Impact of Irregular configuration on Seismic Vulnerability of RC Frame Structures

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Abstract - *Irregular buildings are frequently constructed across the globe for functional as well as aesthetic considerations. Many buildings in the present scenario have irregular configurations both in plan and elevation. This in future may subject to devastating earthquakes. In case, it is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. A case study comprising d of irregular structures are opted for performing response spectral as well as nonlinear static analyses. The irregular buildings can be strengthened by providing shear wall. Shear walls contribute the stiffness and strength during earthquakes which are often neglected during design of structure and construction. This study shows the effect of shear walls which significantly affect the vulnerability of structures. In order to test this hypothesis, G+10 storey building was considered with and without shear walls and analyzed for various parameters like base shear, storey drift ratio, lateral displacement.*

Key Words: **Vulnerability, Nonlinear Static, Irregular, Base shear, Story Drift, Lateral Displacement.**

1. INTRODUCTION

Earthquake or seismic analysis is a subset of structural analysis which includes the figuring of the reaction of a structure subjected to earthquake excitation. This is required for doing the basic plan of the structural design, structural assessment and retrofitting of the structures in the regions where earthquakes are pervasive. Different seismic information are important to complete the seismic examination of the structures. These information are accessible into two different ways viz. in deterministic form or in probabilistic form. Information in deterministic shape are utilized for outline of structures etc whereas data in form are used for seismic hazard investigation, investigation of structure subjected to random vibration and harm evaluation of structures under specific earthquake ground movement. Major seismic input includes ground acceleration/velocity/displacement data, magnitude of earthquake, peak ground parameters, duration etc. The part of non-linear equivalent static (pushover) analyses is being more and more recognized as a practical device for the assessment of the seismic response of structures. Pushover analyses are therefore increasingly being considered within modern seismic codes, both for outline of new structures and for evaluation of existing ones. Pushover is a nonlinear static analysis method in which the structures are subjected to gravity loading and a displacement monotonically. The levels of building performance is determined, building model is done by ETABS 2000 which is subjected to lateral load of various shape.

1.1 OBJECTIVES

The basic objective of study of the present research work are given below

1. To analyze RC frame structures like Regular, Irregular L shaped, and Regular, Irregular L shaped buildings by nonlinear static analyses.
2. To determine the plastic hinge formation and to compare seismic capacity of multistory reinforced concrete structure.
3. To stiffen the buildings by providing Shear walls at corners and to compare the performance parameters, Vulnerability distribution.
4. To quantify the degradation in seismic capacity of RC frames with plan irregularity in terms Base shear capacity, displacement, Performance point & the nature of hinges formed.

1.2 METHODOLOGY

In the present study, the modeling and analysis of the G+10 storey regular, irregular building without shear wall and regular, irregular building with shear wall is carried out using ETABS 2015 software in with Equivalent Static analysis, Response Spectrum Analysis, and the Nonlinear Static Push over Analysis are adopted for analysis. The models are analyzed and results are extracted like displacements, story drifts from equivalent static analysis. The hinge formation of all the buildings with force v/s displacement curve, Vulnerability index are obtained by non linear static analysis. The hinge formation of all the buildings with force v/s displacement curve, Vulnerability index is determined by comparing regular and irregular building with and without shear wall.

2. MODELLING

In the present dissertation work, G+ 10 storeys building of reinforced concrete structures are done.

Model 1-Regular building without shear wall

Model 2- Regular building with shear wall

Model 3-Irregular building without shear wall

Model 4- Irregular building with shear wall

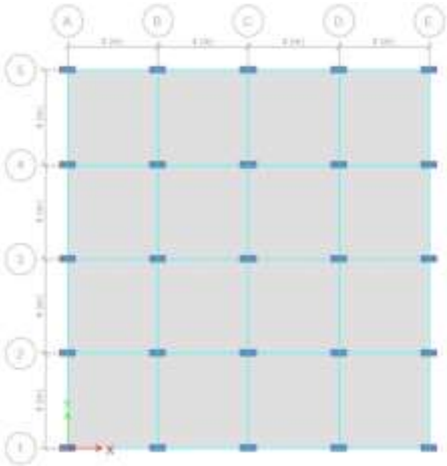

Figure-1: Model 1

The figure 1 represents the plan of the regular building of G+ 15 storeys without shear wall.

