

Analytical Study on Horizontal and Vertical Irregularity in Structure under Seismic Load with Shear Wall and Bracing

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Abstract

In present scenario most of the buildings damage due to the torsional irregularity in structure. Torsional effects are nothing but the twisting moment induced in the structures. In high-rise structure torsion may occurs due to different reasons, such as mass inequality, different geometrical configurations, uneven stiffness and strength etc. Two types of irregularity are available in structures namely horizontal and vertical irregularity. The Symmetric structures are less affected by torsion or it's out of accidental damages. In this study to understand the behaviour of torsion create in the structure under the effect of earthquake loads. Consider G+20 storied RC frame structures which have both horizontal and vertical irregularity. The Response spectrum analysis is carried out for building analysis by using Etab2015 software. The main objective of this work is to prevent torsional irregularity by providing shear wall and bracing member. To compare and analyze the model in various structural parameters like story displacement, story drift, story shear and torsional irregularity for each floor level.

Keywords: Horizontal irregularity, Vertical irregularity, Torsional irregularity, Shear wall, Bracing.

1. Introduction

Earthquake is nothing but shaking of earth's surface to release of energy in the lithosphere to form seismic waves. These waves caused damages of building cracks, faults and sudden collapse structure due to earthquake. The structure having discontinuity in mass, geometry, stiffness and strength are termed as an irregularity in structure. The structural irregularity developed in structure will reduced the seismic performance of buildings. Due to certain irregularity, the structures against ground motion is torsional unbalanced to introduced displacement and high lateral forces which can causes damage and most of time collapse structure. Because of that reasons most of structures avoid the irregularity in construction. But present scenario, need and demand of the latest generation and increasing population has made the architects or engineers inevitable towards planning of irregular structures.

1.1 Structural Irregularity

In structure as per requirement provided different geometry, mass distributions, stiffness and strength will caused to failure structure under seismic loads. Two most important terms are responsible for the torsional effects induced one of centre of mass and other centre of rigidity. The seismic loads act as centre of mass and resisting forces behave as a centre of rigidity. The torsion created in structure when the mass centre and centre of rigidity are not on same place. The eccentricity means distance between two points by increases the structure will unbalance and it forces to twist around the rigid section. When the structure is responsible to resists lateral forces that time small displacement takes place in section. The following figure.1.1 to shows the torsional effect in structure under seismic loads.

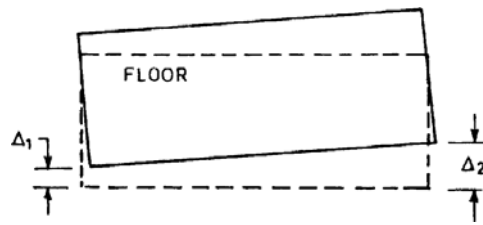


Fig 1.1: Torsional Irregularity

In Plan Irregularity, refer to discontinuous geometric configuration and horizontal resisting elements like diaphragms, larger opening, out cuts, re-entrant corners, etc. and induced torsion in structure. The elements that are responsible for vertical irregularity forms in the structure are stiffness, mass, geometry, strength, etc. The solution to this problem, the lateral resisting member like the shear wall, bracing, etc. are inserted in the structure to resist lateral forces.

Shear wall is especially important in high rise building which resists wind load and seismic loads. Bracing is a frame structural member to connected pin joint between the column and beam. Bracing is in the form of steel frame and has various types of sections like single diagonal, double diagonal, X braced and K braced etc.

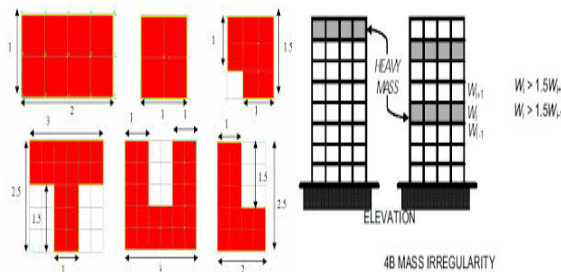


Fig 1.2: Plan Irregularity

Fig 1.3: Vertical Irregularity

3. Objective and Scope

3.1 Scope of Work

Based on the gaps found in the literature review:

- To understand the behaviour of structure considering both horizontal irregularity and vertical irregularity in the model.
- The carry out a comparative study of centre located shear wall and single diagonal bracing used in structure.
- To calculate various structural parameters like storey displacement, story shear, storey drift and torsional irregularity.

