International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

# STUDY OF SEISMIC ANALYSIS OF STRUCTURE USING BRACING, DAMPER, BASE ISOLATION BY TIME HISTORY METHOD

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**Abstract -** *Safety of people in a building depends on capability of building to resist earthquake waves and then stands upright after earthquake situation without or with few damage and maintenance. Various systems like dampers, base isolators, shear wall, elevated water tank, etc., are use to dissipate seismic energy. Effectiveness of these systems is based on its type and position of these elements. In this research paper, seismic analysis of G+9, G+15, G+20 storey residential structure is studied based on storey shear and overturning moment by Time History Analysis. Time history data is obtained From PEER Ground Motion Database. Based on maximum storey shear and storey overturning moment, effect of cross bracing, base isolation, Fluid viscous damper and shear wall is compared with Ordinary moment resisting structure. Effective and suitable model is found out by placing these elements at the corner of Structure in different models.*

***Key Words***: Time history analysis, storey shear, storey overturning moment, bracing, fluid viscous damper

## 1. INTRODUCTION

Dynamic action likes wind and earthquakes have major effect on structure. The main focus of earthquake resistant design of structure is to control the damage of structural element and also to control sequence of damage in different structural elements. Safety of people in a building highly depends on the capability of building to resist movement due to earthquake, and then on standing upright after the earthquake without or with few damage and maintenance. Losses due to building collapses can be reduce and protecting contents, services & utilities of buildings. Various systems are use to dissipation of energy; also to control or reduce excessive structural vibration. Seismic effect on building can be reduce by using non structural elements or components like dampers, isolators, elevated water tank. Out of various seismic resisting systems Bracing, base isolation and dampers are effective and these are more commonly used. Effectiveness of these systems is based on its type and position of these elements. As per various research papers, Out of different bracings cross bracing is most effective; Fluid Viscous damper in dampers and Lead Rubber Bearing (LRB) type of base isolators are most effective systems. In any structure seismic waves generate inertia forces which produce shear and overturning moments. Storey shear is lateral seismic load acting per storey.

Objectives of study :-

i. Analysing multi-storey residential model by using Fluid viscous damper, cross Bracing, shear wall and lead Rubber bearing Base isolation.
ii. Compare ordinary moment resisting structure with structure with Fluid viscous damper, cross Bracing, shear wall and LRB Base isolation.
iii. Study behaviour of these models on basis of storey shear. Obtain effective type of model in case of maximum storey shear.
iv. Study behaviour of these models on basis of storey overturning moment. Obtain effective type of model in case of overturning moment.

## 2. MODELLING AND ANALYSIS

A square shaped (G+9), (G+15) and (G+20) storey residential buildings are modelled and analysed in ETABS Software using conventional columns, beams & slabs as shown in fig. As per IS:1893(Part-1) -2002 Dead load, Live load and Seismic loads are considered. These models are analyzed using Time History Analysis Method for Severe intensity earthquake (zone IV). The details of the modeled building are listed below.