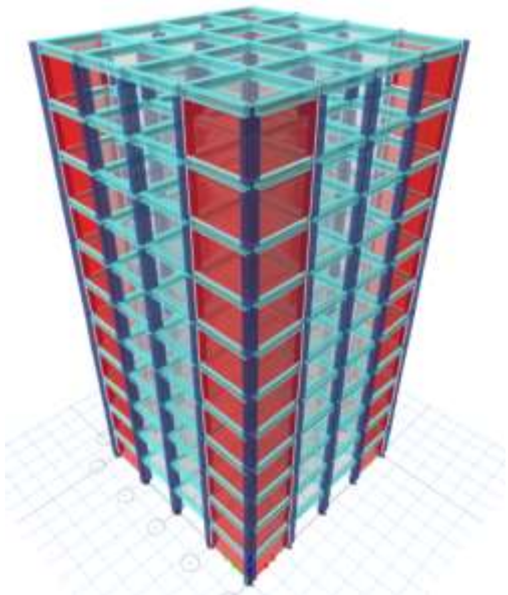

Figure-2 Model 2

Figure 2 represents the plan of the regular building of G+ 15 storey with shear wall. Shear wall of230 mm is provided at each corners.

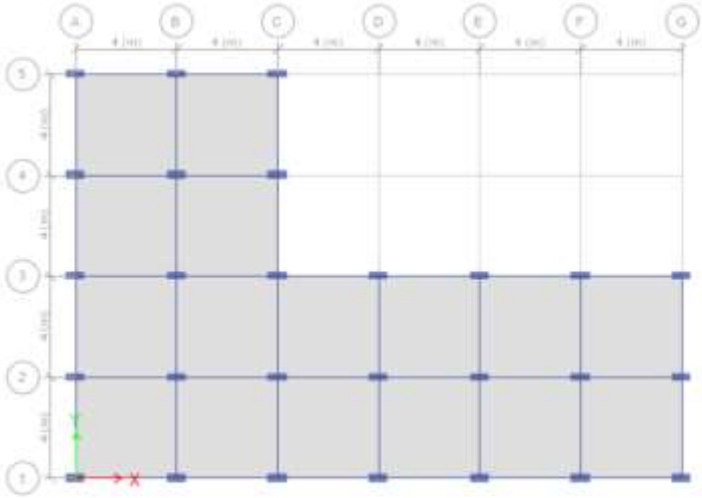

Figure-3 Model 3

The figure 3 represents the plan of the irregular building of G+ 15 storey without shear wall.

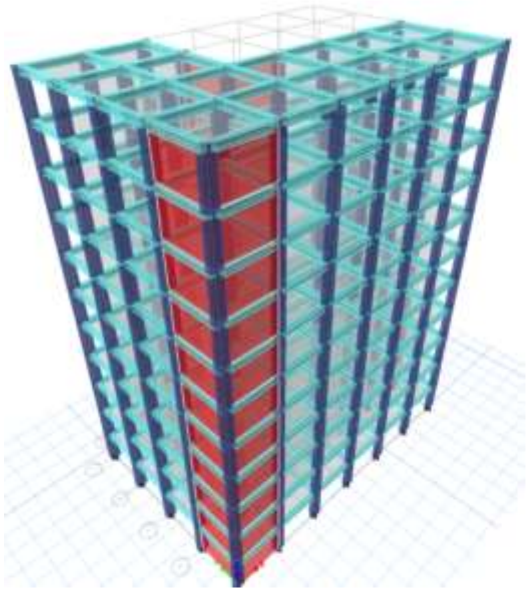

Figure-4 Model 4

Figure 4 represents the plan of the irregular building of G+ 15 storey with shear wall. Shear wall of230 mm is provided at each corners.

