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Seismic Analysis of Buildings Resting on Sloping Ground and Considering Bracing System

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Abstract:

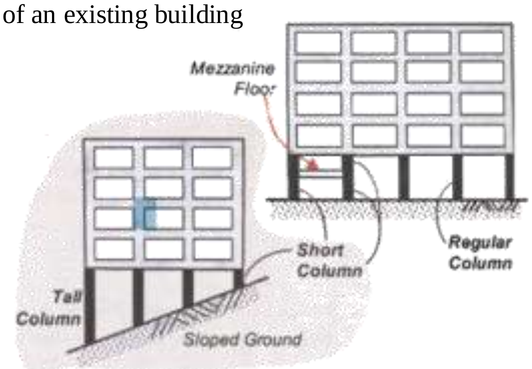
Most of the constructions in hilly regions are constrained by local topography which results in the adoption of either a step back or step back &set back configuration. Due to this the structure is irregular by virtue of varying column heights leading to torsion and increased shear during seismic ground motion. The dynamic analysis is carried out using response spectrum method to the step back and step back & set back building frames. The dynamic response i.e. fundamental time period, storey displacement & drift, and base shear action induced in columns have been studied for buildings of different heights. These results show that the performance of step back & set back building frames are more suitable in comparison with step back building frames. But after considering bracings to the step back building frames, a better performance can be observed when compared with step back & set back building frames.* Seismic *analysis is a method to carry out the response of the building structure during ground motions. It is a part of process structural design, which includes seismic assessments of the buildings and also the retrofitting measures to strengthen the retaining structure in the seismic regions.

KEYWORDS-

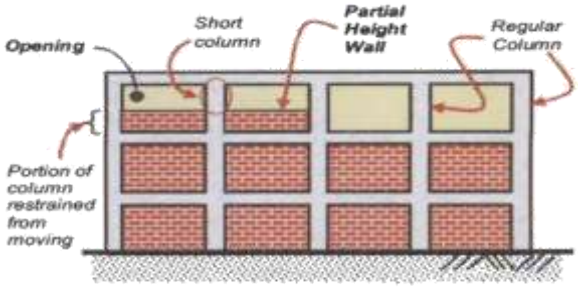
step back frames, step back & set back frames, step back with bracings, Static analysis, response spectrum analysis, Hill slope angle, number of bays.

I.INTRODUCTION

Seismic analysis is a method to carry out the response of the building structure during ground motions. It is a part of process structural design, which includes seismic assessments of the buildings and also the retrofitting measures to strengthen the retaining structure in the seismic regions. In recent days the buildings with irregular configurations in both plan and elevation are common. These buildings asymmetry will suffer severely during earthquakes and undergo coupled torsion and lateral motions. A building can be designed to be earthquake proof for a rare but strong earthquake proof, but such buildings will be more expensive. The most logical approach to seismic design problem is to accept the uncertainty of the seismic phenomenon.this procedure gives the engineer a better understanding of the seismic characteristics of the structure and results in more logical and effective designs in future buildings and will be more economical for the retrofitting strategy of an existing building



There is another special situation in buildings when short-column effect occurs. Consider a wall (masonry or RC) of partial height built to fit a window over the remaining height.