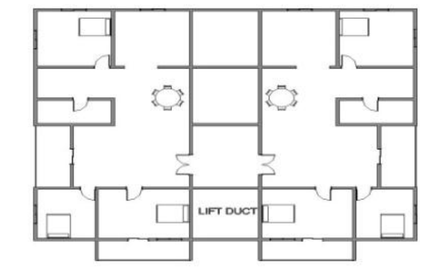



**Fig.1:** Architectural plan

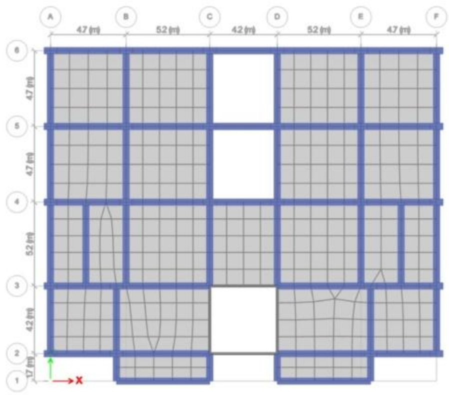


**Fig.2:** Centerline plan

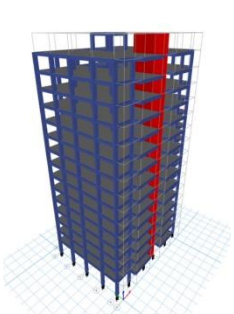
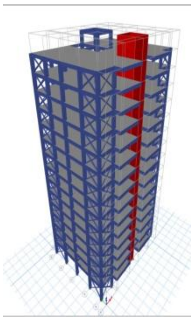
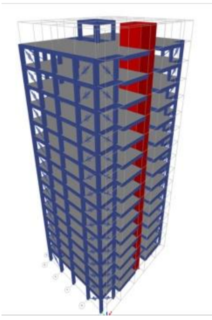




**Fig.3:** Base Isolation **Fig.4:** Cross Bracing **Fig.5:** FV damper

**Table 1:** Model Details

| **Type of Model** | **G+9 Storey** | **G+15 Storey** | **G+20 Storey** |
|---|---|---|---|
| **Floor to floor height (in mm)** | 3000 | 3000 | 3000 |
| **Beam size (mm x mm)** | 450x350 | 500x400 | 600x450 |
| **Column size (mm x mm)** | 600x350 | 800x400 | 1000x450 |
| **Slab thickness (in mm)** | 125 | 125 | 125 |
| **Grade of concrete** | M25 | M25 | M25 |
| **Seismic Zone (z)** | 0.24 | 0.24 | 0.24 |
| **Importance factor (I)** | 1 | 1 | 1 |
| **Soil Type** | Medium Type 2 | Medium Type 2 | Medium Type 2 |
| **Base Isolation** | LRB base isolator | LRB base isolator | LRB base isolator |
| **Damper** | Fluid Viscous Damper | Fluid Viscous Damper | Fluid Viscous Damper |
| **Bracing** | Cross Bracing | Cross Bracing | Cross Bracing |

### 2.1 Specifications:-

i. Base isolation
   Effective stiffness U1 – 11.75 * 105 kN/m
   Effective stiffness U2 & U3 – 1175.42 kN/m
   Yield Strength U2 & U3 – 34.7 kN
   Effective damping – 5%

ii. Bracing
   Type – cross bracing
   Section – angle section 150*150*15

iii. Damper
   Type – Fluid Viscous Damper (FVD)
   Mass – 44kg
   Weight – 250
   Directional property – U1 Fixed

### 2.2 Different Loads:-

i. Dead Load (DL) = Self weight of Slab, beam and column (generated by Etabs software)

ii. Live load (LL) = 3 kN/m2

iii. Super dead load (SDL)

   a. Floor finish = 1.5 kN/m2

   b. Masonary = 1.8 kN/m2

iv. Time History data = CORRALIT , From PEER Ground Motion Database

### 2.3 Load combinations:-

Based on IS 1893-2002,

i. 1.5 (DL + LL + SDL)

ii. 1.2 (DL + LL + SDL ± EQX)

iii. 1.2 (DL + LL + SDL ± EQY)

iv. 1.5 (DL + SDL ± EQX)

v. 1.5 (DL+ SDL ± EQY)

vi. 0.9 DL + 0.9 SDL ± 1.5 EQX

vii. 0.9 DL + 0.9 SDL ± 1.5 EQY

### 2.4 Methodology:-

i. Modelling of structure in Etabs. Defining Material properties for concrete and Reinforcement bars.

ii. Defining Section properties to all sections of proper size with proper properties. For dampers, base isolation define proper link properties.

iii. Assign links as per requirement of damper or base isolation or bracing. Assign supports to structure.

iv. Define mass source.

v. Define and Assign Loads to respective members.

vi. Define time history function. Use proper time history data with required number of steps. Assign time history function in load cases.

