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# EARTHQUAKE RESISTANT BUILDINGS

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## ABSTRACT

Advances in seismic design technology today enable structural engineers to design construting buildings with 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 period, 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 atintervals that are longer than life of individual building or people.

***Keywords****: Base isolation, Retrofitting, Seismic ponding,Bracing,Dampers.*

## I. INTRODUCTION

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. These principles fall into several broad categories:

i. Planning and layout of the building involving consideration of the location of rooms and walls, openings such as doors and windows, the number of floors, etc. At this stage, site and foundation aspects should also be considered.
ii. Lay out and general design of the structural framing system with special attention to furnishing lateral resistance.

### Needs for Supreme Seismic Performance without Cost Increase

Recently, concepts of performance based design are often discussed and issues such as PML an BCP are becoming more popular in structural engineering. Other methods to evaluate seismicperformances are being studied and developed from various aspects. At the same period, we need tohave practical methods to respond various requests for enhancement of seismic performance.The prescribed arguments call for the development of structural systems which realize supremeseismic performance without or with very slight increase of cost compared with those required inordinary buildings. If substantial increase in cost is not required, then, it is rational to designbuildings which suffer substantially no damage from very rare earthquakes and such design will beaccepted by the society. As the results of enhancement of seismic performance of individualbuilding in a city, the performance of the city itself will be improved remarkably. Development ofsuch structural system will make it reasonable to design buildings for the seismic action based onthe return period corresponding to the life of a city, say 2000 to 3000 years. Of course we should beaware of the fact that our knowledge is still limited and further researches and studies are necessary to identify the seismic actions corresponding to such long return periods.

## II. PROCESS

### Concept of Isolation

The foregoing discussion of earthquakeresistant designhas emphasized the traditionalapproach ofresisting 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 construction of 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 as well as

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foundation,one suggested technique is to place two layers of good quality plastic between the structure as well as foundation, so that the plastic layers may slide over each other.

**Base-isolated systems**

Conventional earthquake-resistant structural systems are fixed-base systems that are 'fixed' to the ground. They derive their earthquake resistance from their capability to absorb seismic energy in specially designed country of the structures, such as in beams near beam-column joints of RC frames. This country should be capable of deforming into an inelastic range and sustaining large reversible cycles of plastic deformation, all without losing strength and stiffness to a level where it would danger the stability and integrity of the structure. These inelastic activities also mean large deformations in primary structural members resulting in significant amount of structural and nonstructural damage. However, in base-isolated systems, the superstructure is isolated from the foundation by certain devices, which reduce the ground motion transmitted to the structure20–22. These devices help decouple the superstructure from damaging earthquake components and absorb seismic energy by adding significant damping. In comparison to fixed-base systems, this technique considerably reduces the structural response and damages to structural as well as non-structural components. A significant number of base-isolation devices have been developed, some of which have already found applications in real life structures. Designing a base-isolated system is still a complex process, and its dynamic response tends to be more difficult than the fixed-base system. Presently, only certain types of structures are best suited for base-isolation for earthquake resistance, although technology is step by step over coming these limitations. There is consider able interest now in base-isolated systems among earth quake engineers – especially in countries like Japan, USA and New Zealand – with an eye towards developing lowest systems with broader applications. For example, in the recently held 12th World Conference of Earthquake Engineering in New Zealand, a significant 8% of the papers presented were only about base-isolation systems and their applications.

**Active, semi-active and hybrid control systems**

In different the earthquake-resistant systems mentioned earlier,there is another expanding class of systems referredto as 'smart' or active control systems. The active systemsdiffer from the passive systems in the sense that they controlthe seismic response through appropriate adjustmentswithin the structure, as the seismic excitation changes. Inother words, active control systems introduce elements ofdynamism and adaptability into the structure, therebyaugmenting the capability to resist exceptional earthquakeloads. A majority of the proposed technology involvesadjusting lateral strength, stiffness and dynamic propertiesof the structure during the earthquake to reduce the structuralresponse. Many studies and a few field applicationshave emphasized their potential in reducing the structuralresponse. However, many serious problems exist withrespect to the time delay in control actions, modeling errors, inadequacy of sensors and controllers, structuralnonlinearities and reliability, not to mention the highoperational costs. Researchers are experimenting withmany novel concepts to overcome these limitations and todevelop a cost-effective hybrid and semi-active class ofsystems which can combine the robustness of passive systemswith the adaptability of active systems.

