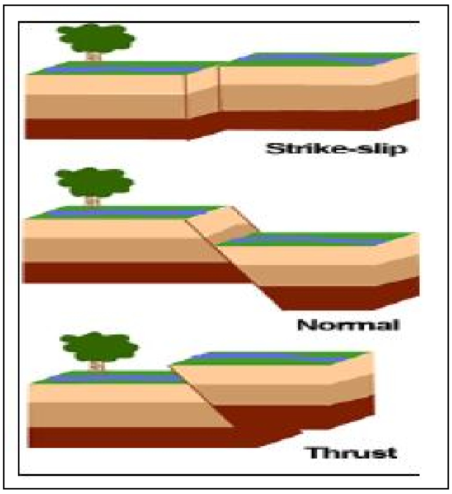

Figure.1 Fault Types

2. EARTH QUAKE

2.1. Earthquake Fault Types

There are three main types of fault, all of which may cause an interplate earthquake: normal, reverse (thrust) and strike-slip. Normal and reverse faulting are examples of dip-slip, where the displacement along the fault is in the direction of dip and movement on them involves a vertical component. Normal faults occur mainly in areas where the crust is being extended such as a divergent boundary. Reverse faults occur in areas where the crust is being shortened such as at a convergent boundary. Strike-slip faults are steep structures where the two sides of the fault slip horizontally past each other; transform boundaries are a particular type of strike-slip fault. Many earthquakes are caused by movement on faults that have components of both dip-slip and strike-slip; this is known as oblique slip (Figure.2).

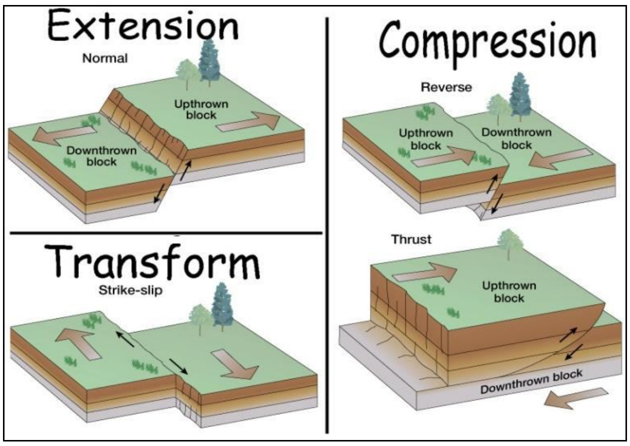

Figure.2 Earthquake Fault Types

Reverse faults, particularly those along convergent plate boundaries are associated with the most powerful earthquakes, megathrust earthquakes, including almost all of those of magnitude 8 or more. Strike-slip faults, particularly continental transforms, can produce major earthquakes up to about **8** magnitude 8. Earthquakes associated with normal faults are generally less than magnitude 7. For every unit increase in magnitude, there is a roughly thirtyfold increase in the energy released. For instance, an earthquake of magnitude 6.0 releases approximately 30 times more energy than a 5.0 magnitude earthquake and a 7.0 magnitude earthquake releases 900 times (30 × 30) more energy than a 5.0 magnitude of earthquake. This is so because the energy released in an earthquake, and thus its magnitude, is proportional to the area of the fault that ruptures and the stress drop. Therefore, the longer the length and the wider the width of the faulted area, the larger the resulting magnitude. The topmost, brittle part of the Earth's crust, and the cool slabs of the tectonic plates that are descending down into the hot mantle, are the only parts of our planet which can store elastic energy and release it in fault ruptures.

The purpose of earthquake engineering is to:

- Avoid the loss of lives resulting from the collapse of infrastructure or a building in a major earthquake (a design earthquake or ultimate limit state earthquake) Limit personal injury and building damage (including contents) in moderate earthquakes (serviceability limit state earthquake). Infrastructure / building should be fully functional after a cleanup.
- Minimise damage and disturbance to residents in moderate and minor earthquakes.
- Maintain the key function of the infrastructure / building.
- Protect the lives of those outside the building.
- Protect other property & the environment.

