SEISMIC ANALYSIS OF GEOMETRICAL AND STIFFNESS IRREGULAR MULTISTOREY REINFORCED CONCRETE BUILDINGS

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ABSTRACT - The performance of a multi-storey framed building during sturdy earthquake motions depends on the distribution of mass, stiffness, and strength in both the horizontal and vertical planes of the building. In multi-storied framed buildings, smash up from earthquake ground motion generally initiates at locations of structural weaknesses present in the lateral load resisting frames. In some cases, these weaknesses may be produced by discontinuities in stiffness, strength or mass between adjoining storey. This work shows the performance and behavior of regular, geometric and stiffness irregular R.C.C. multistoried structures under seismic motions. In present study Two type of structures analyzed. Setback structures are analyzed for geometric irregularity and Structures having reduction in column sizes as stiffness irregular structures. Various seismic response such as Natural period, Storey displacement, and Base shear are obtained.

KEY WORDS: Geometric irregularities, Stiffness irregularity, Natural period, Storey displacement, Base shear.

I. INTRODUCTION

The presence of structural irregularity in a building has a significant impact on its seismic response. The structural irregularity aspect has not been adequately addressed by the codes in formulating the seismic design methodologies. The past earthquake records show that the irregular buildings exhibit a poor seismic performance which shows inadequacy of the seismic design codes based on which these buildings were designed. Therefore, structural irregularity aspect needs to be incorporated in formulating the seismic design methodologies. Moreover, the code procedures of seismic design are based on elastic analysis and single degree of freedom system (SDOF) which is unrealistic. In this study, the building models with different types, magnitude and location of irregularity have been described at first. Secondly, different analysis methods available to obtain the seismic response have been discussed and based on review of analysis methods a suitable method has been adopted for analysis of irregular building models.

II. PROPOSED WORK

1. Decide various irregularities in building such as geometric irregular or stiffness irregular.
2. Identifying effect of positions of irregularities mentioned above in building.
3. Analyze building frames with different irregularities for different loading combinations.
4. Develop generalized charts to highlight effect of irregularities on building frame.

III. METHODOLOGY

Structure has been defined into Geometric and stiffness irregularity as specified in IS1893-2002 code. In this present work, an effort is made to study the seismic effects on structures due to this irregularity. Different configurations of structures are considered for the FE analysis using ETABS software. Equivalent Static, and Response Spectrum are studied for the structure and results like natural frequencies, mode shapes, accelerations, displacements and storey drifts are obtained for an irregular building.

Methods of Analysis: I. Equivalent Static Analysis(ESA) II. Response Spectrum Analysis (RSA)

Linear Static Approach – According to this approach design forces and displacements are computed by applying set of static lateral forces to the structure. This method is based on following two important assumptions. Firstly, an adequate design action can be obtained using static analysis even though it is recognized that earthquake response is dynamic. Secondly linear elastic model is considered acceptable, even though nonlinear response to strong ground motion may be accepted.

The equivalent lateral force procedure forms the backbone of seismic analysis of building structures. The basic assumptions of the ELF procedure are that the structure responds in its fundamental mode of vibration and that the shape of this fundamental mode varies linearly with the height of the structure. These assumptions are reasonable for structures with regular distributions of stiffness, strength or mass along the height of structure. The heart of ELF procedure is given by the equations for design base shear.

Total design base shear in a given direction is determined by

$$Vb = Ah.W$$

Where

Ah is design horizontal seismic coefficient

$$Ah = \frac{ZISa}{2Rg}$$

Provided that for any structure with $T \leq 0.1$s, the value of *Ah* will not be taken less than Z/2 whatever be the value of *I/R*

Response spectrum analysis (RSA):

This approach permits the multiple modes of response of a building to be taken into account. This is required in many building codes for all except for very simple or very complex structures. The structural response can be defined as a combination of many modes. Computer analysis can be used to determine these modes for a structure. For each mode, a response is obtained from the design spectrum, corresponding to the modal frequency and the modal mass, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building are observed.