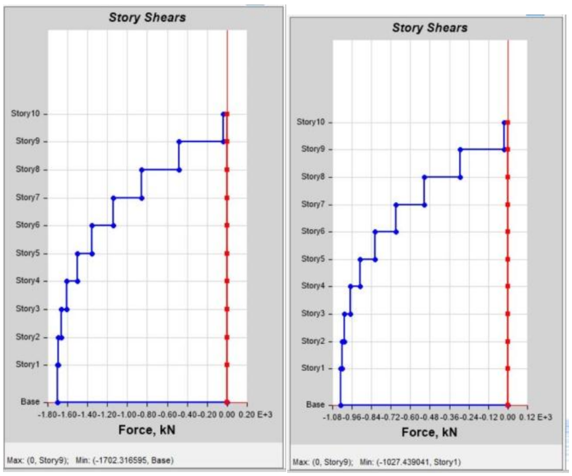
vii. Checking the Model. Then performing analysis on model.

viii. Obtain required parameters like maximum storey displacement, maximum storey drift, maximum storey shear, maximum storey overturning moment.

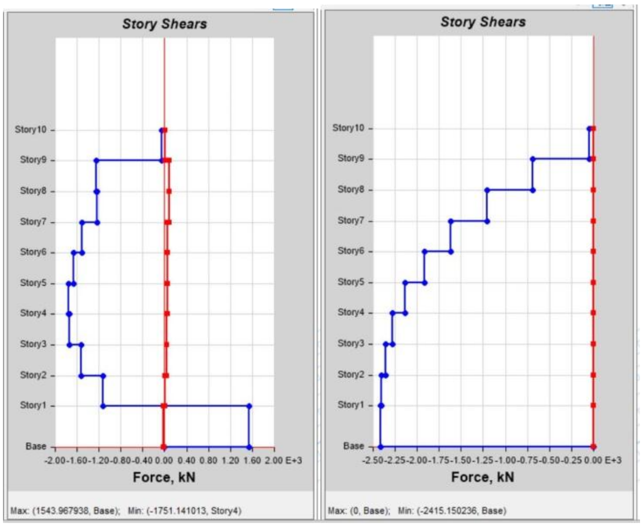
## 3. RESULT AND DISCUSSION

### 3.1 Maximum Storey Shear

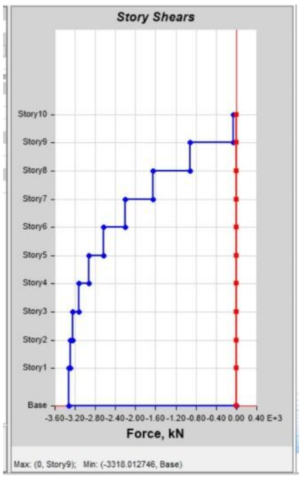
Storey shear is a graph, shows lateral seismic load acting per storey.




(a) (b)




(c) (d)




(e)

**Fig -6** Max Story shear of a, b, c, d & e (G+9) structure respe.

For G+9 Storey structure Maximum Story Shear can be obtained From above graphs, similarly for G+15 and for G+20 structures Maximum Story Shear is obtained and shown in table below,

**Table 2:** Maximum Story Shear (in kN)

| | Ordinary Moment resisting Building | With Base Isolation | With Fluid Viscous Damper | With Cross Bracing | With shear wall |
|---|---|---|---|---|---|
| G+9 | 1702 | 1027 | 1543 | 2415 | 3318 |
| G+15 | 2137 | 1319 | 1629 | 2609 | 3262 |
| G+20 | 2832 | 1717 | 1782 | 3178 | 3831 |

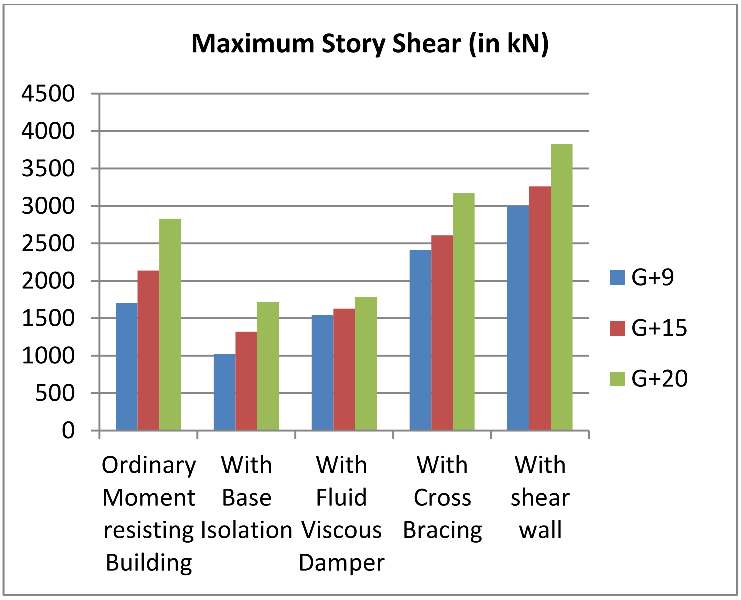



**Fig -7** Maximum storey Shear

From above charts and graphs, we can clearly observe that, Storey shear is maximum near the base of structure and gradually decreases to top of structure.

