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Seismic Parametric Study on Different Irregular Flat Slab Multi-Story Building

Mr. Muralidhara G. B[1], Mrs. Swathi Rani K. S[1], Mr. Melese Worku[2]
[1] Lecturer, Civil Engineering Department, University of Gondar, Ethiopia
[1] Assistant Prof., Civil Engineering Department, East West Institute of Technology, Karnataka, India
[2]HOD, Civil Engineering Department, University of Gondar, Ethiopia

***Abstract*— With the advancement in the growth of urbanization and for aesthetic requirements, building with irregular structural forms are widely constructed. Irregularity in structures are mainly due to variable distribution of mass, stiffness, and strength or due to irregular geometrical configuration. This present study summarizes the behavior of G+10 irregular Flat Slab building with Vertical irregularity and Plan irregularity under seismicity. Linear static and dynamic analysis of models are performed by using ETABS to determine Earthquake response parameters like Base Shear, Natural Period and Displacement. Conclusions are woven based on the obtained results.**

Keywords—Urbanization, Aesthetic, Response, Seismic

I. INTRODUCTION

Earthquake is one of the natural disasters which the world is facing time to time. Based on previous earthquakes data, loss of human lives and properties which ultimately affects the national economy. The structure should possess, namely simple and regular configuration, adequate lateral strength, stiffness and ductility to accomplish well under Earthquake. Structures with simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation are considered to suffer much lesser damage than structures with irregular forms. But nowadays, irregular buildings are preferred due to their functional and aesthetic considerations is evident from examples of realistic existing irregular buildings. As per IS 1893(part1):2002 enlists the irregularity in buildings. These irregularities are categorised as follows [4]:

1. Vertical irregularities referring to sudden change of strength, stiffness, geometry and mass results in irregular distribution of forces or distribution over the height of the building.

2. Plan irregularities which refer to asymmetrical plan shapes(L-,T-,U-,F-) or discontinuities in the horizontal resting elements (diaphragms) such as cut-outs, large openings, re-entrant corners and other abrupt changes resulting in torsion, diaphragm deformations and stress concentration.

II. ANALYTICAL MODELLING

The structure analysed consists of a Multi-storey reinforced concrete flat slab building, characterized by its geometrical irregularity. Our study is restricted to Diaphragm discontinuity and Vertical discontinuity as shown in Fig 2 to Fig 7.

A. *Preliminary data*

- Type of Structure: Multi Storeyed RC Rigid Jointed Flat Plate Frame (Special Moment Resisting Frame)
- Number of Stories: Eleven (G+10); 35m X 25m

Data of structural Components:

- Floor Height: 4m for Ground Floor, 4m for other Floors & 3m below plinth.
- Grade of Concrete: M40 for Ground, First & Second Floors Columns.
- M35 for Other Floors Columns
- M25 for Beams and Slabs
- Size of Columns: 600mmX600mm
- Size of Beams: 600mmX300mm
- Depth of Slab: 200mm thick
- Thickness of Wall: 230mm
- Imposed Load: 3.0KN/m2
- Floor Finish & Partitions: 2.0 KN/m^2
- Specific Weight of RCC: 25 KN/m^3
- Density of brick:18KN/m^3

Earthquake data:

- Type of Soil: III
- Seismic Zone: V
- Importance Factor: 1.5
- Response reduction Factor: 5.0
- Structural Software: ETABS Version ultimate 15.1.0

