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EFFECT OF HORIZONTAL IRREGULARITY ON SEISMIC BEHAVIOR OF BUILDING

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ABSTRACT

Asymmetry in structures makes analysis of the seismic behavior very complicated. Recent earthquakes have shown that the structure with plan irregularity results in irregular distribution of mass and stiffness. In this paper an effort has been made to understand seismic behavior of building with plan irregularity and symmetric building. The results of analysis carried out by the authors for investigating the seismic behavior of asymmetric-plan buildings are reported. A G+9 storied bare RC special moment resisting framed building is considered for the response spectrum analysis using SAP 2000 v.15. It is concluded that the symmetric building performs well as compared to asymmetric building in the event of earthquake.

KEYWORDS: Symmetric and Asymmetric plan, Response spectrum analysis, Earthquake.

INTRODUCTION

Earthquakes are one of the most devastating natural hazards that cause great loss of life and livelihood. Most recent earthquakes have shown that the irregular distribution of mass, stiffness and strengths may cause serious damage in structural systems. Asymmetric building structures are almost unavoidable in modern construction due to various types of functional and architectural requirements. An ideal multistory building designed to resist lateral loads due to earthquake would consist of only symmetric distribution of mass and stiffness in plan at every storey and a uniform distribution along height of the building. Such a building would respond only laterally and is considered as torsionally balanced (TB) building[1]. But it is very difficult to achieve such a condition because of restrictions such as architectural requirement and functional needs. The structures whose performances were evaluated in this study, are designed with the provisions from IS: 1893-2002. The purpose of this paper is to investigate seismic behavior of G+9 storied building having irregularity in plan.

METHODS OF SEISMIC ANALYSIS

Different methods of seismic analysis are shown in fig. 1. The method of seismic analysis used here is Response Spectrum Method.

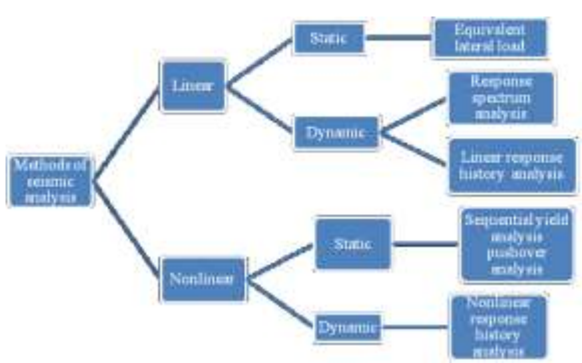

Fig. 1 Methods of seismic analysis

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Linear Static Procedure:

Under the Linear Static Procedure (LSP), design seismic forces, their distribution over the height of the building, and the corresponding internal forces and system displacements are determined using a linearly elastic, static analysis. In the LSP, the building is modelled with linearly-elastic stiffness and equivalent viscous damping that approximate values expected for loading to near the yield point. Design earthquake demands for the LSP are represented by static lateral forces whose sum is equal to the pseudo lateral load. The magnitude of the pseudo lateral load has been selected with the intention that when it is applied to the linearly elastic model of the building it will result in design displacement amplitudes approximating maximum displacements that are expected during the design earthquake. If the building responds essentially elastically to the design earthquake, the calculated internal forces will be reasonable approximations of those expected during the design earthquake. If the building responds in elastically to the design earthquake, as will commonly be the case, the internal forces that would develop in the yielding building will be less than the internal forces calculated on an elastic basis. For buildings that have irregular distributions of mass or stiffness, irregular geometries, or no orthogonal lateral-force-resisting systems, the distribution of demands predicted by an LDP analysis will be more accurate than those predicted by the LSP. Either the response spectrum method or time history method may be used for evaluation of such structures.

Linear Dynamic Procedure:

Under the Linear Dynamic Procedure (LDP), design seismic forces, their distribution over the height of the building, and the corresponding internal forces and system displacements are determined using a linearly elastic, dynamic analysis. The basis, modelling approaches, and acceptance criteria of the LDP are similar to those for the LSP. The main exception is that the response calculations are carried out using either modal spectral analysis or Time- History Analysis. Modal spectral analysis is carried out using linearly-elastic response spectra that are not modified to account for anticipated nonlinear response. As with the LSP, it is expected that the LDP will produce displacements that are approximately correct, but will produce internal forces that exceed those that would be obtained in a yielding building. There are two methods of linear dynamic procedures Response Spectrum Method and Time History Method.

Response Spectrum Method:

The requirement that all significant modes be included in the response analysis may be satisfied by including sufficient modes to capture at least 90% of the participating mass of the building in each of the building’s principal horizontal directions. Modal damping ratios shall reflect the damping inherent in the building at deformation levels less than the yield deformation. The peak member forces, displacements, story forces, story shears, and base reactions for each mode of response shall be combined by recognized methods to estimate total response. Modal combination by either the SRSS (square root sum of squares) rule or the CQC (complete quadratic combination) rule is acceptable.

BUILDING DETAILS

In the present study the gravity load analysis and lateral load analysis as per the seismic code IS 1893 (Part 1): 2002 are carried out for two buildings one is symmetric and other is asymmetric in plan for building height G+9 and for comparison criteria, numbers of columns are kept same for all buildings and an effort is made to study the effect of seismic loads on them also determined base shear, displacement and time period by using response spectrum method by using software SAP2000.

