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Study of Seismic Effect on Re-entrant Corner Column

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Abstract – Irregularities in buildings are always expected due to many reasons like aesthetics, light, ventilation, etc. The irregularity is due to the reason the stiffness center and mass center of the building is not at the same location. Hence it is needed to study behavior of such structures during earthquake. The objective of this study is to understand plan irregularity and to analyze the seismic performance of the irregular frame using nonlinear static analysis in SAP2000. The study includes identification and measure of the irregularity level due to the irregular plan and improvement of the structural system considering seismic behavior.

Keywords — Plan Irregularity, Pushover Analysis, Performance, Irregularity Level.

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I. INTRODUCTION

Earthquake engineering deals with designing and constructing a structure such that during earthquake there is no damage to the structure. Seismic excitations diversely affect constructions. Seismic response of the structure depends on many parameters like structural configuration, quality of construction, soil condition, etc. It is observed that Structural and architectural configuration in plan and elevation are responsible for making the building irregular.

Irregularities in buildings are always expected due to many reasons like aesthetics, light, ventilation, etc. A structure is identified as irregular from the geometrical positioning of the stiffness and mass center. Hence there is a need to estimate the seismic response of such structures and also quantify the eccentricity. Such an understanding on seismic response of irregular building would obviously help to modify the structural system at the design stage itself. With this as aim the paper tries to quantify the magnitude of irregularity and identifies the members that need to perform in the same way as that of performance of regular structure.

II. MODELLING AND ANALYSYS

To verify the validity of pushover analysis with the actual situation and for fixing the pushover parameters for proposed study, push over analysis has been carried on a structure which was tested and the results are reported in the literature (Ref.7). As explained in the paper, a three storied 2x2 bay structure is modelled and analysed in the SAP2000 software. Plan and elevation reinforcement detailing for the structure are shown in fig 1 to 3 respectively.

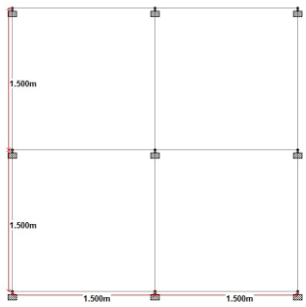

Figure 1: Plan

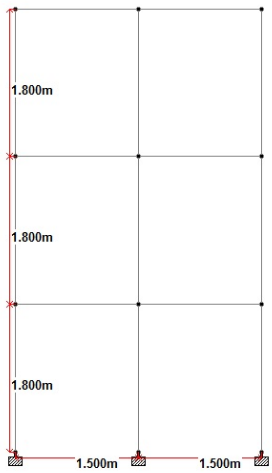

Figure 2: Elevation

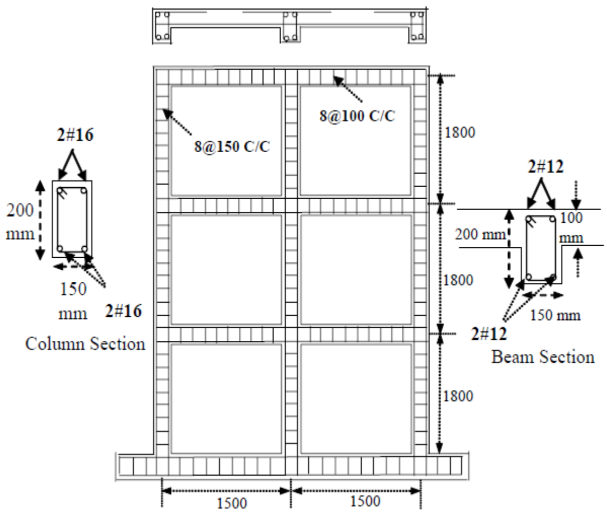

Figure 3: Reinforcement Detailing

Result is obtained after doing pushover analysis, It is found that they are identical this can be seen from fig. 4 and 5.