2.2. Rupture Dynamics

A tectonic earthquake begins by an initial rupture at a point on the fault surface, a process known as nucleation. The scale of the nucleation zone is uncertain, with some evidence, such as the rupture dimensions of the smallest earthquakes, suggesting that it is smaller than 100 m while other evidence, such as a slow component revealed by low-frequency spectra of some earthquakes, suggest that it is larger. The possibility that the nucleation involves some sort of preparation process is supported by the observation that about 40% of earthquakes are preceded by foreshocks. Once the rupture has initiated, it begins to propagate along the fault surface. The mechanics of this process are poorly understood, partly because it is difficult to recreate the high sliding velocities in a laboratory. Also the effects of strong ground motion make it very difficult to record information close to a nucleation zone. Rupture propagation is generally modeled using a fracture mechanics approach, likening the rupture to a propagating mixed mode shear crack. The rupture velocity is a function of the fracture energy in the volume around the crack tip, increasing with decreasing fracture energy. The velocity of rupture propagation is orders of magnitude faster than the displacement velocity across the fault. Earthquake ruptures typically propagate at velocities that are in the range 70–90% of the S-wave velocity, and this is independent of earthquake size. A small subset of earthquake ruptures appear to have propagated at speeds greater than the S-wave velocity. These supershear earthquakes have all been observed during large strike-slip events. The unusually wide zone of coseismic damage caused by the 2001 Kunlun earthquake has been attributed to the effects of the sonic boom developed in such earthquakes. Some earthquake ruptures travel at unusually low velocities and are referred to as slow earthquakes.

2.3. Size And Frequency Of Occurrence

It is estimated that around 500,000 earthquakes occur each year, detectable with current instrumentation. About 100,000 of these can be felt. Minor earthquakes occur nearly constantly around the world in places like California and Alaska in the U.S., as well as in El Salvador, Mexico, Guatemala, Chile, Peru, Indonesia, Iran, Pakistan, the Azores in Portugal, Turkey, New Zealand, Greece, Italy, India, Nepal and Japan, but earthquakes can occur almost anywhere, including Downstate New York, England, and Australia. Larger earthquakes occur less frequently, the relationship being exponential; for example, roughly ten times as many earthquakes larger than magnitude 4 occur in a particular time period than earthquakes larger than magnitude 5.

2.4. Effects Of Earthquakes

1. Ground Shaking

Shaking and ground rupture are the main effects created by earthquakes, principally resulting in more or less severe damage to buildings and other rigid structures. The severity of the local effects depends on the complex combination of the earthquake magnitude, the distance from the epicenter, and the local geological and geomorphological conditions, which may amplify or reduce wave propagation. The ground-shaking is measured by ground acceleration. Specific local geological, geomorphological, and geostructural features can induce high levels of shaking on the ground surface even from low-intensity earthquakes.

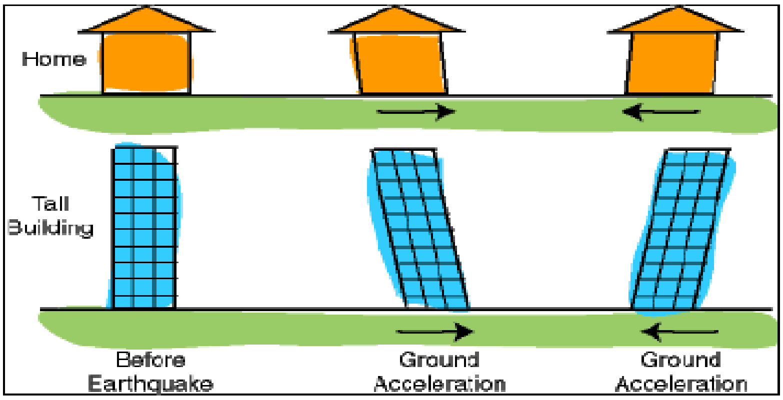

Figure.3 Ground Acceleration Due To Earthquake

As mentioned above, the principal cause of earthquake-induced damage is ground shaking. As the earth vibrates, all buildings on the ground surface respond to that vibration in varying degrees. Earthquake induced accelerations, velocities and displacements can damage or destroy a building unless it has been designed and constructed or strengthened to be earthquake resistant. Therefore, the effect of ground shaking on buildings is a principal area of consideration in the design of earthquake resistant buildings. Seismic design loads are extremely difficult to determine due to the random nature of earthquake motions. However, experiences from past strong earthquakes have shown that reasonable and prudent practices can keep a building safe during an earthquake.(Figure.3)

