ISSN: 2278-0181
RACEE - 2015 Conference Proceedings

Seismic Response of Set-Back Structure Due to Nature of Soil

Mr. Neeraj Mehta
Department of Civil Engineering
RPS Group of Institutions
Balana, Mahendergarh (HR)

Abstract- **A structure is said to be irregular, if it has irregular distribution of mass, strength, stiffness and irregular configuration. This type of building category is termed as setback structure. As per IS 1893:2002, when the horizontal dimension of the lateral force resisting system in any storey is more than 150% of that in an neighboring storey is termed as irregular geometric configuration i.e. set-back, storey in a building is said to contain mass irregularity if its mass exceeds 200% than that of the neighboring storey. If stiffness of a storey is less than 60% of the neighboring storey, in such a case the storey is termed as weak storey, if stiffness is less than 70% of the storey above or less than 80% of the combined stiffness of the three stories above, then the storey is termed as soft storey. This set-back affects the mass, strength, stiffness, center of mass and center of stiffness of building as compare to regular building. Dynamic characteristics of such buildings differ from the regular building due to changes in geometrical and structural property.**

Many existing reinforced concrete (RCC) frame building in seismic zone are deficient to resist moderate to severe earthquake due to insufficient lateral resistance. Keeping in view the above fact, the seismic response of vertical set-back structure for different soil conditions are presented here. In this present paper lateral storey displacement of different three types of models (nine cases) with constant in bay length i.e. 5x5m and with same storey height will be examined. Storey drift criteria were considered for critical and optimum value of set-back ratio for different soil conditions i.e. hard soil, medium soil and soft soil. This paper is an attempt to understand the seismic behavior of setback structure with different soil condition using STAAD.Pro 2006. It also aims to explore the storey drifts in X direction as well as Z direction with special reference to optimum value of setback ratio.

Keywords: Setback structure; seismic zone; stiffness;storey drift; vertical irregularity

I. INTRODUCTION

The growth rate of population in urban areas has exceeded the general population increase rate due to industrial revolution. It results in increase in the severe pressure on space for living and for office complexes. It has leaded the construction in vertical direction rather than horizontal direction. For low to medium rise structures, the analysis and design based upon vertical load resisting system has the ability to resist lateral forces. However, for tall buildings, the vertical load resisting system can't resist the lateral forces efficiently. From structural stiffness and strength point of view, it is considered that the lateral force resisting system can be integrated as a key feature of total design. These lateral force resisting system have been introduced in multi-storied buildings and can be in the form of moment resisting frames, shear walls and frame-shear wall dual systems.

The damage in these structural systems usually initiates at location of structural weak planes. These weaknesses result in structural deformation followed by collapse in the structures. These weaknesses may be due to the presence of structural irregularities in the form of strength, mass or stiffness of the building.

A. Structural Irregularities

On the basis of location and scope, there are many types of irregularities in the buildings. These irregularities are divided into two categories- plan irregularities and vertical irregularities. In the present study, main emphasis is given on vertical irregularities. As per IS:1893-2000, the following types of vertical irregularities are listed out:

- *Stiffness Irregularity-*
  Soft storey- A storey whose lateral stiffness is 70% of the storey which has more than three floors and whose average lateral stiffness is around 80% is known as soft storey.
  Extreme Soft Storey- A storey whose lateral stiffness is 60% of the storey which has more than three floors and whose average lateral stiffness is around 80% is known as soft storey. Buildings on stilt are the most frequent example of this category.
- *Mass Irregularity-* When the effective mass of a storey is more than 150% mass of the adjacent storey then, the mass irregularities are considered to be exist. The effective mass is the actual mass of a storey which consist of the combination of the dead weight of the floor and the actual weight of partition walls, equipments etc. Excess mass may results in increase in the lateral inertial forces; reduce ductility of vertical load resisting elements. It may also increase the tendency of the storey to collapse due to P - Δ effect. These mass irregularities lead to the complex dynamics and irregular response.
- *Vertical Geometric Irregularity-* Vertical geometric irregularities are considered to be exist, when the horizontal dimension of the lateral force resisting system in the storey is more than 150% of that in the adjacent storey.
- *Weak Storey-* Weak storey is the one in which storey lateral strength is less than 80% of that in the above storey. The storey lateral strength is the lateral strength of all seismic resisting elements sharing the storey shear in the considered direction.

