SEISMIC PERFORMANCE OF SETBACK RC BUILDINGS WITH SOIL STRUCTURE INTERACTION

RASHMI J[1], Prof SHIVASHANKAR K M[2]

[1]PG Student, Dept. of Civil Engineering, ACS College of Engineering, Bangalore
[2]Professor, Dept. of Civil Engineering, ACS College of Engineering, Bangalore

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Abstract - In high rise framed structures, harm from seismic activity ground motion generally initiates at locations of structural weaknesses present in the lateral load resisting frames .The performance of high rise framed structures during strong seismic activity depends on the factors including distribution of mass, stiffness, and strength among the horizontal and vertical planes of structures. In certain cases, these weaknesses may arise due to discontinuity in stiffness, mass among adjacent storeys. Such discontinuity among stories are frequently associated with abrupt variations in the frame geometry alongside the height of structure. A common variety of vertical geometrical irregularity in building structures arises is the presence of setbacks, i.e. the presence of abrupt decrease of the lateral measurement of the structure at specific levels of the elevation. This structure group is recognised as 'setback building'. This structure form is attractive and more popular in current high rise structure building mostly since of its functional and artistic architecture. Stepped structure is the one with vertical geometric irregularity, where the horizontal dimension of the lateral force resisting system in any storey is extra than 150% of that in adjacent storey. These structural irregularity isn't acceptable from stability point of view, as seismic activity has proven to affect the structure in case of seismic activity. All the buildings during seismic activity is proven to be susceptible but the structures with soft storey configuration are being found to be mostly susceptible during seismic activity. Shortage of plain ground in mountainous regions and urge of mining, lead us to build asymmetrical constructions in the hills. Thus, the danger factor of these asymmetrical buildings rises sharply as even the base of the buildings becomes inclined at slope. This deadly combination of geometric irregularity, mass irregularity, stiffness irregularity makes the buildings too much weak to last during seismic activity. Hence, it is important to study the responses of such buildings to make such buildings seismic -resistant and avoid their downfall to save the damage of life and property.

Key Words: Stiffness,lateral,setbacks,irregularity etc...

1.INTRODUCTION

A building having difference among the center of mass and center of resistance is named as irregular building. Irregularity among the buildings are classified as

1. Stiffness irregularity
2. Mass irregularity
3. Vertical geometric irregularity
4. In plane discontinuity in vertical elements resisting lateral force
5. Discontinuity in capacity

Stiffness Irregularity- It is one in which the lateral stiffness is less than 70 percent of that in the storey above.

Mass Irregularity- It is considered when the seismic weight of the story is extra than 200 percent of that of its contiguous storeys.

Vertical Irregularity- A structure is said to be vertically irregular when the horizontal dimension of lateral force resisting system in the story is other than 150 percent of that in its adjacent storey.

In plane discontinuity- The in plane discontinuity is considered to exist in the primary element of lateral force resisting system whenever a lateral force resistance element is existing in one story but does not continue

Discontinuity in capacity- Discontinuity in capacity is considered when the story shear strength is fewer than the story above.

1.1 Literature review

Chandler and Mendis (2000), studied the force based seismic design system and also the displacement based seismic assessment methodology. They also presented a case study for reinforced concrete moment resisting frames according to European and Australian code provisions having low, medium and high ductility capacity. They used Elcentro NS earthquake ground motion as the seismic participation to get the performance features.

Roy and Chandrasekaran (2006): The authors analysed 10 storey R C framed structure from dynamic and static analysis. They have reported that base shear, storey shear and storey drifts was increased as the height of structure increased. They have reported that predominant of hinge formation in pushover analysis.

Poursharifi and Yasrebinia (2012): The authors analysed unsymmetrical concrete structures using pushover analysis and time history analysis for dissimilar stories (4, 6 and 8) with fixed base. They have reported that both pushover analysis and time history analysis had extreme lateral storey displacement and maximum base shear and pushover analysis was very sensitive for the given loading. The researchers also stated that the direction of loading plays an significant role for determining the critical condition of the buildings.

Literature outcome

From the above literature review, we can see many researches have analysed for different configurations such as set-back buildings, from the study done it is observed that setback building performs better under seismic loads. Also it is observed that pushover results were accurate enough for design applications. And the outcome of soil conditions also affects the structure majorly.

1.2 Objectives of the study

In the present study, Pushover analysis has been carried out on the 23 models consisting of setback building with the different foundation properties.