2. Ground Failure
Earthquake-induced ground failure has been observed in the form of ground rupture along the fault zone, landslides, settlement and soil liquefaction. Ground rupture along a fault zone may be very limited or may extend over hundreds of kilometers. Ground displacement along the fault may be horizontal, vertical or both, and can be measured in centimeters or even metres. Obviously, a building directly astride such a rupture will be severely damaged or collapsed. While a landslide can destroy a building, settlement may only damage it. Soil liquefaction can occur in low density saturated sands of relatively uniform grain size. The phenomenon of liquefaction is particularly important for dams, bridges, underground pipelines, and buildings standing on such ground.

3. Tsunami
Tsunamis or seismic sea waves are generally produced by a sudden movement of the ocean floor. As the water waves approach land, their velocity decreases and their height (run-up height) increases to 5 to 8 m, or even more. Obviously, tsunamis can be devastating for buildings built in coastal areas. A huge tsunami occurred in Aceh, Indonesia, on December 26, 2004, killing more than 200,000 people. The conditions for a tsunami to occur are as follows:
- Under-Sea Earthquake Reverse Or Normal Fault,
- Shallow Earthquake, And
- Magnitude Greater Than 6.5

The Tsunami destruction is greater if the beach is slightly sloped. Tsunamis are long-wavelength, long-period sea waves produced by the sudden or abrupt movement of large volumes of water. In the open ocean the distance between wave crests can surpass 100 kilometers (62 mi), and the wave periods can vary from five minutes to one hour. Such tsunamis travel 600-800 kilometers per hour (373–497 miles per hour), depending on water depth.

3.IMPORTANT PARAMETERS IN SEISMIC DESIGN
The following properties and parameters are most important from the point of view of seismic design.
- Building material properties - Strength in compression, tension and shear, including dynamic effects - Unit weight (density) - Modulus of elasticity
- Dynamic characteristics of the building system, including periods, modes of vibration and damping.
- Load-deflection characteristics of building components.

Structural Design
Three important aspects to be considered in the design of earthquake resistant structures are given below:
- The structure should be ductile, like the use of steel in concrete buildings. For these ductile materials to have an effect, they should be placed where they undergo tension and thus are able to yield.

- Apart from ductility, deformability of structures is also essential. Deformability of structures is also essential. Deformability refers to the ability of a structure to dispel or deform to a significant degree without collapsing. For this to happen, the structure should be well- proportioned, regular and tied together in such a way that there are no area of excessive stress concentration and forces can be transmitted from one section to another despite large deformations. For this to happen, components must be linked to resisting elements.
- Damageability is another aspect to be taken into consideration. This means the ability of a structure to withstand substantial damage without collapsing.

4. INTRODUCTION TO SAP

The SAP R/3 enterprise application suite for open client/server systems has established a new standards for providing business information management solutions. SAP product are consider excellent but not perfect. The main problems with software product is that it can never be perfect. The main advantage of using SAP as your company ERP system is that SAP have a very high level of integration among its individual applications which guarantee consistency of data throughout the system and the company itself.

4.1 SAP ERP

- Enables a company to link its business processes.Ties together disparate business functions (integrated business solution).Helps the organization run smoothly.
- Real-time environment
- Scalable and flexible.

4.2 SAP Architecture

- Client/Server Environment-Client – hardware/software environment that can make a request for
- Services for a central repository of resources-Server – hardware/software combination that can provide services to a group of clients in a controlled environment.

4.3 Development, Quality Assurance And Production

The development system is where most of the implementation work takes place. The quality assurance system is where all the final testing is conducted before moving the transports to the production environment. The production system is where all the daily business activities occur. It is also the client that all the end users use to perform their daily job functions. To all company, the production system should only contains transport that have passed all the tests. SAP is a table drive customization software. It allows businesses to make rapid changes in their business requirements with a common set of programs. User-exits are provided for business to add in additional source code. Tools such as screen variants are provided to let you set fields attributes whether to hide, display and make them mandatory fields.

