Response Reduction of Plan and Vertical Irregular Structures Using Dampers

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Abstract **- The structural response of a building is affected by the earthquake mainly depends on its configuration. These days' structures are constructed with irregularities for architectural views which show poor seismic performance. This project work deals with studying and analyzing the seismic response of RC structures having both individual and combined horizontal and vertical geometric irregularities. For this study G+10 storied "C" and "H" building models were considered. The models are provided with Fluid Viscous dampers and the enhancement in the seismic response is studied. These configurations are analyzed using the Response Spectrum Method, Time History method as per IS-1893 (Part-1): 2016 in Etabs 2019. Different dynamic parameters such as base shear, story drift and torsion response were evaluated and compared with models installed with dampers.**

Index Terms **- Fluid viscous damper, Irregularity, Response spectrum method, Structural configuration, Time history method.**

I.INTRODUCTION

Urbanization and modern architectural influence resulted irregularities in residential, commercial and multistoried buildings. The building is said to be irregular when the distribution of its mass, stiffness and strength varies along its configuration. It has been found that regular shaped buildings perform better while irregular structures show poor performance when subjected to earthquakes. Earthquakes are random in nature, unpredictable and devastating of all the natural disasters, which cause severe damages where both economic and loss lives occur. Most of the losses are due to building collapses and damages. To reduce these undesirable effects caused by the lateral forces on structures, different seismic resisting systems are to be incorporated. Base isolators are used as an effective way to mitigate earthquake damages. Though the idea appears to be acceptable, it is a very uneconomical, hence not a desirable. The use of energy dissipating viscous dampers without isolating the structure is the most effective alternative.

II. OBJECTIVE OF THE STUDY

The objectives of this study are as follows:

1. To model G+10 C and H shaped building models using finite element modeling.
2. To evaluate seismic response of these building models due to earthquake excitations.
3. Studying the seismic behavior of these building models with dampers.

III. LITERATURE REVIEW

1. Firoz Alam , Dr. Manju Dominic performed analysis and design of structural components of G+10 storey RCC building of different plan configurations like rectangular C L and I-shape. Results of the structure were analysed for maximum shear forces, bending moments and maximum story displacement and then compared for all the cases. They concluded that shear walls are one of the most reliable in resisting lateral forces in building elements during earthquake.
2. Yogita K. Kalambe, Sanjay Denge, had performed analysis on R.C.C buildings of plan irregularities using response spectrum method. They performed analysis on regular and irregular building in different seismic zones, evaluated different parameters by Linear static analysis and linear dynamic analysis. From the analysis of results, for the regular building displacement, peak story shear, base shear, max shear force and bending moment are maximum than irregular

models and T shape has minimum values than regular and C- shape models.

3. Zabihullah, Priyanka Singh and Mohammad Zamir Aryan have studied the Effect of Vertical and Horizontal Geometric Irregularities on the Seismic Response of Reinforced Concrete Structures. Along with a regular configuration, six number of irregular configurations were analyzed and compared using the Response Spectrum Method as per IS-1893 (Part-1): 2016. The compared all the models based on the Base shear, Fundamental period, Storey Stiffness, Lateral- displacement, Storey Drift, Eccentricity and Torsional irregularity. Their result showed that with individual irregularity, the horizontally irregular model (M-V) confirmed as the most susceptible during the considered earthquake and the vertically irregular model (M-III) observed to have a superior seismic performance. Among the building models with a combination of geometric irregularities, M-VII showed a better seismic performance. They concluded that the more asymmetric a building is, the more will be its eccentricity as well as torsional irregularity it's because, eccentricity functions as an arm for the torsion moment.
4. Siva Naveen E, Nimmy Mariam Abrahamb, Anitha Kumari S D (2019), had performed analysis on irregular structures under earthquake loading. Their study they modified a nine-storeyed regular frame by incorporating irregularities in various forms in both plan and elevation to form 34 configurations with single irregularity and 20 cases with combinations of irregularities. All the models are subjected to seismic loads and the response of the structures is computed numerically. Their results showed that irregularity considerably affects the structural response as in the way with combinations of irregularities mass, stiffness and vertical geometric irregularities has shown maximum response whereas with the combination of re-entrant corner and vertical geometric irregularities has shown less displacement response. They concluded that, the structural response depends on the type, location and degree of irregularity by taking care of these factors, designing of irregular structures can be done without compromising their performance.
5. Pradeep Pujar, Amaresh, has performed seismic analysis of plan irregular multi-storied building with and without shear wall in ETABS. In their work 3 types of structures are considered i.e. I shape, L-shape, C-shape of ten stories each. The analysis of structures is finished by Equivalent static technique with the assistance of E-tabs software. They analysed parameters such as story displacement, story drift and base shear of structures with and without shear wall. From the analysis of results, L-shape, C-shape structures with Shear walls are having great reaction or great outcomes in base shear, story drift and displacement. They concluded, building gives better execution by utilizing the shear wall in it for opposing seismic tremor while comparing with bare frame building.

