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Soil-Interaction of Multistorey R. C. C. Frames

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ABSTRACT

Comprehensive experimental and analytical studies have been carried out to understand the behavior of existing frame buildings constructed before the introduction of seismic design codes in 1970's. Different aspects of the response have been investigated and inherent weaknesses have been pointed out. This usually has been done assuming a fixed-base structure while ignoring the flexibility of soil and foundation. In this thesis, the interaction between the super-structure and sub-structure (SSI) is investigated by modelling the soil as simple as possible to capture the overall response of the system. As new analytical hysteresis rules and more advanced tools of analysis have been developed in recent years, the linear response of a structure which can be representative of a broad range of existing or newly designed structures, is investigated while allowing for flexibility of the soil-foundation system and SSI effects. The use of flexible base in the analysis can lead to reduction in the structural response and damage consequences in joints and infills. The results of this study suggest that the compliance of simply modelled soil for typical building structures have in average beneficial effects in terms of structural demand especially for stiff structures.

Keywords: Soil Structure Interaction, Linear Analysis, Shear Wall, Soft Soil.

I. INTRODUCTION

A common design practice for dynamic loading assumes the building to be fixed at their bases. In reality the supporting soil medium allows movement to some extent due to its property to deform. This may decrease the overall stiffness of the structural system and hence may increase the natural periods of the system, such influence of partial fixity of structures at foundation level due to soil flexibility intern alters the response. On the other hand, the extent of fixity offered by soil at the base of the structure depends on the load transferred from the structure to the soil as the same decides the type and size of foundation to be provided. Such an interdependent behavior of soil and structure regulating the overall response is referred to as soil structure interaction. This effect of soil flexibility is to be accounted through consideration of springs of specified stiffness. Thus the change in natural period due to effect of soil structure interaction may be an important issue from the viewpoint of design considerations. Also it is usual practice to treat the brick infill as a non-structural element and therefore all the lateral loads are assumed to be resisted by the frame, but performance of buildings in the recent earthquakes (e g:1985 Mexico City earthquake, 2001 Bhuj earthquake) clearly illustrates that the presence of infill wall has significant structural implication. Therefore, the structural contribution of infill wall cannot simply be neglected particularly in regions of moderate and high seismicity where the frame infill interaction may cause substantial increase in both stiffness and strength. A review of analysis and design provisions related to masonry infill RC frames in seismic design codes of different countries show that only a few codes have considered the effect of infill in analysis and design of masonry in filled RC frames. On the other hand, the stiffness and strength of in filled frames with openings are not taken care of by most of the codes. Hence the behavior of in filled frames with opening needs to be studied extensively in order to develop a rational approach or guidelines for design. In the last three decades, the effect of SSI on earthquake response of structures has attracted an intensive interest among researchers and engineers. Most of these researches focus on theoretical analysis, while less has been done on the experimental study. The interaction among the structure, foundation and soil medium below the foundation alter the actual behaviour of the structure considerably as obtained by the consideration of the structure alone. Flexibility of soil medium below foundation decreases the overall stiffness of the building frames resulting in an increase in the natural period of the system.

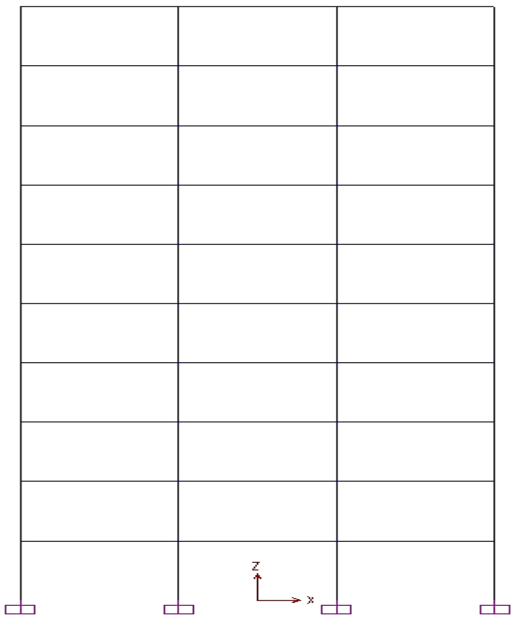
II. MODELLING AND ANALYSIS

Idealization of Structure

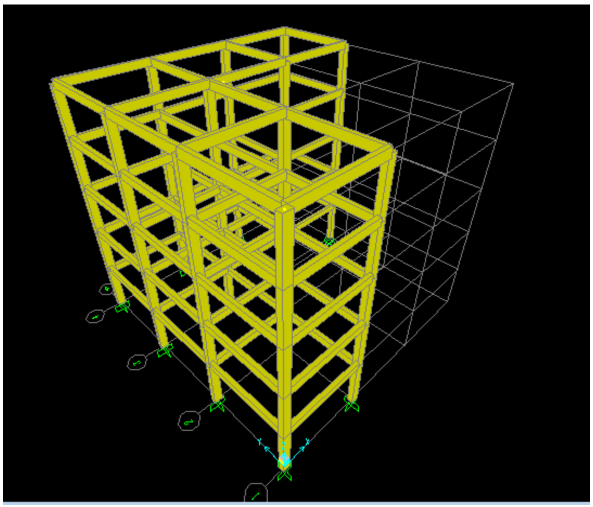
To study the dynamic behavior of building structure while considering the effect of soil structure interaction, building frame is modeled as 3D space frame using standard two nodded frame element with two longitudinal degrees of freedom and one rotational degree of freedom at each node. At the interface of infill and frame, the infill element and the frame element are given same nodes. The idealized form of a typical 3 bay x 3 bay 10 storey building frame with infill wall modeled as represented schematically in figure the present study also considers bare frame to see how correctly the influence of soil structure interaction on dynamic behavior can be predicted. This may give an idea about the error, which one should liable to commit if this popular but grossly inaccurate approach is invoked. A 3 bay x 3 bay building frames with 10 storey's on isolated footing have been considered. The height of each storey is taken as 3. 6 m and the longitudinal and transverse dimensions of 3 bays x 3 bay building is taken as 6 m for central bay and 6 m for the two side bays. For all the buildings the dimensions of reinforced concrete column are taken as 600 x 600 mm and for beam it is 200 x 600 mm. Similarly thickness for roof and floor is taken as 150 mm and their corresponding dead load is directly applied on the beam. The brick infill with thickness 150 mm. All the above dimensions were arrived on the basis of the design following the respective Indian code for design of reinforced concrete structure . However, these design data are believed to be practicable and hence, do not affect the generality of the conclusion. irregularity scenario has been performed. The results of non-linear static pushover analysis obtained in the form of capacity curve for considered irregularity in the model in longitudinal and transverse direction are shown in Fig. 4 and Fig. 5 respectively. The response reduction factor (R) is calculated from the formulations given in Lakhade et al. (2017) for collapse prevention level. The formulation adopted for determining response reduction factor of the considered models is given by equation (1) (Lakhade et al. 2017).