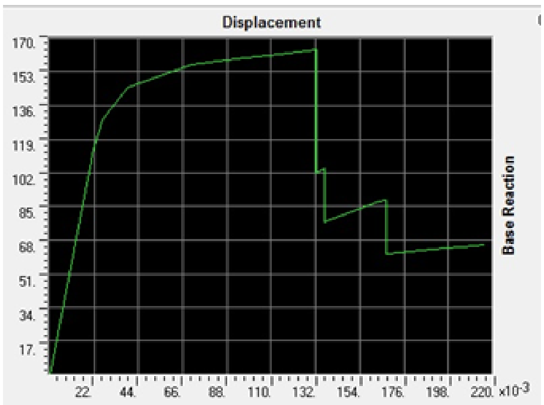

Figure 4: Pushover curve in SAP2000

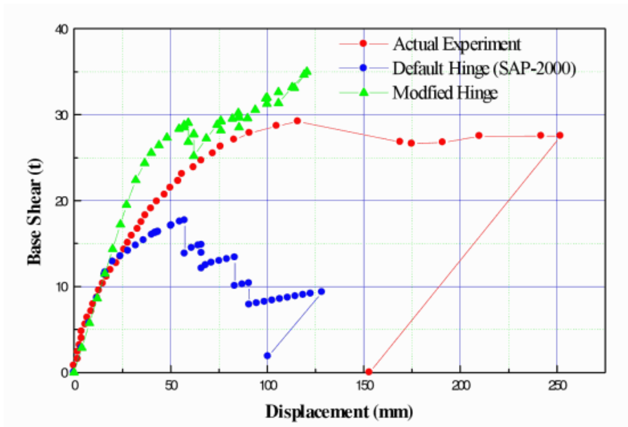

Figure 5: Comparison of Experimental results with Analysis

Based on this study material parameters and the procedure are finalised for beam and column model withM3 hinge.

For the purpose of this study a realistic residential structure with irregular plan is considered. Plan of the building and 3D view are as shown in Fig. 6 and 7 respectively. It is a five storied residential building located in zone V area. The soil is hard. For comparison, a regular building is considered, its plan and 3D view is as shown in fig. 8 and 9.