II. SET-BACK BUILDING

Setbacks may be defined as the presence of immediate reduction of the lateral dimension of building at specific levels of the elevation. Its is a very common kind of vertical geometrical irregularity in building structures.
As per IS:1893-2000, a structure is said to be a set-back structure if ratio between A/L = 0.25 as shown below:

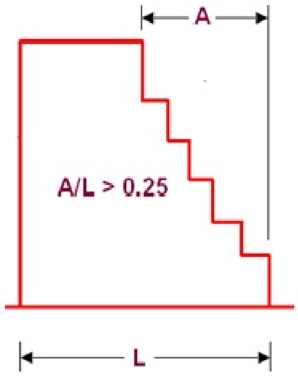

Fig. 1.1 A/L Ratio As Per IS:1893-2000

Mainly, the set-back structures are characterized by staggered sudden decrease in the floor area along the building height, with the drop in mass, strength and stiffness subsequently. The change in height alters the stiffness and mass. This combined action of non-uniform distribution of mass, strength and stiffness along the height of set-back frames leads to the poorer seismic performance due to inelastic action at set-back level.

III. AIM OF THE STUDY

Keeping in view the above fact, the seismic response of vertical set-back structure for different soil conditions are presented here. In this present paper lateral storey displacement of different three types of models (nine cases) with constant in bay length i.e. 5x5m and with same storey height will be examined. The storey drift criteria are considered for critical and optimum value of set-back ratio for different soil conditions i.e. hard soil, medium soil and soft soil. This paper is an attempt to understand the seismic behavior of setback structure with different soil condition using STAAD.Pro 2006. It also aims to explore the storey drifts in X direction as well as Z direction with special reference to optimum value of setback ratio.

IV. FRAME-WORK

To understand the seismic behavior of set-back structures for different soil conditions, the effective strategies are supposed to be implemented by the prudent use of various tools. This implementation requires the efforts from well focused research and development. Many considerable platforms exist based upon the different methods that can be used to the study the different impacts of seismicity on structures. The emphasis will be done on the questions that how to prepare the different structural models with the varying A/L ratio.

A. Tools and Strategies

For low to medium rise structures, the analysis and design of different model is done with respect to type of soil. According to IS:1893-2000 guidelines, the following types of soil is considered:

- *Hard Soil:* It is the mixture of well-graded gravels and sand gravels with or without clay binder, and clayey sands poorly graded or sand clay mixture having the value of N above 30, where N is the standard penetration value.
- *Medium soil:* All type of soils with the value of N ranges between 10 to 30, and poorly graded sand or gravelly sand with little or no fines with N>15.
- *Soft Soils:* All the types of soil other than with N<10.

B. Approach

There are various platforms through which the different models can be prepared and subsequently, can be analyzed to study the desired behavior. The various platforms can be STAAD.Pro 2006, SAP 2006, ANSYS 14 (Structural), etc.

C. Subjects

The present study is based on a set-back building. Three models are considered for the study. Model 1 (M1), Model 2 (M2) and Model 3 (M3) consist of 5x5m bay length. The floor to floor height is considered to be of 3.5m and hence, the total height is of 87.5m i.e. 25 storey as shown in figures. The different amount of set-back irregularities varies with the variation of successive reduction ratio i.e. 25%, 50% and 75% are considered. The structures are mainly prepared and progressively analyzed using STAAD.Pro 2006. The seismic motions is defined by the equivalent static analysis using the above said software. The various column sections for the frames are defined such that they should fulfill all the stiffness and strength requirements.

