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Experimental Analysis of Earthquake Resistant Structures with Shear Wall

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Abstract : Constructions made of shear walls are high in strength ,they majorly resist the seismic force, wind forces and even can be built on soils of weak bases by adopting various ground improvement techniques[2]. Not only the quickness in construction process but the strength parameters and effectiveness to bare horizontal loads are very high.

Shear walls generally used in high earth quake prone areas, as they are highly efficient in taking the loads. Not only the earth quake loads but also winds loads which are quite high in some zones can be taken by these shear walls efficiently and effectively.in this project the shear wall will be analysed. This study determines the solution for shear wall location in multi-storey building based on its both elastic and elasto -plastic behaviour. The earthquake load is to be calculated and applied to a multi-storeyed building. Model results will be calculated and analysed for the effective location of shear wall.

1.0 Introduction

Earthquake-resistant structures are designed and constructed to withstand various types of hazardous earthquake exposures at the sites of their particular location[4,6].

According to building codes, earthquake-resistant structures are meant to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare Earthquakes while the loss of functionality should be limited for more frequent ones.

Building designed to prevent total collapse, preserve life, and minimize damage in case of an earthquake or tremor[5]. Earthquakes exert lateral as well as vertical forces, and a structure's response to their random, often sudden motions is a complex task that is just beginning to be understood. Earthquake-resistant structures absorb and dissipate seismically induced motion through a combination of means: damping decreases the amplitude of oscillations of a vibrating structure, while ductile materials (e.g., steel) can withstand considerable inelastic deformation[7]. If a skyscraper has too flexible a structure, then tremendous swaying in its upper floors can develop during an earthquake. Care must be taken to provide built-in tolerance for some structural damage, resist lateral loading through stiffeners (diagonal sway bracing), and allow areas of the building to move somewhat independently.

1. Structures should not be brittle or collapse suddenly. Rather, they should be tough, able to deflect or deform a considerable amount.

2. 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.
3. All elements, such as walls and the roof, should be tied together so as to act as an integrated unit during earthquake shaking, transferring forces across connections and preventing separation
4. iv) The building must be well connected to a good foundation and the earth. Wet, soft soils should be avoided, and the foundation must be well tied together, as well as tied to the wall.
5. Care must be taken that all materials used are of good quality, and are protected from rain, sun, insects and other weakening actions, so that their strength lasts.
6. Unreinforced earth and masonry have no reliable strength in tension, and are brittle in compression. Generally, they must be suitably reinforced by steel or wood.

Seismic performance

Earthquake or seismic performance defines a structure's ability to sustain its due functions, such as its safety and serviceability, at and after a particular earthquake exposure[3].

- A structure is, normally, considered safe if it does not endanger the lives and well-being of those in or around it by partially or completely collapsing
- A structure may be considered serviceable if it is able to fulfil its operational functions for which it was designed.
- Building should survive a rare, very severe earthquake by sustaining significant damage but without globally collapsing.
- Building should remain operational for more frequent, but less severe seismic events.

1.1 General Planning and Design Aspects

The behaviour of building during earthquakes depends critically on its overall shape, size and geometry. Hence, at planning stage itself, architects and structural engineers must work together to ensure that the unfavourable features are avoided and a good building configuration is chosen. If both shape and structural system work together to make the structure a marvel.

"If we have a poor configuration to start with, all the engineer can do is to provide a band-aid – improve a basically poor solution as best as he can. Conversely, if we start-off with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much"[2].

1.2 Size of Buildings

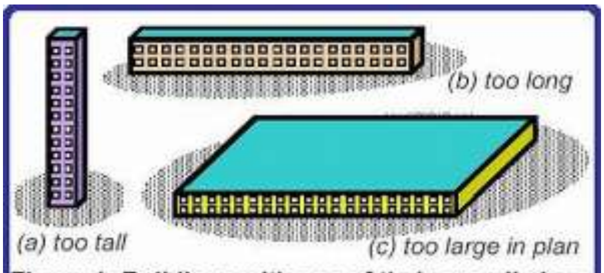


Figure 1: Buildings with one of their overall sizes much larger or much smaller than the other two, do not perform well during earthquakes.

