Evaluation of Seismic Effect Reduction Techniques using SAP

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Abstract— The design of any structure has been constantly updating with many innovations in structural engineering field. Even though the consequences of seismic force are unchanged, many seismic retrofitting measures have come into existence which can minimize the seismic effect. Some of those methods are utilized in this research work to study the behavior of buildings during Earthquake. As a matter of fact all the methods perform a similar task i.e. minimizing the vibrations of the building caused due to the earthquake by inducing enough amount of damping onto the building. The intention of this research work is to evaluate the efficiency of these methods and thereby declare the extent of seismic effect reduction for the design conditions and zone chosen. The methods considered for this study include the installation of Shear walls and Bracings. The efficiency of each method will be expressed through the building response under the seismic effect.

Keywords: Seismic Retrofitting, Shear walls, Bracings

I. Introduction

Destruction because of seismic force is inevitable but the effects of Earthquake can be reduced up to a certain extent. All the buildings undergo lateral and torsional deflections that cause a great damage to life and property. Various techniques have been reported till date to decrease the seismic effect on the buildings. All these techniques are collectively known as seismic retrofitting techniques. The objective of the Structural- Engineer must be to design a building with enough lateral resistance against all the lateral loads. The lateral force resisting system comprises of many methods such as implementation of bracings, usage of dampers, provision-of shear walls and base isolation techniques.

In this report a multi-storey building which is located in a highly Earthquake prone region is analysed using SAP software. The preliminary analysis-of the building will be carried out without any Seismic remedial measures and the total building-response in terms of maximum deflection, base shear, storey-shear and-story drifts are noted. After that, the building is analysed by employing the shear walls and bracings. The response plots of the building for the cases above specified are noted and the maximum building deflection is compared to know the efficiency-of each method. Whichever method leads to the minimum story-response of the building will be known at the end of this study.

A total-of four models are prepared. Model I is with shear walls. Model II is with the installation of bracings, Model III is with viscous-dampers and finally Model IV is the base-isolated-building with the help of rubber bearings. All the models are employed with the shear wall along with which the other types of seismic effect reduction techniques are used.

II. Objectives of the Proposed Study

- To check the structure with various seismic effect reduction techniques.
- To compare the outcome of the analysis of all models.
- To justify the most efficient method for seismic effect reduction.

III. Description of the Model

The model considered for the analysis is a G+6 residential building.

A. *Required-data:*

- Structure type = Multi-storey framed structure.
- Zone = V (Table 2, IS-1893 (part 1): 2002).
- Stories = Seven, (G+6).
- Floor-height = 3 m.
- Infill-wall = 230 mm and 150 mm.
- Imposed-load = 3.5 kN/m2.
- Materials = M 30 and Fe415.
- Size of columns = (230 mm× 450-mm) and (230-mm × 750-mm).
- Size of beams = (230 mm × 450-mm) and (230 mm × 300 mm).
- Slab-thickness = 130 mm thick.
- Specific weight of RCC = 25 k N/m3.
- Specific weight of infill = 20 kN/m3.
- Type of soil = Rock.

IV. Analysis using SAP 2000

The above defined sectional properties are assigned for the model using SAP 2000. The building is assigned with each of the seismic effect reduction techniques and analysed for the dynamic load cases.

A. *Model I (Bare frame with Shear wall)*

The frame model is generated as per the architectural plan and then the shear wall with a minimum reinforcement is defined as shell member. The thickness of the shear- wall will be 230mm and the grade of concrete used for shear wall is M30. HYSD 415 grade rebar is used as top and bottom reinforcement. The shear wall is placed in the exterior periphery of the building structure continuous from base to the top floor of the building. The function of the shear-wall is to cut off the lateral seismic and wind forces and to increase the building stiffness.

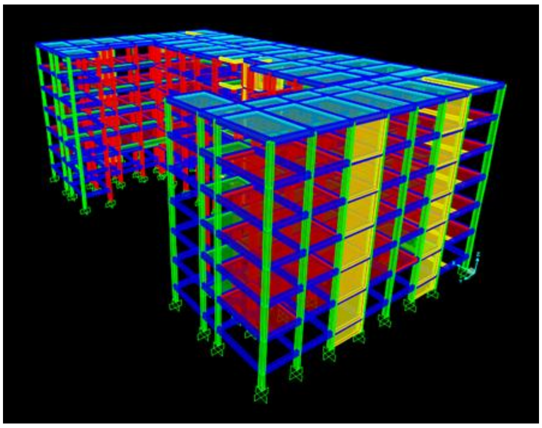

Fig. 1: Shear wall assigned to the building.

