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Effect of Irregular Distribution of Load on RC frame Structures

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Abstract – *Earthquake are one of the most dangerous natural hazards which results in economic as well as life losses. Most of the losses are due to building collapses or damage. Hence, it is important to design the structures to resist moderate to severe earthquake ground motions depending on its site of location and importance of the structure. In the present study an attempt is made to understand the seismic response of the building(G+11) due to irregular distribution of mass by equivalent static force method as well as response spectrum method in three different seismic zones(III, IV V) and two different soil types (II, III)as per IS 1893(part 1):2002. The analysis is performed by ETABS 2015 software. The study concludes that the as the eccentricity ratio increases maximum lateral displacement also increase. The analysis proves that irregularities are harmful for the buildings and it is important to have regular as well as uniform load distribution around the structures.*

Key Words: equivalent lateral force method, response spectrum method, eccentricity ratio, maximum lateral displacement, ETABS 2015

1. INTRODUCTION

Structural engineers often encounter buildings which exhibits some degree of plan asymmetry. Structures with non coincident with centre of rigidity and centre of mass are referred as torsionally unbalanced structures. Torsion in building during earthquake shaking may be from a variety of reasons, the most common of which are non-symmetric distribution of mass and stiffness.

1.1 Torsional behavior

When the irregular structures are subjected to seismic excitation, torsion induces in the structures because of eccentricity between the mass and stiffness centre.

Torsional irregularity in the structure can be represented by Eccentricity ratio (i.e. the ratio of eccentricity between the centre of mass and centre of rigidity to the building dimension in the direction of eccentricity)

Eccentricity ratio is a non dimensional parameter, which depends on the distribution of mass and stiffness in the building. it also depends on the building configuration but independent of the method of analysis chosen.

2. METHODOLOGY

The software used in this research is ETABS 2015.Equivalent lateral force method of analysis as well as Response spectrum method of analysis have been adopted in the present study to dealt the seismic response of the building in three different seismic zones (III, IV ,V) and two different soil types(II, III). For this study, four types of models having 12 storeys of plan dimension(6x6)m is considered. Each model have different eccentricity ratio. In all models stiffness distribution is regular; however the mass distribution is irregular along Y-axis. The overall mass and stiffness are kept constant in all the models. However the mass distribution in plan is made such a way that the eccentricity ratio in Y-direction is 0.0, 0.1, 0.2 and 0.3 for models 1, 2, 3 and 4 respectively. All other properties of the building models are assigned accordance to table 1. The floor slab is assumed to be in-plan rigid.

Fig.1 shows the typical loading pattern for 1 storey frame structures, in the similar manner the loading is considered for G+11 storey frame structures so that eccentricity ratio along Y-axis is 0,0.1,0.2and 0.3 for models 1, 2, 3 and 4 respectively.

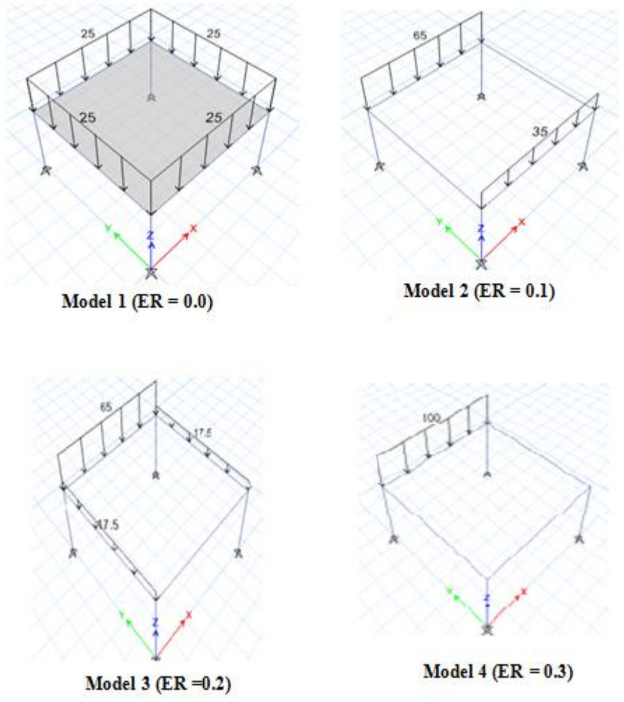

Fig -1: Typical loading pattern in kN/m² for single storey building

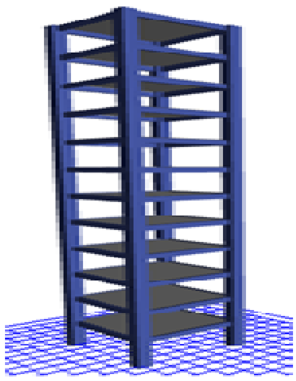

Fig -1: typical 3D model of the frame considered in the present study

3. ANALYSIS AND RESULTS

The results obtained after the analysis by both static as well as response spectrum methods as per IS 1893(part 1):2002 are tabulated in this section. The range of parameters considered in the present study is tabulated in the table 1.