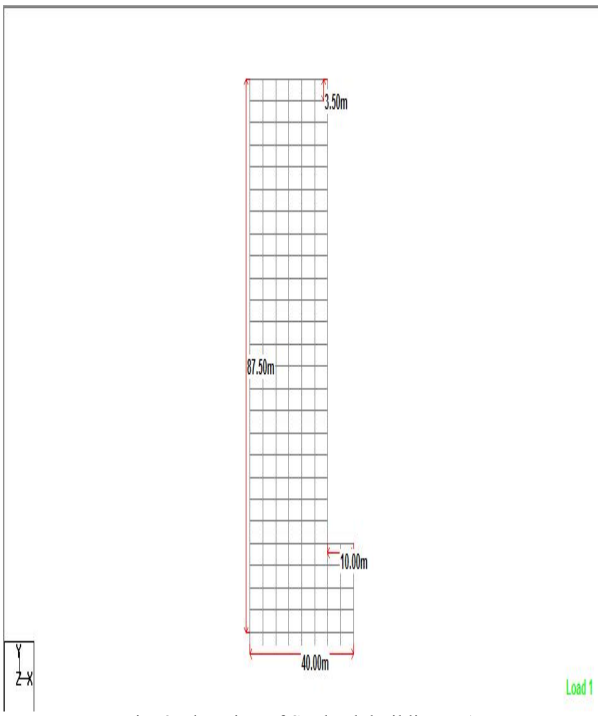

Fig: 2 Elevation of Set-back building M1

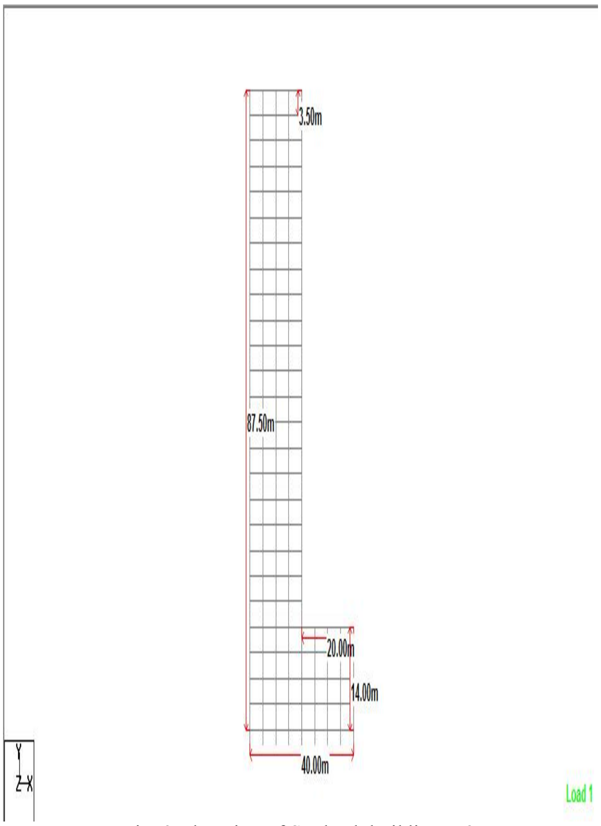

Fig: 3 Elevation of Set-back building M2

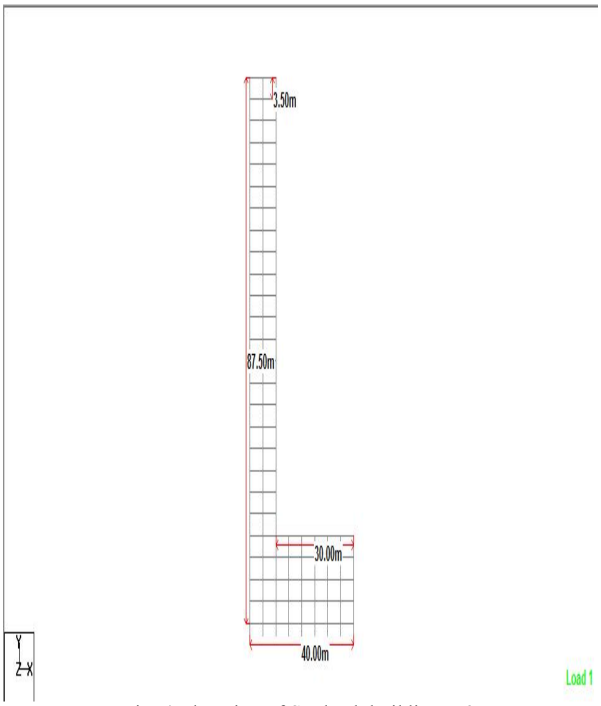

Fig: 4 Elevation of Set-back building M3

D. Set-Back Critical Ratio

The different set-back ratio details of all models are presented in table below:

TABLE 1 DESCRIPTION OF MODELS

S.No.	A/L Ratio	Along Height
1	A/L=0.25	H=4/25 (M1 A)
		H=8/25 (M1 B)
		H=12/25 (M1 C)
2	A/L=0.50	H=4/25 (M2 A)
		H=8/25 (M2 B)
		H=12/25 (M2 C)
3	A/L=0.75	H=4/25 (M3 A)
		H=8/25 (M3 B)
		H=12/25 (M3 C)

V. RESULTS AND DISCUSSION

On the basis of the above critical set-back ratio, nine models were prepared and earthquake analysis is performed on each models with the different type of soil. The different results for all the models are presented in graphical forms. For various set-back ratios (M1, M2 and M3), the storey drift values for seismic waves are compared with different soil conditions in both X and Z direction.

a) Storey drift of hard soil in Z-direction
b) Storey drift of hard soil in X-direction
c) Storey drift of medium soil in Z-direction
d) Storey drift of medium soil in X-direction
e) Storey drift of soft soil in Z-direction
f) Storey drift of soft soil in X-direction

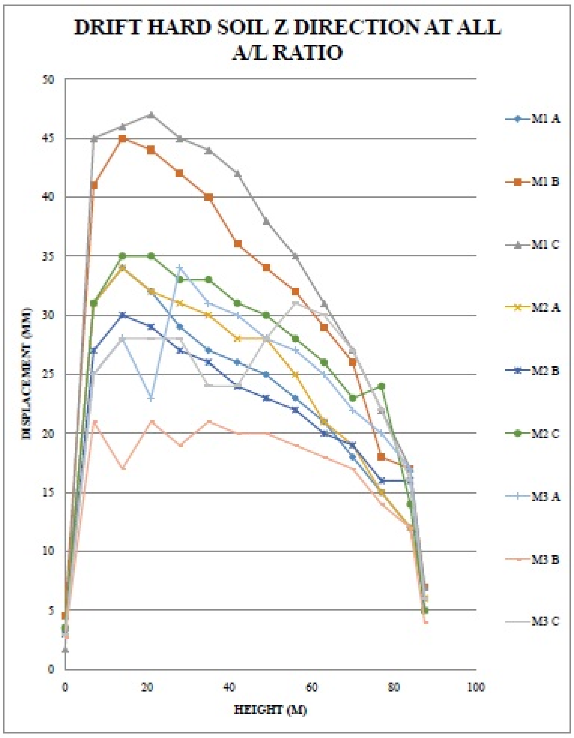

Fig: 5 Storey Drift for Hard soil in Z-Direction

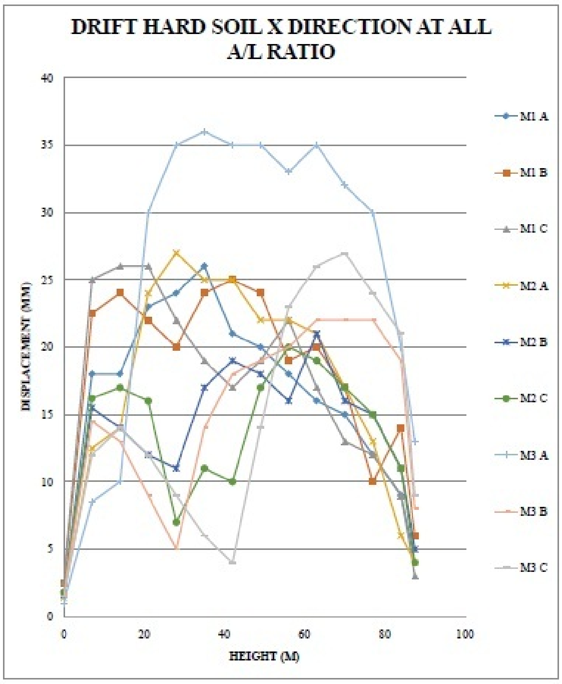

Fig: 6 Storey Drift for Hard soil in X-Direction

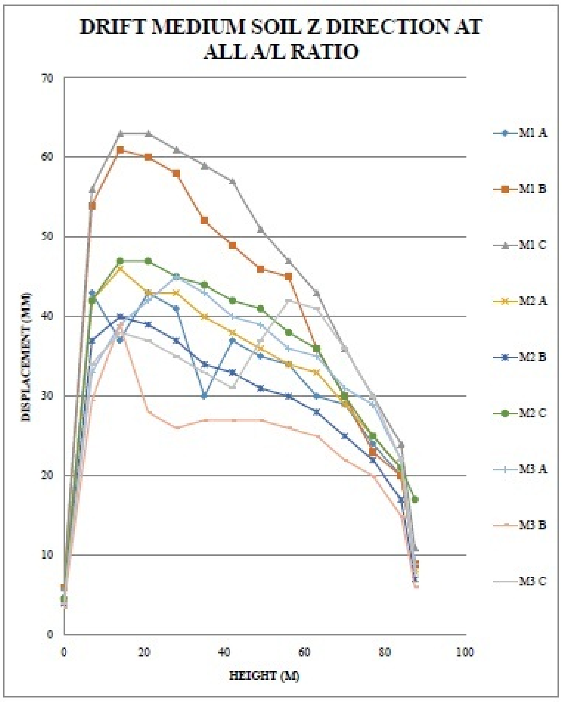

Fig: 5 Storey Drift for Medium soil in Z-Direction

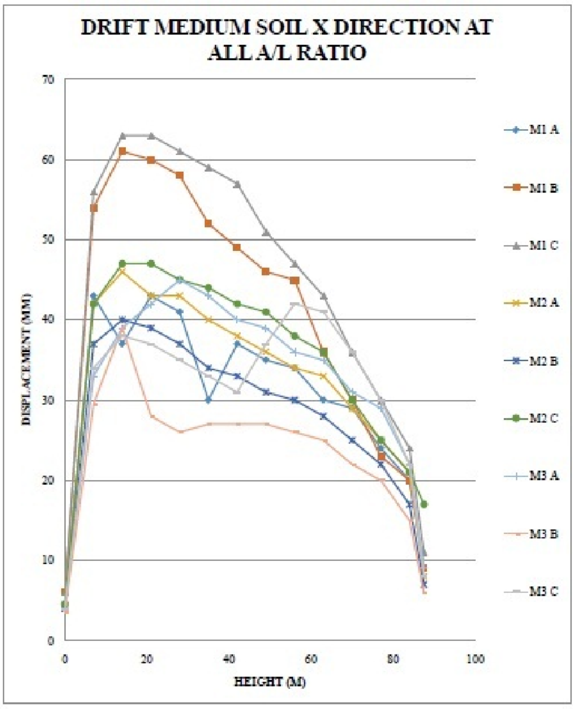

Fig: 8 Storey Drift for Medium Soil in X-Direction

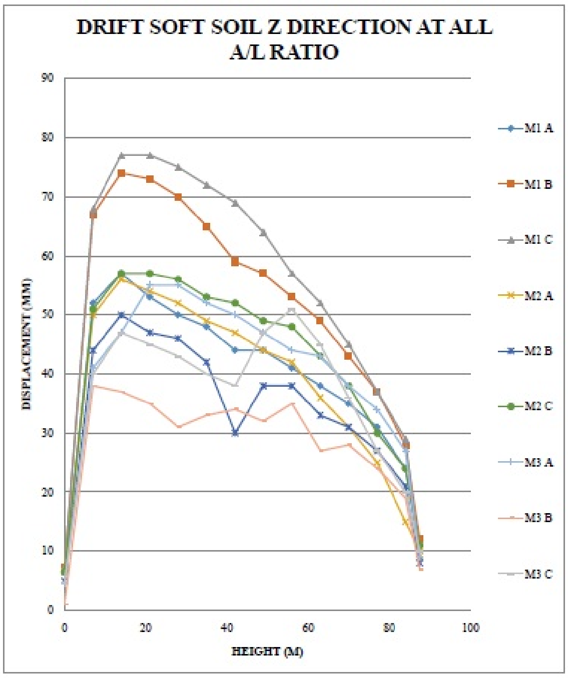

Fig: 9 Storey Drift for Soft Soil in Z-Direction