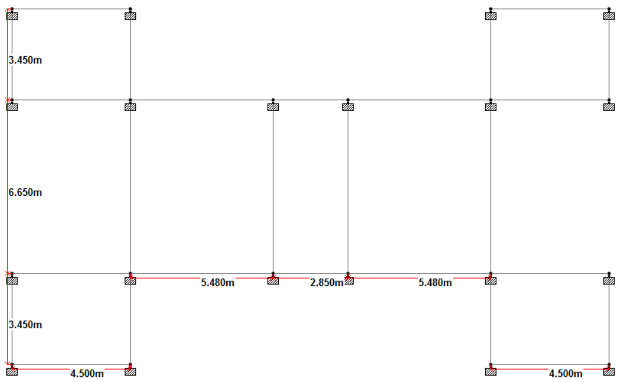

Figure 6: Plan of Proposed Irregular Structure

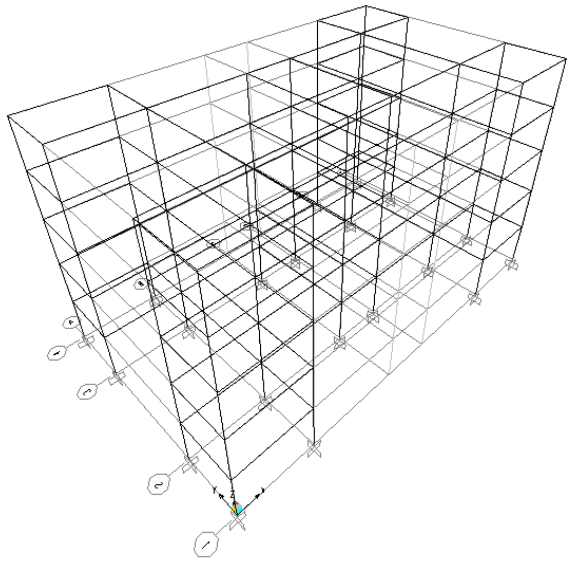

Figure 7: 3D view of Proposed Irregular Structure in SAP2000

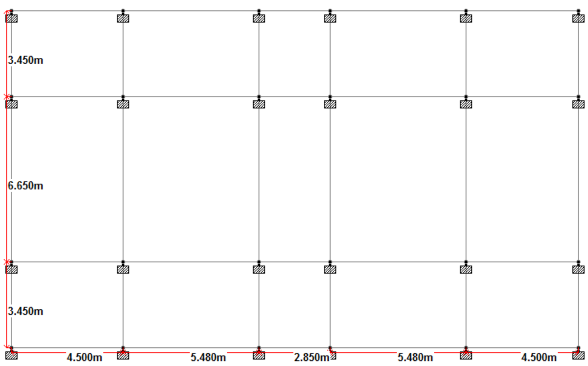

Figure 8: Plan of Proposed Regular Structure

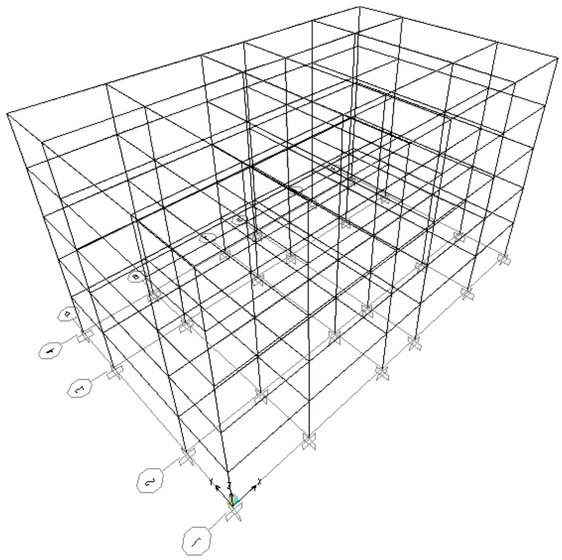

Figure 9: 3D view of Proposed Regular Structure in SAP2000

The analysis and design of the structure is done in STAAD Pro. Detailing of beam and columns are done as per the provision given in IS456:2000 and IS13920:1993. They are computed and given in Table 1 and Table 2 respectively

Table 1: Geometrical details of the structural members of the proposed structures with IS456:2000

Structural Member	Cross-section	Longitudinal Reinforcement	Transverse Reinforcement
Columns	250x400	8φ12mm	1φ6mm @200mm
X Beams	250x450	2 φ12mm & 2φ16mm	1φ6mm@1500mm
Y Beams	250x600	4φ16mm & 4φ20mm	1φ6mm@1500mm

Table 2: Geometrical details of the structural members of the proposed structures with IS13920:1993

Structural Member	Cross-section	Longitudinal Reinforcement	Transverse Reinforcement
Columns	600x600	12φ20mm	1φ8mm @100mm
X Beams	300x600	6φ16mm	1φ8mm@130mm
Y Beams	300x550	8φ16mm	1φ8mm@130mm

With the help of design and detailing obtained from STAAD Pro., the proposed structure is modelled in SAP2000. All the properties has been assigned and analysed. Pushover analysis is done on all the models in X and Y directions i.e. Irregular and Regular Structures with consideration of IS456 and IS13920, using SAP2000.

III. RESULT AND DISCUSSION

Results are obtained after pushover analysis. Comparison of base shear and roof displacement are given in Fig 10 to 13. Table 3 gives the base shear and roof displacement for the different models analysed.