3.2 Objective of Work

The main objective of work to reduced torsion irregularity in a structure under seismic loads. Also to study the effect of both horizontal and vertical irregularity in the structure model during earthquake loading acts. The following points were studied.

1. Analysis of G+20 storied RC framed structure having both irregularities under the seismic loads.
2. To prepare model having horizontal and vertical irregularity which will be analyzed with centre located shear wall and single diagonal bracing.
3. To evaluate the performance of the model by Response spectrum Analysis by using ETAB software.
4. To obtained result in various structural parameters like story displacement, story shear, story drift and torsional irregularity for each floor level.

4. Methodology

In this project were the analysis of G+20 storied building under seismic loads carried out using Response spectrum method. To resists torsional irregularity from the model by inserting lateral resisting member in a structure like a shear wall, bracing.

The response spectrum is a linear dynamic analysis method to evaluate of maximum responses related to acceleration, velocity and displacement under performance of ground motion. The response spectrum analysis method is useful for approximate evaluation of seismic reliability of the structure. This method being time consuming and tedious process and it is computer based application. The analysis is carried out on the ETAB 2015 software name as “Extended 3D Analysis of Building Structure” Software.

5. Problem Statement

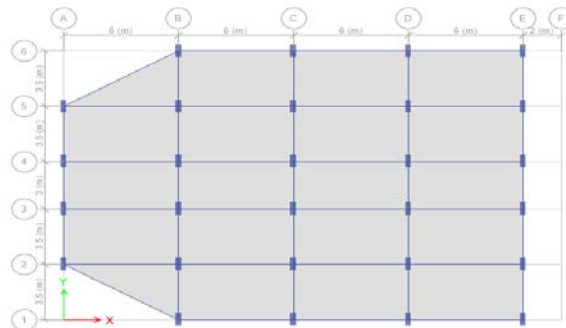


Fig 5.1: Typical floor Plan

In this present study, the structures have both horizontal irregularity and vertical irregularity. Consider G+20 storied building structures with the irregularity of mass, shape, dimensions and structural properties. The solution to this problem to use structural member place in a model like shear wall and bracing. In this study consider three models having the same dimensional properties of building G+20 with height 63m.

Model 1 – Frame Structure

Model 2 – With Shear Wall

Model 3 – With Single Diagonal Bracing

Plan Dimension: 26m X 17m

Column size: 300mm X 800mm, 300mm X 700mm, 300mm X 600mm

Beam size: 300mm X 600mm, 300mm X 500mm, 300mm X 450mm

Grade of Concrete: M30 for column, M25 for beam

Grade of Steel: Fe415

Soil Type: Medium (Type II)

Type of Zone: Zone V

Following are the building load configurations as per IS 875 Part 1, 2:1987 shown in Table 5.1.

Table 5.1: Load Configuration

Description	Loading
Live load	3 kN/m ²
Dead load	1 kN/m ²
Floor Finish load	1 kN/m ²

Followings are the primary load cases considered for the analysis of building:

- Dead Load
- Live Load
- Floor Finish Load
- Earthquake load in the X- direction
- Earthquake load in the Y- direction

6. Results

The Response Spectrum Analysis is carried out using ETAB software. The results are obtained in the various parameters like storey displacement, drift, shear and torsional irregularity which are being presented below in graphical form.

6.1 Storey Displacement

-Model 1

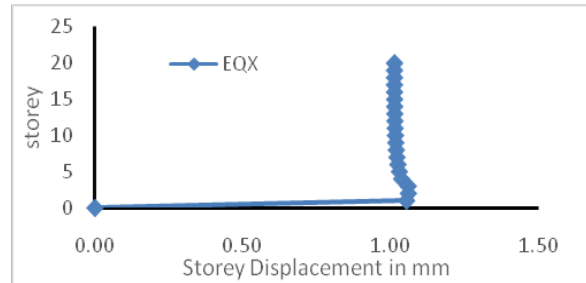


Fig 6.1: Storey Displacement in X

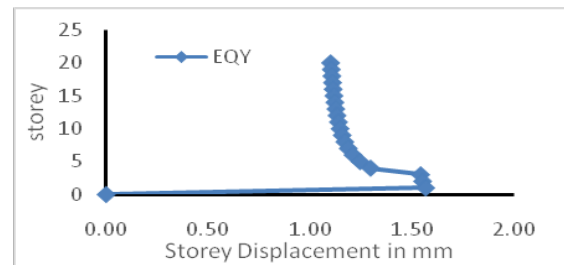


Fig 6.2: Storey Displacement in Y

From the above figures for Storey displacement in model 1 are 1.0618mm and 1.5644mm in X and Y direction respectively.