In ordinary moment resisting building, for G+9 structure maximum storey shear is 1702 kN, for 15 storey and for 20 stories, it is 2137kN & 2832 kN respectively.

For G+9 storey structure with Base isolation, it decreases 39.65% ; for G+15 and G+20 structure, it decreases 38.27% & 39.37% respectively.

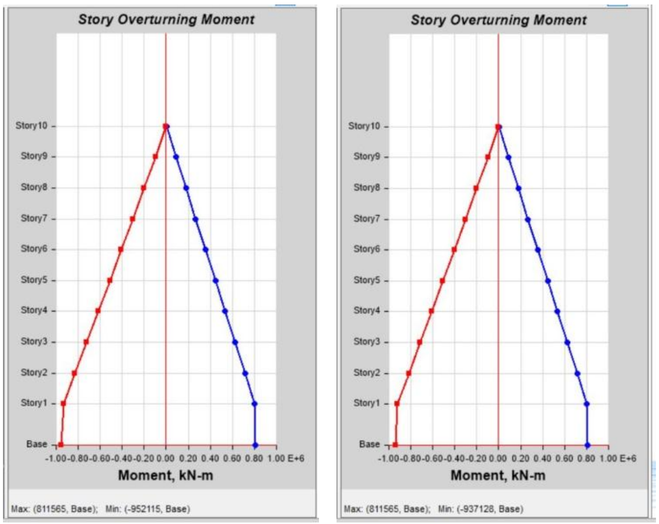
For G+9 storey structure with Fluid Viscous Damper, it decreases 9.342% ; for G+15 and G+20 structure, it decreases 23.77% & 37.07% respectively.

For G+9 storey structure with Cross Bracing, it increases 41.89% ; for G+15 and G+20 structure, it increases 22.08% & 12.21% respectively.

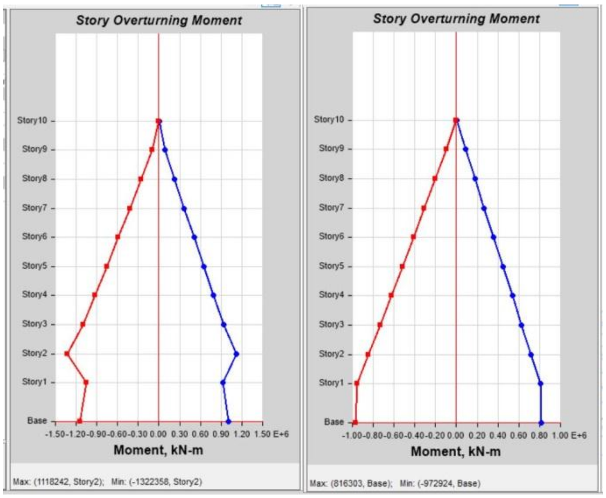
For G+9 storey structure with shear wall, it increases 76.26% ; for G+15 and G+20 structure, it increases 52.64% & 35.27% respectively. Due to position of shear wall at corner of structure, there is increase in storey shear.

### 3.2 Maximum Storey Overturning Moment

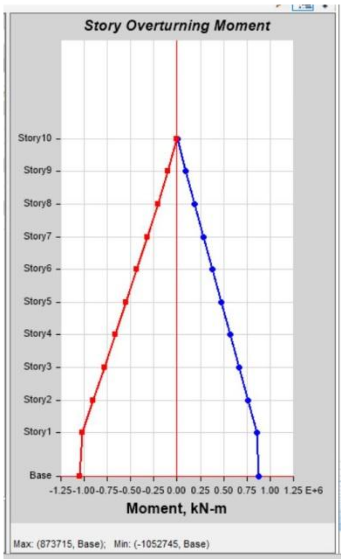
Overturning moments are moments or shear forces applied on storey which causes unstability of storey. Overturning moment plays major role in design of any structure.