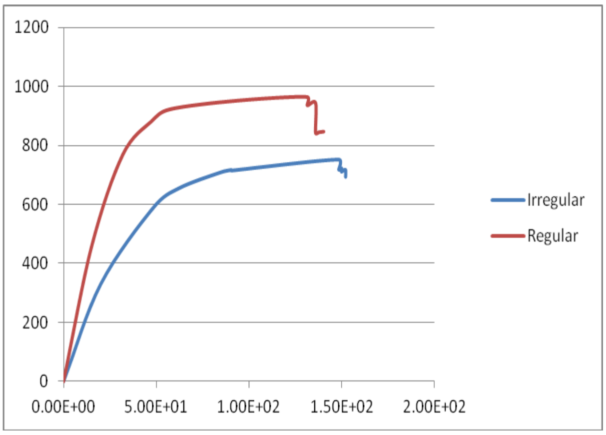

Figure 10: Pushover curves for IS456 in X Direction

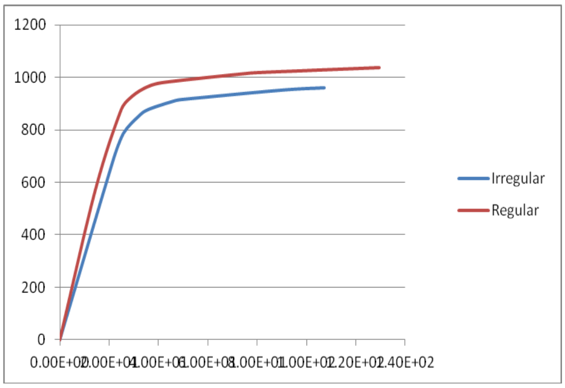

Figure 11: Pushover curves for IS456 in Y Direction

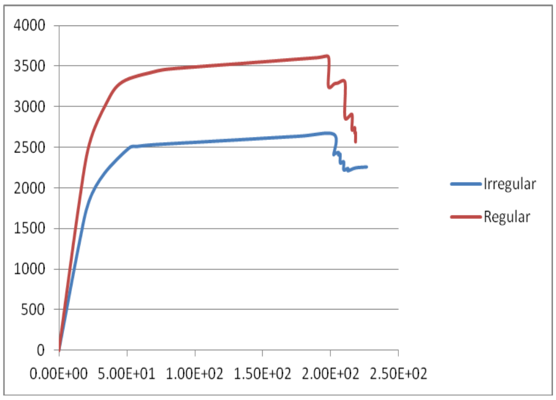

Figure 12: Pushover curves for IS13920 in X Direction

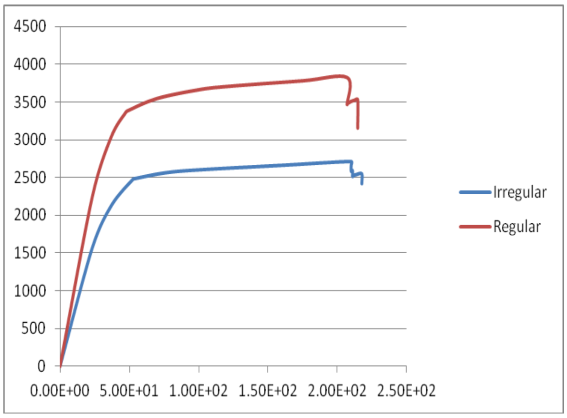

Figure 13: Pushover curves for IS13920 in Y Direction

Table 3 : Base Shear and Roof Displacement for global structure

Structure		Irregular		Regular	
		Base Shear (kN)	Roof Displacement (mm)	Base Shear (kN)	Roof Displacement (mm)
456	X	756	160	**1040**	160
	Y	980	104	**1000**	104
13920	X	2700	200	**3600**	215
	Y	2750	200	**3800**	215

Base Shear and Roof displacement at the performance point are given in Table 4. Comparison irregular and regular frame is done with respect to same.

Table 4: Comparison of Shear Force and Displacement at Performance Point

Structure		Irregular		Regular	
		V(kN)	D(mm)	V(kN)	D(mm)
456	X	459	34	**715**	29
	Y	769	27	**900**	27
13920	X	1563	18	**2110**	18
	Y	1603	24	**2221**	23

Bending moment of the re-entrant column is checked for all frames at the performance level i.e bending moment demand and moment of resistance i.e bending moment capacity of the same column is calculated manually using SP16. Bending moments are tabulated in Table 5.

Table 5: Comparison of Bending Moment with respect to demand and capacity at Performance Point

Structure			Bending Moment Demand	Bending Moment Capacity
456	Irregular	X	**83**	80
		Y	63	70
	Regular	X	64	75
		Y	64	70
13920	Irregular	X	**402**	338
		Y	408	486
	Regular	X	405	448
		Y	245	378

From Table 5, it is observed that the bending moment demand is more than the capacity for both the irregular structures i.e IS456 and IS13920 when pushover analysis is done in X Direction. Though the demand and capacity is matching for global structure as shown in figure 14 and 15, we need to take due care while designing re-entrant corner columns, as moment at the re-entrant corner columns is more than the capacity of the column. It can be seen from Table 5.

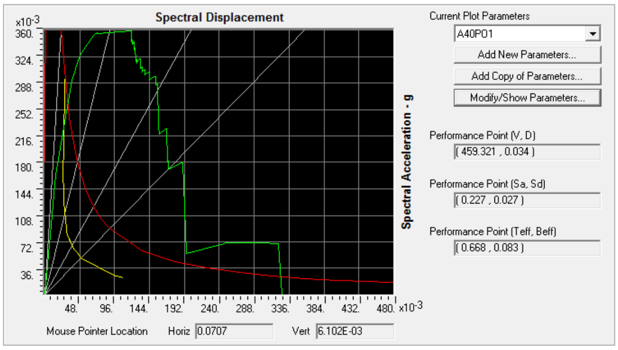

Figure14 : Capacity Spectrum for Pushover analysis of Irregular 456 in X Direction