Structure properties

a) No of stories – G+15, G+19, G+23
b) Storey height – 3 meter
c) No of bays in X and Y direction - 8 bays and 5 bays
d) Spacing of frames in X and Y direction – 4 meter
e) Seismic zone – III
f) Soil type – II
g) Response reduction factor (R) – 5
h) Zone factor (Z) – 0.16
i) Importance factor (I) – 1.5

3.3Section properties

Column size **–** 300 x 900mm, 300 x 750mm
Beam size – 230 x 450mm,300x750mm
Slab thickness – 150 mm

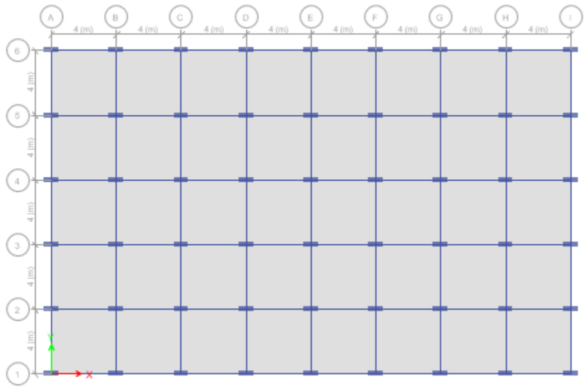
3.4Material Properties

a) Reinforced concrete	
i) Grade of concrete	M 25
ii) Density of concrete	25 KN/m^3
iii) Poisson's ratio (U)	0.2
iv)Modulus of elasticity	25000 Mpa
b) Reinforcement steel	
i) Grade of steel –	FE 500 FE 415
ii) Density of steel	76.97 KN /m^3
iii) Poisson's ratio (U)	0.2
iv) Modulus of elasticity `	200000 Mpa

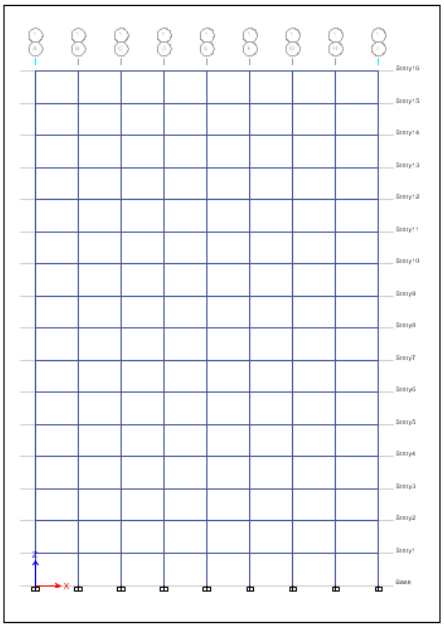
Table- 1

IV. MODELLING - In this paper an analytical study is made to find response of different regular and irregular structures located in zone III. Analysis has been made by taking G+15,G+19,G+23 storey rectangular buildings having 8 x 5 bays by static and dynamic methods using ETABS 2016 and IS code 1893-2002 (part1). These structures are considered as resting on medium soil. In geometric irregular structure setback is provided at 25%, 50%, 75% height of structure while in stiffness irregular structure column size is reduced from 300x 900mm to 300x750 mm at 25%, 50%, 75% height of structure.

Regular model

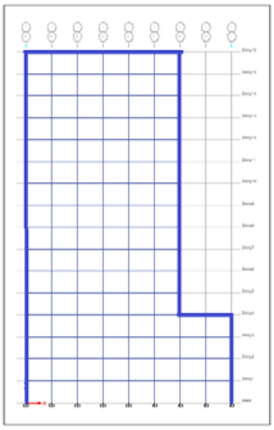


Plan
Figure - 1



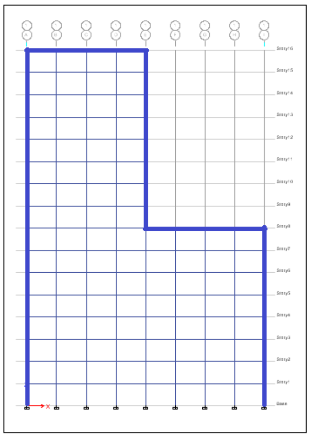
Elevation
Figure - 2

Geometric irregularity – Set back structures.