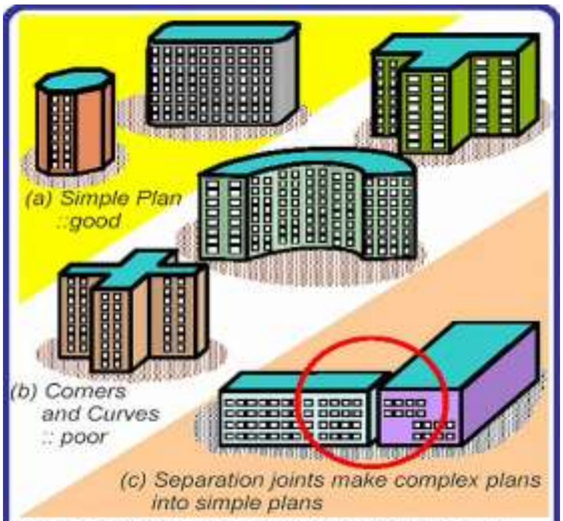


Figure 2: Simple plan shape buildings do well during earthquakes.

In tall buildings with large weight-to-base size ratio the horizontal movement of the floors during ground shaking is large. In short but very long buildings, the damaging effects during earthquake shaking are many. And, in buildings with large plan area, the horizontal seismic forces can be excessive to be carried by columns and walls.

1.3 Horizontal Layout of Buildings

Buildings with simple geometry in plan perform well during strong earthquakes. Buildings with re-entrant corners, like U, V, H and + shaped in plan sustain significant damage. The bad effects of these interior corners in the plan of buildings are avoided by making the buildings in two parts by using a separation joint at the junction.Vertical Layout of Buildings

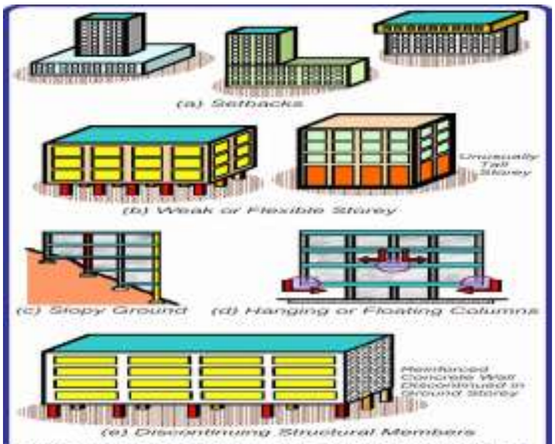


Figure 3: Sudden deviations in load transfer path along the height lead to poor performance of buildings.

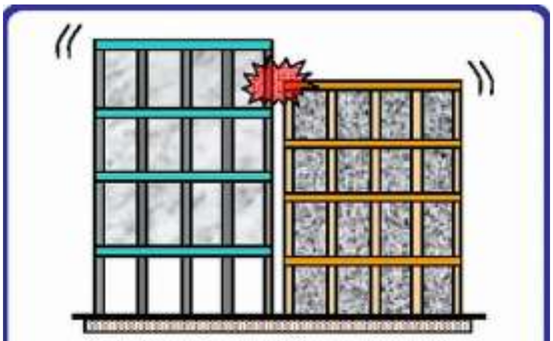


Figure 4: Pounding can occur between adjoining buildings due to horizontal vibrations of the two buildings.

Earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path, any deviation or discontinuity in this load transfer path results in poor performance of building[7]. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey[4]. Buildings on sloppy ground have unequal height columns along the slope, which causes twisting and damage in shorter columns that hang or float on beams have discontinuity in load transfer. Buildings in which RC walls do not go all the way to the ground but stop at upper levels get severely damaged

1.4 Adjacency of Buildings

When two buildings are close to each other, they may pound on each other during strong shaking. When building heights do not match the roof of the shorter building may pound at the mid- height of the column of the taller one; this can be very dangerous.

1.5 Plan of building

1. Symmetry: The building as a whole or its various blocks should be kept symmetrical about both the axes. Asymmetry leads to torsion during earthquakes and is dangerous; Symmetry is also desirable in the placing and sizing of door and window openings, as far as possible.

2. Regularity: Simple rectangular shapes, behave better in an earthquake than shapes with many projections . 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. If longer lengths are required two separate blocks with sufficient separation in between should be provided.

3. Separation of Blocks: Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block. For preventing hammering or pounding damage between blocks a physical separation of 3 to 4 cm throughout the height above the plinth level will be adequate as well as practical for upto 3 storeyed buildings.

The separation section can be treated just like expansion joint or it may be filled or covered with a weak material which would easily crush and crumble during earthquake shaking. Such separation may be considered in larger buildings since it may not be convenient in small buildings.

