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Effect of Plans Configurations on the Seismic Behaviour of the Structure By Response Spectrum Method

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ABSTRACT

The bahaviour of building during earthquake depends critically on its overall shape, size and geometry. Building with simple geometry in plan have performed well during strong past earthquake but building with u, v, H & + shaped in plan have sustained significant damage. So the proposed project attempts to evaluate the effect of plan configurations on the response of structure by RSM(response spectrum method)
The Indian Standard Code (IS-Code) of practice IS-1893 (Part I: 2002) guidelines and methodology are used to analyse the problem.
In this proposed work the study is carried on the effect of difference geometrical configurations on the behaviour of structure of the already constructed building located in the same area during earthquake by RSM in tis paper, more emphasis is made on the plan configurations and is anlysed by RSM since the RSM analysis provides a key information for real – world application.

Keywords - **Geometry, configurations, RSM, irregular profiles, susceptible**

1. INTRODUCTION

Buildings are the complex system and multiple items have to be considered at the moment of designing them. Hence at the planning stage itself, architects and structural engineers must work together to ensure that the unfavourable features are avoided and good building configuration is chosen.
"If we have a poor configuration to start with , all the engineers can do is to provide a band aid → improve a basically poor solution as best as he can.
Conversely, if we start off with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much. But constructions can suffer diverse damages when they put under seismic excitations, although for same structural configuration, region, EQ damages in the systems are neither nor homogenous. A desire to create an aesthetic and functionally efficient structure drives architects to conceive wonderful and imaginative structures.
Sometimes the shape of building catches the eye of visitor, sometimes the structural system appeals, and in other occasions both shape and structural system work together to make the structure a Marvel. However, each of these choices of shapes and structure has significant bearing on the performance of building during strong earthquake.
So the symmetry and regularity are usually recommended for a sound design of earthquake resistant structure.

Fig. 1: Residential building

Earthquake resistant engineering emphasis the inconvenience of using irregular plans, recommending instead the use of simple shapes. The effects that cause seismic action in irregular structures were observed in many recent earthquake.(8)

Structural Irregularity

Is defined by location at the resistant elements, walls, columns, joints with nonstructural elements, floor systems, wall openings and geometric arrangement.
When irregular features are included in buildings, a considerably higher level of engineering effort is required may not be as good as one with simple architectural features.
Observations of structural damage due to strong earthquake shows the class of building.
So the structure can be classified on the basis of irregularity.

1. Regular
2. Moderately irregular

3. Strongly irregular

Fig. 2: + shape building

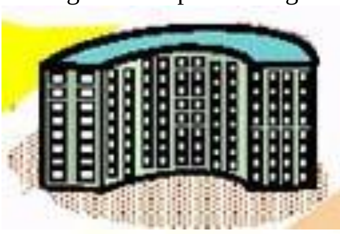

Fig. 3: C-shape building

Decisions made at the planning stage on building configuration are more important since the wide range of structural damages observed educative past earthquake across the world is very educative in identifying structural configurations that are desirable versus those which must be avoided. So the irregular structure needs a more careful structural analysis to reach a suitable earthquake system.
For this reason small mistakes caused by infcorrect analysis simpications of these structures could cause important damages during earthquake and represents vulnerability conditions that are not quantified correctly in all occasions by some simplified method such as Response Spectrum Method (RSM).

2. RESEARCH SIGNIFICANCE

Dynamic analyses are more complex, both in concept as well as in implementation than the simple and readily usable codal formulas. That is why, most of the building designer are increasingly depending on the codal formulae.
Most of the codes generally do not provide enough guidance on when the code formulas should be abandoned in favour of dynamic analysis, whether the dynamic response should be determined by response History or response spectrum analysis.
At present, many countries have their own building codes of practice. These building codes give design requirements and construction aspects of structures to reduce damage as well earthquake resistance in simple buildings, but are insufficient for buildings having special characteristics. The buildings included in the later category are as follows.