Problem statement: G+9 storied bare RC Special Moment Resisting Frame has plan as shown in Fig.2, Fig.3, and Fig.4. is situated in seismic zone IV

Beam size - 0.30m x 0.45m
Column size - 0.30m x 0.45m
Thickness of slab- 150mm
Height of storied – 3m
Plinth height above GL – 2m
Unit weight of concrete – 25kN/m3
Live load on floor – 3kN/m3
Live load on roof – 2kN/m3
Grade of concrete – M20
Grade of steel – Fe415
Soil type – Medium soil

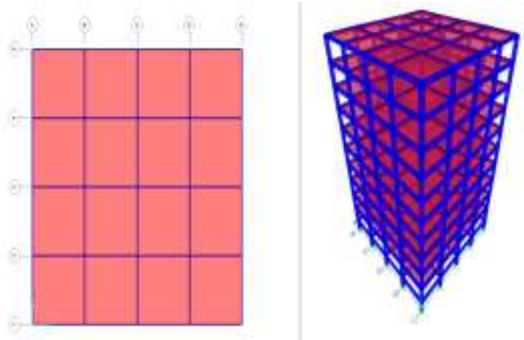

Fig. 2 Plan and 3D view of symmetric G+9 building in SAP2000

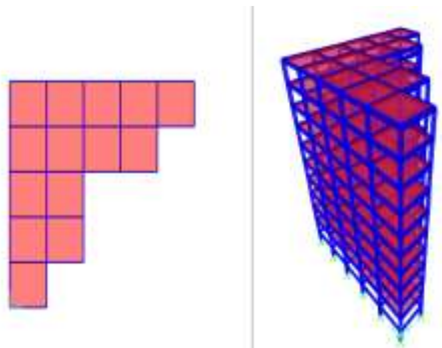

Fig. 3 Plan and 3D view of L shape G+9 building in SAP2000

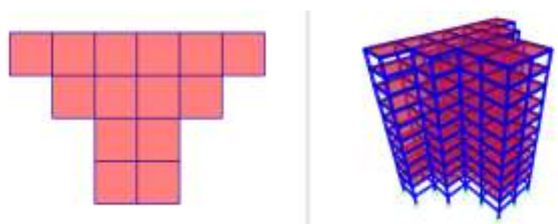

Fig. 4 Plan and 3D view of T shape G+9 building in SAP2000

RESULTS AND DISCUSSION

Seismic weight for symmetric and L & T shape G+9 storied building is shown in table 1 and table 2 respectively. Time period, base shear and displacement obtained by response spectrum analysis in SAP 2000 for these buildings are tabulated in table 3. Table 4 shows comparison of Torsional moments of column and beam for G+9 building.

Table 1*– *Seismic weight for Symmetric building G+9

Element		Size (m) (LxBxH)	Numbers	D.L.@ (kN/m3)	Dead Wt. (kN)
Beam		0.40x0.40x5	40x10	25	8000.000
Column		0.45x0.45x3	25x10	25	3796.875
Slab		20x20x0.15	10	25	15000.000
LL	Floor	20x20x3x0.25	9		2700.000
	Roof	20x20x2x0.25	1		200.000
Total seismic weight (W) 29696.875 kN					

Table 2– Seismic weight for L and T shape building G+9

Element		Size (m) (LxBxH)	Numbers	D.L.@ (kN/m3)	Dead Wt. (kN)
Beam		0.40x0.40x5	38x10	25	7600.000
Column		0.45x0.45x3	25x10	25	3796.875
Slab		(350)x0.15	10	25	13125.000
LL	Floor	(350)x3x0.25	9		2362.500
	Roof	(350)x2x0.25	1		175.000
Total seismic weight (W) 27059.375 kN					

Table 3 – Base shear and Time period for G+9

G+9 Storied building	By using software SAP2000 Response spectrum method			
	Seismic weight (*kN*)	Time period (*sec*)	Base shear (*kN*)	Disp. (*mm*)
Symmetric	**29696.875**	**1.64**	**557.920**	**18.47**
T shape	**27059.375**	**1.55**	**561.107**	**22.96**
L shape	**27059.375**	**1.46**	**573.750**	**24.73**

Table 4 – Comparison of Torsional moments of column and beam for G+9

G+9 Storied building	Torsional moment (*N-mm*) in Y direction					
	Symmetric building		T shape building		L shape building	
	Column	Beam	Column	Beam	Column	Beam
Story no 9	**0**	**0**	**48769**	**80541**	**63442**	**104335**
Story no 8	**0**	**0**	**41832**	**74360**	**57658**	**98448**
Story no 7	**0**	**0**	**36435**	**69690**	**51435**	**87656**
Story no 6	**0**	**0**	**32525**	**63651**	**44532**	**81769**
Story no 5	**0**	**0**	**29892**	**59802**	**39325**	**78436**
Story no 4	**0**	**0**	**25549**	**48411**	**34784**	**71548**
Story no 3	**0**	**0**	**21788**	**37140**	**29568**	**67329**

Story no 2	**0**	**0**	**15978**	**32356**	**26574**	**56439**
Story no 1	**0**	**0**	**11345**	**27215**	**23325**	**42325**

CONCLUSION

1. Time period and base shear calculation by using equivalent static method is approximately equal with response spectrum method in SAP.
2. Comparing results of tortional moment in beam and column shows that tortional moment is more for asymmetric building than symmetrical hence it is necessary to design beam and column for tortional moment.
3. By using equivalent static method and response spectrum method in SAP it shows that, base shear and roof displacement for asymmetrical building is more than symmetrical building.
4. Seismic behaviour of symmetrical building is always better than asymmetric building. Among T and L shape buildings T shape building is more stable than L shape building.

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