ANALYSIS AND STUDY OF SEISMIC RESPONSE OF A G+13 MULTISTORIED BUILDING FOR DIFFERENT TYPES OF DAMPERS USING ETABS SOFTWARE

ABSTRACT

Structural vibration means repetitive motion that causes fatigue and reduction of the performance of a structure. An earthquake may release high amount of energy that can have adverse effect on all components of a structure. Therefore, decreasing of vibration or maintaining performance of structures such as bridges, dams, roads and buildings is important for life safety and reducing economic loss. Various types of dampers are being developed at present to reduce the vibration in those structures. One of the solutions for reducing the earthquake vibration in a structure is using of vibration control devices such as dampers and base isolators. The objective of this study is to investigate the better seismic response for different types of base isolators and dampers. A 13 storey building is modelled and responses of Storey displacement, story drifts and overturning moments were determined and compared using ETABS software.

I. Introduction

With rapid economic development and advanced technology, public buildings such as high-rise buildings, towers and long bridges are designed with greater flexibility, leading to an increase in their tendency to the external future. Therefore, these flexible structures are vulnerable to exposure to high levels of vibration under strong winds or earthquakes. Earthquake loads should be carefully modeled to assess the actual behavior of the structure with a clear understanding that damage is expected but should be controlled. It has finally forced engineers and scientists to come up with new ideas and ways to save buildings and structures from destructive earthquakes.

Two basic technologies are used to protect buildings from the destructive effects of earthquakes. They are Base isolation devices and seismic dampers. The concept of subdivision is to subdivide the building into such a way that seismic movements can be transferred across the structure, or at least significantly reduced. Seismic dampers are special tools introduced into the building to absorb the energy provided by ground movement in the building (similar to how shock absorbers in vehicles absorb impact due to road flexibility).

The basis for the concept of isolation was introduced by engineers and scientists in early 1923 and thereafter developed a variety of methods to distinguish buildings and structures from earthquakes around the world. Countries like the USA, New Zealand, Italy Japan, China and European countries have used these techniques as their common practice in many public buildings and residential buildings. Hundreds of buildings are built each year in a system of segregation and foundation in these countries. To date, in India, the use of base isolating methods in public or residential buildings has begun with the exception of a few buildings is in its inception and except few buildings. The method of base isolation was first demonstrated in India after the 1993 Killari (Maharashtra) earthquake. Two single-storey buildings (one school building and another shopping mall) in the recently relocated town of Killari are constructed of rubber isolators mounted on a sturdy surface.

1.1 Friction pendulum bearing system

Friction pendulum bearings (FPBs) is a modern slide-based earthquake protection system and has been emerging steadily and in importance over the past decade. The first official model was designed by Victor Zayas in 1985, and FBS is now the best security system in the world today. Today, FPBs are available in a variety of configurations, including single, double, and triple concave systems. It consists of a load-bearing bottom plate covered with a slide (Teflon). The building that sits on the top plate also moves until the quake work stops, and then the area returns to its original position, i.e. in the middle of the concave area. During this process, most earthquakes are dispersed; thus preventing future damage and the structure remains the same vertical axis throughout the earthquake event.