Table -1: Range of parameters considered in the present study

Structure type	Ordinary moment resisting frame
No. of storey	G+11
Typical storey height	3.5m
Foundation type	Isolated footing
Seismic zone	III, IV, V
Soil type	II, III
Material properties type	
Grade of concrete	M_{20}, M_{25}
Grade of steel	Fe 415
Poisson's ratio of reinforced concrete	0.2
Density of reinforced concrete	25 kN/m³
Member properties	
Thickness of Slab	0.15m
Beam size	0.230x0.600 m
Column size	0.750x0.750 m
Dead load intensities	
Roof finishes	2.0 kN/m²
Floor finishes	1.0 kN/m²
Partition wall load	1.0 kN/m²
Live load intensities	
Roof	1.5 kN/m²
floor	3.0 kN/m²
Percentage of earthquake LL considered on slab as per clause 7.3.1 and 7.3.2 of IS 1893(part 1):2002	25%

Variations of maximum displacement at roof level along X and Y direction is dealt in the present study.

Table -2: Variation of Maximum Lateral displacement at roof level in Equivalent Lateral Force method

Soil type	zone	Model No.	Ecc. ratio	Maximum Lateral Displacement(mm)			
				ELF -X		ELF-Y	
				X	Y	X	Y
II	III	1	0	51	0	0	51
		2	0.1	52.7	1.9		51
		3	0.2	53.8	4.1		51
		4	0.3	54.5	6.2		51
	IV	1	0	76.6	0	0	76.6
		2	0.1	79	2.9		76.6
		3	0.2	80.7	6.2		76.6
		4	0.3	81.7	9.3		76.6
	V	1	0	114.8	0	0	114.8
		2	0.1	118.5	4.4		114.8
		3	0.2	121.1	9.3		114.8
		4	0.3	122.6	13.9		114.8
III	III	1	0	62.7	0	0	62.7
		2	0.1	64.7	2.4		62.7
		3	0.2	66.1	5.1		62.7
		4	0.3	66.9	7.6		62.7
	IV	1	0	94	0	0	94
		2	0.1	97	3.6		94
		3	0.2	99.1	7.6		94
		4	0.3	100.3	11.4		94
	V	1	0	141	0	0	141
		2	0.1	141.5	5.4		141
		3	0.2	148.7	11.4		141
		4	0.3	150.5	17.1		141

Table -3: Variation of Maximum Lateral displacement at roof level in Response Spectrum Method

Soil type	zone	Model No.	Ecc. ratio	Maximum Lateral Displacement(mm)			
				ELF -X		ELF-Y	
				X	Y	X	Y
II	III	1	0	38.4	0	0	38.4
		2	0.1	40.9	3.2		38.4
		3	0.2	42.6	6.2		38.4
		4	0.3	42.6	8.1		38.4
	IV	1	0	57.7	0	0	57.7
		2	0.1	61.4	4.8		57.7
		3	0.2	63.9	9.4		57.7
		4	0.3	63.9	12.1		57.7
	V	1	0	86.5	0	0	86.5
		2	0.1	92.1	7.3		86.5
		3	0.2	93.3	14		86.5
		4	0.3	95.8	17.7		86.5
		1	0	48	0		48

III		2	0.1	51.1	4	0	48
		3	0.2	53.2	7.8		48
		4	0.3	53.5	10.1		48
	IV	1	0	72	0	0	72
		2	0.1	76.6	6		72
		3	0.2	79.6	11.7		72
		4	0.3	80.2	15.2		72
	V	1	0	108	0	0	108
		2	0.1	115	9.1		108
		3	0.2	119.8	17.5		108
		4	0.3	120.4	22.8		108

As the eccentricity ratio increase maximum lateral displacement at roof level also increases. The maximum lateral displacement at roof level is more in seismic zone V when compared to seismic zone III and IV.

The results of equivalent static analysis are approximately uneconomical for irregular buildings because the values of displacement are higher than dynamic analysis.

3. CONCLUSIONS

Static analysis is not sufficient for high raised as well as irregular buildings and it is necessary to provide dynamic analysis. As the eccentricity ratio increases maximum Lateral Displacement also increase. Therefore, the study concludes that as far as possible it is important to have regular distribution of load around the buildings. But, if irregularities have to be introduced for any reason, they must be analyzed and designed properly.

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