1. To analyze the nonlinear static behavior of the vertical irregular structures.
2. To study the seismic performance of set-back building on varying soil conditions by linear static method.
3. To learn the outcome of number of bays and height of the building which is resting on different soil conditions.

2. Modelling and Analysis

In the present thesis, 92 models of setback and step back were modelled and analysed for the different foundation conditions using ETABS

Sl No	Model	Foundation Properties	Description of the Model
1	R-6	Fixed Foundation	6 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
2	R-8	Fixed Foundation	8 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
3	R-10	Fixed Foundation	10 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
4	R-12	Fixed Foundation	12 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
5	R-15	Fixed Foundation	15 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
6	R-18	Fixed Foundation	18 storey building – no bays were removed in any floor
		Hard soil	
		Medium soil	
		Soft soil	
7	S1-6	Fixed Foundation	6 storey building – one bay on 4th, two bays on 5th floor and three bays on the 6th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	

Table 3.1: The SET BACK models considered for the analysis

8	S1-8	Fixed Foundation	8 storey building – one bay on 6th, two bays on 7th floor and three bays on the 8th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
9	S1-10	Fixed Foundation	10 storey building – one bay on 8th, two bays on 9th floor and three bays on the 10th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
10	S1-12	Fixed Foundation	12 storey building – one bay on 10th, two bays on 11th floor and three bays on the 12th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
11	S1-15	Fixed Foundation	15 storey building – one bay on 13th, two bays on 14th floor and three bays on the 15th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
12	S1-18	Fixed Foundation	18 storey building – one bay on 16th, two bays on 17th floor and three bays on the 18th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
13	S2-6	Fixed Foundation	6 storey building – one bay on 1st and 2nd, two bays on 3rd and 4th floor and three bays on the 5th and 6th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
14	S2-8	Fixed Foundation	8 storey building – one bay on 3rd and 4th, two bays on 5th and 6th floor and three bays on the 7th and 8th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
15	S2-10	Fixed Foundation	10 storey building – one bay on 5th and 6th, two bays on 7th and 8th floor and three bays on the 9th and 10th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	

Fig 3.1: Model of R-6

16	S2-12	Fixed Foundation	12 storey building – one bay on 7th and 8th, two bays on 9th and 10th floor and three bays on the 11th and 12th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
17	S2-15	Fixed Foundation	15 storey building – one bay on 10rh and 11th, two bays on 12th and 13th floor and three bays on the 14th and 15th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
18	S2-18	Fixed Foundation	18 storey building – one bay on 13th and 14th, two bays on 15th and 16th floor and three bays on the 17th and 18th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
19	S3-8	Fixed Foundation	8 storey building – one bay on 1st and 2nd, two bays on 3rd and 4th and 5th floor and three bays on the 6th and 7th and 8th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
20	S3-10	Fixed Foundation	10 storey building – one bay on 2nd and 3rd and 4th , two bays on 5th and 6th and 7th floor and three bays on the 8th and 9th and 10th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
21	S3-12	Fixed Foundation	12 storey building – one bay on 4th and 5th and 6th , two bays on 7th and 8th and 9th floor and three bays on the 10th and 11th and 12th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	
22	S3-15	Fixed Foundation	15 storey building – one bay on 7th and 8th and 9th , two bays on 10th and 11th and 12th floor and three bays on the 13th and 14th and 15th floor has been removed
		Hard soil	
		Medium soil	
		Soft soil	