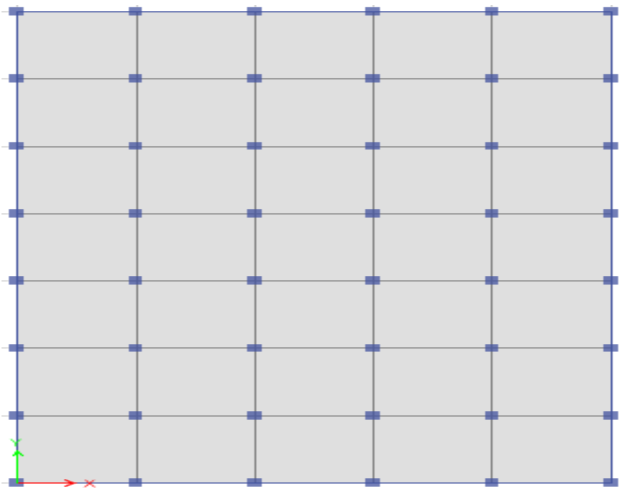

Fig. 1. Model with Regular plan. *(Model 1)*

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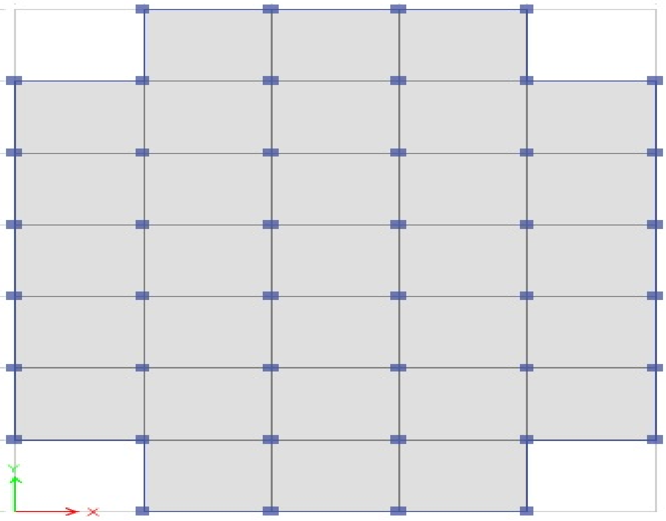

Fig. 2. Model with Re-entrant corners. *(Model 2)*

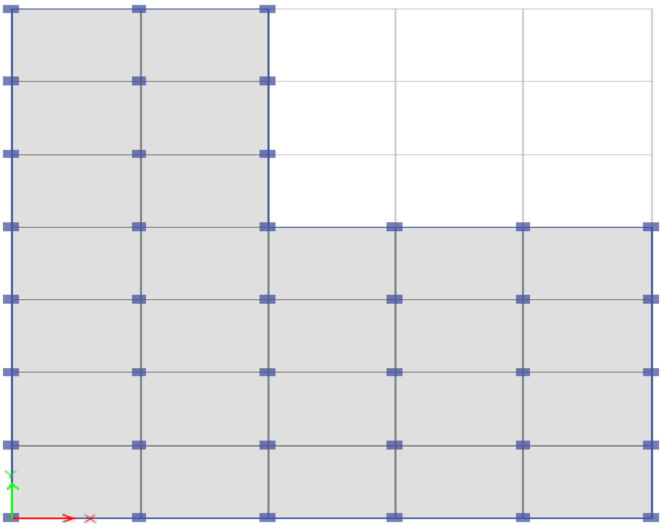

Fig. 3. Model with Re-entrant corner L-Shape. *(Model 3)*

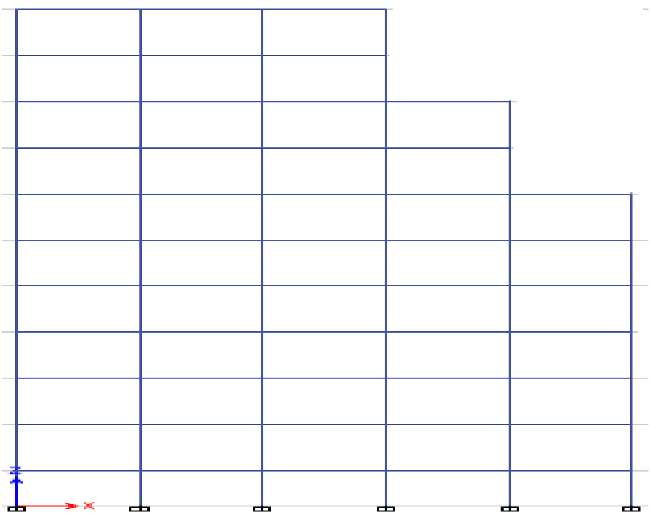

Fig. 4. *Elevation of the model with Vertical Irregularity on one side. (Model 4)*