Table -1: Building information

building and loading details			
Building height	33m	Story height	3m
Type of structure	Multistory RC buildings(G+10)	Support condition	Fixed
Zone	III	Live load	3kN/m2
Soil type	Medium	Wall load on beams	11.73 kN/m
Damping	5%	Equivalent lateral loads	IS 1893 (Part I):2002

3. RESULTS AND DISCUSSIONS

Equivalent static analysis is carried out for all the four Models for zone III. The building hinge count original is modified in an attempt to produce a local vulnerability index for every story frame.

TABLE 2 HINGE COUNT FOR IRREGULAR BUILDING ALONG PUSH X DIRECTION

Step	Monitored Displ mm	Base Force kN	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	Total
0	0	0	2332	0	0	0	0	2332	0	0	0	2332
1	-6.073	356.7673	2324	8	0	0	0	2332	0	0	0	2332
2	-138.133	3603.2272	1644	688	0	0	0	2332	0	0	0	2332
3	-270.205	5630.1711	1446	886	0	0	0	1996	332	0	4	2332
4	-411.544	7588.6515	1288	1046	0	0	0	1834	494	0	4	2332
5	-419.738	7700.0802	1276	1056	0	0	0	1828	498	0	6	2332

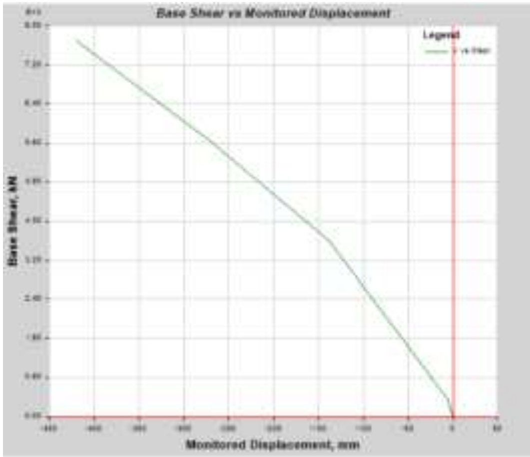

Figure 6 Base shear v/s displacement in Push X After Analysis in for Irregular Building

The base shear vs. roof displacement curve from Figure 6 is obtained from the pushover analysis in Push X After Analysis in for Irregular Building from which the maximum base shear capacity of Irregular Building is 7700.08 KN can be obtained.

Table 3 HINGE COUNT FOR IRREGULARBUILDING WITH SHEAR WALL ALONG PUSH X DIRECTION

Step	Monitored Displ mm	Base Force kN	A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	Total
0	0	0	2332	0	0	0	0	2332	0	0	0	2332
1	-5.923	739.0801	2324	8	0	0	0	2332	0	0	0	2332
2	-15.48	1781.3001	2140	192	0	0	0	2330	0	0	2	2332

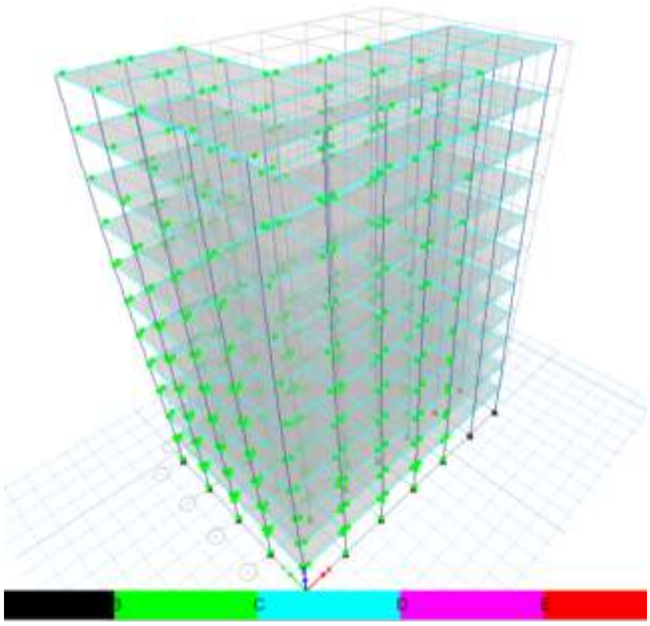

Figure 5 Hinge Formation And Displacement in Push X After Analysis in for Irregular Building