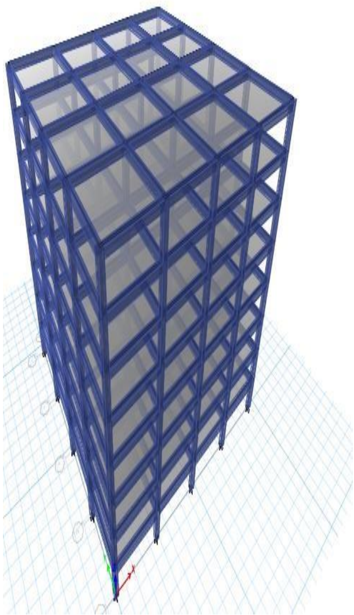

Fig 2.1: Model of R-6

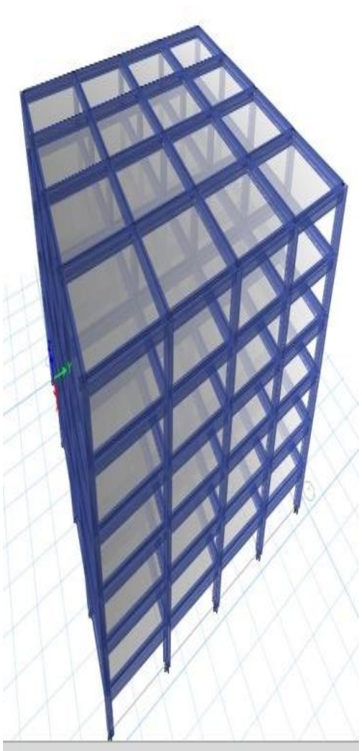

Fig 2.2: Model of R-8

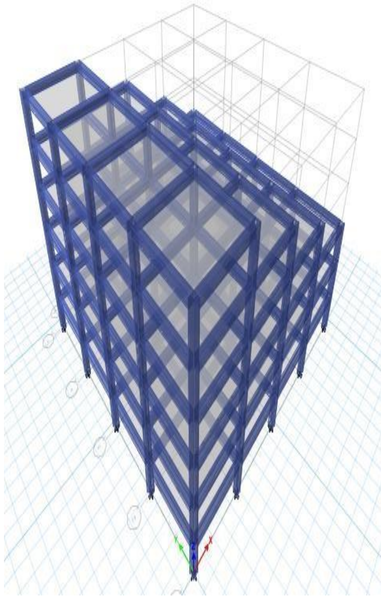

Fig 2.3: Model of S

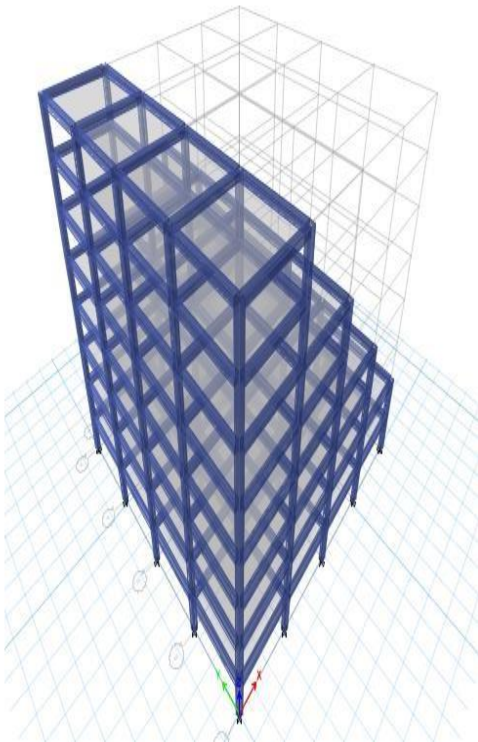

Fig 2.4: Model of S2-8

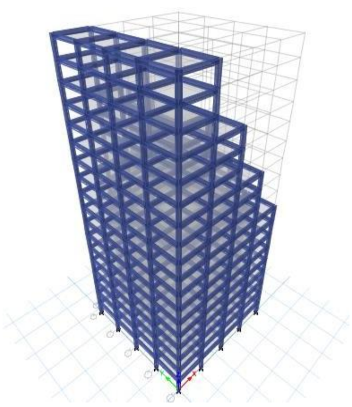

Fig 3.23: Model of S3-18

Modelling and Analysis of the Structure

The stages involved in the geometric modelling and analysing of the structure

1. Developing a Geometrical model
2. Define and Assigning the Material property and Sectional property
3. Define and Assigning the Foundation properties
4. Define Response properties
5. Define the Load patterns
6. Define Load cases
7. Run the Analysis

Creating a geometrical model

A building of 6, 8,10,12,15 and 8 stories have been modelled with the plan dimension of 24mx24m with a bay width of 6m on either side of the model. The height of each floor is 3m.

Defining and Assigning the material property and sectional property

Table 3.2: Materials properties and dimension considered for modellingDefine the Load patterns

Grade of concrete	M 2 5
Grade of steel for main reinforcement	Fe 415
Grade of steel for transverse reinforcement	Fe 250
Column dimension	450mmx500mm
Beam dimension	450mmx500mm
Slab thickness	125mm
Covers – Beam – Column	25mm 40mm

Define the Load patterns

The dead load, live load, wall load and earthquake loads are defined. The earthquake loads are defined by the code provision of IS 1893. The lateral load is auto generated in the software itself.

Live loads:

Imposed loads are those loads whose position can be change from one position to another position. Imposed loads can generally be taken from the code IS 875 (part 2).