B. Model II (Bare frame with Shear wall + Bracings)

As per the literature review the efficient type of bracings are the X bracings. This consists of two steel members of L sections. The standard dimensions of the bracings such as thickness and flange dimensions are assigned. The efficiency of the bracings is based on the story displacements. In X bracings the two members of the bracing connect diagonally in between the joints of a frame, thus creating a stiff connection in between the frames. These two members absorb the seismic energy by yielding.

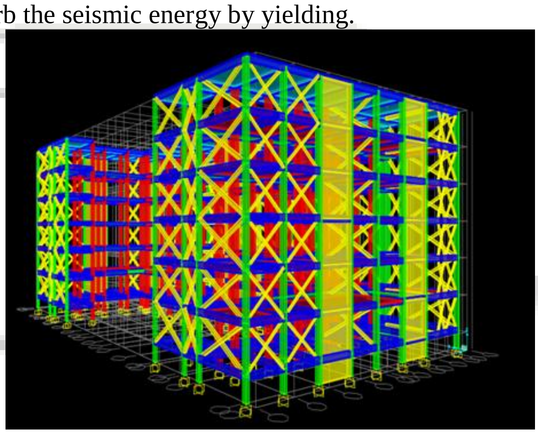

Fig. 2: Bracings assigned to the building.

V. Results and Discussions

The models are then Analyzed using the sap 2000 software and then the story responses are compared in order to evaluate the efficiency of the seismic effect reduction techniques.

A. Model I (Bare frame with Shear wall)

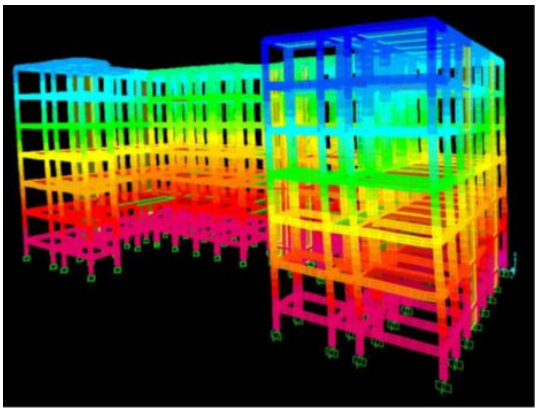

Fig. 3: Deflection due to dynamic FNA with Shear wall.

The Fig.3 indicates the deflection of the building employed with shear wall under the action of seismic load. The maximum horizontal displacement of the building recorded is 4.18mm. All the story responses under the action of seismic force are noted and represented graphically.

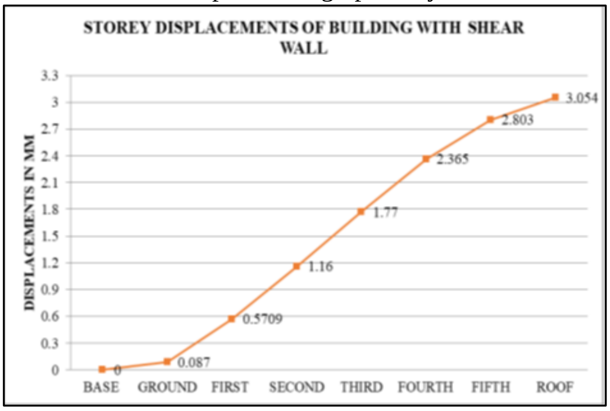

Fig. 4: Storey displacements of the model with Shear wall

The Fig.4 shows the story displacement values under the action of seismic force. The displacement values goes on increasing towards the top floor and the effect of lateral seismic force becomes maximum at the top of the building. In the later stages these values are compared for all other methods of seismic effect reduction techniques.

1) Storey displacements of the model with Shear wall

STOREYS	DISPLACEMENT
Base	0
Ground	0.087
First	0.5709
Second	1.16
Third	1.77
Fourth	2.365
Fifth	2.803
Roof	3.054

Table 1: Storey displacements of the model with Shear wall

2) Storey drifts of the model with Shear wall

STOREYS	DRIFT
Base	0
Ground	0.087
First	0.4839
Second	0.5891
Third	0.61
Fourth	0.595
Fifth	0.438
Roof	0.25