4. Simplicity: Ornamentation invo1ving large cornices, vertical or horizontal cantilever projections, facia stones and the like are dangerous and undesirable from a seismic viewpoint. Simplicity is the best approach. Where ornamentation is insisted upon, it must be reinforced with steel, which should be properly em-bedded or tied into the main structure of the building.
5. Enclosed Area: A small building enclosure with properly interconnected walls acts like a rigid box since the earthquake strength which long walls derive from transverse walls increases as their length decreases. Therefore structurally it will be advisable to have separately enclosed rooms rather than one long room. For unframed walls of thickness t and wall spacing of a, a ratio of a/t = 40 should be the upper limit between the cross walls for mortars of cement sand 1:6 or richer, and less for poor mortars
6. Separate Buildings for Different Functions: In view of the difference in importance of hospitals, schools, assembly halls, residences, communication and security buildings, etc., it may be economical to plan separate blocks for different functions so as to affect economy in strengthening costs.

1.6 Requirements of Structural Safety

As a result of the discussion of structural action and mechanism of the following main requirements of structural safety of buildings can be arrived at.

1. A free standing wall must be designed to be safe as a vertical cantilever. This requirement will be difficult to achieve in un-reinforced masonry in Zone A[5]. Therefore all partitions inside the buildings must be held on the sides as well as top. Parapets of category I and II buildings must be reinforced and held to the main structural slabs or frames
2. Horizontal reinforcement in walls is required for transferring their own out-of-plane inertia load horizontally to the shear walls.
3. The walls must be effectively tied together to avoid separation at vertical joints due to ground shaking.
4. Shear walls must be present along both axes of the building.
5. A shear wall must be capable of resisting all horizontal forces due to its own mass and those transmitted to it.
6. Roof or floor elements must be tied together and be capable of exhibiting diaphragm action.
7. Trusses must be anchored to the supporting walls and have an arrangement for transferring their inertia force to the end walls.
8. Masonary stone walls should be properly interconnected by through stones.
9. Heavy masses at top should be avoided.

2.0 Literature Review

The idea for this project is collected from a paper presented in a journal of Environmental Geotechnics on the topic "Utilisation of used tyres in civil engineering the pneusol Tyresoil " by Nguyen -Thanh - Long.In this investigation the use of passenger car tyres in reinforcement ofembankments has been studied[8,10]. The heavy pneusol was used to relieve the active earth pressure and also to eliminate tensile forces on the piles. It was made of treads arranged in layers and tied together by polyester straps. Since the f ill inside the treads exerts no active earth pressure and that between two layers is highly confined, the pneusol mass, behaves like gravity wall made of thousands of tiny gabions stacked one to another.

The idea of tyre as an energy absorption spring i s seen from common place observations of daily life. Tyres are used at tricky corners on motor racing circuits to slow the occasional car that spins of the track. This illustrates the energy absorption property of the tyres.

The salient conclusions based on the investigation are as follows.

1. Tensile tests of tyre parts and soil - tyre adherence have yielded good results.
2. The presence of tyres and the voids they create gives the pneusol embankment
3. good anti -vibration, anti - frost and perhaps anti -sei smic properties.

4. Finally, long life of the tyres, their ability to withstand aggression of all kinds (in particular chemical) the simplicity of the process make tyre an ideal material.

Referring to the above, the energy absorption properties of the tyre were seen.

A study has been made to find the suitability of using tyre as an isolator in structures to provide an effective seismic resistant structure

2.1 Advanced Earthquake Resistant Structures by Planning and Design Approach

Earthquakes have plagued man for millennia. It is a destructive force, which was once upon a time declared to be wrath of God for infidelity of human beings. But today, we understand what causes earthquakes, and can design effective mechanisms to mitigate the effects of earthquakes.

Basically, there is the Conventional approach to achieving earthquake resistance, then there is the basic approach, and nowadays, there are active control Devices which can counteract the effects of earthquakes on buildings.

2.1.1 Conventional Approach

Design depends upon providing the building with strength, stiffness and inelastic deformation capacity which are great enough to withstand a given level of earthquake-generated force. This can be accomplished by selection of an appropriate structural configuration and careful detailing of structural members, such as beams and columns, and the connections between them.