4.5 ERP Advantages

- Allows easier global integration (barriers of currency exchange rates, language, and culture can be bridged automatically)
- Updates only need to be done once to be implemented company-wide
- Provides real-time information, reducing the possibility of redundancy errors
- May create a more efficient work environment for employees.
- Vendors have past knowledge and expertise on how to best build and implement a system
- User interface is completely customizable allowing end users to dictate the operational structure of the product.

5. FAILURE MECHANISMS OF STRUCTURES

5.1 Free-Standing Masonry Wall

Consider the free-standing masonry walls. the ground motion is acting transverse to a free-standing wall. The out-of-plane inertia force acting on the mass of the wall tends to overturn it. The seismic resistance of the wall is by virtue of its weight and tensile strength of mortar. It is obviously very small. This wall will collapse by overturning under the ground motion. The free standing wall fixed on the ground in is subjected to ground motion in its own plane. In this case, the wall will offer much greater resistance because of its large depth in the direction of the force and the plane of bending. Such a wall is termed a shear wall. The damage modes of an unreinforced shear wall depend on the height-to-length ratio or aspect ratio of the wall. A wall with large aspect ratio will generally develop a horizontal crack at the bottom due to bending tension and then slide due to shearing.(Figure.4)

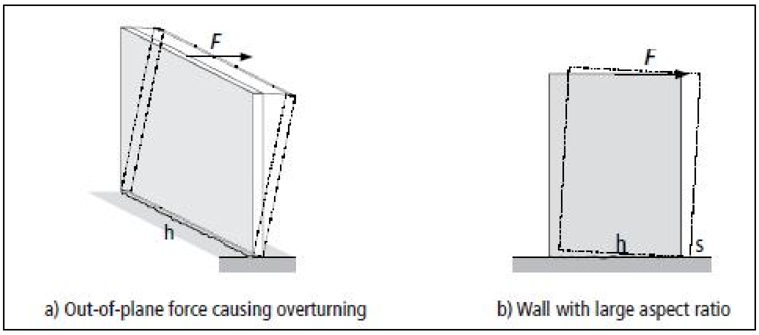

Figure. 4 Failure Mechanism Of Free Standing Walls

5.2 Wall Enclosure Without Roof

Now consider the combination of walls A and B as an enclosure.For the earthquake force F as shown, walls B act as shear walls and, besides taking their own inertia, they offer resistance against the collapse of walls A as well. As a result walls A now act as vertical slabs supported on two vertical sides and the bottom plinth. The walls A are subjected to the inertia force acting on their own mass.

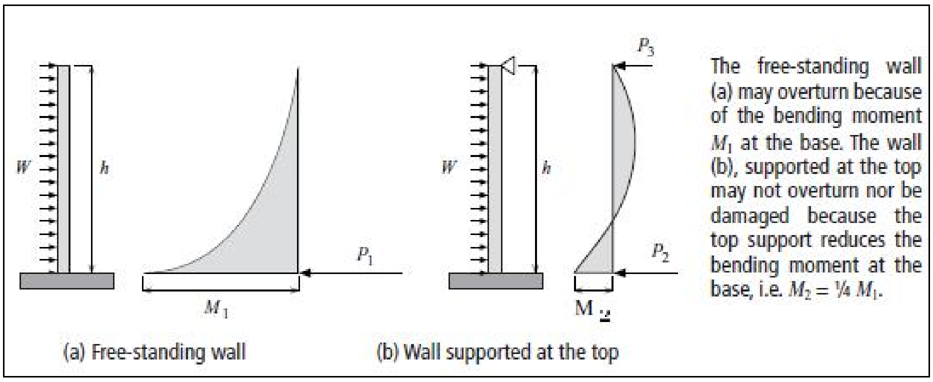

Figure.5 Out Of Plane Bending Moment Of A Wall Fixed At Its Base

It can be seen that in the action of walls B as shear walls, the walls A will act as flanges connected to the walls B acting as web. Thus if the connection between walls A and B is not lost due to a lack of bonding action, the building will tend to act as a box and its resistance to horizontal loads will be much larger than that of walls B acting separately. (Figure.5)