- Model 2

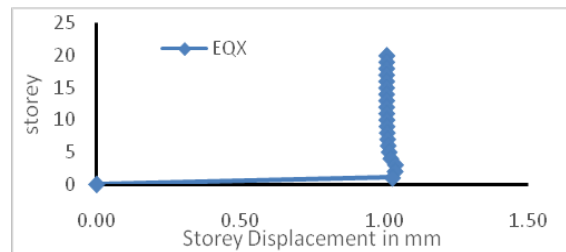


Fig 6.3: Storey Displacement in X

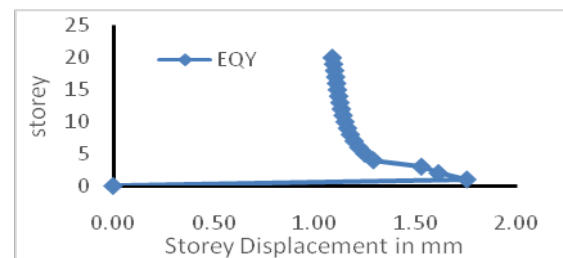


Fig 6.4: Storey Displacement in Y

From the above figures for Storey displacement in model 2 is 1.0373mm about X direction and 1.7516mm in Y direction. Compare with model 1 of 2.31% reduction of displacement in the X direction and 12% in the Y direction.

-Model 3

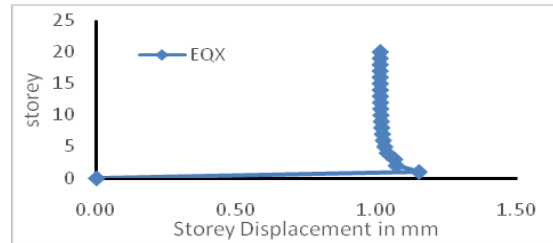


Fig 6.5: Storey Displacement in X

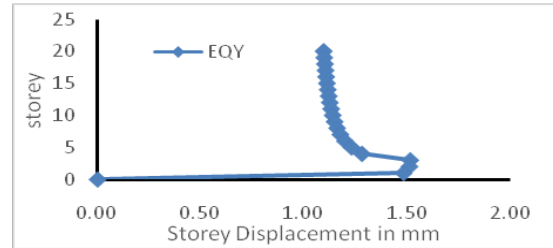


Fig 6.6: Storey Displacement in Y

From the above figures for Storey displacement in model 3 is 1.1517mm about X direction and for displacement of 1.5146mm in Y direction. Compare with model 1 of 8.46% and 3.18% reduction of displacement in X and Y direction respectively.

6.2 Storey Drift

-Model 1

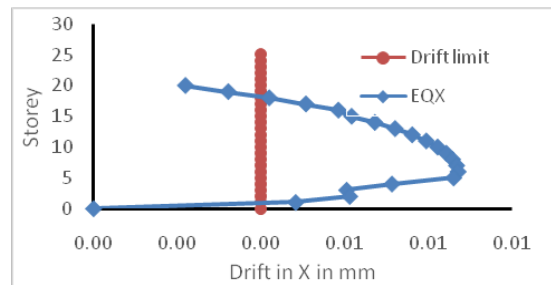


Fig 6.7: Storey Drift in X

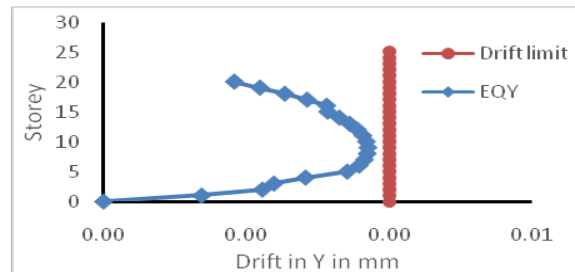


Fig 6.8: Storey Drift in Y

From figure 6.7 for Storey drift in model 1 is 0.0087mm about X direction and from figure 6.8 for a drift of 0.0037mm in Y direction.