- High rise buildings
- Long and narrow buildings
- Asymmetric buildings
- Buildings with irregular configurations
- Setback buildings
- Buildings with flexile first story
- Buildings with vertical structural irregularities, etc.

In the present study effect of various plan configurations on the response (behaviour) of already constructed three buildings of college will be studied with the help of response spectrum method and at the end out of these three buildings vulnerable building will be detected.

3. STRUCTURAL CONFIGURATIONS

Configuration plays an important role in the seismic performance of structures subjected to earthquake actions. Past earthquake reconnaissance has pointed towards the observation that buildings with irregular configurations are more vulnerable than their regular counterparts. To prevent unfavourable failure modes adequate 'Conceptual design' is required at an early stage. In addition, through assessment of the structural configuration is vital to achieve adequate seismic performance.
Structural configuration has two fundamental aspects"

- Overall form
- The types of lateral resisting system employed.

The impact of structural configuration in plan and elevation on seismic performance depends on Building forms has to be decided initially in the deisgn process. Different aspects of building forms such as Height, Horizontal size, proportion and symmetry are discussed below.

Scale:

"It is not possible to alter the size of a structure and its components and still retain the same structural behaviour".

Height:

Increasing the height of a building may be similar to increasing the span of cantilever beam. As the build grows taller there is a change in the level of response to the seismic force .the effect of an increase in height may be quiet disproportionate to the increase in seismic force itself.

Fig. 4: Sky scrapper Building with irregularity

Horizontal Size

It is easy to visualize the Overturning forces associated with height as a seismic problem, but large plan areas can also be detrimental. When the plan becomes extremely large, even if it is symmetrical, simple shape. The building can have trouble responding as one unit to earth vibration.
Increase in length of building increases the stresses in a floor working as a horizontal distribution diaphragm in a transverse direction. The rigidity of the floor may not be sufficient to redistribute the horizontal load during an

earthquake from weaker or damaged supporting elements of the building to stronger elements or those with minor damage. As the absolute size of the structure increases, the range of cost-efficient configurations of system is reduced.

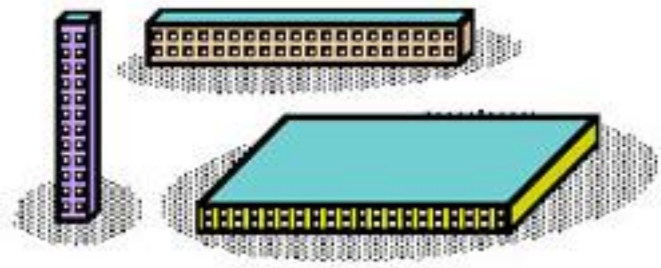

Fig. 5: Buildings with one their overall sizes much large or much smaller do not perform well during earthquake

Proportion

In seismic design, the proportions of a building may be more important than its absolute size. For tall buildings the slenderness ratio of a building is one of the important considerations than just the height alone. The more slender the building is worse are the overturning effects of an earthquake and greater are the earthquake stresses.
Some experts suggest limiting the height/depth ratio to 3 or 4 to safeguard the building against overturning.

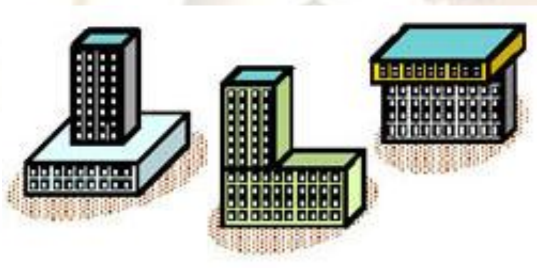

Fig. 6: Unsymmetrical buildings

Symmetry

The plan shape of a building should be as simple as possible. The theoretical optimum shape is a round tower, where as long buildings, L-shaped or zigzag shape or buildings with attached wings are undesirable in the high risk areas and therefore should be avoided.