IV.METHODOLOGY

Modeling and analysis of various structures is done by finite element package ETABS. Linear dynamic analysis i.e., Response spectrum method and Time history method is carried out on building models. Time history analysis of the building models are carried out using the ELCENTRO earthquake ground motion data. Dampers are modeled using link property and installed to the building models. Comparison had been done based on parameters Storey drift, Base shear and Torsion response for models with and without dampers.

V. TYPES OF BUILDING MODELS CONSIDERED FOR THE STUDY

The building models considered for the study are ordinary moment resisting reinforced concrete space frames of G+10 storey with irregular plan and vertical configurations. The analysis is carried-out on two different asymmetric shaped buildings of C and H using ETABS software. The plan and isometric views of the buildings are shown below.

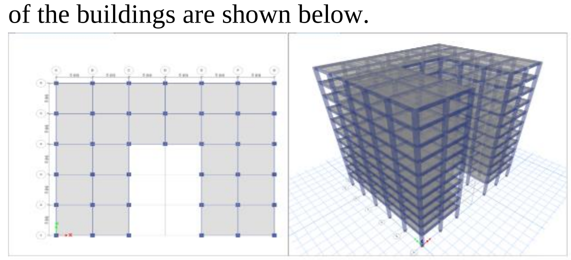

Fig:1. Plan and Isometric view of C shaped building

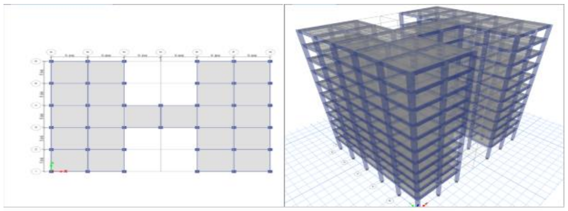

Fig:2. Plan and Isometric view of H shaped building

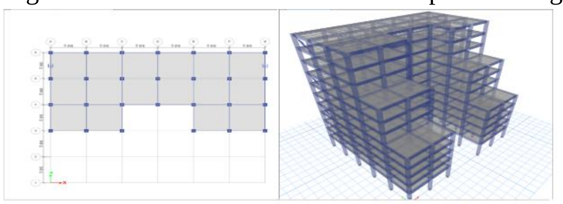

Fig 3: C- shaped building with plan and vertical irregularity

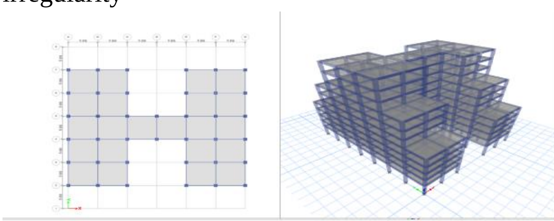

Fig 4: H- shaped building with plan and vertical irregularity

VI. GEOMETRICAL PARAMETERS OF THE BUILDING

The load calculations has been taken according to IS-875 (Part 1) and the live load consideration in loads according to IS-1893 (Part 1): 2002 i.e. 25% of the live load has to be considered if the LL < 3 KN/m2.

- Floor height of each storey: 3m
- Materials: M35 and Fe 550
- Size of Beams: 450 x 450
- Size of columns: 600 x 600
- Depth of slab: 150 mm
- Live load: 4.0KN/m^2
- Wall load: 12, 6 KN/m
- Floor finish: 1.5 KN/m^2
- Seismic zone: II
- Zone factor: 0.10
- Importance factor: 1
- Response Reduction Factor: 3
- Type of structure: Moment resisting frame

VII. RESULTS AND FINDINGS

A parametric study is done to find the effectiveness of Fluid viscous dampers in the structures with varying irregularities due to earthquake excitation. The design parameters such as base shear, story drift and torsion response are obtained from the analysis results. The results are showed changes in parameters for different analyzed cases.

