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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.

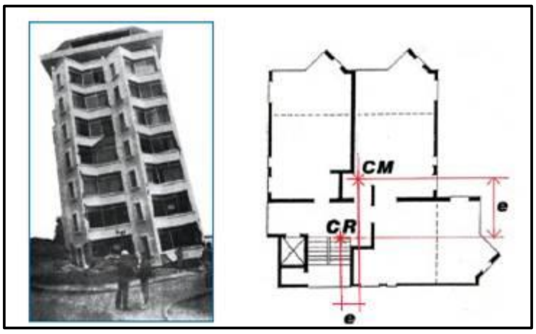

Fig. 1.1 Damage in a structure due to torsion
(Source: www.taxonomy.openquake.org)

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.

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

From the point of stability, one must place the shear wall in building in such position which in turn does not cause eccentricity between centre of mass and centre of stiffness. This is the reason for development of torsion forces in the building. In a nutshell, shear wall is a boon for structures only if it does not impart torsion in the building.

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.

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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.

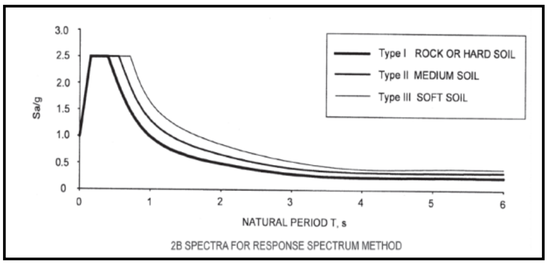


Fig. 2.2 Source- Fig. 2 of IS 1893:2016 (Part-1)

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

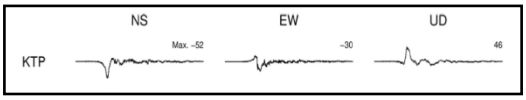


Fig. 2.3 Time History Data of Nepal Earthquake (Source- [2])

IV. GEOMETRICAL DETAILS OF THE TEST MODELS

TABLE 4.1

Sr. No.	PARTCULARS	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
05	Storeys	G+10
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 ▪ Floor Load ▪ Parapet Load	 6.9 kN/m 2 kN/m^2 3.5 kN/m
02	LIVE LOAD ▪ Floor Load ▪ Terrace Load	 3 kN/m^2 1 kN/m^2
03	SEISMIC LOAD ▪ For Response Spectrum ▪ For Time History Analysis	Auto-generated as per IS 1893:2002 for Response Spectrum and as per Time History data of Nepal Earthquake for Time History Analysis in CSI- ETABS ver. 16