5.3 Roof On Two Walls

Assuming that there is enough adhesion between the slab and the walls, the slab will transfer its inertia force at the top of walls B, causing shearing and overturning action in them. To be able to transfer its inertia force to the two side walls, the slab must have enough strength in bending in the horizontal plane. This action of the slab is known as diaphragm action. Reinforced concrete or reinforced brick slabs have enough strength to inherently and act as rigid diaphragms. However, other types of roofs or floors such as timber or reinforced concrete joists with brick tile covering will be very flexible. Any joists have to be connected together and fixed to the walls suitably so that they are able to transfer their inertia force to the walls. At the same time, the walls B must have enough strength as shear walls to withstand the force from the roof and their own inertia forces. when subjected to ground motion perpendicular to its plane will collapse very easily because walls B have little bending resistance in the direction perpendicular to their length.

5.4 Roofs And Floors

Earthquake-induced inertia force can be distributed to the vertical structural elements in proportion to their stiffness, provided the roofs and floors are rigid and act as horizontal diaphragms. Otherwise, the roof and floor inertia will only go to the vertical elements on which they are supported. Therefore, the stiffness and integrity of roofs and floors are important for earthquake resistance. Roofs and floors, which are rigid and flat and are bonded or tied to the masonry, have a positive effect on the wall. Slab or slab and beam construction directly cast over the walls or jack arch floors or roofs provided with horizontal ties and laid over the masonry walls through good quality mortar fall into this category.

Others that simply rest on the masonry walls will offer resistance to relative motion only through friction, which may or may not be adequate depending on the earthquake intensity. In the case of a floor consisting of timber joists placed at center to center spacing of 200 to 250 mm with brick tiles placed directly over the joists and covered with clayey earth, the brick tiles have no binding effect on the joists. Therefore, relative displacement of the joists is quite likely to occur during an earthquake. This could easily bring down the tiles, damaging property and causing injury to people.

6. CONCEPT OF EARTH QUAKE RESISTANT DESIGN

Experience in past earthquakes has demonstrated that many common buildings and typical methods of construction lack basic resistance to earthquake forces. In most cases this resistance can be achieved by following simple, inexpensive principles of good building construction practice. Adherence to these simple rules will not prevent all damage in moderate or large earthquakes, but life threatening collapses should be prevented, and damage limited to repairable proportions. From these studies, certain general principles have emerged: At present, the principle of earthquake-resistant design of building has two aims:

- The building shall withstand with almost no damage to moderate earthquake which have probability of occurring several times during life of a building.
- The building shall not collapse or harm human lives during severe earthquake motions which have a probability of occuring less than once during the life of the building.

In order to satisfy these aims, building design should conform following rules:
The configuration of the building (Plan and elevation) should be as simple as possible.

- The formation should generally be based on hard and uniform ground.
- The members resisting horizontal forces should be arranged so that torsional deformation is not produced.
- The structure of the building should be dynamically simple and definite.
- The frame of the building structure should have adequate ductility in addition to required strength.
- Structures should not be brittle or collapse suddenly. Rather, they should be toughable to deflect or deform a considerable amount.
- Planning and layout of the building involving consideration of the location of rooms and walls, openings such as doors and windows, the number of storeys, etc. At this stage, site and foundation aspects should also be considered.
- Lay out and general design of the structural framing system with special attention to furnishing lateral resistance.
- Resisting elements, such as bracing or shear walls, must be provided evenly throughout the building, in both directions side-to-side, as well as top to bottom.

7. GENERAL PLANNING AND DESIGN ASPECTS

7.1 Structural Design

Three important aspects to be considered in the design of earthquake resistant structures are given below:

- The structure should be ductile, like the use of steel in concrete buildings. For these ductile materials to have an effect, they should be placed where they undergo tension and thus are able to yield.
- Apart from ductility, deformability of structures is also essential. Deformability of structures is also essential. Deformability refers to the ability of a structure to dispel or deform to a significant degree without collapsing. For this to happen, the structure should be well- proportioned, regular and tied together in such a way that there are no area of excessive stress concentration and forces can be transmitted from one section to another despite large deformations. For this to happen, components must be linked to resisting elements
- Damageability is another aspect to be taken into consideration. This means the ability of a structure to withstand substantial damage without collapsing. To achieve this objective “minimum area which shall be damaged in case a member of the structure is collapsed” is to be kept in view while planning. Columns shall be stronger than beams for that purpose and it is known as strong column and weak beam concept.