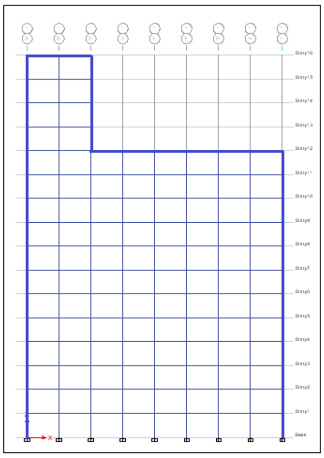


Irregular structure having setback at 25% level of structure height

Figure – 3



Irregular structure having setback at 50% level of structure height

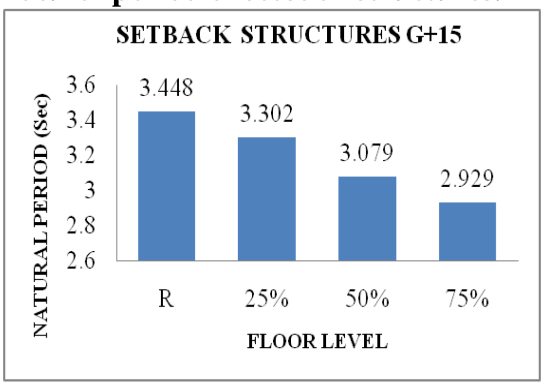


Irregular structure having setback at 75% level of structure height

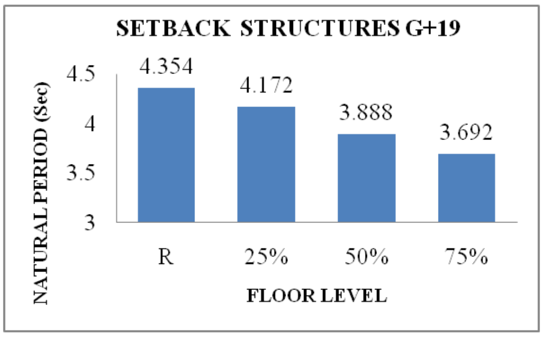
V. RESULTS

The seismic parameters considered for present study are Natural period, Top storey displacement, Base shear. Top storey displacement and base shear is noted down for X and Y direction from equivalent static analysis and response spectrum analysis.

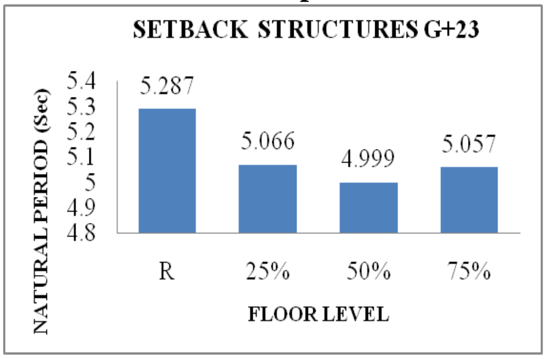
Natural period of setback structures.



