International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 10 | Oct 2020 www.irjet.net p-ISSN: 2395-0072

SEISMIC RESPONSE OF STRUCTURES USING RESPONSE SPECTRUM ANALYSIS

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Abstract - *The structures with irregular plan are more common in present situation. Due to uneven distribution of mass and stiffness their will be generation of torsion in the structures. Seismic response of structures may be modified by torsional effects and this effects have caused damage or even collapse of structures in case of past earthquakes.*

The analysis is made for different models with same area and soil type and zone conditions so as to compare the results. The symmetric model like square model is analysed for with and without shear wall conditions and results of this model is compared with the results of other models. Results include maximum storey drifts, inter storey drifts, time period, modal frequency, translation in Z direction (Rz), modal mass participating ratio, Storey maximum/average displacement. These results are used to study in detail on the torsional effects on the models considered.

Key Words: **Seismic response**, **Torsional response, Etabs, Shear wall etc**

1. INTRODUCTION

At present situation, the structures with irregular plans are common. This structures will induce torsion phenomenon and also based on mass and stiffness distribution. Previous damage surveys on structures with different failure modes on past earthquakes have concluded that asymmetric buildings are most susceptible in nature. Tall regular buildings have uniformness in height, mass per storey and cross sectional area will have similar mode shape of vibration. Due to lack of computational facilities in the past, the detailed investigations of static analysis and dynamic analysis are not reported. Symmetric buildings are considered as regular buildings and special provisions are made in all seismic codes including Indian standards. Buildings are irregular, as it responds to seismic forces which are random in nature.

1.1 STRUCTURAL DESCRIPTIONS

The models considered are 10 storey buildings, with spacing of columns as 8m in both the directions. And floor to floor weight as 3m, zone 4 is considered with seismic reduction factor of 5. Every blocks are with 8m spacing, the total area of every blocks for every shape is equal so as to compare the results. Vertical irregularities are considered and compared with results for that of shape irregularities.

The total number of blocks is16 and total plan area is 128 square metres and area same for all models except vertically irregular structures where same number of blocks are up to 7thstorey and are different for above 3 storeys. The dynamic analysis is made using Response spectrum method and also using IS 1893-2002 code.

1.2 STRUCTURAL DIMENSIONS

- Beam size = 200x600mm
- Column size = 500x900mm
- Wall thickness = 200mm
- Wall density = 20KN/m^3
- Grade of concrete for beams = M20
- Grade of concrete for columns = M45
- Grade of steel = Fe415

1.3 LOAD CASES

- Live load upto 9th storey = 5KN/m^2
- Floor finish load upto 9th storey = 1.5KN/m^2
- Live load on terrace floor = 1.5KN/m^2
- Floor finish on terrace floor = 2KN/m^2
- Wall load on beams on terrace = 0.2 X 20 X 1.2 = 3.6KN/m

1.4 STRUCTURAL MODEL

Totally there are 9 models of structures which are considered and out of which 2 models are of plan irregularities and other 2 models are of irregularities in vertical direction. But the total area of plans are same, each block are of 8mx8m and totally there are 16 blocks in each structural model. The following are models that are considered for the analysis:

Fig: Plan of H shape model

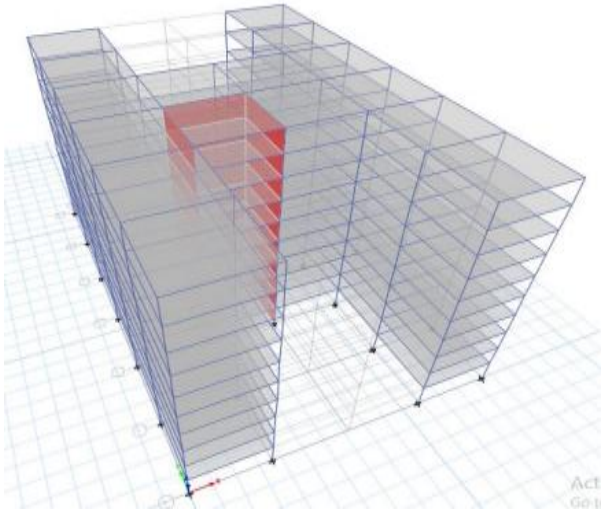

Fig: 3D MODEL

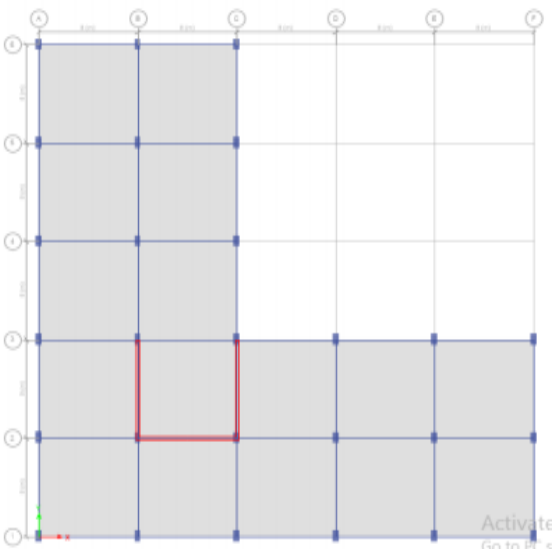

Fig: Plan of L shape model

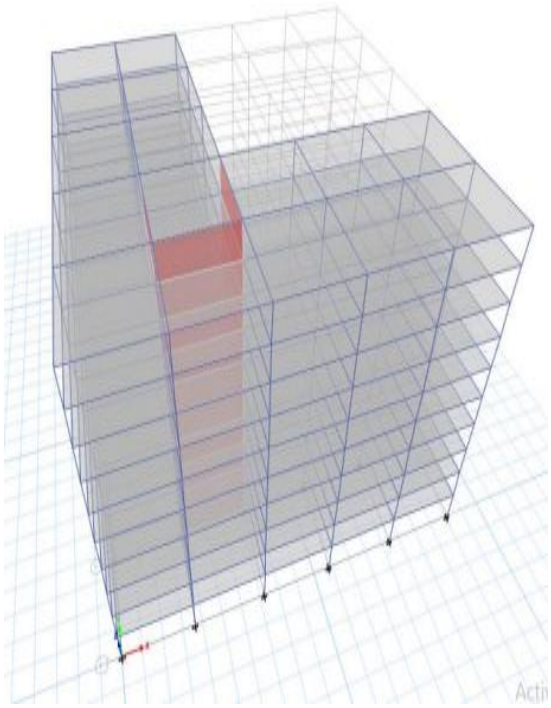

Fig: 3D MODEL

1.5 TORSIONAL EFFECTS

Studies on analysis have made to liken the torsional effects on behaviour of inelastic and elastic of structures. Sedarat and Betaero described that linear dynamic analysis may drastically underestimate torsional effects on inelastic dynamic behaviour of structures. On other side, study of 13th storey frame buildings showed that torsional effects severe as structure modelled as building as elastic apart from inelastic. Results was found as highly depending on earthquake motions characteristics. There was issue on sternness of torsional effects based on inelastic response of structures wasn't been settled.

2. ANALYSIS AND RESULTS

In symmetric buildings, all elements resisting the lateral load which are located in dissimilar positions in plan and exposed to unidirectional forces experiences even lateral displacement. Hence lateral stiffness is proportional to force established in every element.

H-shape model results:

Story	Elevation(m)	With shear wall		Without shear wall	
		X (mm)	Y(mm)	X_1 (mm)	Y_1 (mm)
Story10	30	19.5	22.2	30.6	28.5
Story9	27	18.1	20	29.5	27
Story8	24	16.5	17.6	27.8	25
Story7	21	14.7	15.1	25.5	22.6
Story6	18	12.6	12.5	22.6	19.7
Story5	15	10.4	10	19.1	16.3
Story4	12	8.1	7.5	15.2	12.6
Story3	9	5.8	5.1	10.9	8.6
Story2	6	3.5	2.9	6.4	4.8
Story1	3	1.4	1	2.2	1.5
Base	0	0	0	0	0

Table 1: Maximum Storey Displacement for H-shape model

Modal case	With shear wall			without shear wall		
	Time period(sec)	Frequency (cyc/sec)	Rz(radians)	Time period(sec)	Frequency (cyc/sec)	Rz(radians)
1	1.65	0.6	0.65	2.34	0.43	0
2	0.88	1.14	0.02	2.07	0.48	0
3	0.79	1.26	0.08	1.92	0.52	0.78
4	0.48	2.09	0.11	0.74	1.35	0.00
5	0.26	3.87	0.01	0.61	1.62	0.00
6	0.24	4.18	0.03	0.59	1.69	0.10
7	0.20	5.1	0.01	0.40	2.45	0.00
8	0.15	6.53	0.02	0.31	3.21	0.00
9	0.13	7.57	0	0.31	3.23	0.05
10	0.11	9.34	0.01	0.26	3.80	0.00
11	0.09	10.64	0.004	0.19	5.24	0.03
12	0.09	10.99	0	0.18	5.38	0