Table 3.5 Live loads on the structure

Level	Live loads (KN/m^2)
Roof level	1.5
Floor level	3

ead loads:

Dead loads are the stationary or permanent loads which are due to its own weight of members, which are going to stay throughout the lifespan of the structure. This load intensity depends on the type of the material, as earlier mentioned it varies based on its density. As the density increases, its self-weight also increases. Dead loads generally be determined according to IS 875 (Part-1)

Wall Load

Wall load on the floors = 19.2 * (3 – 0.45) * 0.23

= (density) * (height) * (wall thickness)

= 11.26 kN-m

Parapet wall load on the roof = 19.2 * 1.5 * 0.23

= (density) * (height) * (wall thickness)

= 6.624 kN-m

Consider 25% of the live load and 100% contribution for the other loads.

Analysis

The model has been analysed for the given combination and the results are obtained for storey displacement, storey drift, storey shear, overturning moments. The graph has been drawn with respect to available results.

3.Results and discussions

In the current thesis work, the outcomes were evaluated for different models and the Displacement, Drift, Shear, overturning moments are computed for the setback buildings. These models were analysed for different flexible foundation condition of zone IV as per IS 1839- 2016 (part-I).

Comparison of storey displacement for all the setback models along X direction

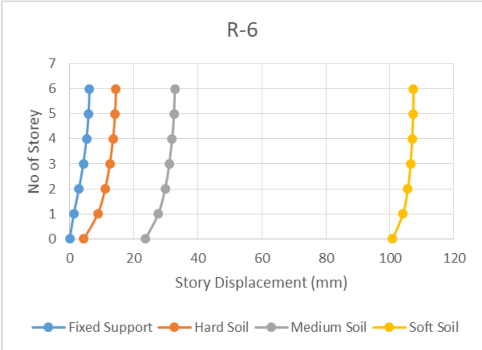

Fig 3.1: Storey displacementof R-6 along X direction

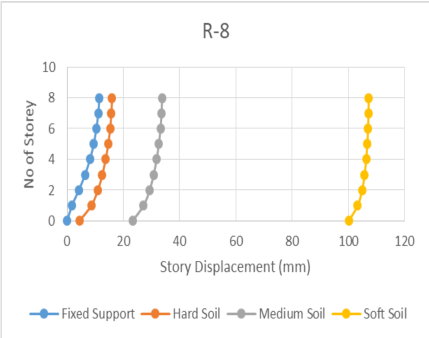

Fig 3.2: Storey displacement of R-8 along X direction

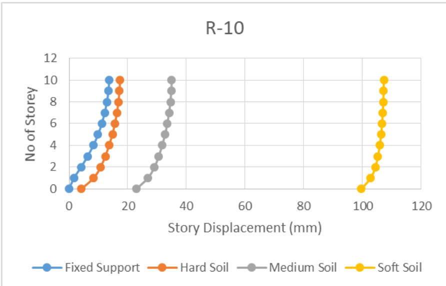

Fig 3.3 story displacement of R-10 along x-direction

Comparison of storey displacement for all the setback models along Y direction

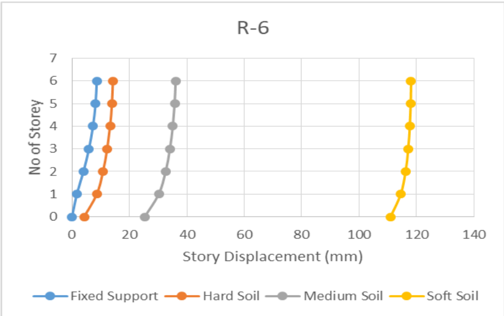

Fig 3.4: Storey displacement of R-6 along Y direction

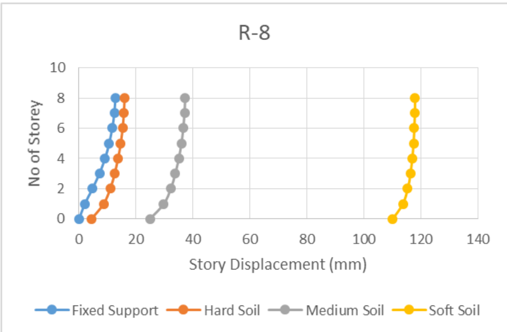

Fig 3.5: Storey displacement of R-8 along Y direction

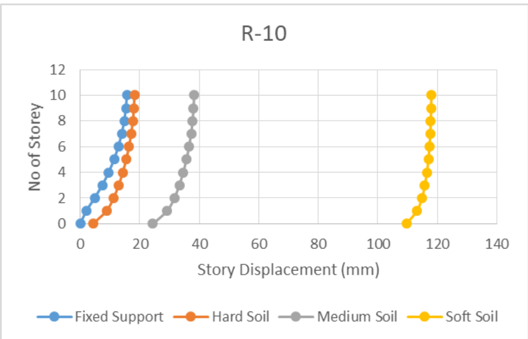

Fig 3.6: Storey displacement of R-10 along Y direction

Comparison of storey drift for all the setback models along X direction

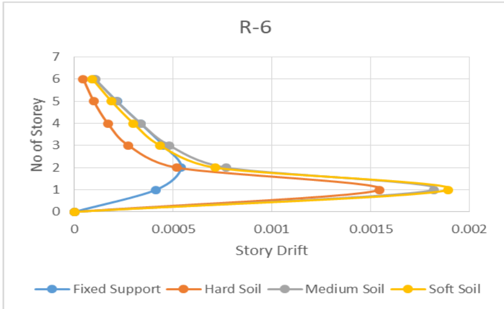

Fig 3.7: Story Drift of R-6 along X direction

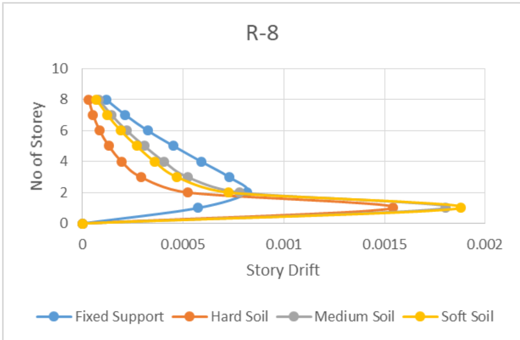

Fig 3.8: Story Drift of R-8 along X direction

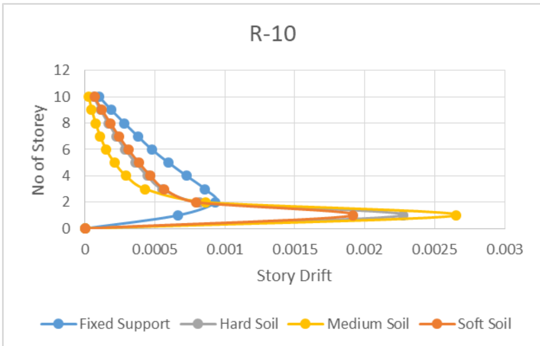

Fig 3.9: Story Drift of R-10 along X direction