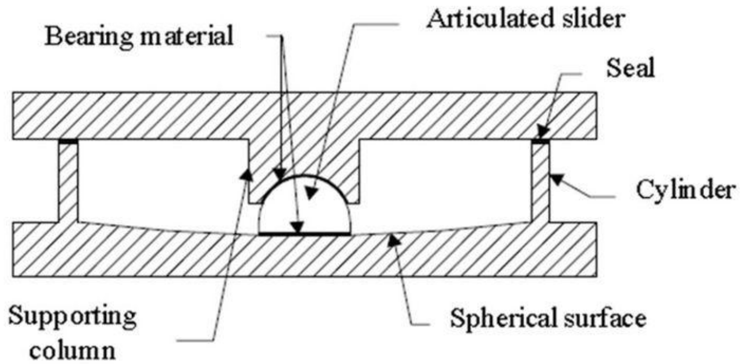
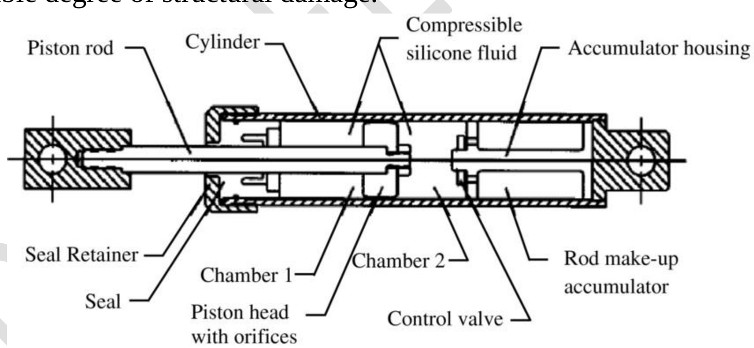


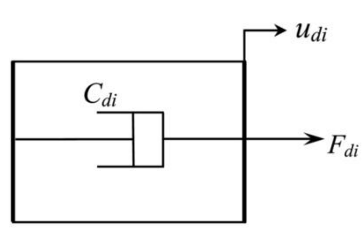
Figure 1: Friction Pendulum Bearings

1.2 Fluid Viscous dampers (FVD):

Fluid viscous damping is a method of adding energy dissipation to the lateral system of a building structure. The fluid viscous damper dissipates energy by pushing liquids from the orifice, producing water-repellent pressure creating force. This power dissipates 90 degrees outside the phase and the power is driven away from the structure. This means that mitigation forces do not significantly increase earthquake loads with a comparable degree of structural damage.



(a) Schematic diagram of fluid viscous damper (Symans and Constantinou, 1998)



(b) Mathematical model of fluid viscous damper

The force generated in each viscous damper is characterized by the following constitutive expression:

$F=CV^{\alpha}$

Where F= total output force provided by the damper

C= damping coefficient
V= relative velocity between the ends of the damper
α = damping exponent (characteristic value of the fluid viscosity), value can vary between 0.1 to 2 (Guerreiro, 2006).

1.3 Viscoelastic Damper (VED):
Solid viscoelastic damper uses a polymeric material that dissipates with shear deformation when loaded, and the most important factor is that the mechanical properties are the functions of frequency excitation and ambient temperature. The damper consists of plates between polymer-filled elements between kinetic forces applied by shear modification of polymer layers, so that the viscoelastic material has a polymer molecule structure as its molecules are connected together like a chain. As a result of the cellular network, viscoelastic materials show a high degree of resistance to modification. In fact, the durability of the building systems will be enhanced by the use of this material in the structure which is usually applied to bracing. On the other hand, when deformation is applied to this material, some of the molecular bonds are broken and heat is produced, depending on the temperature and loading frequency. Therefore, some forces are used to break the bonds, and they are wasted. Immersion of these substances is caused by friction or collapse of the intermolecular bond. After loading over time, the material returns to its original strength, which is the amount of this return depends on the material temperature, the recurring frequency and the size of the strain. In short, by installing this material, stiffness and damping in the structural elements are increased. The installation of dampers should not be limited to braces, but can be used with special arrangements throughout the building where shear deformation occurs.