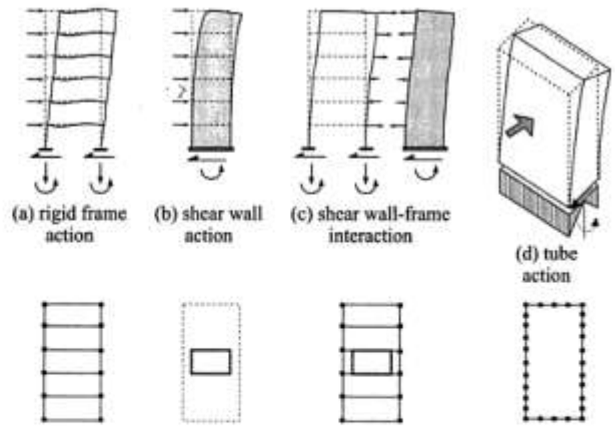


The adjacent columns behave as short columns due to presence of these walls. In many cases, other columns in the same storey are of regular height, as there are no walls adjoining them. When the floor slab moves horizontally during an earthquake, the upper ends of these columns undergo the same displacement. However, the stiff walls restrict horizontal movement of the lower portion of a short column, and it deforms by the full amount over the short height adjacent to the window opening. On the other hand, regular columns deform over the full height. Since the effective height over which a short column can freely bend is small, it offers more resistance to horizontal motion and thereby attracts a larger force as compared to the regular column. As a result, short column sustains more damage. X-cracking in a column adjacent to the walls of partial height

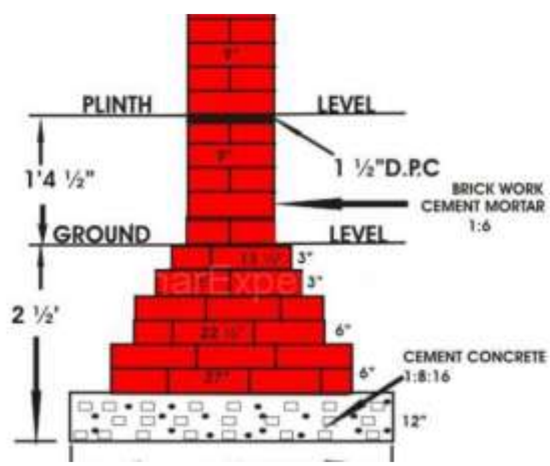
because brick is cheaper than the concrete. It is also increases the lateral stiffness of the ground storey which is required to minimize the soft storey effect.

II.LATERAL LOAD RESISTING SYSTEMS

The horizontal and vertical sub-systems of a structural system interact and jointly resist both gravity loads and lateral loads. Lateral load effects (due to wind and earthquake) predominate in tall buildings, and govern the selection of the structural system. There are three basic types of lateral load resisting systems there are moment-resisting frames, shear walls, and braced frames. Generally, shear walls are the most rigid, that is, they deflect the least when subject to a given load. Braced frames are usually less rigid than shear walls, and moment-resisting frames are the least rigid. Lateral load resisting systems of reinforced concrete buildings generally consist of one of the followingFrames These are generally composed of columns and beams [Their ability to resist lateral loads is entirely due to the rigidities of the beam-column connections and the moment-resisting capacities of the individual members. They are often (albeit mistakenly) called 'rigid frames', because the ends of the various members framing into a joint are 'rigidly'



connected in such a way as to ensure that they all undergo the same rotation under the action of loads. In 'flat plate' or 'flat slab' system, a certain width of the slab, along the column line, takes the place of the beam in 'frame action'. Frames are used as the sole lateral load-resisting system in buildings with up to 15 to 20 storeys.When earthquake motion causes a building to move, energy is induced into the building structure. The function of the lateral load resisting system is to absorb this energy by moving, or deforming, without collapse. The building will probably be damaged during a major earth-quake, but the damage is expected to be repairable.



The ability of structural systems and materials to deform and absorb energy, without failure or collapse, is termed ductility. Materials or sys-tems that arc able to absorb energy through movement are called ductile, whereas those which arc less able to do so are termed non-ductile or brittle. An extreme example of a ductile, though non-structural , material would be a rubber band, while an example of a non-ductile material would be unreinforced concrete.

III BRACINGS

Braced Frames

Rigid frame systems are not efficient for buildings taller than about 30-stories because the shear racking component of deflection due to the bending of columns are girders causes the drift to be too large. A braced frame attempts to improve upon the efficiency of a rigid frame by virtually eliminating the bending of columns and girders. This is achieved by adding web members such as diagonals or chevron braces. The horizontal shear is now primarily absorbed by the web and not by the columns. The webs carry the lateral shear predominantly by the horizontal component of axial action allowing for nearly a pure cantilever behaviour.