Model 2

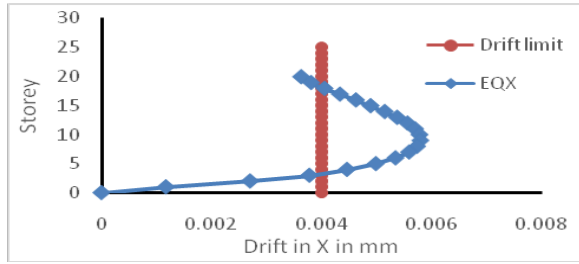


Fig 6.9: Storey Drift in X

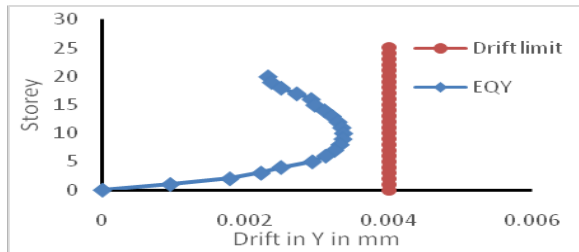


Fig 6.10: Storey Drift in Y

From figure 6.9 for Storey drift in model 2 is 0.0058mm about X direction and from figure 6.10 for a drift of 0.0034mm in Y direction. Compare with model 1 of 33.33% and 8.11% reduction of drift in X and Y direction respectively.

-Model 3

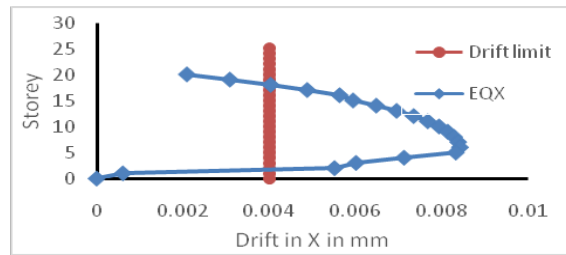


Fig 6.10: Storey Drift in X

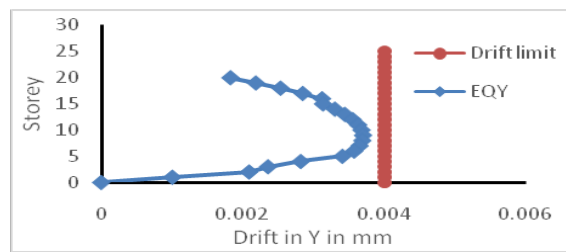


Fig 6.11: Storey Drift in Y

From the above figures for Storey drift in model 3 is 0.0084mm and 0.0037mm about X and Y direction respectively. Compare with model 1 of 3.44% reduction of drift in the X direction. No reduction of drift in the Y direction when compared with model 1.

6.3 Storey Shear

-Model 1

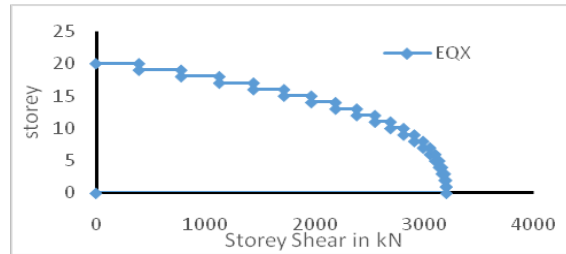


Fig 6.12: Storey Shear in X

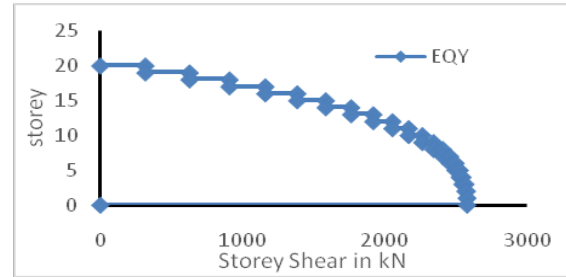


Fig 6.13: Storey Shear in Y

From the above figures for Storey shear in model 1 is 3201.33kN and 2579.62kN about X and Y direction respectively.
-Model 2