VI. MODEL LAYOUT

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

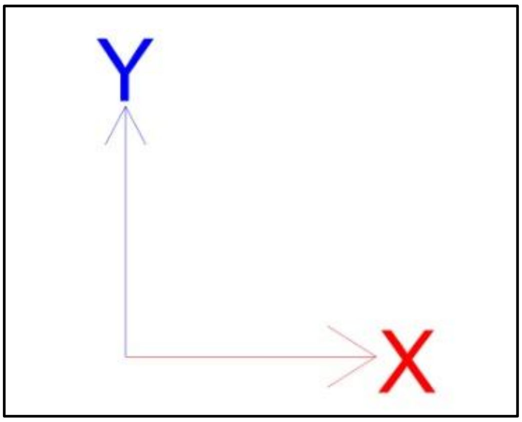


Fig. 6.1 Assumed Direction

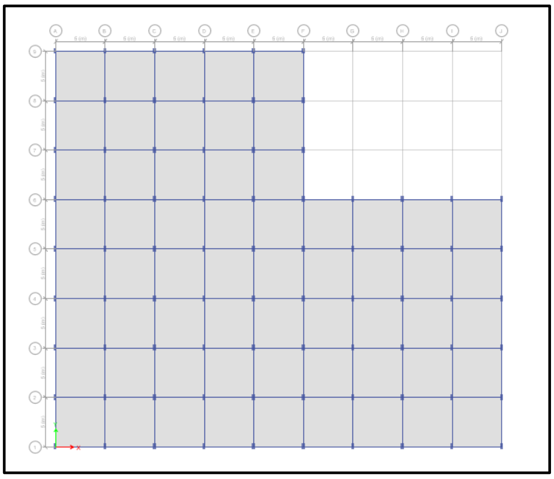


Fig. 6.2 BARE FRAME 'L' SHAPED

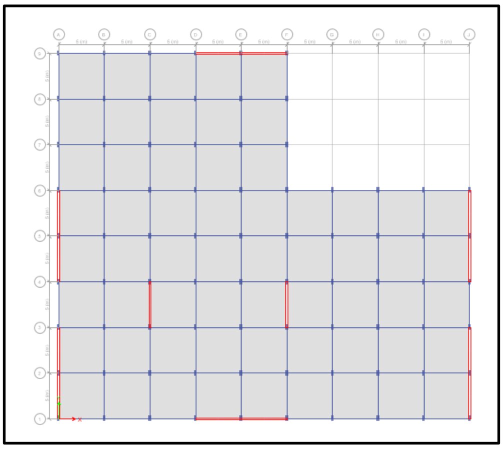


Fig. 6.3 MODEL 01 'L' SHAPED

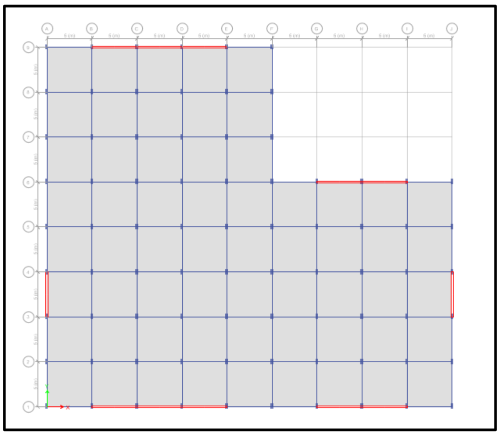


Fig. 6.4 MODEL 02 'L' SHAPED

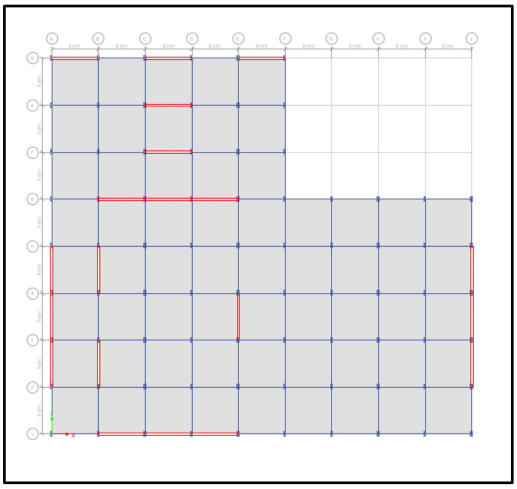


Fig. 6.5 MODEL 03 'L' SHAPED

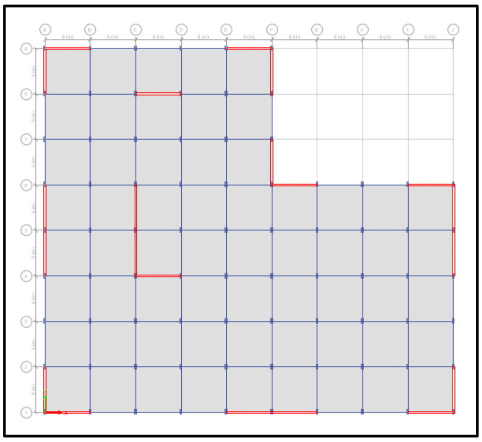


Fig. 6.6 MODEL 04 'L' SHAPED