2.1.2 Basic Approach

Design depends upon underlying more advanced techniques for earthquake resistance is not to strengthen the building, but to reduce the earthquake generated forces acting upon it. This can be accomplished by de-coupling the structure from seismic ground motion it is possible to reduce the earthquake induced forces in it by three ways.

1. Increase natural period of structures by Base Isolation.
2. Increase damping of system by Energy Dissipation Devices.
3. Mitigate earthquake effects completely by using Active Control Devices
4. Design Philosophy of Earthquake Resistant Designs

Engineers do not attempt to make earthquake proof buildings that will not get damaged even during the rare but strong earthquake; such buildings will be too robust and also too expensive. Instead the engineering intention is to make buildings earthquake-resistant; such buildings resist the effects of ground shaking, although they may get damaged severely but would not collapse during the strong earthquake. Thus, safety of people and contents is assured in earthquake-resistant buildings, and thereby a disaster is avoided. This is a major objective of seismic design codes throughout the world.

2.1.3 Design Philosophy

Under minor but frequent shaking, the main members of the buildings that carry vertical and horizontal forces should not be damaged; however buildings parts that do not carry load may sustain repairable damage.

Under moderate but occasional shaking, the main members may sustain repairable damage, while the other parts that do not carry load may sustain repairable damage.

Under strong but rare shaking, the main members may sustain severe damage, but the building should not collapse.

Earthquake resistant design is therefore concerned about ensuring that the damages in buildings during earthquakes are of acceptable variety, and also that they occur at the right places and in right amounts. This approach of earthquake resistant design is much like the use of electrical fuses in houses: to protect the entire electrical wiring and appliances in the house, you sacrifice some small parts of electrical circuit, called fuses; these fuses are easily replaced after the electrical over-current.

Likewise to save the building from collapsing you need to allow some pre-determined parts to undergo the acceptable type and level of damage.

Earthquake resistant buildings, particularly their main elements, need to be built with ductility in them. Such buildings have the ability to sway back-and-forth during an earthquake, and to withstand the earthquake effects with some damage, but without collapse.

2.2 Earthquake resistant Techniques

Conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements and to some structural members in the buildings[12]. This may render the buildings non-functional after the earthquake, which may be problematic in some structures, like hospitals, which need to remain operational in aftermath of earthquake.

Special techniques are required to design buildings such that they remain practically undamaged even in a severe earthquake. Buildings with such improved seismic performance usually cost more than the normal buildings do.Two basic techniques are used to protect buildings from damaging earthquake effects. These are base isolation devices and seismic dampers.

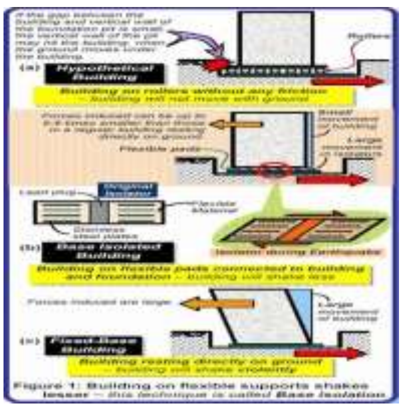
Seismic Base Isolation Technique

It is easiest to see the principle at work by referring directly to the most widely used of these advanced techniques, known as base isolation. A base isolated structure is supported by a series of bearing pads, which are placed between the buildings and building foundation.

The concept of base isolation is explained through an example building resting on frictionless rollers. When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to the shaking of the ground; simply, the building does not experience the earthquake.

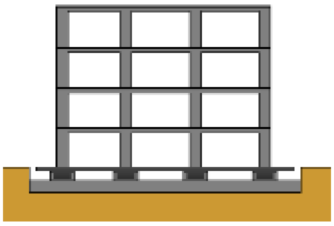
Now, if the same building is rested on the flexible pads that offer resistance against lateral movements, then some effect of the ground shaking will be transferred to the building above. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that experienced by the building built directly on ground, namely a fixed base building .The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base-isolated buildings. The main feature of the base isolation technology is that it introduces flexibility in the structure.

As a result, a robust medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed, to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. Many of the base isolators look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to other. Also, base isolation is not suitable for all buildings. Mostly low to medium rise buildings rested on hard soil underneath; high-rise buildings or buildings rested on soft soil are not suitable for base isolation.