Table 2: Storey drifts of the model with Shear wall

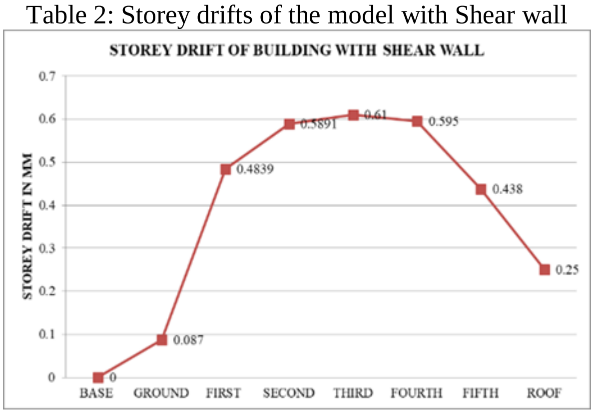

Fig. 5: Storey drifts of the model with Shear wall

The Fig.5 shows the story drift values of the building with shear wall. The story drift values are obtained by finding the difference between the story displacements of two consecutive floors of a building. From the graph we can see that the story drift tends to decrease towards the roof of the building.

3) Storey shears of the model with Shear wall

STOREYS	SHEAR IN KN
Ground	6921
First	6606
Second	6324
Third	6221
Fourth	5557
Fifth	4049.2
Roof	1846

Table 3: Storey shears of the model with Shear wall

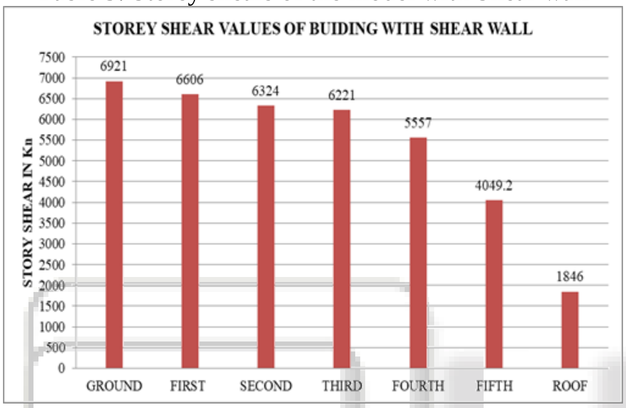

Fig. 6: Storey shears of the model with Shear wall

The Fig.6 shows the story shear values of the building. The story shear values are maximum at the base while compared to that of the top of the building. This will be a result of increased stiffness due to the addition of shear walls.

B. Model II (Bare frame with Shear wall + Bracings)

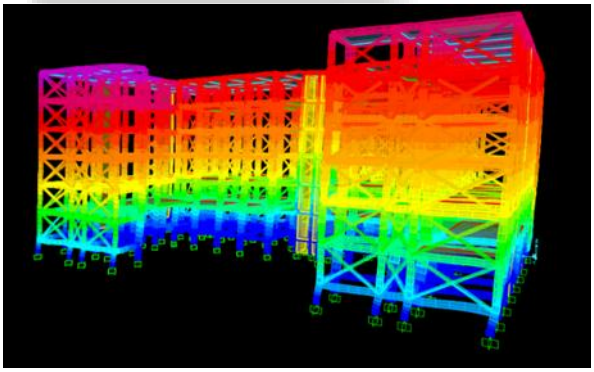

Fig. 7: Deflection due to dynamic FNA with Bracings.

The Fig.7 shows the deflected shape of the building with bracings under the action of seismic load. The bracings installed increase the overall stiffness of the building. The maximum-displacement of the building recorded is 1.47mm. All the story responses under the action of seismic-force are noted and represented graphically.

1) Storey displacements of the model with Shear wall and Bracings

STOREYS	DISPLACEMENT
Base	0
Ground	0.25
First	0.4032
Second	0.6051
Third	0.8102
Fourth	0.99
Fifth	1.13
Roof	1.22

Table 4: Storey displacements of the model with Shear wall and Bracings

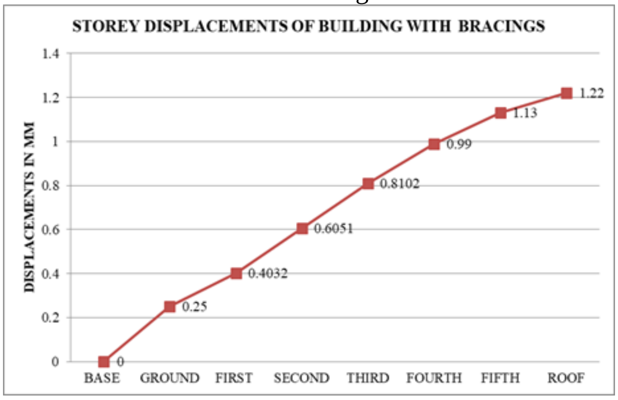

Fig. 8: Storey displacements of the model with Shear wall and Bracings.