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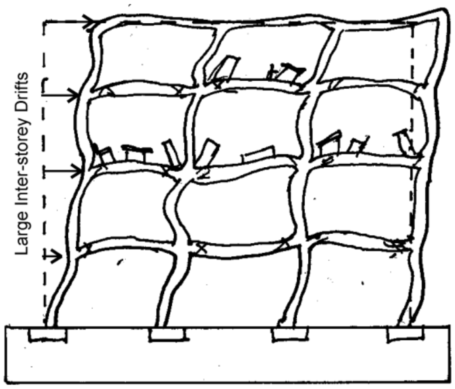
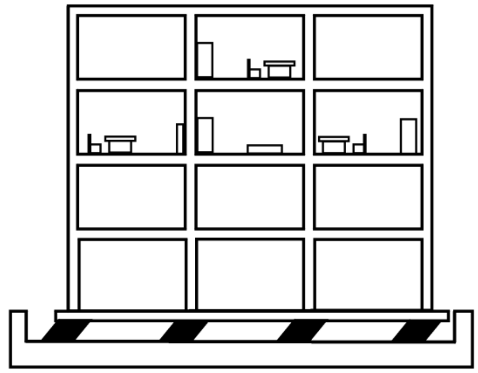
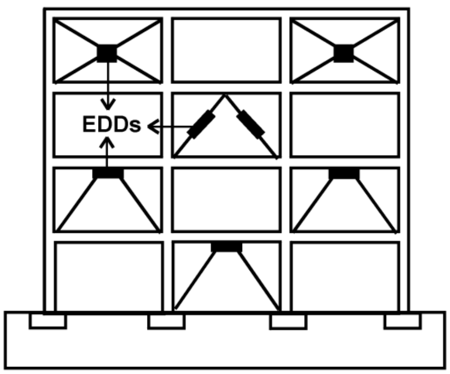


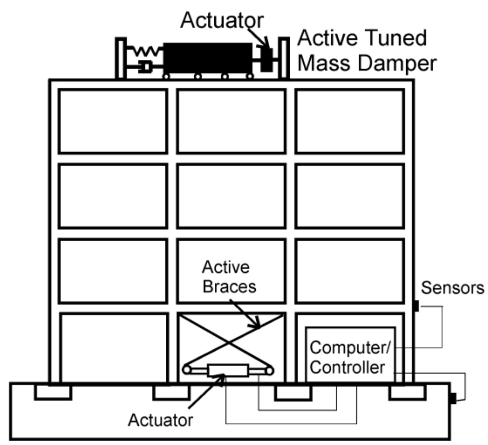

**(a) Fixed-Base Systems:**
Conventional structures absorb seismic energy through inelastic deformations in structural members. Large Inter-storey drifts cause structural and nonstructural damage, however, loss of life and collapse is prevented.



**(b) Seismic Isolation Systems:**
Structures are supported on isolators which decouple structures from damaging earthquake components and absorb seismic energy adding substantial damping.




**(c) Energy Dissipation Systems:**
Energy Dissipation Devices (EDDs) absorb seismic energy thereby reducing the demand on primary structural members. Structural and nonstructural damage is signficantly reduced.




**(d) Active Control Systems:**
Lateral strength, stiffness and dynamic properties of a structure are adjusted during the earthquake to control its response. Complex control mechanism and elaborate hardware is required.

## III. REASON FOR FAILURE DURING EARTHQUAKE

### A. The soil fail

Earthquakes move the ground side and up and down-same time. The force behind this movement is powerful enough to turn soft soil instantly into quicksand, eliminating its ability to bear weight. Building constructed on either soft soil or on steeply sloped sites in a seismic zone, therefore, is at special risk. When the shaking finally stops, these buildings are sometimes found slumping into the soil. Taller buildings are those built of rigid concrete may stay intact but collapse over in the soil. Both problems can be directly attributed to soil failure.

### B. The foundation fails

One of several factors that determine a foundations capability to withstand the forces of an earthquake is the buildings mass .all buildings can carry their own weight ;even poorly constructed ones can resist some additional lateral loads, such as those from a normal wind ,Its not necessary to design or construct the building, multi-directional and loads occur during the earthquake, when earthquakes in series of waves. This kind of failure is an

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indication that as the foundation was moved by shock waves, a building height also impacts its capability to withstand the forces of an earthquake .the higher the building, the greater it's potential to break apart – especially near the foundation – as it shifts back and forth. The use of anchor bolts to tie the building to its foundationhelps prevent the two from separating. Reinforcements to the foundation wall also help to protect against the concentration of shear forces at grade.

### C. A soft floor fails

You've visited them hundreds of times medical office buildings, hospitals, or other structures constructed at a top of a parking garage or an expansive ground-floor lobby. These lower-level floors are known as soft floors i.e , floors with minimum interior shear walladditional floor-to-floor height,or large open spaces with concentrations of building mass above.study photographs of older failed buildings and you'll find that the upper levels of a building often remain intact while the lower floors crumble. This is because the concentration of forces is at the ground floor, where most soft floors are located. Wherever they are, however, soft floors represent a break in a building's structural continuity. With fewer walls and little infill, soft floors are typically less rigid than the building constructed on top of them, making soft floors and the columns that support them susceptible to failure in an earthquake.