In simple terms, braced frames may be considered as cantilevered vertical trusses resisting lateral loads primarily through the axial stiffness of columns and braces. The columns act as a chord in resisting the overturning moment, with tension in the windward column and compression in the leeward column. The diagonals and girders work as the web members in resisting the horizontal shear, with diagonals in axial compression or tension depending upon their direction of inclination. The girders act axially, when the system is a fully triangulated truss. They undergo bending also when the braces are eccentrically connected to them. Because the lateral load on the building is reversible, braces are subjected in turn, to both compression and tension; consequently, they are most often designed for the more stringent case of compression.

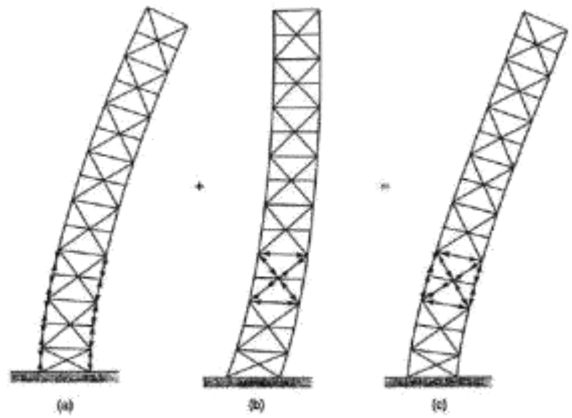


Figure 1 : Braced frame deformation: (a) flexural deformation; (b) shear deformation; (c) Combined configuration

IV NUMERICAL MODELING

Geometrical Properties

4.1 Two Models

1.Set and Step Back

1. Height of typical storey=3 m
1. Height of ground storey=3.5m
2. Length of the building = 56m
3. Width of the building = 8 m
4. Height of the building = 45 m
5. Number of stores=15

6. Wall thickness =230 mm
7. Slab Thickness =115 mm
8. Grade of the concrete =M20
9. Grade of the steel= Fe415
10. Support = fixed
11. Column sizes
    1 to 10th storey =0.53m X 0.53m
    11 to 15th storey=0.45m X 0.45 m
    Beam sizes
    1 to 10th storey =0.23m X 0.4 m
    11 to 15th storey =0.23m X0.45 m

Step Back

1. Height of typical storey =3 m
2. Height of ground storey=3.5m
3. Length of the building =56m
4. Width of the building = 8 m

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5. Height of the building =45 m
6. Number of stores=15
7. Wall thickness =230mm
8. Slab Thickness =115mm
9. Grade of the concrete=M20
10. Grade of the steel = Fe415
11. Support=fixed
12. Column sizes
1 to 10th storey = 0.53m X 0.53m
11 to 15th storey =0.45m X 0.45 m
13. Beam sizes
1 to 10th storey=0.23m X 0.4 m
11 to 15th storey =0.23mX0.45m

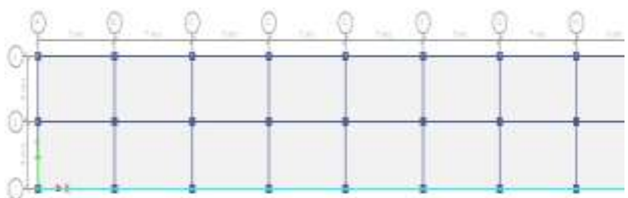


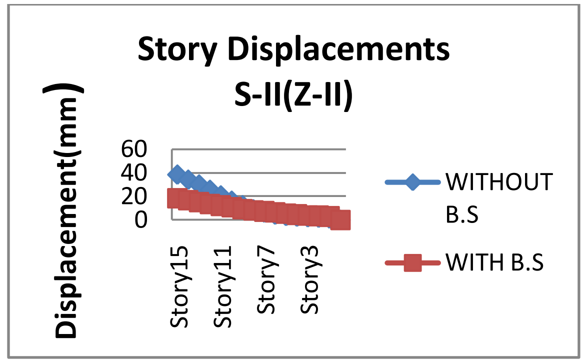
Fig2.: Base plan of step back &set &step back