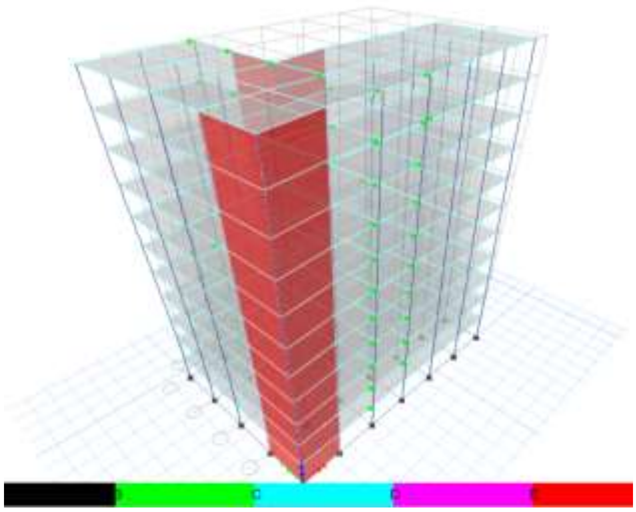

Figure 6 Hinge Formation And Displacement in Push X After Analysis in for Irregular Building With Shear Wall

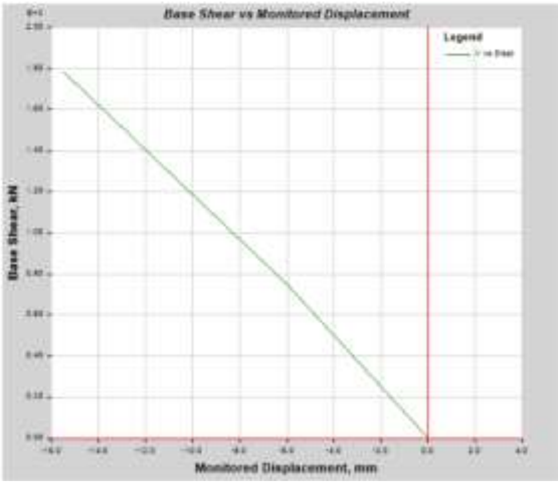

Figure 7 Base shear v/s Displacements in Push X After Analysis in for Irregular Building with Shear Wall

The base shear vs. roof displacement curve from Figure 4.15 is obtained from the pushover analysis in Push Y. After Analysis in for Irregular Building with shear wall from which the maximum base shear capacity of Irregular Building with shear wall is 1781.30 KN can be obtained.

Table 4 Lateral displacement of Irregular building with or without Shear wall Along EQX

STOREY	1.2 (DL+LL+EQ X) Lateral displacement in mm	
	MODEL 3	MODEL 4
GF	0	0
1	1.675	0.182
2	5.05	2.661
3	9.027	5.183
4	13.154	8.198
5	17.229	11.548
6	21.123	15.091
7	23.116	18.702
8	27.91	22.287
9	30.575	25.78
10	32.642	29.09
11	34.162	31.914

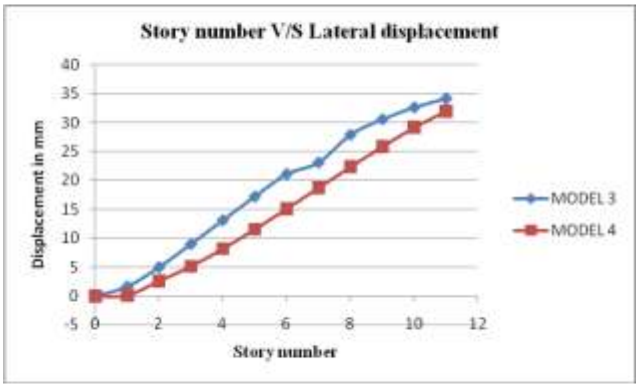

Figure 8 Lateral Displacement Profile of Irregular building with And Without Shear Wall Along EQX

It is observed that from Table 4 that, the lateral displacement value of Model 3 along longitudinal direction with respect to equivalent static method of analysis at 11th floor is found to be 34.162 mm. After providing the shear wall at corners , the lateral displacement value reduced to 31.914 mm. Reduction 6.58% of lateral displacement value is observed at top most story.