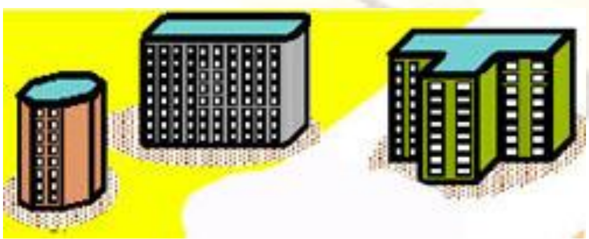

Fig. 7: Symmetrical building

The term of symmetry denotes a geometrical property of the plan configuration, whereas the structural symmetry means that the centres of mass and the centre of resistance are located at the same point. In a symmetrical configuration the eccentrically between the center of mass and resistance will produce torsion and stress concentration and therefore the symmetrical forms are preferred to the asymmetrical ones.
This suggest that when good seismic performance has to be achieved along with maximum economy of design and construction, the simple, regular and symmetrical shapes are much preferred.(8)

4. RESPONSE SPECTRUM METHOD

A response spectrum is simply a plot of the peak or steady – state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency, that are forced into motion by the same base vibration or shock.
The RSM plays an important role in practical analysis of multistory buildings for earthquake motions. The maximum response of the building is estimated directly from the elastic or inelastic design spectrum characterizing the design earthquake for the site and considering the performance criteria for the building.(1-3)
The resulting estimates of maximum forces and deformations provide a basis for preliminary design of buildings. Furthermore, most building code specifications for earthquake forces are based on simplifications of the response spectrum method of analysis.
The response spectrum method (RSM) was introduced in 1932 in the doctoral dissertation of Maurice Anthony Biot at Coltech. It is an approach to finding earthquake response structures using waves or vibrational mode shapes.
The concept of the “Response Spectrum” was applied in design requirements in the mid 20th century for example in building codes in the state of California. (Hudson, 1956; Trifunac and Todorovska, 2008). It came into widespread use as the primary theoretical tool in earthquake engineering in the 1970s when strong-motion accelerograph data become widely available. The response spectrum involves simplifying assumptions; however, it can yield important information S.a. effect of varying damping.
Final goal of using a method such as RS analysis is to design mechanism that actively or passively absorb energy associated with an earthquake for e.g. seismic isolation involves mounting a building on bearings with low horizontal stiffness, thus increasing the natural vibration frequency and reducing acceleration.
Thus RSM provides key information for real-world applications and is the primary tool in engineering seismology.
RSM is very useful tool for earthquake engineering for analyzing the performance of structures and equipments in earthquake. Since many behave principally as simple oscillators (also known as single degree of freedom systems). Thus if natural frequency is find out then the peak response of the building can be estimated by regarding the value from the ground response spectrum for the appropriate frequency.
In the 1982 Newmark & Hall describe how they developed an “Idealized” seismic response spectrum based on a range of response spectra generated for available earthquake record. This was then further developed into a design response spectrum for use in structural design and this basic form with some modifications is now the basis for structural design in seismic regions throughout the world.

Earthquake engineers prefer to report interaction between ground acceleration and structural systems through.

5. PROBLEM

Three eight storey reinforced concrete frame buildings of three different configurations have been considered & analyzed with the help of ETAB software by using Response spectrum method.

Following properties are considered for three buildings naming building B1, B2, B3.