V RESULTS

5.1 COMPARISON OF DISPLACEMENT IN SET & STEP BACK MODEL WITHOUT & WITH BRACING

Table1:Showing Displacement values of 1.2(DL+LL+EQL) in Z-II, S-II

STORY	BRACINGS	
	WITHOUT B.S	WITH B.S
	X-DIR(MAX)	X-DIR(MAX)
Story15	38.3	18.1
Story14	34	16.5
Story13	29.9	14.9
Story12	25.4	13.5
Story11	20.7	12
Story10	16.2	10.6
Story9	12.4	9.2
Story8	8.9	8.1
Story7	6.1	7.1
Story6	4.4	6.2
Story5	3.3	5.3
Story4	2.7	4.5
Story3	2.2	3.8
Story2	1.8	3.3
Story1	1.1	2.8
Base	0	0



Graph 1 Showing Displacement of 1.2(DL+LL+EQL), Z-I, S-II

Table2:Showing Displacement values of 1.2(DL+LL+EQL) in Z-V, S-II

STORY	BRACINGS	
	WITHOUT B.S	WITH B.S
	X-DIR(MAX)	X-DIR(MAX)
Story15	67	27.8
Story14	60.9	25.3
Story13	53.9	22.7
Story12	45.7	20.2
Story11	36.7	17.7
Story10	27.9	15.2
Story9	20.3	13
Story8	13.2	10.8
Story7	7.9	9
Story6	4.6	7.4
Story5	2.8	5.9
Story4	1.9	4.6
Story3	1.4	3.6
Story2	1.1	2.7
Story1	0.6	2
Base	0	0

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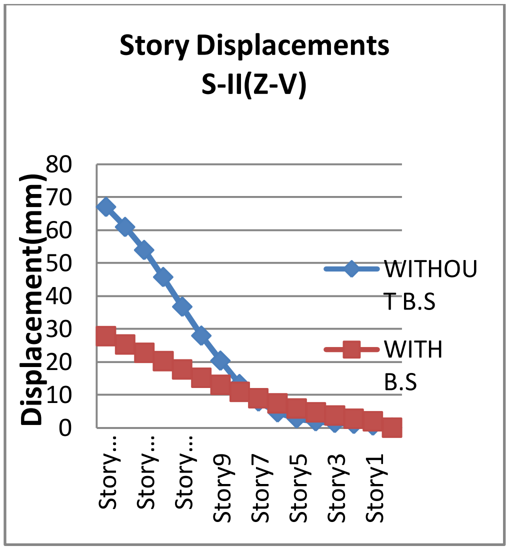
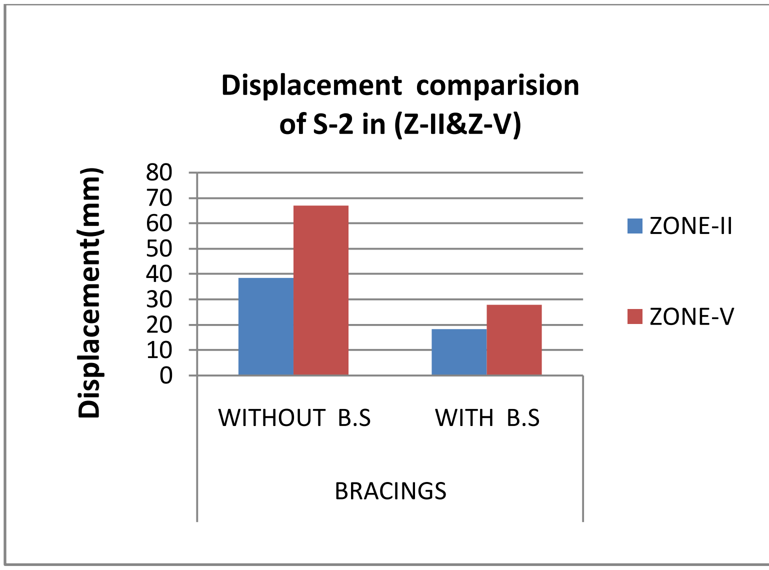