From Table 4, it can be observed that , by providing shear wall at corners in the G+10 building, model 4 reduces the overall lateral displacement value upto 20.87% with respect to Model 3.

Table 5 Inter Storey Drift of Irregular building with or without Shear wall Along EQX

STOREY	1.2 (DL+LL+EQ X) Inter story drift	
	MODEL 3	MODEL 4
GF	0	0
1	0.000558	0.000271
2	0.001128	0.000617
3	0.001326	0.000841
4	0.001376	0.001005
5	0.001358	0.001117
6	0.001298	0.001181
7	0.0012	0.001204
8	0.001063	0.001195
9	0.000889	0.001164
10	0.000689	0.001105
11	0.00051	0.000945

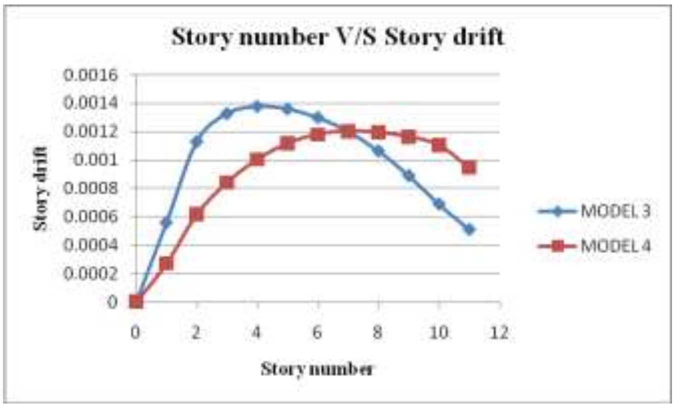

Figure 9 Inter Storey Drift of Irregular building with and without Shear Wall along EQX

From the Figure 4.3.3, it can be seen that reduction of storey drift in EQY direction MODEL 4 with shear wall when compared to the MODEL 3 without shear wall and it decreases by 12.5%.

Table 6 Base shear of Irregular Building Along Longitudinal Direction

	BASE SHEAR in KN		
Description	EQ X	SPEC X	Scale Factor
MODEL 3	29.14	88.32	3.29
MODEL 4	23.71	57.27	4.14

Table 7 Base shear of Regular Building Along Lateral Direction

	BASE SHEAR in KN		
Description	EQ Y	SPEC Y	Scale Factor
MODEL 3	37.55	170.42	2.20
MODEL 4	34.10	103.71	3.28

It is observed that from table 6 and table 7, the base shear value of Model 4 has been increased 20.55% in longitudinal direction and 32.92% in lateral direction as compared with Model 3.This indicates that, after providing the shear wall at corners at every floor, the stiffness of the structure has increased.

3. CONCLUSIONS

In the present study, an attempt has been made to study the seismic deficiency of plan irregular buildings and their possible improvement by the introduction of shear walls using pushover analysis. Pushover analysis is a convenient and efficient tool to quantify the seismic behavior of RC framed structures.

- ETABS is an effective FE analysis tool that can be used for gravity as well as nonlinear lateral load analysis on the structures.
- It was seen that introduction of plan irregularity resulted considerable degradation in the seismic performance of RC framed structures.
- It was also found that increase in the amount of plan irregularity resulted in decrease in the base shear carrying capacity of the structure.
- The introduction of shear walls proved to be an effective solution for the buildings with plan irregularity. The increase in base shear capacity because of shear wall was about 50.55% increase from MODEL 1 to MODEL 2 and about 33% increase from MODEL 3 to MODEL 4.
- Introduction of shear walls also brought down the vulnerability of the hinges formed during the performance point of the pushover analysis.

SCOPE OF FUTURE WORK

- The effect of other types of irregularities (vertical, tensional) can be studied using pushover analysis.
- The results can be confirmed using non-linear dynamic and incremental dynamic analysis.
- Other methods for strengthening the buildings by using dampers, isolators etc can be studied.

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