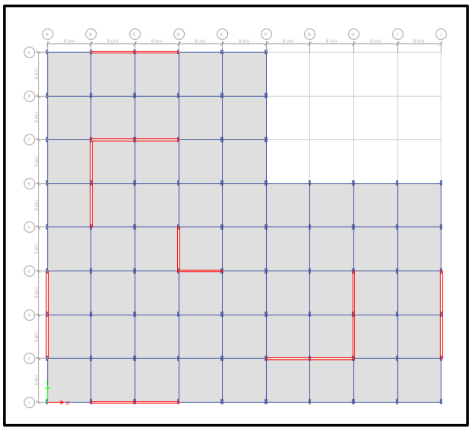


Fig. 6.7 MODEL 05 'L' SHAPED

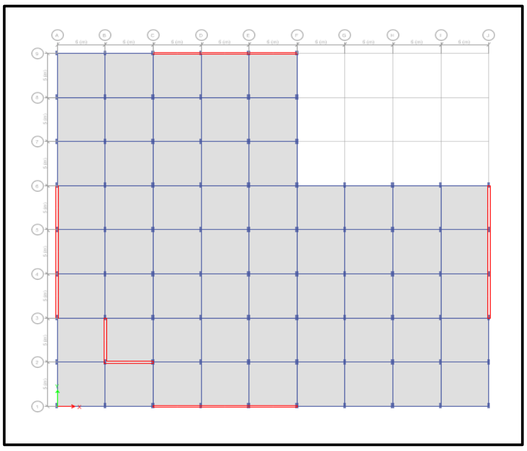
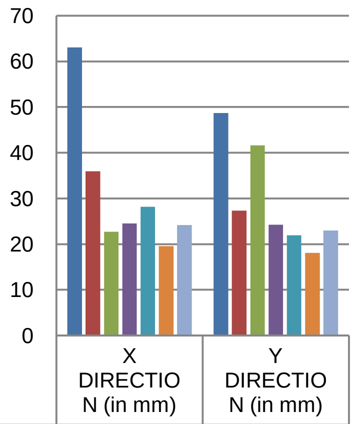


Fig. 6.8 MODEL 06 'L' SHAPED

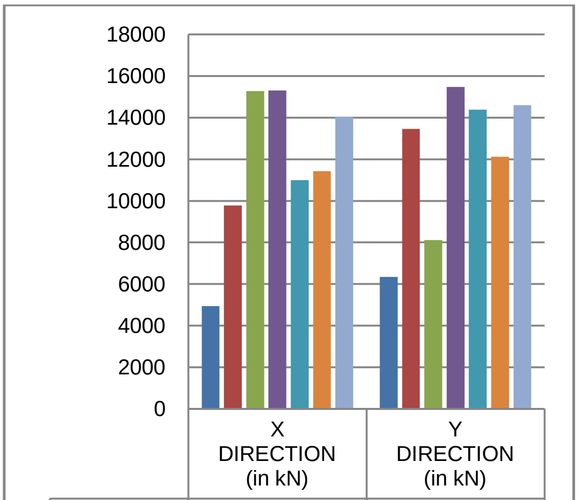
VII. COMPARATIVE STUDY

STOREY DISPLACMENT



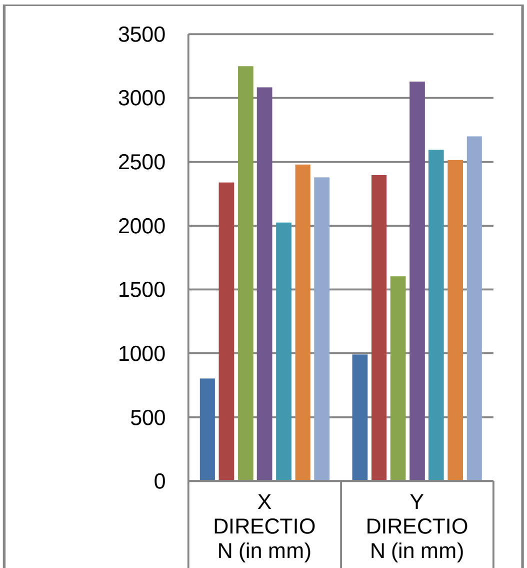
	X DIRECTION (in mm)	Y DIRECTION (in mm)
Bare Model	63.07	48.7
Model 01	35.92	27.31
Model 02	22.68	41.6
Model 03	24.52	24.23
Model04	28.16	21.9
Model 05	19.52	18.06
Model 06	24.15	22.98