Concept of Base Isolation

Lead-rubber bearings are the frequently-used types of base isolation bearings. A lead rubber bearing is made from layers of rubber sandwiched together with layers of steel. In the middle of the solid lead "plug". On top and bottom, the bearing is fitted with steel plates which are used to attach the bearing to the building and foundation. The bearing is very stiff and strong in the vertical direction, but flexible in the horizontal direction.


(a)

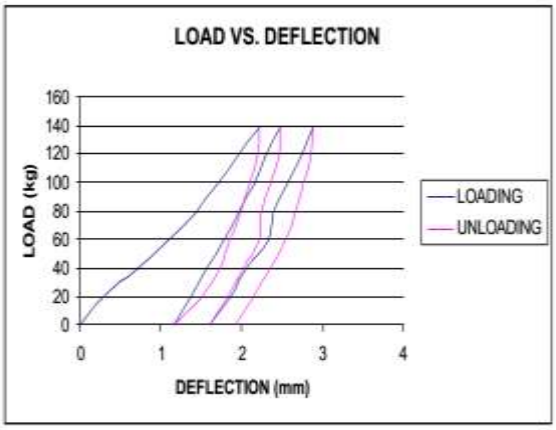
3.0 Methodology

To get a basic idea of how base isolation works, first examine the above diagram. This shows an earthquake acting on base isolated building and a conventional, fixed-base, building. As a result of an earthquake, the ground beneath each building begins to move. . Each building responds with movement which tends towards the right. The buildings displacement in the direction opposite the ground motion is actually due to inertia. The inertia forces acting on a building are the most important of all those generated during an earthquake.

In addition to displacing towards right, the un-isolated building is also shown to be changing its shape from a rectangle to a parallelogram. We say that the building is deforming. The primary cause of earthquake damage to buildings is the deformation which the building undergoes as a result of the inertial forces upon it.

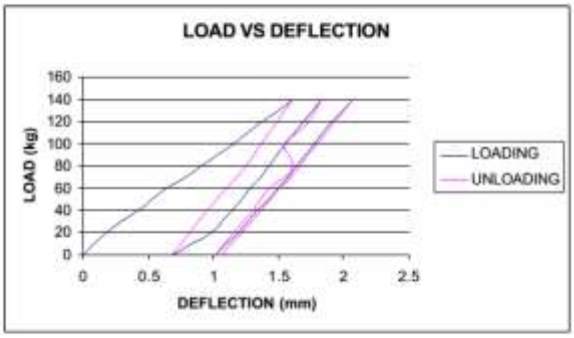
Tabulation Without Shear Wall

SL. NO.	NODE	VELOCITY (mm/sec)	DISPLACEMENT (Micron)	DOMINANT FREQUENCY (Hz)
1	1	14	300	14.87
2	4	5.8	100	18.48
3	7	8.4	70	38.24
4	2	13	260	15.93
5	5	5.2	40	41.43
6	8	7	34	65.61
7	3	15	140	34.14
8	6	5.8	42	44.01
9	9	5	24	66.39
10	10	14	120	37.18
11	12	5	48	33.19
12	14	10	70	45.52
13	11	8	90	28.33
14	13	4	30	42.49
15	15	8	58	43.95
16	A	9	62	46.26
17	B	14	80	55.77



With Shear Wall

SL. NO.	NODE	VELOCITY (mm/sec)	DISPLACEMENT (Micron)	DOMINANT FREQUENCY (Hz)
1	1	2.5	240	3.32
2	4	1.2	80	4.78
3	7	3.8	70	17.30
4	2	1.7	180	3.01
5	5	1.5	130	3.68
6	8	4	40	31.87
7	3	2.8	50	17.85
8	6	2.4	30	25.49
9	9	3	30	31.87
10	10	3.8	42	28.83
11	12	6	38	50.32
12	14	14	84	53.11
13	11	4	15	84.98
14	13	5.8	40	46.21
15	15	10	72	44.26
16	A	17	74	73.21
17	B	16	180	28.33



3.1 Advantages

- Possible to evaluate the earthquake resistant structure
- The passive control system are vary low cost compare to other control system and also works (absorbs vibrations) without external power consumptions.
- Active control 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
- 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.

4.0 Conclusion

This research project began with a desire to provide an inexpensive and plausible means of earthquake protection for residences in developing nations.

Availability of materials, methods of construction, and simplicity were the decisive factors throughout the testing process. The data presented here are preliminary, but show the potential for this system. Although more extensive testing is necessary before this concept is implemented, the first step has been taken, and the results are very promising.

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