1. All the three buildings are having approximately equal area, spacing of the frame =3-3.2m,spacing of columns =10-11m.
2. Height of building =25.1m
3. Size of beams=300*750mm
4. Size of columns=300*600mm
5. Seismic zone factor=0.36
6. Type of soil =medium
7. Nature of three buildings is explained as follows-

Type of building	Nature of building
B1	Regular profile
B2	Moderately irregular
B3	Severely irregular

Plan of all the B1, B2, B3 buildings are as follows:

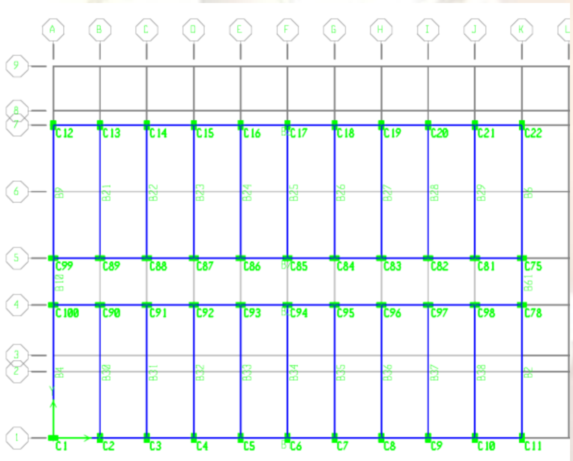

Fig. 8: Plan of B1 Building

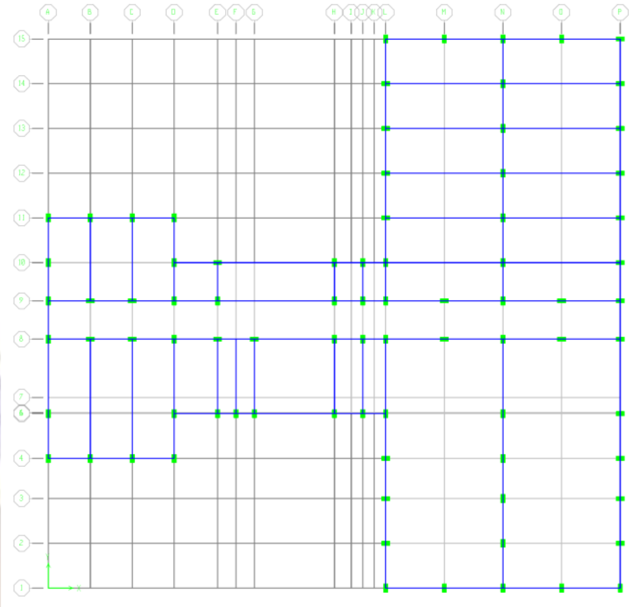

Fig. 9: Plan of B2 building

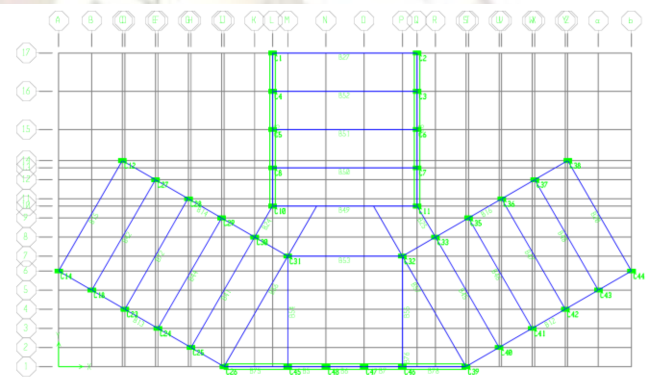

Fig. 10: Plan of B3 building

6. RESULT

Table 1: Story shear data of buildings of B1, B2 and B3

STORY	EQX DIRECTION			EQY DIRECTION		
	CIVIL	MECH	COMP	CIVIL	MECH	COMP
8	353	723.47	400.82	264.35	707.15	253.57
7	602.42	1420.48	813.78	451012	1387.13	514.832
6	819.33	1991.38	1107.2	613.56	1951.3	700.46
5	973.45	2441.02	1301.47	728.97	2407	823.36
4	1075.48	2813.33	1416.94	805.38	2789.18	896.41
3	1136.14	3184.3	1474	850.8	3130.17	932.51
2	1166.11	3470.78	1493.03	873.25	3430.74	944.55
1	1176.32	3719.53	1493.62	-880.89	3656.77	944.92