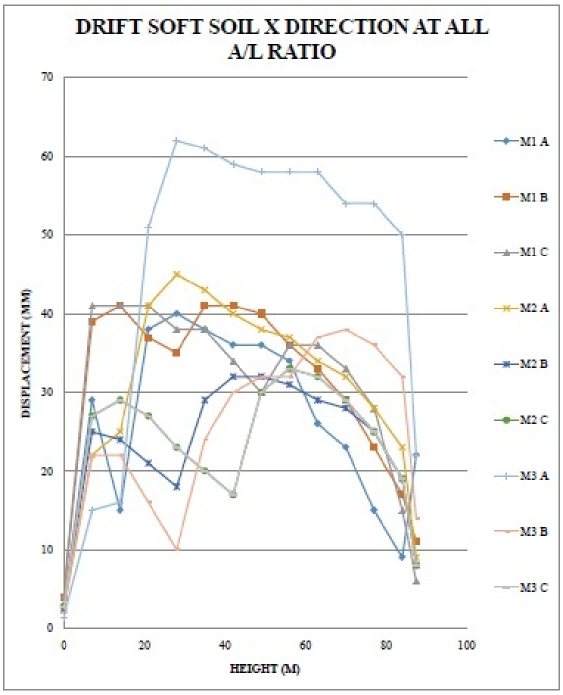

Fig: 10 Storey Drift for Soft Soil in X-Direction

From the above storey drift graphs, it can be seen that there is first increase in storey drift in the structure and then, decreases as the height increases. For model M3A i.e. at A/L =0.75 and H = 4/25, storey drift increases because of low stiffness at upper storey and for models M1C i.e. at A/L =0.25 and H = 12/25, storey drift is most affected due to increase in mass. For model M3B i.e. at A/L =0.75 and H = 8/25, storey drift varies with change in mass and stiffness.

VI. CONCLUSIONS

In order to understand the seismic response of set-back structures, earthquake analysis was undertaken. The comparative study of the above various cases has led to the following conclusions:

1. For seismic waves in Z-direction, the optimum value of critical set-back ratios A/L and H comes out to be at 0.75 and 8/25 respectively, for all types of soil.
2. For seismic waves in X-direction, the optimum value of critical set-back ratios mostly A/L and H comes out to be at 0.50 and 8/25 for hard and soft soil respectively, and 0.75 and 8/25 for medium soil.
3. It may also be concluded that the set-back structures are supposed to be treated with proper analytical approach and provisions as per the given codes.

VII. ACKNOWLEDGMENT