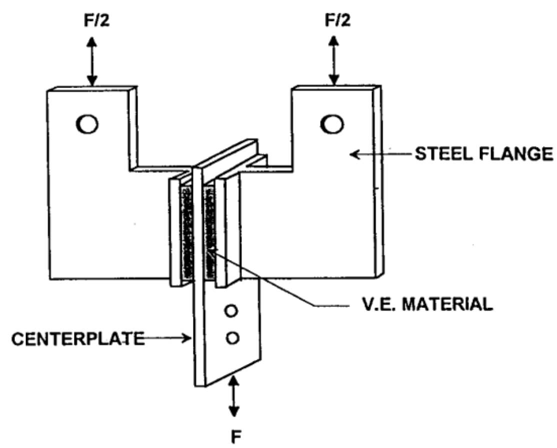


Figure 2: Layout of Viscoelastic Damper

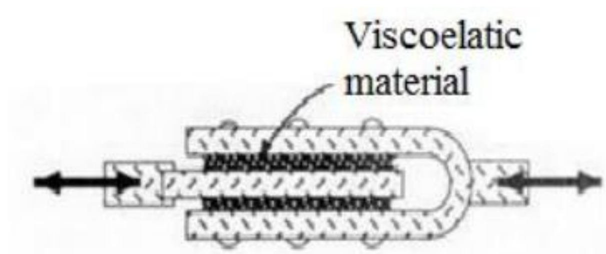


Figure 3: Visco Elastic Damper

$kd = AG'/t$...................... (1)
$Cd = AG''/ \omega t$....................... (2)
$G' = 16.0\omega\ 0.51\ \gamma\ -0.23e\ (72.46/Temperature)$
$G'' = 18.5\omega\ 0.51\ \gamma\ -0.20e\ (73.89/Temperature)$
where
A = area of the damper ,
t = thickness of one layer of visco-elastic material ,
ω = natural frequency of the structure ,
kd = damper stiffness ,
Cd = damping co-efficient,
G' = shear storage modulus and G" = shear loss modulus .

1.4 Lead rubber bearing (LRB):

Lead Rubber Bearing (LRB) is a laminated rubber bearing that contains one or more lead plugs to deflect in shear. Lead loading is physically enabling to a 10 MPa flow stress, which provides dual response. For that reason the lead should fit snugly on the elastomeric bearing, and this is achieved by making the lead plug slightly larger than the hole and using force when inserting it into the hole. The main purpose of the foundation division is to modify the structural response so that the soil can move under the structure without passing these movements to the structure. In the proper system these separations would be complete. A completely solid building will have a zero period. When the ground moves the acceleration caused to the building will be equal to the acceleration of the ground and there will be a slight zero movement between the building and the ground. The building and the ground movement is in same amount.

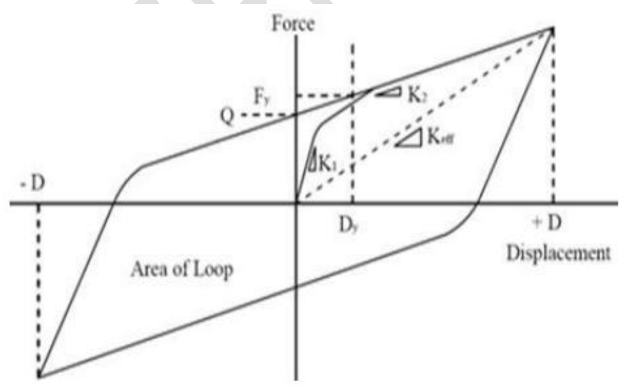


Figure 4 : Parameters Basic Hysteresis Loop of head of Lead rubber Bearing

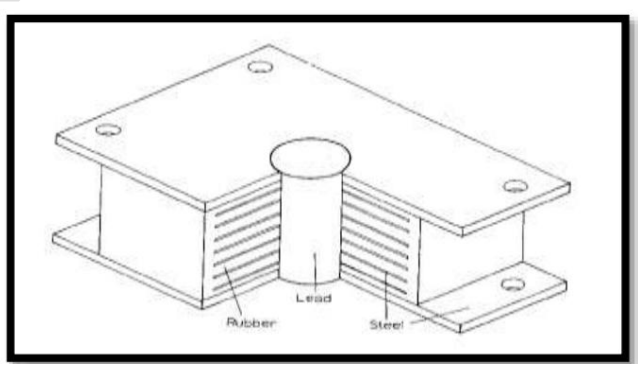


Figure 5: Lead Rubber Bearing

Table 1: For designing the base isolator following data should be input in ETABS.