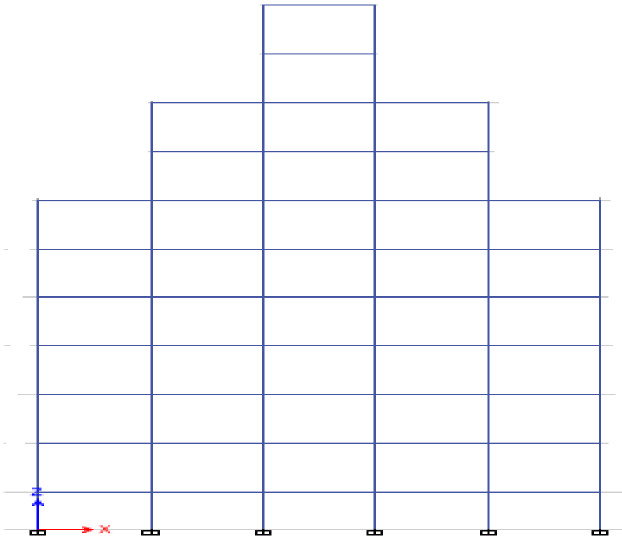

Fig. 5. Elevation of the model with Vertical Irregularity on both side.*(Model 5)*

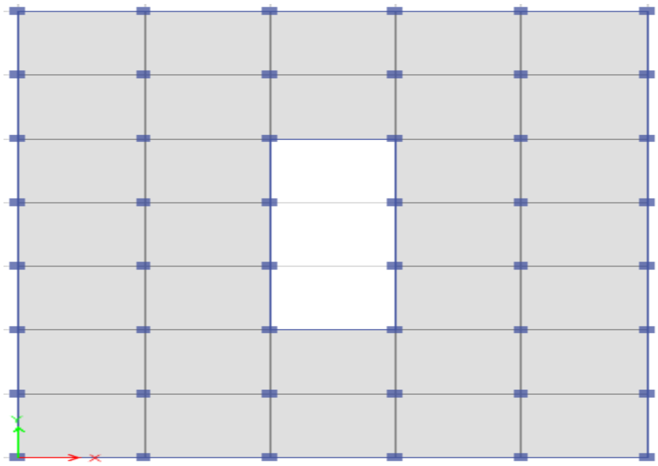

Fig. 6. Model with Rectangle shape as Diaphragm discontinuity. *(Model 6)*

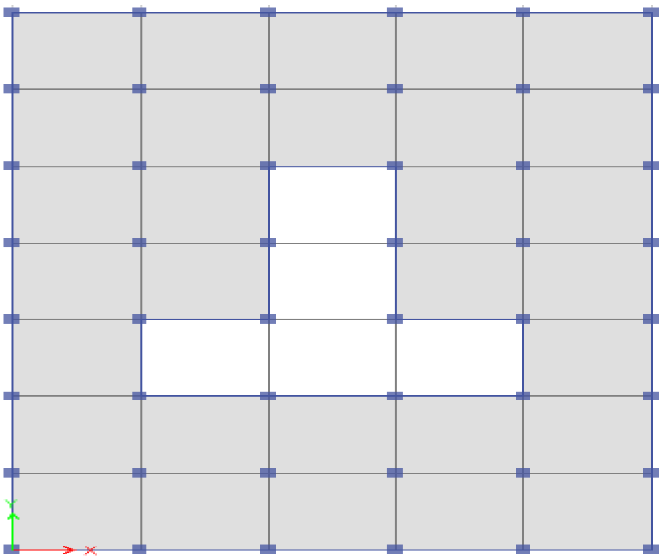

Fig. 7. Model with Inverse- T as Diaphragm Irregurality. *(Model 7)*

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III. RESULTS AND DISCUSSIONS

In the present study, the behavior of each models are captured and the results are tabulated in Table-I to Table-V and referring to tables variations are shown in Chart 1 to Chart 4 for Time period, Base shear, eccentricity, top displacements and inter storey drifts in linear analysis.