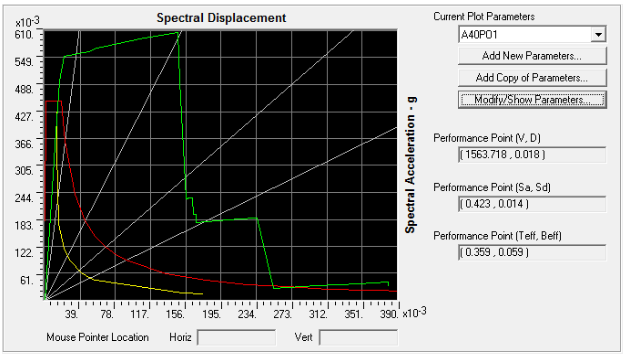

Figure15 : Capacity Spectrum for Pushover analysis of Irregular 13920 in X Direction

To match with required demand of bending moment, the re-entrant corner colums are modified. The modified details of column are given in Table 6.

Table 6: Geometrical details of the modified structural members of the proposed structures

Structure	Cross-section	Longitudinal Reinforcement	Transverse Reinforcement
456	400x400	12φ12mm	1φ6mm @150mm
13920	650x650	12φ25mm	1φ8mm@100mm

Again pushover analysis is done on both the modified structures. The bending moment demand and capacity is given in Table 7.

Table 7: Comparison of Bending Moment of Modified Structures with respect to demand and capacity at Performance Point

Structure	Bending Moment	Bending Moment
456	94	**112**
13920	306	**617**

Comparison of base shear and roof displacement of original and modified structure are given from fig 10 to 13

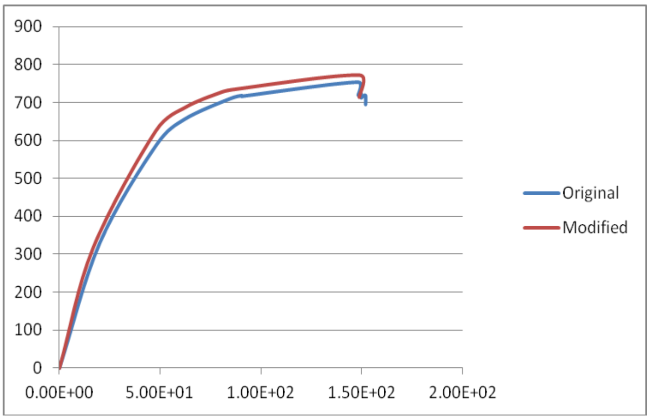

Figure 10: Pushover curves for IS456 in X Direction

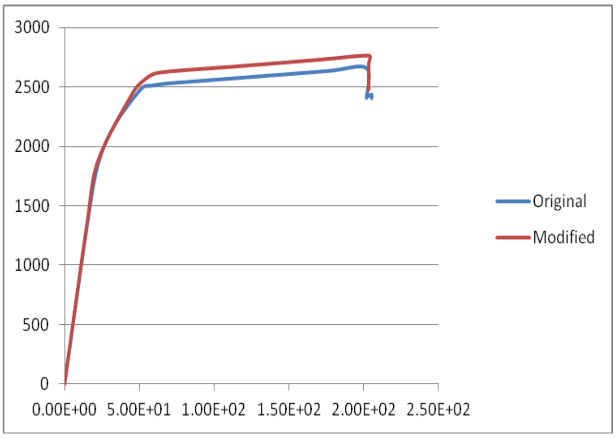

Figure 10: Pushover curves for IS13920 in X Direction

Irregularity Level is calculated as response of regular structure to the irregular structure and is given in Table 8

Table 6: Irregularity Level at Performance Point

Structure	Difference (%)
IS 456	27
Is 13920	25

IV. CONCLUSION

Irregularity in plan is unavoidable. It is because of many reasons like requirement of client, functional requirements, etc. Due care is needed while designing such structures. It is observed from above study that for re-entrant corner columns need more attention than the other columns. These columns should be designed properly.

- After proper modifications the bending moment capacity of re-entrant corner column is increased by 1.5 and twice in case of IS456 and IS13920 respectively.
- Base Shear for regular Structures is more than that of irregular structures.
- Base shear for modified structures is more than the original structures.
- Irregularity level is almost about 25% for both the irregular structures.

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