Table 2: Displacement data of buildings of B1, B2 and B3 for combination 1

	EQX			EQY		
	CIVIL	MECH	COMP	CIVIL	MECH	COMP
	DIRECTION					
STORY	X1	X1	X1	X2	X2	X2
8	9.307	29.176	36.33	0.161	15.098	0.61
7	8.888	28.012	32.2	0.128	14.408	0.52
6	8.2	26.187	27.226	0.106	13.373	0.42
5	7.294	23.716	21.411	0.076	12.016	0.32
4	6.225	20.695	15.09	0.051	10.394	0.22
3	5.055	17.202	8.844	0.28	8.554	0.12
2	3.819	13.367	3.5	0.006	6.603	0.05
1	2.537	8.819	2.8	0.0016	4.333	0.2

Table 3: Displacement data of buildings of B1, B2 and B3 for combination 2

	EQX			EQY		
	CIVIL	MECH	COMP	CIVIL	MECH	COMP
	DIRECTION					
STORY	Y1	Y1	Y1	Y2	Y2	Y2
8	0.688	10.809	14.284	12.284	22.217	31.806
7	0.486	10.224	12.26	11.837	21.195	29.062
6	0.428	9.457	10.299	10.884	19.714	25.468
5	0.31	8.48	8.176	9.675	17.763	20.978
4	0.125	7.329	5.933	8.213	15.409	15.859
3	0.124	6.032	3.644	6.599	12.712	10.345
2	0.044	4.614	1.464	4.884	9.723	4.742
1	0.067	3.015	0.122	3.077	6.347	4.16

Table 4: Storey drift data of buildings of B1, B2 and B3 for combination 1

	EQX			EQY		
	CIVIL	MECH	COMP	CIVIL	MECH	COMP
	DIRECTION					
STORY	X1	X1	X1	X2	X2	X2
8	0.139	0.434	1.377	0.011	0.254	0.000003
7	0.23	0.68	1.658	0.007	0.379	0.000003
6	0.302	0.906	1.938	0.1	0.49	0.000003
5	0.357	1.073	2.107	0.008	0.573	0.000003
4	0.391	1.208	2.082	0.008	0.634	0.000003
3	0.411	1.319	1.777	0.007	0.682	0.000002
2	0.427	1.521	1.073	0.007	0.762	0.000009
1	0.619	2.151	0.2	0.004	1.057	0.000019

Table 5: Storey drift data of buildings of B1, B2 and B3 for combination 2

	EQX			EQY		
	CIVIL	MECH	COMP	CIVIL	MECH	COMP
	DIRECTION					
STORY	Y1	Y1	Y1	Y2	Y2	Y2
8	0.067	0.735	0.675	0.149	0.369	0.915
7	0.02	0.535	0.654	0.318	0.539	1.198
6	0.039	0.479	0.708	0.403	0.702	1.497
5	0.031	0.447	0.748	0.487	0.828	1.706
4	0.031	0.407	0.763	0.538	0.926	1.838
3	0.026	0.353	0.727	0.571	1.008	1.868
2	0.037	0.28	0.447	0.602	1.128	1.442
1	0.016	0.209	0.111	0.751	1.548	0.0378

9. CONCLUSION

From the experimental investigations carried out following conclusions can be drawn -

1. The plan configurations of structure has significant impact on the seismic response of structure in terms of displacement, story drift, story shear.
2. Effect of Area on STORY SHEAR-It was observed that the story shear in building no. 2 was more though the irregularity in the plan configuration was less as compared to building no. 3.
3. Torsion- Torsion was observed only in building no. 3 as the level of irregularity is maximum. The building is symmetrical about ONE axis but the Orientation of block is oblique.
4. Displacement – Large displacement were observed in the building no. 3 and least displacement were observed in building no. 1. It indicates that building with severe irregularity shows maximum displacement and storey drift.

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