$$R = R_S R_\mu \qquad \text{……(1)}$$

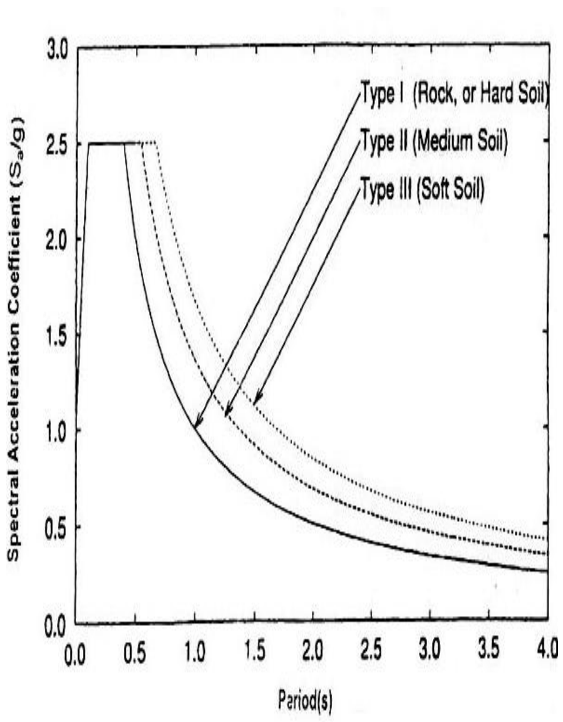
As mentioned in IS 1893(1):2016, value of R for considered model is taken as 5. But the value of R obtained for model is 5. 77 (i. e. , greater than 5) in



Plan and Elevation of building



irregularity scenario has been performed.



Response spectra for rock and soil sites for 5% damping (IS1893

III. RESULTS AND DISCUSSION

Linear Static Analysis

The plan layout and elevation of G+10 storey building is shown in fig. The building is deliberately kept symmetric

in plan along both orthogonal directions. The building considered is assumed to be located in Seismic Zone II.

Data

1) Live Load = 3. 5 kN/m2 at typical floor, 1. 5 kN/m2 at terrace

2) Floor finish = 1 kN/m2

3) Terrace finish = 1 kN/m2

4) Location = Nagpur city

5) Earthquake load = As per IS-1893(Part-1)-2002

6) Storey height = 3. 6 m

7) Walls = 0. 15 m thick

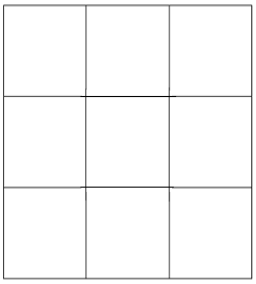
8) Column size = 0. 6 X 0. 6 m

9) Beams = 0. 2 X 0. 6 m

10) Slab thickness = 0. 15 m

11) Density of concrete = 25 kN/m3
12) Density of brick = 20 kN/m3
13) Seismic zone = II

Bare frame (Soft soil)



The results of non-linear static pushover analysis obtained in the form of capacity curve for considered irregularity in the model in longitudinal and transverse direction are shown in Fig. 4 and Fig. 5 respectively. The response reduction factor (R) is calculated from the formulations given in Lakhade et al. (2017) for collapse prevention level. The formulation adopted for determining response reduction factor of the considered models is given by equation (1) (Lakhade et al. 2017).

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Table 1

Case No.	Storey	Max Reaction In KN	Max. Displacement of top storey In mm	Frequency In Cyc/sec.	Period In Sec	Base shear In KN
SB2'a (Without SSI)	G+10	5758	40	0. 75	1. 3	436
				0. 84	1. 1	
				0. 84	1. 1	
SB2'b (With SSI)	G+10	5248	50	0. 60	1. 6	412
				0. 64	1. 5	
				0. 62	1. 59	
SB2'b' (With SSI)	G+10	4558	74	0. 4	2. 4	291
				0. 4	2. 4	
				0. 53	1. 8	

IV. CONCLUSION

In the present study, the effect of soil structure interaction on the dynamic characteristics of structure has been studied. Some of the conclusions that can be drawn from the observations made above are,

1. The study shows that consideration of different parameter such as soil structure interaction, and location of walls influences time period, displacement and base shear of building frame considerably. Hence it is important to consider to all these parameters in the analysis of structures.

2. Shear walls located in the central part of the multistoried building gives lesser displacement and more

V. REFERENCES

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