The author hereby acknowledges the extensive help given by Dr. Arabinda Sharma (Associate Professor and head, Department of Civil Engineering, BRCM, Bahal) and Mr. Avijit Paul (Assistant Professor, Department of Civil Engineering, BRCM, Bahal) for their support and valuable suggestion to complete the research work.

VIII. REFERENCES

[1] Anil K. Chopra, Dynamics of Structures.
[2] Aranda, G.R. (1994), “Ductility Demands for R/C Frames Irregular in Elevation”, In Proceedings of the eighth World Conference on Earthquake Engineering, San Francisco, U.S.A., Vol. 4, pp. 559-566.
[3] Earthquake Resistant Design of Structures, Pankaj Agrawal and Manish Shrikhande.
[4] Humar, J.L, and Wright, E.W. (1977), “Earthquake Response of Steel-Framed Multistory Buildings with Set-Backs”, Earthquake Engineering & Structural Dynamics, Vol. 5, No. 1, pp. 15-39.
[5] IS:1893(Part 1) 2002, “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards, New Delhi.
[6] Shahrooz, B.M. Moehle, J. P. (1987). "Experimental study of seismic response of R.C. setback buildings." Earthquake Engineering. Research Center Univ. of California, Berkeley, Calif., Oct.
[7] Wong, C.M., and Tso, W.K. (1994), “Seismic Loading for Buildings with Setbacks”, Canadian Journal of Civil Engineering, Vol. 21, No. 5, pp. 863-871.
[8] Wood, S.L. (1992), “Seismic Response of RC Frames with Irregular Profiles”, Journal of Structural Engineering, ASCE, Vol. 118, No. 2, pp. 545-566.