7.2 Concept Of Isolation

The foregoing discussion of earthquake resistant design has emphasized the traditional approach of resisting the forces an earthquake imposes on a structure. An alternative approach which is presently emerging is to avoid these forces, by isolation of the structure from the ground motions which actually impose the forces on the structure. This is termed base-isolation. For simple buildings, base- friction isolation may be achieved by reducing the coefficient of friction between the structure and its foundation, or by placing a flexible connection between the structure and its foundation. For reduction of the coefficient of friction between the structure and its foundation, one suggested technique is to place two layers of good quality plastic between the structure and its foundation, so that the plastic layers may slide over each other. Flexible connections between the structure and its foundation are also difficult to achieve on a permanent basis. One technique that has been used for generations has been to build a house on short posts resting on large stones, so that under earthquake motions, the posts are effectively pin connected at the top and bottom and the structure can rock to and fro somewhat.

7.3 Development Of Seismic Design Method

Starting with a simple seismic resistant design where strength of building structures only is the bases for seismic performances, new technologies and design methods to provide various levels of seismic safety in buildings have been studied and developed. They are grouped into: Seismic isolation where seismic energy input to building is remarkably reduced; Passive control system where energy absorption devices of various types are installed; Orthodox strength dependent system where seismic safety is mainly provided by the strength of structures; and Ductility dependent system where seismic safety is mainly provided by ductility of structures.(Figure.6)

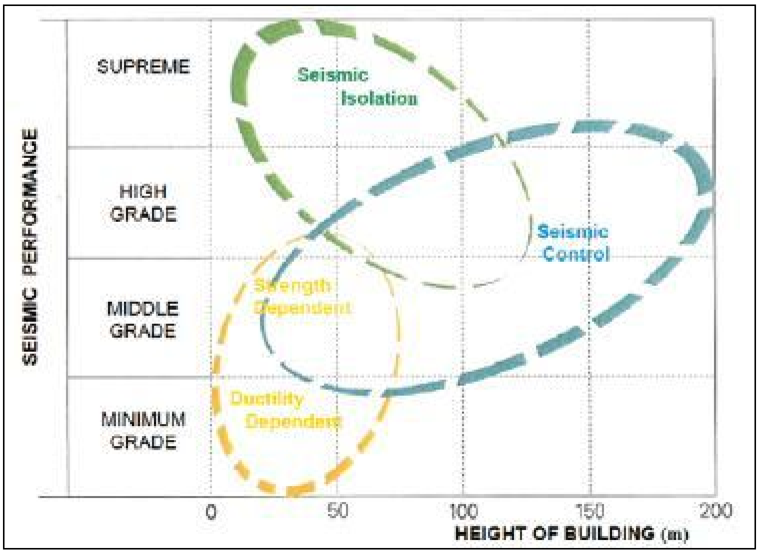

Figure. 6 Design Method and Seismic Performance

8. CONCLUSION

Technology is available to drastically mitigate the earthquake related disasters. This is confirmed by minimal damage generally without any loss of life when moderate to severe earthquake strikes developed countries, where as even a moderate earthquake cause‟ s huge devastation in developing countries as has been observed in recent earthquakes. The reason being that earthquake resistant measures are strictly followed in these countries where as such guidelines are miserably violated in developing countries. The administration system is efficient and effective in developed countries, and its not the same in developing countries – so the government should ensure the implementation of earthquake resistant design guidelines. RC frame buildings with soft story are known to perform poorly during in strong earthquake shaking. Because the stiffness at lower floor is 70% lesser than stiffness at storey above it causing the soft storey to happen. For a building that is not provided any lateral load resistance component such as shear wall or bracing, the strength is consider very weak and easily fail during earthquake. In such a situation, an investigation has been made to study the seismic behaviour of such buildings subjected to earthquake load so that some guideline could be developed to minimize the risk involved in such type of buildings. It has been found earthquake forces by treating them as ordinary frames results in an underestimation of base shear. Investigators analysis numerically and use various computer programs such as Staad Pro, ETABS, SAP2000 etc.

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