Graph2:Showing Displacement of 1.2(DL+LL+EQL), Z-V, S-II



Graph:3

Showing Displacementof1.2(DL+LL+EQL), Z-II&V,(S-II)

5.2 ZONE COMPARISON OF DISPLACEMENT IN SET & STEP BACK MODEL WITHOUT & WITH BRACING (Z-V)

Table:3Showing Displacement values of 1.2(DL+LL+EQL) in Z-II&V, (SOILS-II)

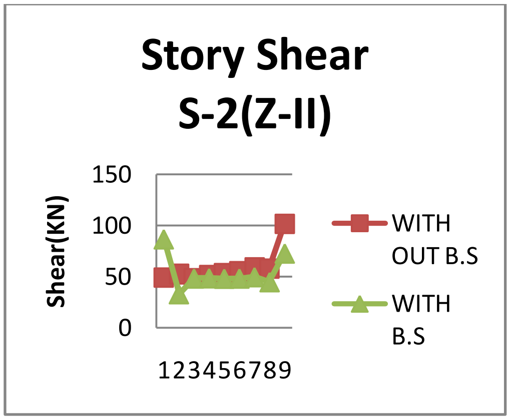
Zone	BRACINGS	
	WITHOUT B.S	WITH B.S
Z-II	38.3	18.1
Z-V	67	27.8

5.3 COMPARISON OF SHEAR IN SET & STEP BACK MODEL WITHOUT & WITH BRACING

Table:4

Showing Shear values of 1.2(DL+LL+EQL) in Z-II, S-II

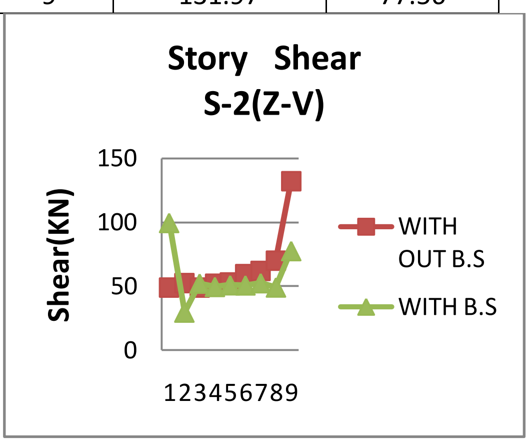
STORY	S-II	
	WITH OUT B.S	WITH B.S
1	49.24	86.93
2	52.85	33.31
3	48.84	48.61
4	52.14	48.83
5	53.54	48.4
6	55.61	48.56
7	59.27	49.91
8	58.26	45.06
9	102	73.04



Graph5:
Showing Shear of 1.2(DL+LL+EQL), Z-II ,S-II

Table6:howing Shear values of 1.2(DL+LL+EQL) in Z-V, S-II

STORY	S-II	
	WITH OUT B.S	WITH B.S
1	48.96	99.53
2	52.57	29.53
3	48.9	52.13
4	51.66	49.56
5	53.05	50.87
6	59.59	50.77
7	62	52.48
8	69.71	49.13
9	131.97	77.56



Graph6:Showing Shear of 1.2(DL+LL+EQL), Z-V ,S-II

VI CONCLUSION

- The performance of step back frames during seismic excitation can be effected more than other configurations of building frames. Hence, step back building frames without bracings on sloping ground are not desirable. However, it may be adopted by providing bracing system to control displacements.
- Step back & set back frames produces less torsion effects as compared to step back frames. In case step back building frames are proposed, then step back frame shall be designed for higher moments induced in columns due to earthquake.
- As number of storey's increases time period & top storey displacement also increases.
- Step back frames with bracings gives less displacements compared with Step back frames without bracings and also Step & Set back frames.
- From the above results Step back frames with shear walls also gives better results among all.
- In Step back buildings and Step back-Set back buildings, it is observed that extreme left column at ground level, which are short, are the worst affected. Special attention should be given to these columns in design and detailing.

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