### D. Building joint fails

A building's shape impacts its capability to resist deflection, and when it comes to shape, most hospitals are not ideal. that's because hospitals typically have irregular shapes, representing multiple additions and expansions made throughout their histories. The problem, at least with many older buildings, is that newer additions were rigidly connected with the old buildings- even if they were of different heights and construction materials. In older masonry buildings, in fact it's not uncommon to find building expansions that share a common wall with the original structure. If these connections don't accommodate the natural inclination of the different structures to move independently of each other, or if there is insufficient clearance between the different structures, the results can be disastrous in an earthquake.

### E. The building fails

A building's capability to withstand an earthquake also depends on the materials it is made of. Not all building failures result in total collapse. Building failures are also at play when large portions of a roof or façade fall from a building during or after an earthquake. Thesefailures can occur because several diverse building elements have been treated like a single system when, in fact, they should be tied separately back to the structure, with space between them to allow for the differential movements of the dissimilar elements.

## IV. TECHNOGIES FOR EARTHQUAKE RESISTANCE

- Structures should not be brittle or collapse suddenly.Rather, they should be tough, able to deflect or deform considerable amount.
- Resisting elements, such as bracing or shear walls, must be provided evenly throughoutbuilding, in both direction side-to-sides, as well as top to bottom.
- All elements, such as walls and the roof, should be tied together so as to act as an integrated unit during earth quake shaking, transferring forces across connections and preventing separation. (4) Unreinforced earth and masonry have no reliable strength in tension, and are brittle in compression .generally; they must be suitably reinforced by steel as well as wood.

## V. BRACING DESIGN IN DUAL SYSTEM

The design of frame structures with added control members for earthquake resistance refers primarilyto the need for the primary systems to exhibit a linear elastic behaviour under seismic actions. Areduction of the energy dissipation demand on primary structural systems was successfully aimed atby a number of researchers Passive metallicyielding, friction, viscoelastic and viscous damping devices may be added to frame structures todissipate input energy during an earthquake and to substantially reduce or eliminate damage to thegravity-load-resisting frames ADAS and TADAS are known examples,available for both, new seismic resistant designs and retrofit of frame structures . In principle, steel plate dampers are introduced in moment resisting frameswith chevron bracings of large hollow section diagonals. The bracing members are typically connectedto the beams and the columns with gusset plates through welting or bolting. In experimental prototypetests conducted the devices showed a stable

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hysteretic behaviour under a number of loading cycles. Nevertheless the bracing components increase the overallstiffness of the system, as they consist of steel members stressed in compression, tension and bending.Before yielding of the integrated damper's plates, such stiff bracings may reduce inter-storydisplacements, while also developing high accelerations. In addition the application of the membersunder compression leads to a relatively inefficient behaviour under cyclic loading; in every halfloadingcycle the compression diagonal buckles and it therefore cannot participate in the energydissipation process.Slender bracing members have found up to date limited applications for the integration of dampers inframe structures (Di Sarno and Elnashai 2005). A reason for this is their tendency of becoming slackunder tension yielding and compression buckling. In addition sudden increases of the tensile forces inthe slender braces create detrimental impact loadings on the connections and the other structuralmembers. The amplification of the static response of the structure due to such impact loading may be accounted for by a respective impact factor (Tremblay and Filiatrault 1996). On the other side theapplication of a tension bracing-mechanism for earthquake resistance purposes seems to be apromising alternative as regards avoidance of stiffness interaction with the primary system, as well asachievement of simplicity and aesthetic qualities of the structure in broader architectural context. Theimplementation of tension-only bracings with damping devices in frame structures may only berealized through the development of suitable bracing-damper configurations, whereas all bracingmembers contribute during the entire load duration to the operation of the integrated damper. In thisway optimization of the control system's operation principles for earthquake structural resistance may

## VI. EARTHQUAKES RESISTANCE STRUCTURE USING DAMPERS

For a decade, many strong earthquakes have occurred one after another in many countries. These earthquakes have caused severe damages to large-scale infrastructures. To protect structures from significant damage and response reduction of structures under such severe earthquakes has become an important topic in structural engineering. Conventionally, structures are designed to resist dynamic forces through a combination of strength, deformability and energy absorption. These structures may deform well beyond the elastic limit, for example, in a severe earthquake. It indicates that structures designed with these methods are sometimes vulnerable to strong earthquake motions. In order to avoid such critical damages, structural engineers are working to figure out different types of structural systems that are robust and can withstand strong motions. Alternatively, some types of structural protective systems may be implemented to mitigate the damaging effects of these dynamic forces. These systems work by absorbing or reflecting a portion of the input energy that would otherwise be transmitted to the structure itself. In such a scenario, structural control techniques are believed to be one of the promising technologies for earthquake resistance design. The concept of structural control is to absorb vibration energy of the structure by introducing supplemental devices. Various types of structural control theories and devices have been recently developed and introduced to large-scale civil engineering structures.