Fig. 7.1 Maximum Storey Displacement from Response Spectrum Analysis



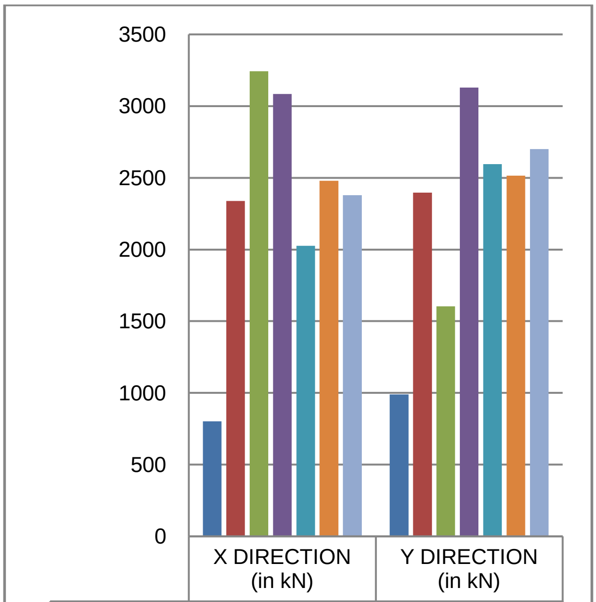
	X DIRECTION (in kN)	Y DIRECTION (in kN)
Bare Model	4945.58	6338.6
Model 01	9784.4	13460
Model 02	15280	8110.37
Model 03	15299	15480
Model04	11001	14385
Model 05	11428	12115
Model 06	14041	14601

Fig. 7.2 STOREY SHEAR from Response Spectrum Analysis



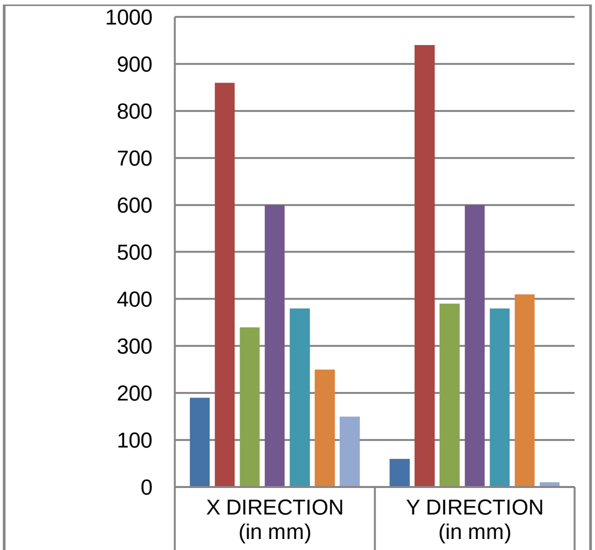
	X DIRECTION (in mm)	Y DIRECTION (in mm)
Bare Model	802.82	989.93
Model 01	2338.3	2396.36
Model 02	3248.23	1604.21
Model 03	3084.46	3128.56
Model04	2025	2595
Model 05	2479	2515
Model 06	2379	2699.9

Fig. 7.3 Maximum Joint Displacement from Time History Analysis



	X DIRECTION (in kN)	Y DIRECTION (in kN)
Bare Model	802.82	989.93
Model 01	2338.3	2396.36
Model 02	3242.23	1604.21
Model 03	3084.46	3128.56
Model04	2025	2595
Model 05	2479	2515
Model 06	2379	2699.9

Fig. 7.4 BASE FORCE from Time History Analysis



	X DIRECTION (in mm)	Y DIRECTION (in mm)
Bare Model	190	60
Model 01	860	940
Model 02	340	390
Model 03	600	600
Model04	380	380
Model 05	250	410
Model 06	150	10

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.

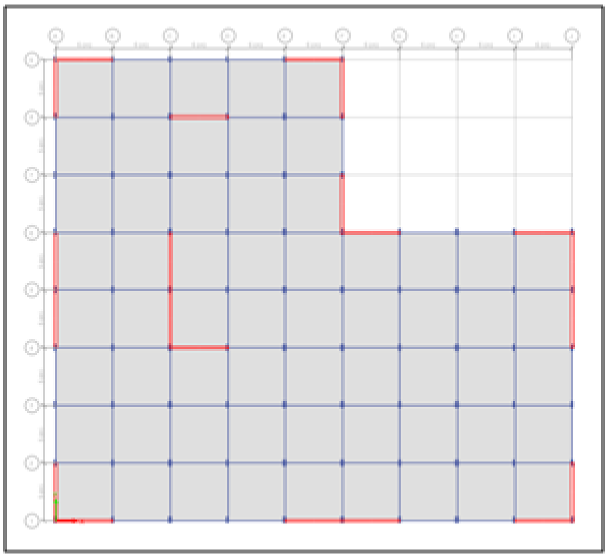


Fig. 8.1 MODEL 06 'L' SHAPED

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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