(a) (b)




(c) (d)




(e)

**Fig 8-** Max Story overturning moment of a, b, c, d & e (G+9) structure respe.

For G+9 Storey structure Maximum Positive and Negative Story Overturning Moment can be obtained From above graphs, similarly for G+15 and for G+20 structures Maximum Positive and Negative Story Overturning Moment is obtained and shown in table below,

**Table 3 :** Maximum Positive and Negative Story Overturning Moment ($10^5$ kNm)

| | Ordinary Moment resisting Building | With Base Isolation | With Fluid Viscous Damper | With Cross Bracing | With shear wall |
|---|---|---|---|---|---|
| G+9 | 8.115<br>- 9.521 | 8.01<br>- 9.371 | 11.182<br>- 13.22 | 8.16<br>- 9.72 | 8.73<br>- 10.52 |
| G+15 | 14.355<br>- 16.885 | 14.31<br>- 16.59 | 20.77<br>- 24.39 | 14.3<br>- 17.13 | 15.37<br>- 18.35 |
| G+20 | 20.771<br>- 24.614 | 20.31<br>- 24.09 | 29.89<br>- 35.21 | 20.87<br>- 24.88 | 22.08<br>- 26.44 |

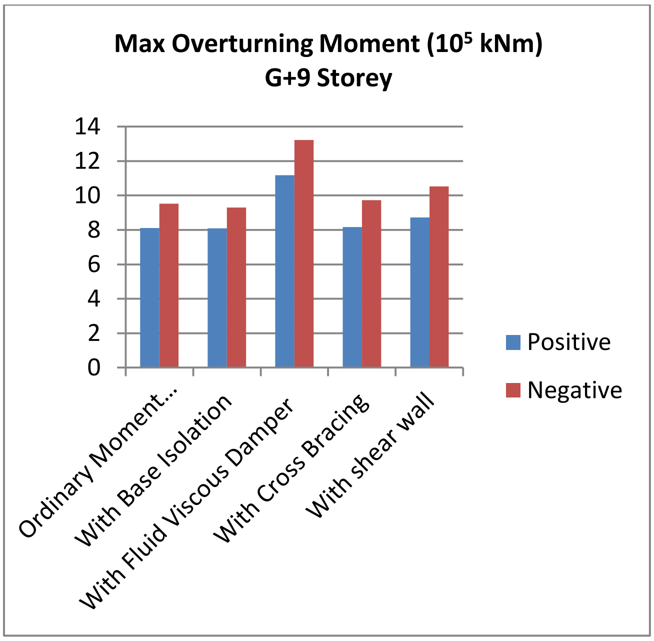



**Fig 9-** Maximum overturning moment of G+9 structure

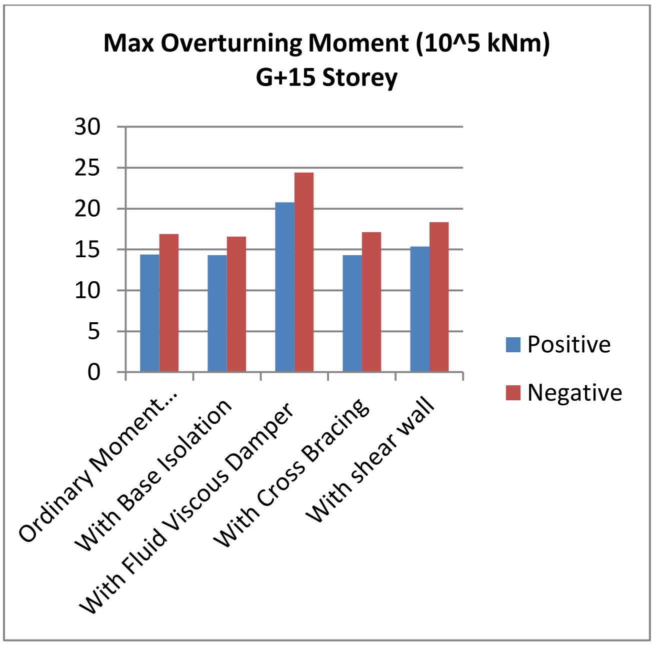



**Fig -10** Maximum overturning moment of G+15 structure

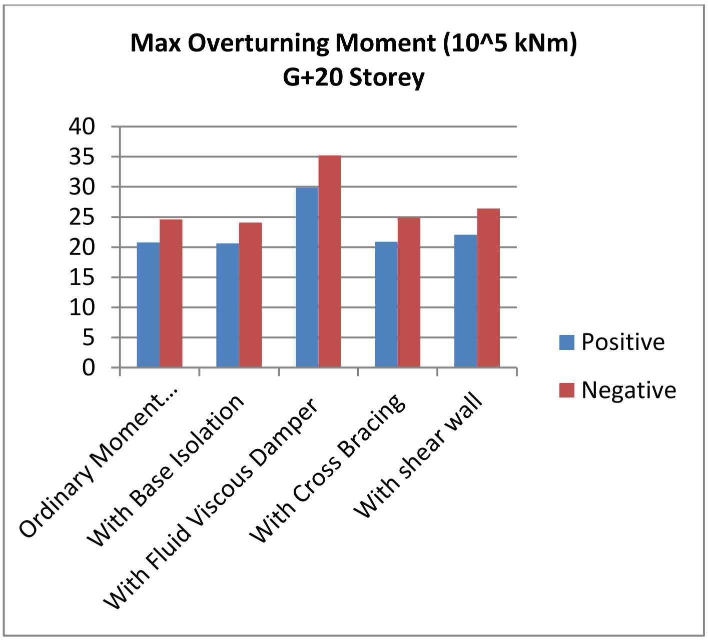



**Fig -11** Maximum overturning moment of G+20 structure

From above charts and graphs, we can clearly observe that, Storey overturning moments is maximum near the base and 1st storey of structure and gradually decreases to top of structure. There are two types of Overturning moments, positive and negative, considered in designing.

In ordinary moment resisting building, for G+9 structure maximum Overturning moments is 952.1*10^3 kNm, for 15 storey & for 20 stories, it is 937.1*10^3 kNm & 1322 *10^3 kNm respectively.

For G+9 storey structure with Base isolation, it decreases 1.85% ; for both G+15 and G+20 structure it decreases by almost 1%.