Rotational Inertia1	0.2180	kN/m
For U1 Effective Stiffness	1316191.49	kN/m
For U2 & U3 Effective Stiffness	4013.432	kN-m
For U2 & U3 Efficient Damping	0.05	Percent
For U2 and U3 distance from end-J	0.0032	M
For U2 & U3 Stiffness	36981.77	kN/m
For U2 & U3 Yield Strength	145.203	k

OBJECTIVES OF THE STUDY:

- Design and normal seismic analysis of RCC structure with fixed bases.
- Study types of base isolators, and different types of dampers, their elements, and effect on structures.
- Using ETABS software, to perform and present a development of theoretical and analytical aspect of the behaviour of base isolated buildings with fixed base buildings and then applying Base isolation and different types of dampers.
- Conclusion from the comparisons of results which helps in providing better, safer structure in earthquake zones

LITERATURE REVIEW:

Dhiraj, Dr. Prof. Pravat, “Base Isolation of Residential Building using Lead Rubber Bearing Technique”, analysed the structures of G+10, G+15 storeys building in seismic zone II. The models are analysed with and without base isolators to investigate the effectiveness of isolator. This study provides an comparative results of the analysis with varied number of storeys following equivalent static method in ETABS software. Design of base isolator was performed to find the stiffness and physical dimension of the core of LRB to be given at the base of structures.

Naziya Ghanchi, Shilpa Kewate, “Dynamic analysis of 25 storey RCC building with and without viscous dampers”, The use of passive dampers to improve seismic performance and improved construction of new buildings has increased in recent years. The main objective of the study was to evaluate the improvement in the response achieved with the use of viscous materials. Energy caused by a strong earthquake will affect the structure. Review of the Response spectrum of the 25-storey RCC building to be used as a commercial building, with a concrete wall and a floor area of 735 sq. m in zone III. Results are concluded as, by adding viscous dampers in the reaction of the building structure is reduced by a significant value.

Puneeth , Praveen,’’ Study on the effect of viscous damper for RCC frame structure”, A symmetrical plan of 8-storey reinforced concrete structure is considered. The damper-free structure is modeled and analyzed in ETABS 2015. In this study, viscous dampers are used to reduce the seismic impact of a structure under an earthquake load. Frames (with viscous damper and outer) are arranged according to the structural properties described in the work. The seismic behavior of the reinforced concrete structure was judged by looking at parameters such as displacement, drift and base shear.

II. METHODOLOGY

The research is based on analysis of six building models in which two models were geometric regular, another two models were plan irregular and remaining two models were vertical irregular buildings. Regular, plan irregular (re-entrant corners) and vertical irregular (vertical geometric irregularity) buildings were considered for both isolated and non-isolated buildings. Lead rubber bearings were designed for different locations (corner, center and side face column) by considering the maximum gravity load coming on column at the base and were used for further analysis. The building models considered for research are as follows.

Model 1: regular RC building with fixed base
Model 2: regular RC building with FPD
Model 3: regular building with FVD
Model 4: regular RC building with VED
Model 5: regular building with LRB

III. STRUCTURAL PROPERTIES OF MODEL

A) Description of G+13 building with descriptive data is mentioned below

Tale 2: Description of G+13 building with descriptive data

Parameter	Dimensions
Type of building	Commercial building
Plan dimensions	40mx40m
Number of floors	13
Length in X-direction	40m
Length in Y-direction	40m
Floor to floor height	3m
Bottom floor height	3m
Total height of building	50
Thickness of slab	150mm
Size of column	900x900mm
Size of beam	300x600mm
Seismic zone	IV
Seismic intensity	Moderate
Importance factor(I)	1.5
Response reduction factor	5 for SMRF
Soil type	TYPE II (Medium soil)
Grade of concrete	M40