TABLE I. FUNDAMENTAL NATURAL PERIOD OF VARIOUS STRUCTURE MODELS

Base shear							
Model No.	Story type	Base Shear in KN				Scale up	Scale up
		Equivalent Static Method		Response Spectrum Method			
		X	Y	X	Y	X	Y
1	G+10	9053.65	9053.65	3360.71	3664.9	3.96	3.63
2	G+10	7874.75	7874.75	3086.81	3352.15	3.75	3.45
3	G+10	6976.74	6976.74	2770.63	2983.7	3.70	3.44
4	G+10	8159.09	8159.09	3283.76	3421.42	3.65	3.50
5	G+10	7290.6	7290.6	3229.02	3556.73	3.32	3.01
6	G+10	8833.3	8833.3	3478.56	3954.81	3.73	3.28
7	G+10	8640.62	8640.62	3630.95	3919.42	3.50	3.24

TABLE II. BASE SHEAR FOR VARIOUS STRUCTURE MODELS

Time period in seconds					
Model No.	Story type	As Per ETABS Analysis			As Per IS 1893-2002
		Mode-1	Mode-2	Mode-3	
1	G+10	2.907	2.696	2.086	1.26
2	G+10	2.863	2.614	1.996	1.26
3	G+10	2.813	2.559	2.1	1.26
4	G+10	2.74	2.538	1.852	1.26
5	G+10	2.425	2.224	1.638	1.26
6	G+10	2.835	2.463	2.095	1.26
7	G+10	2.617	2.431	2.059	1.26

TABLE III. LATERAL DISPLACEMENT (MM) OF BUILDING MODELS

Model No.	Story type	Max.story displacement of 10th and ground floor in mm			
		X		Y	
		10th floor	GFL	10th floor	GFL
1	G+10	352.5	8.9	240.3	6.5
2	G+10	344.2	8.1	281.7	8
3	G+10	319.7	7	254.6	7.5
4	G+10	338.1	7	301.6	8.6
5	G+10	290.7	7.6	231.6	5.7
6	G+10	336.3	7.1	249.6	7.5
7	G+10	276.7	6.5	246	7.3

TABLE IV. ECCENTRICITY OF BUILDING MODELS

Model No.	Storeys	Centre of Mass (CM)		Centre of Rigidity (CR)		ex in m	ey in m
		X	Y	X	Y		
1	Terrace	12.5	17.5	12.5	17.5	0	0
	5th Floor	12.5	17.5	12.5	17.5	0	0
	GFL	12.5	17.5	12.5	17.5	0	0
2	Terrace	12.5	17.5	12.503	17.491	-0.004	0.008
	5th Floor	12.538	17.446	12.513	17.474	0.024	-0.027
	GFL	12.539	17.444	12.566	17.381	-0.027	0.063
3	Terrace	10.746	14.344	9.921	13.597	0.825	0.746
	5th Floor	10.753	14.279	10.042	13.861	0.710	0.417
	GFL	10.753	14.276	10.479	14.2152	0.274	0.060
4	Terrace	7.5	17.5	10.446	17.5	-2.94	0
	5th Floor	10.494	17.5	12.496	17.5	-2.00	0
	GFL	11.427	17.5	12.5	17.5	-1.073	0
5	Terrace	12.5	17.5	12.5	17.5	0	0
	5th Floor	12.5	17.5	12.5	17.5	0	0
	GFL	12.5	17.5	12.5	17.5	0	0
6	Terrace	12.5	17.5	12.5	17.5	0	0
	5th Floor	12.5	17.5	12.5	17.5	0	0
	GFL	12.5	17.5	12.5	17.5	0	0
7	Terrace	12.5	17.628	12.5	16.860	0	0.767
	5th Floor	12.512	17.609	12.5	16.925	0.012	0.683
	GFL	12.512	17.608	12.5	17.345	0.012	0.262

TABLE V. STOREY DRIFT (MM) OF BUILDING MODELS

Model No.	Story type	Max-story drift of 10th and ground floor in mm			
		X		Y	
		10th floor	GFL	10th floor	GFL
1	G+10	3.339	3.004	2.115	2.217
2	G+10	3.52	2.97	2.61	2.69
3	G+10	3.34	2.86	2.46	2.62
4	G+10	3.61	2.82	2.28	2.89
5	G+10	3.29	2.52	1.28	2.3
6	G+10	3.18	2.88	2.08	2.5
7	G+10	2.75	2.7	2.15	2.45