For G+9 storey structure with Fluid Viscous Damper, it increases 37.7% to 1322*10^3 kNm ; also in G+15 and G+20 structure, it increases 44.4% & 43.9% respectively.

For G+9 storey structure with Cross Bracing, it increases 2% to 9.72*10^3kNm ; for both G+15 and G+20 structure, it is increase by 1%..

For G+9 storey structure with shear wall, it increases 10.4% ; for G+15 and G+20 structure, it increases 8% & 7.4% respectively.

## 4. CONCLUSIONS

i. Maximum Storey shear decreases with increase in storey level.

ii. As compared to Ordinary Moment resisting structure, for G+9, G+15 and G+20 storey structure, the maximum reduction in maximum storey shear occurs in structure with Base isolation and then with Fluid Viscous Damper.

iii. There is increase in maximum storey shear in structure with shear wall and with cross bracing by about 76.2% and 41.8% respectively.

iv. Structure with Base isolation reduces 39.65% storey shear and is suitable out of other seismic resisting components on basis of maximum storey shear only.

v. Maximum Storey overturning moment decreases with increase in storey level.

vi. As compared to Ordinary Moment resisting structure, for G+9, G+15 and G+20 storey structure, the reduction in maximum storey overturning moment occurs only in structure with Base isolation.

vii. There is increase in maximum storey overturning moment in structure with shear wall and with cross bracing and with Fluid Viscous Damper by about 8 to 10% , 1 to 2% and 37.8% to 44.4% respectively.

viii. Structure with Base isolation reduces 1.5% to 1.85% storey overturning moment and is suitable out of other seismic resisting components on basis of maximum storey overturning moment only.

ix. As there is increase in storey overturning moment by about 37.7% to 44.4% in structure with shear wall position on corner of structure, this position of shear wall is not suitable in designing.

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