	EQx	EQy
Storey Drift	0.0207	0.0191
Base shear(KN)	1382.571	1372.29
Torsion Response	1.036	1.00

Table:1 Dynamic response of Regular C shape building

	EQx	EQy
Storey Drift	0.0210	0.0198
Base shear(KN)	1383.86	1426.08
Torsion Response	1.078	1.00

Table: 2 Dynamic response of structure with single damper at top story

	EQx	EQy
Storey Drift	0.0219	0.0188
Base shear(KN)	1294.401	1367.681
Torsion Response	1.560	1.00

Table: 3 Dynamic response of C shaped irregular structure

	EQx	EQy
Storey Drift	0.0220	0.0183
Base shear(KN)	1281.036	1345.150
Torsion Response	1.249	1.00

Table 4 Dynamic response of C shaped irregular structure with 3 dampers

	EQx	EQy
Storey Drift	0.0205	0.0197
Base shear(KN)	1309.863	1365.130
TorsionResponse	1.00	1.00

Table 5 Dynamic response of H shaped structure

	EQx	EQy
Storey Drift	0.0192	0.0179
Base Shear(KN)	1218.742	1236.505
Torsion Response	1.001	1.002

Table 6 Dynamic response of H structure with damper at top story both directions

	EQx	EQy
Storey Drift	0.0193	0.0179
Base Shear(KN)	1634.227	1742.015
Torsion Response	1.00	1.00

Table 7 Dynamic response of H structure with irregularities in plan and elevation

	EQx	EQy
Storey Drift	0.0181	0.0160
Base Shear(KN)	1484.044	1535.674
Torsion Response	1.001	1.002

Table 8 Dynamic response of H shaped irregular structure with dampers at top floor in both directions

VIII. RESULTS AND DISCUSSIONS

After analyzing the Reinforced concrete C and H shaped regular and irregularity buildings of ten story high using both Response Spectrum method and Linear Time History Analysis with and without fluid viscous dampers , the results obtained for base shear, storey drift, torsion response in two perpendicular directions are tabulated in Tables. The studies are carried-out with and without dampers. The result showed in the tables listed above clearly shows the use of dampers in reduction of different dynamic parameters during seismic activity. The list of observations made from above tables are as given below.

6.1 Comparison of C shaped regular building with and without damper

1. The base shear for C shaped regular building in Y-direction was found to be reduced by 4% by placing a single damper at top story corner using Response Spectrum method and Time history method.
2. The magnitude of torsion response reduced by 3.89% in X-direction by placing a single damper at corner of top story.).
3. Story drift reduced by 2% and 3.5% in X and Y directions respectively with use of single damper at top story corner.
4. Base shear increased by 20% and 5% in X and Y directions respectively when dampers are placed on alternate floors along X direction.
5. Story drift and torsion decreased by 29% and 4.8% and increased by 6% and 2% respectively when dampers are placed on corners at alternate stories along X direction.
6. The magnitude of base shear increased by 5.27% and 19% respectively in X and Y directions when dampers are placed in Y direction with alternate floor corners.
7. The max story drift and torsion increased by 4.9% and 4.8% and decreased by 27.7% and 27% respectively in X and Y directions when dampers are placed across corners in X direction at alternate floor .
8. The magnitude of base shear increased by 2.7%, 17% and 19%, 2.5% in X and Y directions respectively when dampers are placed at mid-section in Y and X directions.
9. The max story drift decreased by 2.7% and 22% when dampers are placed in mid section at alternate floors in Y direction. Whereas drift decreased by 16% and increased by 3% when placed along X direction.
10. Torsion increased by 1.46% and 1.25% in X direction when dampers are placed at mid section at alternate floors in Y and X direction respectively.
11. Base shear and Drift increased by 1.07%, 14.25% and 1.4%, 6.6% respectively when a single damper is placed in mid section both sides alongY direction.

6.2 Comparison of C shaped irregular building with and without dampers

1. Torsion response reduced by 9.9% in X direction when 3 dampers are placed in Y directions at different floor levels.
2. The magnitude of base shear increased by 4.07% ,12.14% and 4.4%, 15.8% respectively in X and Y directions when dampers are placed at alternate floors along Y direction corners and mid section.
3. The max story drift and torsion values decreased by 2.2%, 14% and 8.97%, 0% in X and Y directions when dampers are placed along Y direction across alternate floors.
4. Story drift decreased by 18% when damper is placed in mid section across alternate floors along Y direction.
5. The base shear decreased by 4.3% in Y direction and 2.4% and 5.1% along X and Y directions when dampers are placed at mid section top bottom floors.
6. The max story drift reduced by 4.7% and 5.3% in Y direction when a single damper is placed along top and bottom stories mid section individually.