Table 2: Time period and Rz for H shape model

Story	With shear wall						Without shear wall					
	X			Y			X			Y		
	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio
Story10	19.5	16.6	1.2	22.2	18.0	1.2	30.6	29.3	1.05	28.5	27	1.06
Story9	18.1	15.3	1.2	20.0	16.2	1.2	29.5	28.2	1.05	27	25.5	1.06
Story8	16.5	13.8	1.2	17.6	14.2	1.2	27.8	26.6	1.04	25	23.7	1.06
Story7	14.7	12.1	1.2	15.1	12.1	1.2	25.5	24.4	1.04	22.6	21.4	1.06
Story6	12.6	10.3	1.2	12.5	10.0	1.3	22.6	21.6	1.04	19.7	18.6	1.06
Story5	10.4	8.4	1.2	10.0	7.9	1.3	19.1	18.4	1.04	16.3	15.5	1.06
Story4	8.1	6.5	1.3	7.5	5.9	1.3	15.2	14.6	1.04	12.6	11.9	1.06
Story3	5.8	4.6	1.3	5.1	3.9	1.3	10.9	10.5	1.04	8.6	8.2	1.06
Story2	3.5	2.7	1.3	2.9	2.2	1.3	6.4	6.2	1.04	4.8	4.5	1.06
Story1	1.4	1.1	1.3	1.0	0.8	1.3	2.2	2.2	1.03	1.5	1.4	1.06
Base	0.0	0.0		0.0	0.0		0	0		0	0	

Table 3: Ratio of Max/Avg story displacement for H-model

Results of L-shape model:

Story	Elevation(m)	With shear wall		Without shear wall	
		X (mm)	Y(mm)	X_1 (mm)	Y_1 (mm)
Story10	30	18.7	79.4	31.2	38.6
Story9	27	16.9	73	30	35.8
Story8	24	15	65.9	28.2	32.5
Story7	21	13	58	25.7	28.8
Story6	18	10.9	49.4	22.7	24.5
Story5	15	8.7	40.3	19.2	19.9
Story4	12	6.5	30.6	15.1	14.9
Story3	9	4.4	20.7	10.7	9.9
Story2	6	2.5	11.3	6.2	5.2
Story1	3	0.9	3.5	2.1	1.6
Base	0	0	0	0	0

Table 4: Maximum Storey Displacement for L-model

Modal case	With shear wall			without shear wall		
	Time period (sec)	Frequency (cyc/sec)	Rz (radians)	Time period (sec)	Frequency (cyc/sec)	Rz (radians)
1	2.14	0.47	0.41	2.43	0.41	0
2	0.9	1.12	0.004	2.39	0.42	0.02
3	0.74	1.35	0.35	2.2	0.45	0.74
4	0.59	1.68	0.04	0.76	1.31	0
5	0.28	3.52	0.04	0.67	1.47	0
6	0.23	4.33	0.01	0.64	1.54	0.11
7	0.21	4.85	0.05	0.41	2.43	0
8	0.17	5.95	0.02	0.32	3.05	0.02
9	0.12	8.55	0.006	0.31	3.19	0.03
10	0.11	9.01	0.01	0.2	3.85	0
11	0.1	9.8	0.01	0.19	5.21	0.02
12	0.08	12.66	0.004	0.17	5.59	0.01

Table 5: Time period and Rz for L-shape model

Story	With shear wall						Without shear wall					
	X			Y			X			Y		
	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio	Max mm	Avg mm	Ratio
Story10	18.7	16.6	1.27	79.4	48.3	1.64	31.2	30.2	1.03	38.6	34.0	1.13
Story9	16.9	14.9	1.13	73	44.4	1.64	30	29	1.03	35.8	31.6	1.13
Story8	15	13.1	1.14	65.9	39.9	1.65	28.2	27.3	1.03	32.5	28.8	1.13
Story7	13	11.3	1.15	58.0	35.0	1.65	25.7	25	1.03	28.8	25.6	1.12
Story6	10.9	9.3	1.16	49.4	29.8	1.66	22.7	22.1	1.03	24.5	21.9	1.12
Story5	8.7	7.4	1.18	40.3	24.2	1.66	19.2	18.6	1.03	19.9	17.8	1.12
Story4	6.5	5.4	1.19	30.6	18.4	1.67	15.1	14.7	1.03	14.9	13.4	1.11
Story3	4.4	3.6	1.21	20.7	12.5	1.66	10.7	10.5	1.02	9.9	9.0	1.1
Story2	2.5	2	1.22	11.3	6.90	1.64	6.2	6	1.02	5.2	4.8	1.1
Story1	0.9	0.7	1.21	3.5	2.20	1.57	2.1	2	1.02	1.6	1.4	1.1
Base	0	0		0	0		0	0		0	0	

Table 6: Ratio of Max/Avg story displacement for L-shape model

3. CONCLUSIONS

1) The top storey maximum displacement for all structures analysed are less than permissible value of deflections= 4/1000 times H. Where H= total height of the building.

2) Similarly Inter storey displacements are found to be less than permissible value = 4/1000 times h. Where h= Floor to floor height.

3) The ratio of maximum/average storey displacement is more than 1.2 for all models with shear wall which is indication of presence of torsion. And the ratio is less in models without shear wall.

4) Translational in Z direction (Rz) is present in 1st mode which is the indication of presence of torsion in case of models with shear wall and Rz is present in 3rd mode in case of models without shear wall.

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