The Fig.8 shows the story displacement values under the action of seismic force. The displacement values goes on increasing towards the top floor and the effect of lateral seismic force becomes maximum at the top of the building. But when compared to the storey displacement values of model I, the story displacement values of model II are less, which is a result of increased stiffness.

2) Storey drifts of the model with Shear wall and Bracings

STOREYS	DRIFT
Base	0
Ground	0.25
First	0.153
Second	0.201
Third	0.205
Fourth	0.17
Fifth	0.14
Roof	0.09

Table 5: Storey drifts of the model with Shear wall and Bracings

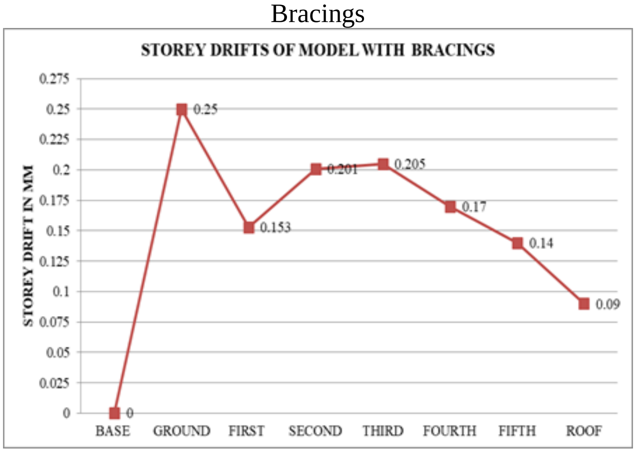

Fig. 9: Storey drifts of the model with Shear-wall and bracings.

The Fig.9 shows the story drift values of the building with shear wall and bracings. The story drift values are obtained by finding the difference between the story displacements of two consecutive floors of a building. Story drift is nothing but the relative movement between two floors. From the graph we can see that the story drift tends to decrease towards the roof of the building. The drift values are very low compared to the story drift values of building with shear wall.

3) Storey shears of the model with Shear wall and Bracings

STOREYS	SHEAR IN KN
Ground	3714
First	3242
Second	3142
Third	2411
Fourth	2146
Fifth	1574
Roof	607.54

Table 6: Storey shears of the model with Shear wall and Bracing

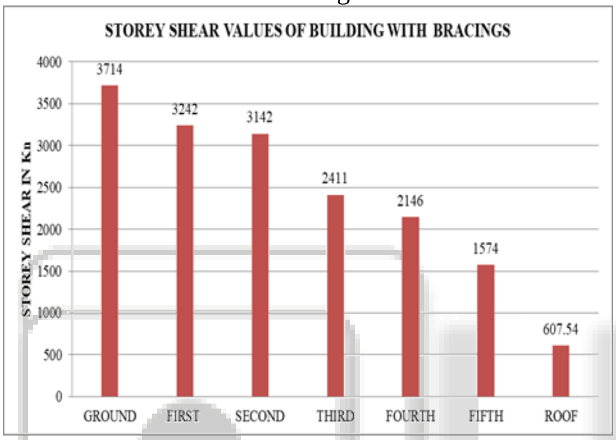

Fig. 10: Storey shears of the model with Shear wall and Bracings.

The Fig.10 shows the story shear values of the building. The story shear values are maximum at the base of the building while compared to that of the top of the building. The story shear values in this case are pretty maximum when compared to the previous case as the building gets stiffer. The increase in story shear values is evident that the building has gained enough resistance against the seismic force.

VI. CONCLUSIONS

There may be number of seismic effect reduction techniques used for the purpose of reducing the seismic damage of the building. But all of the methods are not of same efficiency and are not suitable for all kinds of seismic zones. This was an attempt to find out the best seismic effect reduction technique that can be utilized even in most earthquake prone region. From the analysis results it is evident that the total displacement of the building with bracings is less compared to that of the building with shear wall. The provision of the bracing to the building increases the stiffness of the building thereby reducing the horizontal movement of the building. The story drift values are also less compared to that of the building with shear walls. Finally the increase in the base shear values of the building with the bracings shows the seismic resistance gained by the building. Hence the building with bracings added to that of the shear wall performs well against the seismic force.

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