6.3 Comparison of H shaped regular building with and without dampers

1. The magnitude of base shear is increased by 5.2%, 19.27% and 21%, 5.2% respectively in X and Y directions when dampers are placed along alternate floors in Y and X directions.
2. The max story drift reduced by 28.7% and increased by 6.6% respectively in X and Y directions when dampers are placed on alternate floors along X direction..
3. Torsion response increased by 1.5% and 2.05% respectively in X and Y directions when dampers are placed on alternate floors along Y and X directions.
4. Story drift increased by 6.3% and decreased by 28% respectively in X and Y directions when dampers are placed on alternate storey along Y direction. (table 5.12).
5. The magnitude of base shear and torsion response increased by 24%, 26.9% and 5%, 2% respectively in X and Y directions when dampers are placed on alternate floors along both directions.
6. The value of max drift decreased by 29% and 25% respectively in X and Y directions when dampers are placed on alternate floors along both directions.
7. The magnitude of base shear and the value of max story drift reduced by 6.9%, 9.5% and 6.3%, 9.1% respectively in X and Y directions when damper are placed on top floor in both the directions.

6.4 Comparison of H shaped irregular building with and without dampers

1. The magnitude of base shear increased by 2%, 11.6% and 15.6%, 4.2% respectively in X and Y directions when dampers are placed on alternate floors along X and Y directions.
2. The value of max drift decreased by 21.7% and increased by 25% respectively in X and Y directions when dampers are placed on alternate floors along X direction.
3. The max story drift increased by 3% and decreased by 13.4% respectively in X and Y directions when dampers are placed on alternate floors along Y direction.
4. Base shear is increased by 4.27%, 26.8% and 21.5%, 4.2% respectively in X and Y directions when dampers are placed along corners of stories in Y and X directions.
5. The max drift is increased by 4.9% and 26.8% respectively in X and Y directions when dampers are placed along corners of stories in Y direction.
6. Torsion response increased by 1.8% and 4.03% respectively in X and Y directions when dampers are placed along corners along Y and X directions.
7. The magnitude of base shear and torsion response increased by 27.7%, 30% and 5.2%, 4% respectively in X and Y directions when dampers are placed along corners in both directions.
8. The max story drift decreased by 24.8% and increased by 24.5% respectively in X and Y directions when dampers are placed along corners in both directions.
9. The magnitude of base shear decreased by 9.1% and 11.8% respectively in X and Y directions when dampers are placed along both the corners on top story.
10. The value max story drift decreased by 6.2% in X direction when dampers are placed along both the corners on top story.

IX. CONCLUSIONS

Based on the studies carried out on different C and H shaped buildings with and without dampers the following conclusions are made:

1. With the introduction of the Fluid viscous damper for a building, the magnitude of base shear and torsion response are found to reduce by 4% and 4.45% respectively in Y and X directions for C-shaped building.
2. The twisting of C irregular building about vertical axis due to torsional irregularity has been reduced by 19.9% and it is in the limits as per code.
3. The magnitude of base shear and the value of max story drift reduced by 6.9%, 9.5% and 6.3%, 9.1% respectively in X and Y directions when damper are placed on top floor of H shaped building in both the directions.
4. The max story drift decreased by 24.8% and increased by 24.5% respectively in X and Y directions when dampers are placed along corners in H shaped irregular building in both the directions.
5. The magnitude of base shear decreased by 9.1% and 11.8% respectively in X and Y directions when dampers are placed along both the corners

on top story corners in H shaped irregular building in both the directions.

Based on the conclusions, the present study clearly shows that there is a substantial reduction of base shear, Torsion response and story drift in tall irregular buildings due to seismic activity especially in the direction of weak axis, with the introduction of dampers.

X. CLOSURE

1. In the present study the analysis is done with Linear Time History analysis, but the true behavior of the structure is noticed only when the Non-linear properties of the materials of construction are considered.
2. With increase in irregularity in building, the eccentricity will be increased which in turn increases torsional irregularity as well.

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