Reinforcement	Fe500
Unit weight of concrete	25kN/m3

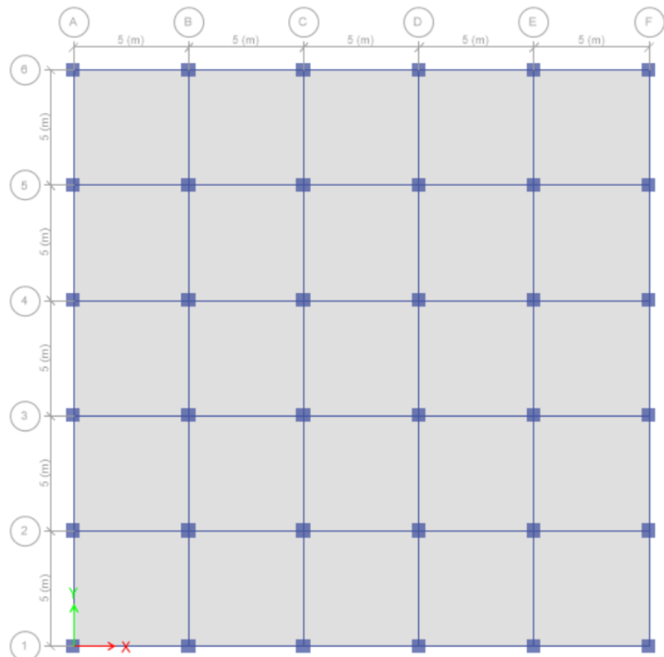


Fig 6: Plan view of G+10 Structure

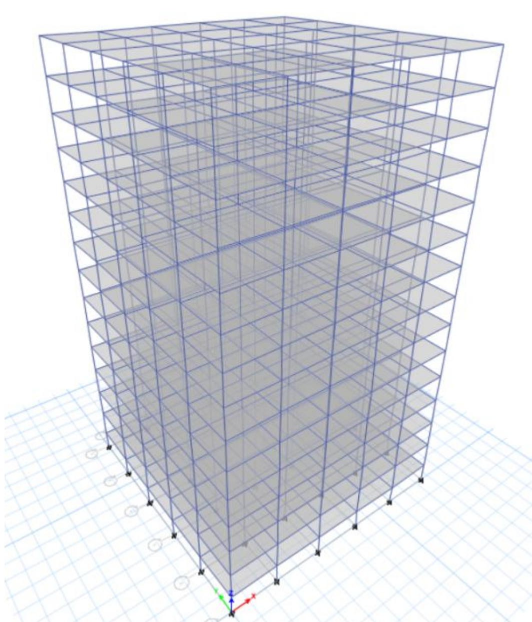


Fig 7: 3d view of G+10 Structure

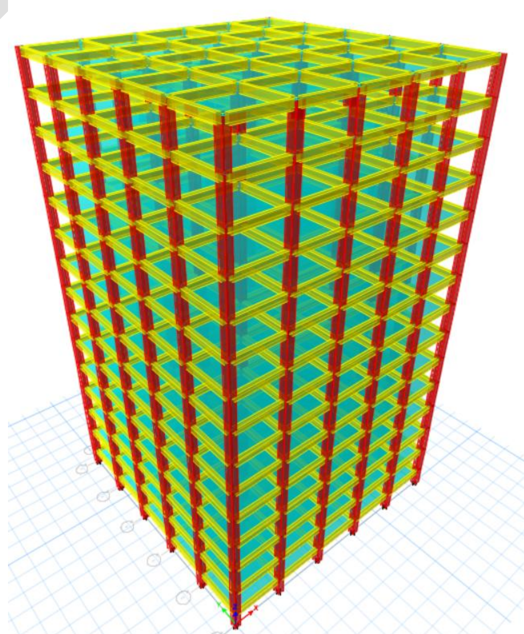


Fig 8:Extruded view of G+20 Structure

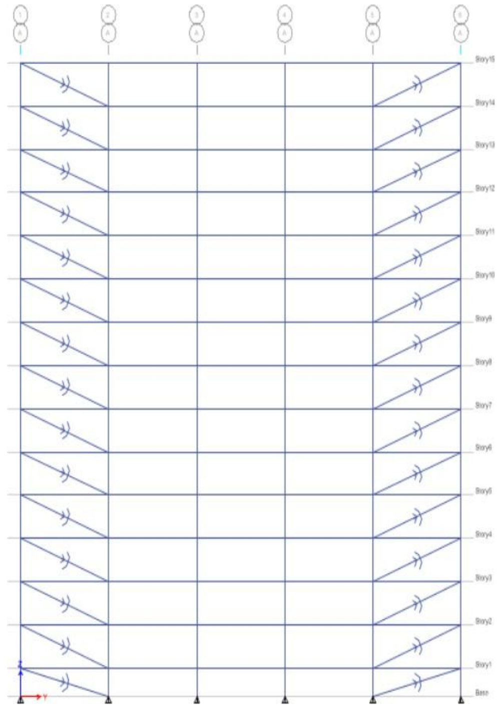


Fig 9: FPB

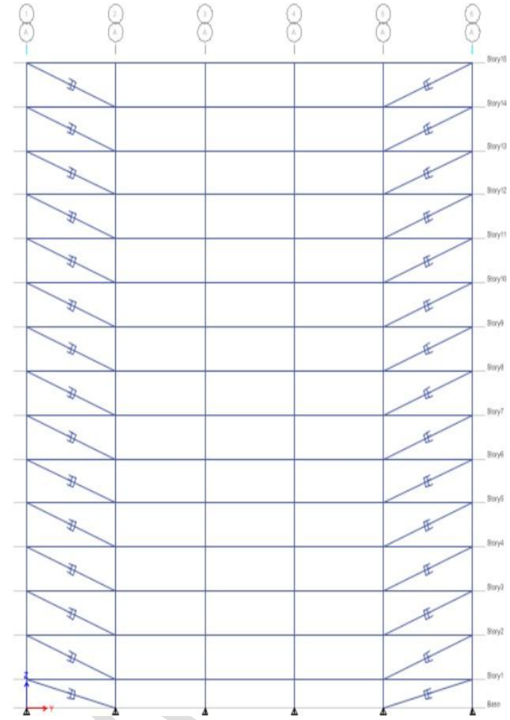


Fig 10: FVD

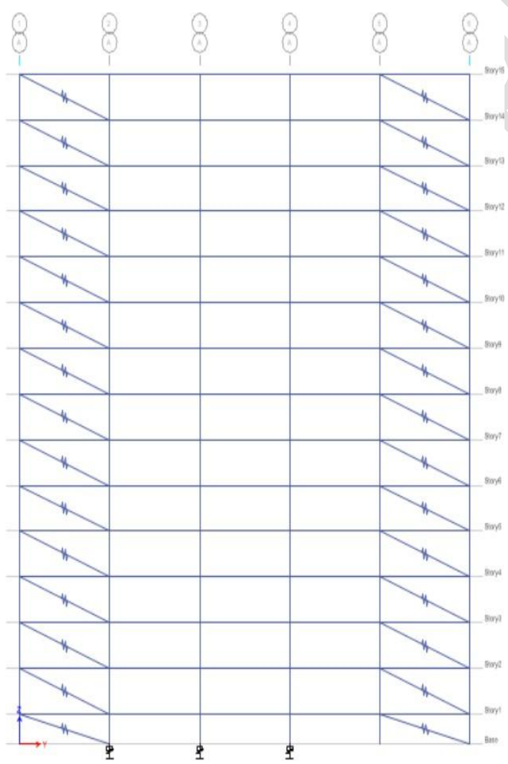


Fig 11: VED

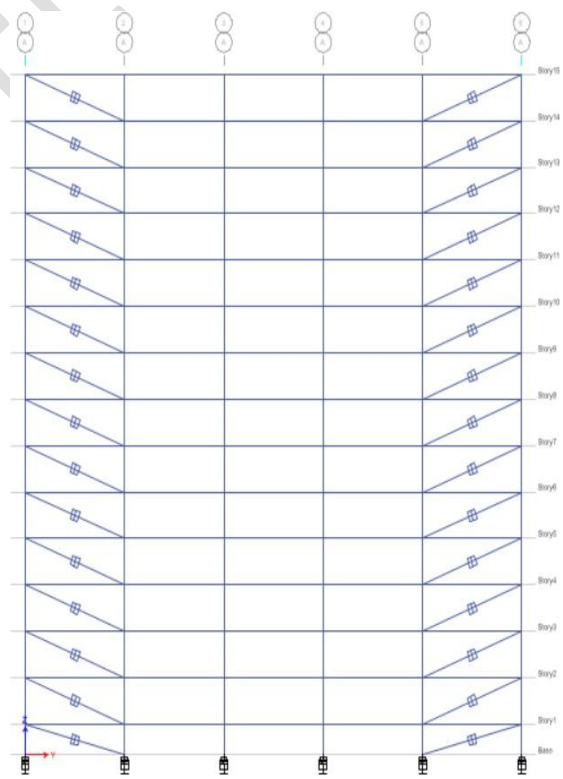