Graph- 1



Graph- 2



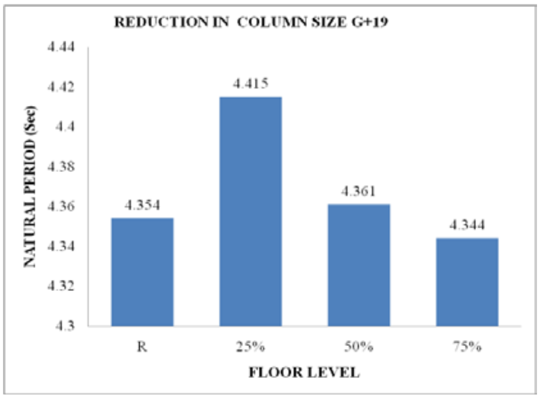
Graph- 3

Top storey displacement of geometrical irregular setback structures

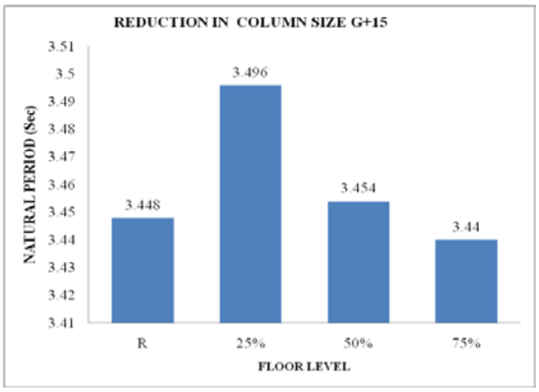
GEOMETRIC IRREGULARITY - DISPLACEMENT						
No of storey	Structure height level	Eqx direction Top storey displacement (mm)	Eqy direction Top storey displacement (mm)	Eqx direction Top storey displacement (mm)	Eqy direction Top storey displacement (mm)
		SETBACK STRUCTURES		SETBACK STRUCTURES	
G+15	R	40.715	52.006	28.012	36.431
	25%	43.23	57.12	27.43	40.57
	50%	47.60	67.47	27.83	41.37
	75%	41.68	61.51	26.94	41.80
G+19	R	52.07	72.43	35.74	50.25
	25%	55.557	76.245	35.308	53.362
	50%	61.613	86.26	35.68	52.348
	75%	53.93	78.57	34.642	52.944
G+23	R	65.037	108.11	44.31	74.452
	25%	68.503	113.782	43.245	78.755
	50%	66.979	118.617	42.742	82.218
	75%	63.283	116.926	42.336	83.342

Table- 2

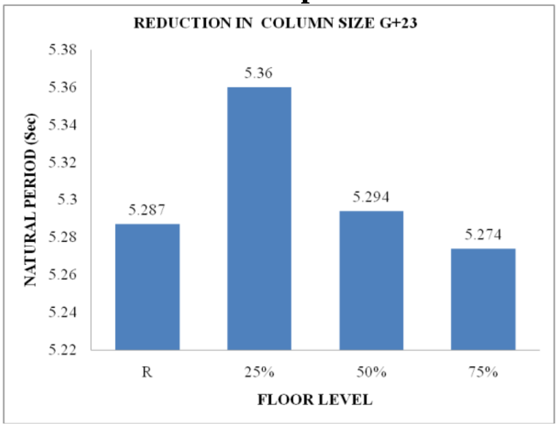
Natural period of structures having reduction in column size



Graph- 4



Graph- 5



Graph- 6

Base shear of structures having reduction in column size

No of storey	Structure height level	Eqx direction (Kn)	Eqy direction (Kn)	Eqx direction (Kn)	Eqy direction (Kn)
		STRUCTURES HAVING REDUCTION IN COLUMN SIZE (ESA)		STRUCTURES HAVING REDUCTION IN COLUMN SIZE (RSA)	
G+15	R	-2168.91	-1647.9253	1927.7993	1497.6942
	25%	-2122.04	-1606.74	1879.52	1457.83
	50%	-2149.55	-1632.64	1903.75	1479.62
	75%	-2164.53	-1645.43	1919.47	1492.97
G+19	R	-2128.30	-1776.52	1921.01	1593.56
	25%	-2084.61	-1756.50	1872.76	1570.07
	50%	-2111.25	-1763.17	1897.73	1577.13
	75%	-2124.87	-1769.85	1913.23	1585.82
G+23	R	-2132.72	-2132.72	1925.07	1857.30
	25%	-2108.69	-2108.69	1893.09	1826.05
	50%	-2116.70	-2116.70	1903.42	1835.99
	75%	-2124.71	-2124.71	1914.44	1848.17

Table- 3

VI. CONCLUSIONS

1 Setback structures

i) Natural period of vibration is less in structures having setback at higher floor levels.

ii) Maximum top storey displacement occurs when setback is provided at 50% height of structure. Due to setback in structure displacement is more as compared with regular structure.

iii) In setback structures base shear is less than that of regular structures. Difference in base shear w.r.t regular structure is from -25% to+0.5 % both in ESA and RSA

Structures having reduction in column sizes –

i) Natural period of vibration is maximum in structures where column size reduction is from 25 % of height level.

ii) Maximum top storey displacement occurs in structure where columns size reduction is done at 25% of structure height. Irregular structures have more top storey displacement than regular structures.

iii) As Column size reduces at upper floors base shear of the structure increases, but base shear of regular structure is more than that of irregular structures.

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