Role of Position of Shear Wall in Reducing Torsion & Storey Displacement in an Irregular Building

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Abstract- The paper elaborates the study of effects of location of shear wall in an irregular shaped building. The main concerned issue is the generation of torsion in a building which is irregular in plan. The paper points out the causes, effects and solution of the torsional forces in an irregular shaped building. The study is done on an 'L' shaped building which G+10 storied and is located in Seismic Zone IV exhibiting medium soil conditions and a damping of 5%. The modelling and analysis will be performed by using CSI ETABS ver.16. Dynamic Analysis is conducted in order to study the topic. The paper will finally point out the reasons for choosing a particular test model which exhibits lowest torsion and storey displacement.

Keyword: Centre of Rigidity, Centre of Mass, Nepal Earthquake 2015, Time History Data, Response Spectrum Data.

I. INTRODUCTION

Multistorey Buildings have become a necessity rather than an infrastructure icon for urban area in present time. The obvious reason for this is rapid increase in population and lack of available land for development in the city. Because of such high demand of the high rise building, the most important point to be considered is the safety of the building. As it is well known that the high rise structures are subjected to risk regarding lateral forces. Any numbers of examples from the past can be quoted which states that, how much damaging can these risks are. Clause 7.1 of IS 1893:2016 (Part -1) clearly identifies the buildings under various categories such as regular, irregular etc. Since we are concerned with torsion in building, it is important to note that the torsional forces are dominant in irregular building. The main reason for this is as follows –The building structure consists of two major points which are Centre of Mass and Centre of Rigidity. On one hand, centre of mass represents the point where the whole mass of the building is assumed to be concentrated and on the other hand centre of rigidity is the point at which the storey shear will act causing only displacement and not torsion when subjected to seismic forces. In a regular shaped building these points naturally coincides at one another. Unlike the regular shaped buildings, in irregular shaped buildings, the centre of mass and centre of rigidity get separated by certain eccentricity. This can be easily seen in Fig. 1.1. The more is the eccentricity, the more severe is the torsion forces due to lateral disturbances.

II. ROLE OF SHEAR WALL

Shear Walls are the planer structural elements which impart lateral stiffness or rigidity to the structure. With the introduction of lateral stiffness, shear wall in a building causes a reduction in lateral displacement. But the merit of shear wall lies in its position.

Fig. 1.1 Damage in a structure due to torsion
(Source: www.taxonomy.openquake.org)

Fig. 2.1 Shear Wall
(Source: www.constructionworld.com)

Thus one has to control the centre of rigidity in order to control the torsional forces in a building. Here comes the role of shear wall.

III. STUDY OF THE TOPIC IN TEST MODELS

For studying the role of shear wall in a reducing the torsion force and lateral displacement in an irregular building, a bare frame model along with five other test models are considered.
The test models are used for dynamic analysis for the following cases—

1. **Response Spectrum Analysis** – As per the Indian Standard, Clause 7.7.5 of IS 1893:2016 (Part-1) using Fig. 2 regarding acceleration coefficient curve at 5% damping and medium stiff soil.

![Fig. 2.2 Source- Fig. 2 of IS 1893:2016 (Part-1)](image)

2. **Time History Analysis** – As per the data of earthquake in Kathmandu, Nepal in 2015.

![Fig. 2.3 Time History Data of Nepal Earthquake (Source- [2])](image)

**IV. GEOMETRICAL DETAILS OF THE TEST MODELS**

| Sr. No. | PARTICULARS       | DETAILS          |
|---------|-------------------|------------------|
| 01      | Beam Details      | 300 x 450 (in mm)|
| 02      | Column Details    | 300 x 700 (in mm)|
| 03      | Thickness of Shear Wall | 230 mm |
| 04      | Depth of Foundation | 2.6 m |
| 05      | Floor to Floor Height | 3 m |
| 06      | Maximum No. Of Shear Wall Panels | 25 |

**V. LOADING DETAILS**

The loading of the test models is kept similar for the sake of simplicity in comparative study.

**TABLE 5.1**

| Sr. No. | PARTICULARS     | DETAILS                  |
|---------|----------------|--------------------------|
| 01      | DEAD LOAD      |                          |
|         | • Wall Load    | 6.9 kN/m                 |
|         | • Floor Load   | 2 kN/m²                  |
|         | • Parapet Load | 3.5 kN/m                 |
| 02      | LIVE LOAD      |                          |
|         | • Floor Load   | 3 kN/m²                  |
|         | • Terrace Load | 1 kN/m²                  |
| 03      | SEISMIC LOAD   | Auto-generated as per IS 1893:2002 for Response Spectrum |

**VI. MODEL LAYOUT**

The red lines in the models denote the position of shear wall in the structure.

![Fig. 6.1 Assumed Direction](image)

![Fig. 6.2 BARE FRAME ‘L’ SHAPED](image)

![Fig. 6.3 MODEL 01 ‘L’ SHAPED](image)
VII. COMPARATIVE STUDY

STOREY DISPLACEMENT

| Model   | X Direction (in mm) | Y Direction (in mm) |
|---------|---------------------|---------------------|
| Bare Model | 63.07               | 48.7                |
| Model 01 | 35.92               | 27.31               |
| Model 02 | 22.68               | 41.6                |
| Model 03 | 24.52               | 24.23               |
| Model 04 | 28.16               | 21.9                |
| Model 05 | 19.52               | 18.06               |
| Model 06 | 24.15               | 22.98               |

Fig. 7.1 Maximum Storey Displacement from Response Spectrum Analysis
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Fig. 7.2 STOREY SHEAR from Response Spectrum Analysis

Fig. 7.3 Maximum Joint Displacement from Time History Analysis

Fig. 7.4 BASE FORCE from Time History Analysis

Fig. 21 ECCENTRICITY (in mm)
VIII. RESULT

The comparative study was carried out in order to study the role of shear wall in reducing the torsion and lateral displacement. On conducting the study at the mentioned models, we got MODEL 06 to be the best in reducing the torsional forces due to eccentricity and lateral displacement.

![Fig. 8.1 MODEL 06 ‘L’ SHAPED](image)

IX. CONCLUSION

On a conclude note, I would like to mention the following points regarding the role of shear wall in reducing the torsion and lateral displacement in the building –

1. The position of the shear wall in Dual System should be such that, it generates minimum eccentricity between centre of mass and centre of stiffness.
2. Avoid the inclusion of soft stories in the high rise building because it will cause concentration of stress and thus failure in the extreme conditions
3. The strength of the structural members is more important than structural stiffness because this is more effective in controlling drift.

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