Fig 11: LRB

4. RESULTS AND DISCUSSION:

1. Storey Displacement:

As per Indian Standard Code 1893-2002, displacement is limited to h/250, where 'h' is total height of building in millimeters (mm). Therefore, the displacements in X and Y Direction must lie within 168mm (50000 / 250 = 200) where 50000 mm is the height of model building.

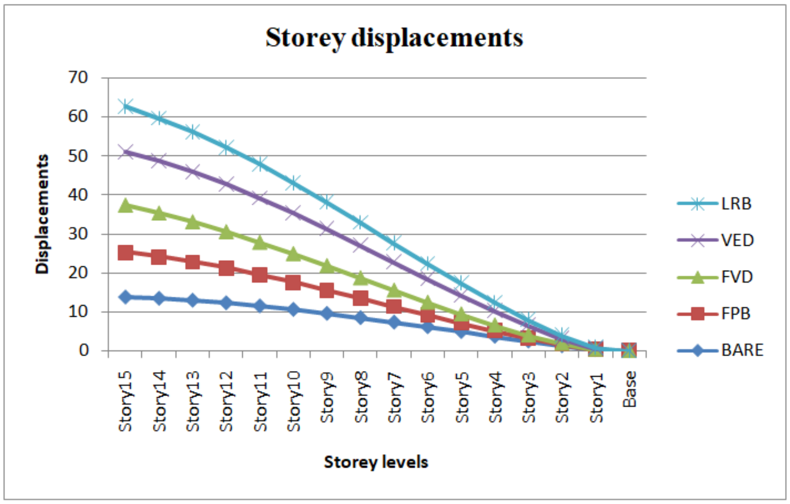


Fig 1: Storey displacement

2.Storey Drift:

Story drift can be defined as the ratio of relative displacements of adjacent two stories and height of the storey. According to IS 1893-2002, Clause no. 7.11.1, the Storey drift in any storey shall not exceed 0.004h, where h is storey height. Drift in building frames is a result of flexural and shear mode contributions, due to the column axial deformations and to the diagonal and girder deformations. As per modeled story height of 3m the maximum permitted drift is 12mm. i.e. Maximum drift permitted = 0.004 x 3000 = 12mm.