4. CONCLUSIONS

In the present analysis of setback buildings (92) models were analysed and has beendiscussed in chapter 3. Based on the outcomes discussed from chapter 4, the subsequent inferences are drawn.

1. The displacement is maximum when the soil is soft (i.e. Soft soil). The displacement is maximum in the top storey of the structure. The variation of displacement on both the directions of the structure is too small (3% to 4%) for all types of foundation, this is due to the effect of variation of mass and stiffness.
2. The storey drift is maximum when the soil is soft (i.e. Soft soil). The storey drift is maximum at the 1st storey of all the setback models except for the fixed foundation condition. The variation of displacement on both the directions of the structure is too small (3% to 4%) for all types of foundation, this is due to the effect of flexibility of soil.
3. The storey shear is maximum for the fixed foundation condition. The story shear is maximum at 1st story for all conditions. Variation of displacement on both the directions of the structure is too small (3% to 4%) for all types of foundation, this is due to the effect of excessive force generated in some of the members.
4. The overturning moments is maximum for all the fixed foundation condition. These moments are maximum at the base of the structure for all the foundation conditions. variation of displacement on both the directions of the structure is too small (3% to 4%) for all types of foundation, this is due to the effect of irregularity.
5. The Pushover Curve is maximum in Base Shear for all the fixed foundation condition. Variation of Base Shear on both the directions of the structure is too small (3% to 4%) for all types of foundation, this is due to the effect of irregularity.
6. The time period is maximum when there is soft soil compared to fixed support this is because of the property of soil which changes resulting in maximum time period.
7. The mass is maximum for regular building this is because the mass is distributed along the members of frame.

Scope of future work

1. The study may be continued for time history analysis.
2. The study may be carried out for different zones of earthquake and different soil conditions.
3. Pushover analysis on retrofitted structures for different irregularities and soil conditions can be studied.

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