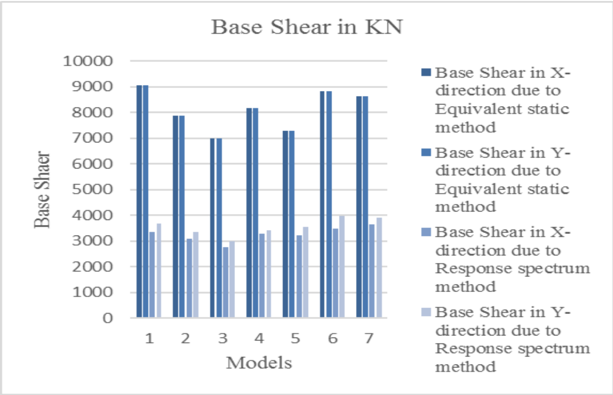

Chart-1: Shows Base Shear of all models

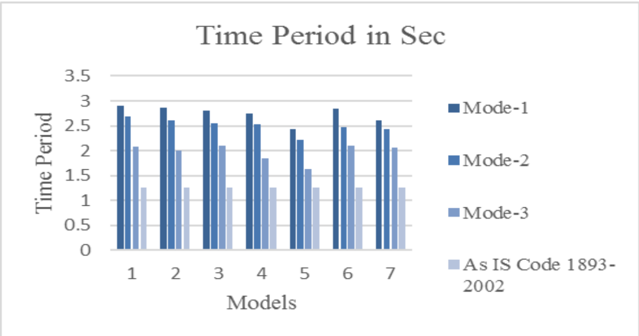

Chart-2: Shows Fundamental natural period of all models

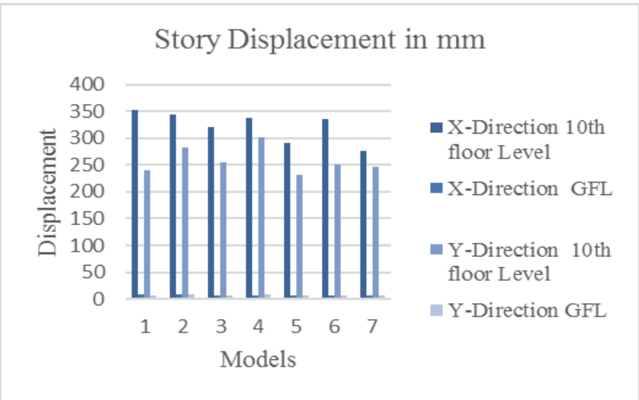

Chart-3: Shows story displacement of all models

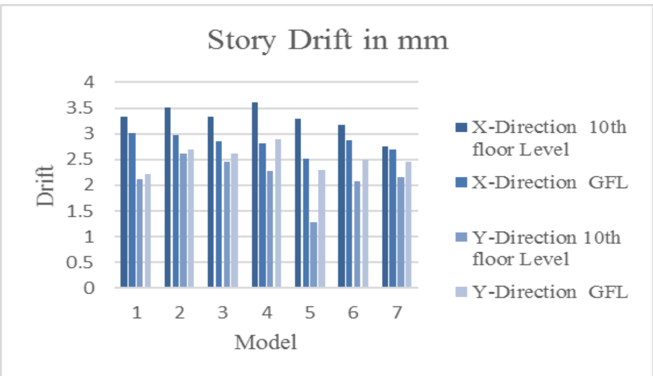

Chart-4: Shows story drift of all models

CONCLUSION

1. Computation of fundamental natural period from Equivalent Static method will not contemplate the irregularities in the building. Since, it depends on empirical formula based on height of the building too.
2. All the building models are subjected to displacement in both directions. When load is applied in particular direction which may result in twisting.
3. Inter- story drift is more in Model IV both in 10^{th} floor and Ground floor.
4. When Plan and Vertical building configurations are asymmetric, building will subjected to torsion.
5. Even in the absence of dual systems, the eccentricity between center of mass and center of rigidity differs with respect to plan, vertical and diaphragm irregularities respectively.
6. Base Shear of Model V is less compared to all other models due to reduction in the stiffness of the building also base shear due to Response spectrum is comparatively very low than Equivalent static method.

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