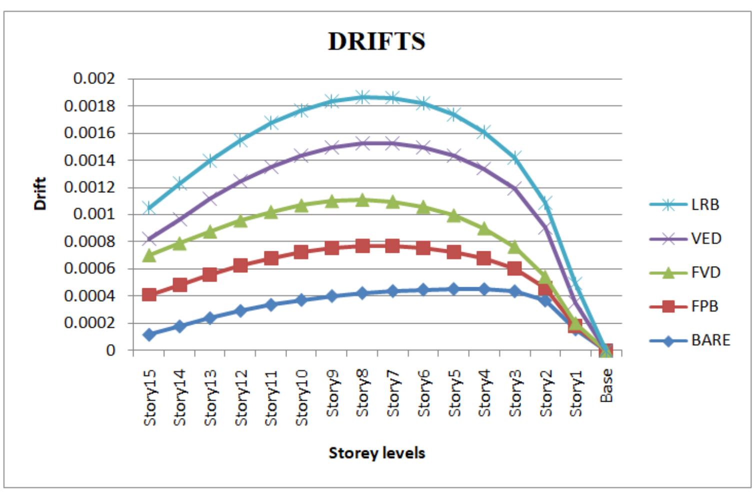


Fig 2: Storey drift

3. Storey shear:

In ETABS software, Storey shear is reported in the global coordinate system. The forces are reported at the top of the storey, just above the storey level, just below the storey level itself, and at the bottom of the storey. Storey shear is reduced in Friction pendulum damper, also reduced in base isolated building, resulting in making the superstructure above the isolation plane as rigid and stiffer. Compared to fixed base buildings, these buildings were subjected to almost half storey shear. This results in the reduction of inertia forces.

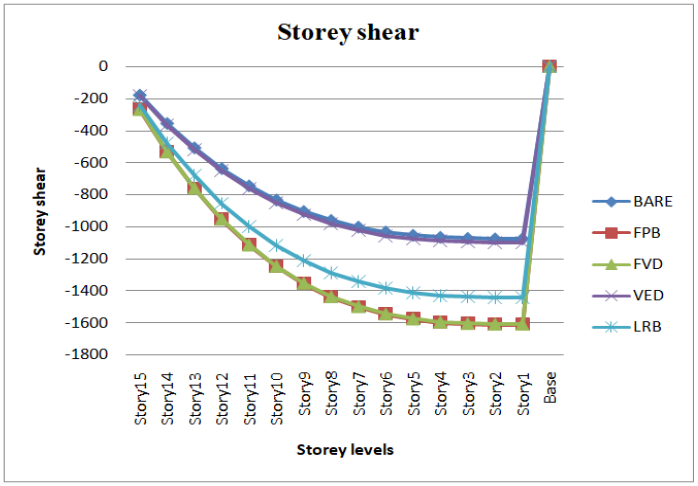


Fig 3: Storey shear

4. Overturning moments:

Maximum overturning moment is observed to be for Lead rubber bearing and the least is for Friction pendulum bearing as follows

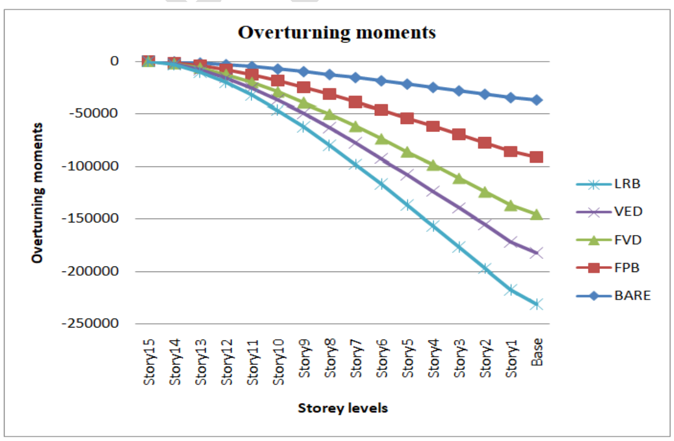


Fig 4: Overturning moment

5. Conclusion:

The output results of seismic parameters were obtained from analysis software ETABS. The results were analyzed, interpreted and compared. The findings of research are as follows.

- The base shear value in FPB building has been reduced up to 60 to 50% as compared to fixed base building.
- The target displacement limit has shown no failure when the structure is subjected to analysis.
- In this study more displacements are formed in Bare frame and least in model with Friction Pendulum Bearings..
- Also it has seen that the maximum overturning moments are formed in model with Friction Pendulum bearings. The structure models analyzed in this state is safe.
- The lateral load to stories is more in Bare followed with VED, LRB and FVD than FPB. But maximum story displacement and story drift results are also.
- The maximum Drifts is within the value of target drift that is assumed. The behavior of the structure is significant to resist the lateral loads.
- Top story drift of building has been decreased up to 60 to 62% by using FPB.

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