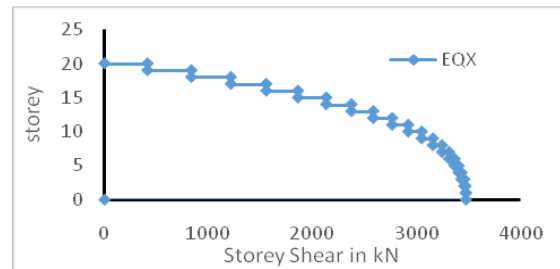


Fig 6.14: Storey Shear in X

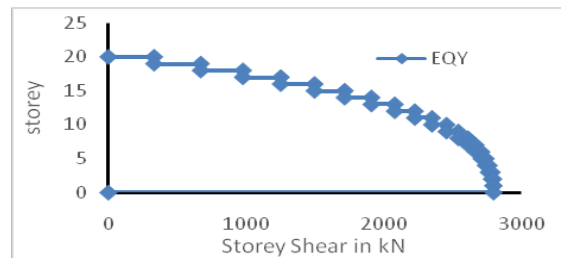


Fig 6.15: Storey Shear in Y

From the above figures for Storey shear in model 2 is 3468.18kN and 2794.65kN about X and Y direction respectively.
Storey shear reduced by 8% in the X direction and 8.33% in the Y direction when compared with model 1.
-Model 3

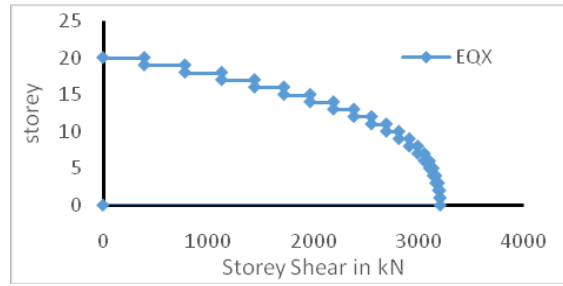


Fig 6.16: Storey Shear in X

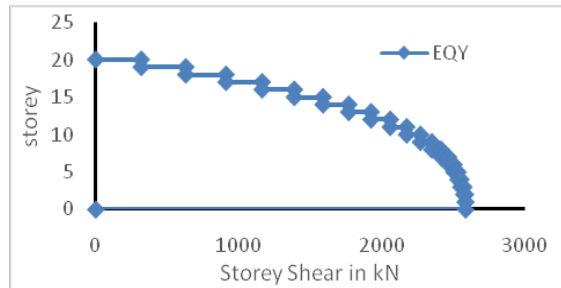


Fig 6.17: Storey Shear in Y

From the above figures for Storey shear in model 3 is 3205.60kN and 2583.08kN about X and Y direction respectively. Storey shear reduced by 0.13% in X and Y direction when compared with model 1.

6.4 Torsional Irregularity -Model 1



Fig 6.18: Torsional Irregularity in X and Y direction

From figure 6.18 shows Torsional Irregularity in model 1 of 1.1320 ratios in the X direction and 3.660 ratios in the Y direction.
-Model 2

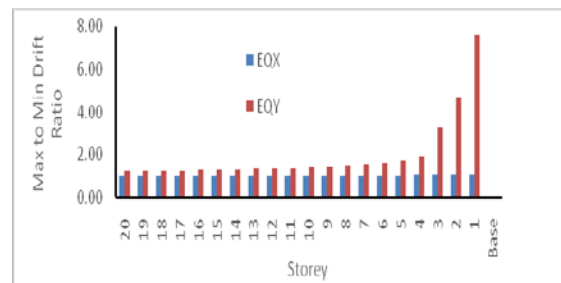


Fig 6.19: Torsional Irregularity in X and Y direction

From figure 6.19 shows Torsional Irregularity in model 2 of 1.0777 ratios in the X direction and 7.600 ratios in the Y direction. Torsional irregularity result compares with model 1 reduced of 5% and 1.5% in X and Y direction respectively.

-Model 3



Fig 6.20: Torsional Irregularity in X and Y direction

From figure 6.20 shows Torsional Irregularity in model 3 of 1.3300 drift ratio in the X direction and 3.1140 drift ratios in the Y direction. Torsional irregularity result compares with model 1 reduced by 18% and 5% in X and Y direction respectively.

7. Conclusions

Based on result and discussion the following conclusion is made:

- The storey displacement is reduced when the shear wall used as lateral resisting member in the structure. It gives good result compared with the bracing system.
- Similarly, the small 8.47% reductions in storey shear are observed when lateral resisting member like a shear wall and bracing is used in a structure system.
- The torsional irregularity is reduced by providing the shear wall and bracing to resist lateral earthquake force.

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