**Control System**

During the last decade more and more attention has been put to vibration mitigation of structures subjected to environmental (i.e. seismic and wind loads) and manmade (i.e. traffic or heavy machinery) loads. Such a structures needs to be protected against vibrations in order to improve the safety and durability.Different types of structural control devices have been developed and a possible classification is done by their dissipative nature. Structural control systems can be classified as passive, active, semi-active and hybrid.

**Passive Control Devices**

A passive control device is a device that develops forces at the location of the device by utilizing the motion of the structure. Through the forces developed, a passive control device reduces the energy dissipation demand on the structure by absorbing some of the input energy (Soong and Dargush 1997) [As Shown in Figure 1(b)]. Thus, a passive control device cannot add energy to the structural system. Furthermore, a passive control device does not require an external power supply. Examples of passive devices include base isolation, tuned mass dampers (TMD), tuned liquid dampers (TLD), metallic yield dampers, viscous fluid dampers and friction dampers.

**Active Control Devices**

The active control systems are the opposite side of passive systems, because they can provide additional energy to the controlled structure and opposite to that delivered by the dynamic loading. Active control devices require considerable amount of external power to operate actuators that supply a control force to the structure. An active control strategy can measure and estimate the response over the entire structure to determine appropriate control forces. As a result, active control strategies are more complex than passive strategies, requiring sensors and evaluator / controller equipments. Cost and maintenance of such systems are also significantly higher than that of passive devices. Examples among active control devices include active tuned mass damper, active tuned liquid column damper and active variable stiffness damper.

**Semi-Active Control Devices**
Semi-active control devices combine the positive aspects of passive and active control devices. Like passive control devices, semi-active control devices generate forces as a result of the motion of the structure and cannot add energy to the structural system. However, like an active control device, feedback measurements of the excitation and structural system are used by a controller to generate an appropriate signal for the semi-active device (Symans and Constantinou 1999, Spencer and Nagarajaiah 2003). In addition, only a small external power source is required for operation of a semi-active control device. Examples of semi-active devices include variable orifice dampers, variable friction dampers, variable stiffness damper, and controllable fluid dampers.

**Hybrid Control Devices**
A hybrid control system typically consists of a combination of passive and active or semi-active devices (Soong and Spencer 2002). Because multiple control devices are operating, hybrid control systems can alleviate some of the restrictions and limitations that exist when each system is acting alone. Thus, higher levels of performance may be achieved. Since a portion of the control objective is accomplished by the passive system, less active control effort, implying less power resource, is required. A side benefit of hybrid systems is that, in the case of a power failure, the passive components of the control still offer some degree of protection, unlike a fully active control system. Examples of hybrid control devices includehybrid mass damper and hybrid base isolation.

## VII.CONCLUSION
We conclude thatIn the coming years, the field of EQRD of structures is most likely to witness the following significant developments:A complete probabilistic analysis and design approach that rationally accounts for uncertainties present in the structural system will gradually replace deterministic approaches, especially in the characterization of the loading environment. Performance-based design processes will take centre stage, making conventional descriptive codes obsolete. The acceptable risk criterion for design purposes willbe prescribed in terms of performance objectives andhazard level. The proposed system consists of a hysteretic damper and a bracing mechanism of closed circuit. ADCS innovative mechanism enables the elastic response of the primary structure and the dissipation of the earthquake induced energy through plastic hysteresis in the damper. The composition of the bracing-damper mechanism leads to a continuous most uniform counteraction of all structural members to resist the earthquake loading, while practically avoiding any stiffness-interaction with the primary frame. The application of the control mechanism becomes an attractive alternative, not only for the design of earthquake resistant structures, but also for the seismic retrofit of existing ones.Control systems are classified as passive control, active control, semi-active control, and a combination of passive and active or semi-active control. The passive control system are very low cost compare to other control system and also works (absorbs vibrations) without external power consumptions. Active control systems use computer controlled actuators to produce the best performance. Active mass dampers are very effective in controlling oscillations in high winds and in medium sized earthquakes. Semi-active devices combine the best features of both passive and active control systems and offer some adaptability, similar to active control systems, but without the requirement of large power sources for their control action. The hybrid control uses active control with a passive control to supplement and improve the performance of the passive control system and to decrease the energy requirement of the active control system. Structural control systems will allow seismic resistance and safer design of building of civil engineering structures.

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