IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 13, Issue 6, June 2026

DOI: 10.17148/IARJSET.2026.13611

SSI ANALYSIS OF G+6 RCC BUILDING ON STIFF SOIL USING ETABS AND SAFE

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Abstract: Soil-Structure Interaction (SSI) changes the seismic response of reinforced concrete buildings because the soil, foundation, and superstructure act together as one system. This paper studies a G+6 RCC moment-resisting frame building resting on stiff soil using ETABS for the building model and SAFE for the raft foundation model. Two cases were compared: a conventional fixed-base model and a flexible-base SSI model. The analysis was carried out according to IS 1893 (Part 1): 2016 for Seismic Zone III, with load details taken from IS 875 and material properties from IS 456:2000. The results show that considering SSI increases the fundamental time period by about 18–24% and the lateral displacement by about 28–35%, while reducing the base shear by about 12–18% compared to the fixed-base case. The SAFE results also show non-uniform soil pressure beneath the raft and noticeable settlement variation, which means the foundation flexibility affects the building response even on stiff soil. Overall, the study shows that fixed-base analysis can miss important serviceability effects such as drift and settlement, and that combined ETABS-SAFE modelling gives a more realistic way to assess mid-rise RCC buildings.

Keywords: Soil-Structure Interaction, ETABS, SAFE, G+6 RCC Building, Stiff Soil, Raft Foundation.

I. INTRODUCTION

Conventional seismic analysis of RCC buildings usually assumes a fixed-base condition, where the foundation is treated as fully rigid. In reality, the soil beneath the structure also moves and deforms, so the building, foundation, and soil work together as one system. This is called Soil-Structure Interaction (SSI). Even on stiff soil, this interaction can affect the building's time period, displacement, drift, and pressure on the foundation.

This study examines a G+6 RCC moment-resisting frame building resting on a raft foundation over stiff soil. The building was modelled and analysed in ETABS, while the raft foundation was analysed in SAFE. The main aim was to compare the fixed-base and flexible-base cases and understand how SSI changes the seismic response in terms of time period, base shear, storey displacement, inter-storey drift, contact pressure, and settlement.

The analysis becomes important because buildings are often designed assuming the soil support does not deform much. This may give acceptable results for basic design, but it can miss the actual behaviour of the structure under earthquake loading. When soil flexibility is included, the structural response becomes more realistic, especially for mid-rise buildings supported on raft foundations.

In this study, the results from ETABS and SAFE are used together to understand both superstructure and foundation behaviour. ETABS helps in studying the overall building response, while SAFE shows how the raft transfers load into the soil. This combined approach gives a better picture of how the building behaves in actual conditions and helps in making the design more reliable.

II. LITERATURE REVIEW

Previous studies have shown that Soil-Structure Interaction can affect the seismic performance of RCC buildings in an important way. Kulkarni and Ghugal found that when soil flexibility is included, the natural period and lateral displacement of the building increase. Jagadale et al. reported that in flexible-base models, the base shear reduces, while the time period and drift increase. Ghosh and Bhattacharya observed that raft foundations help in distributing the load more effectively, but they also make the overall system more flexible.

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These studies show that SSI should not be ignored only because the soil is stiff or the building is not very tall. Even in mid-rise structures, SSI can change the response of the building in terms of displacement, drift, and foundation behaviour. Therefore, considering soil flexibility gives a more realistic understanding of how the structure will perform during earthquake loading.

III. METHODOLOGY

A three-dimensional G+6 RCC building model was developed in ETABS. The building has a regular plan configuration, 7 storeys including ground, and a total height of 24.5 m. The structural system consists of RCC beams, columns, and slabs, while the foundation system is a raft foundation analyzed in SAFE. Seismic analysis was carried out for Zone III according to IS 1893 (Part 1): 2016. Dead and live loads were assigned according to IS 875, and concrete and steel properties were adopted according to IS 456:2000.

Two modelling cases were considered. In the first case, all column bases were assumed fixed. In the second case, soil flexibility was represented through raft foundation analysis and equivalent soil support in SAFE. Column reactions obtained from ETABS were transferred to SAFE for foundation analysis. The comparison between the two models was used to evaluate the influence of SSI on superstructure and foundation behavior.

IV. BUILDING AND INPUT DATA

The building considered in the study is a G+6 RCC frame structure with plan dimensions of approximately 19.2 m × 14.4 m and typical 4 m bay spacing. The storey height is 3.5 m. M30 concrete and Fe500 steel were used in modelling. The slab thickness was taken as 150 mm, beam section as 300 mm × 450 mm, column section as 300 mm × 600 mm, and raft thickness as 500 mm. The structure was analysed on stiff soil with subgrade modulus suitable for raft foundation modelling. In ETABS, the mass source, load combinations, diaphragm action, and seismic parameters were assigned in accordance with Indian Standard provisions.

V. RESULTS AND DISCUSSION

The results show that the fixed-base model behaves stiffer than the SSI model. In the fixed-base case, the building attracts more base shear because the support is assumed to be completely rigid. In the SSI model, the soil flexibility is included, so the overall stiffness of the system reduces. Because of this, the time period increases, but the design base shear decreases. At the same time, the lateral displacement and storey drift become higher.

The comparison shows that the SSI model gives about 18–24% higher fundamental time period, 12–18% lower base shear, and 28–35% higher lateral displacement than the fixed-base model. The drift values also increase in the SSI case, but they still remain within the allowable code limit for this building. This clearly shows that if soil flexibility is ignored, the serviceability response of the structure may be underestimated.

The SAFE results for the raft foundation show that the soil pressure is not uniform below the mat. Higher pressure is seen near the column locations, while the other areas carry less pressure. The settlement pattern is also uneven, which means the raft deforms differently at different points under load. This proves that the foundation does not act as a perfectly rigid support and that foundation behavior plays an important role in the total structural response.

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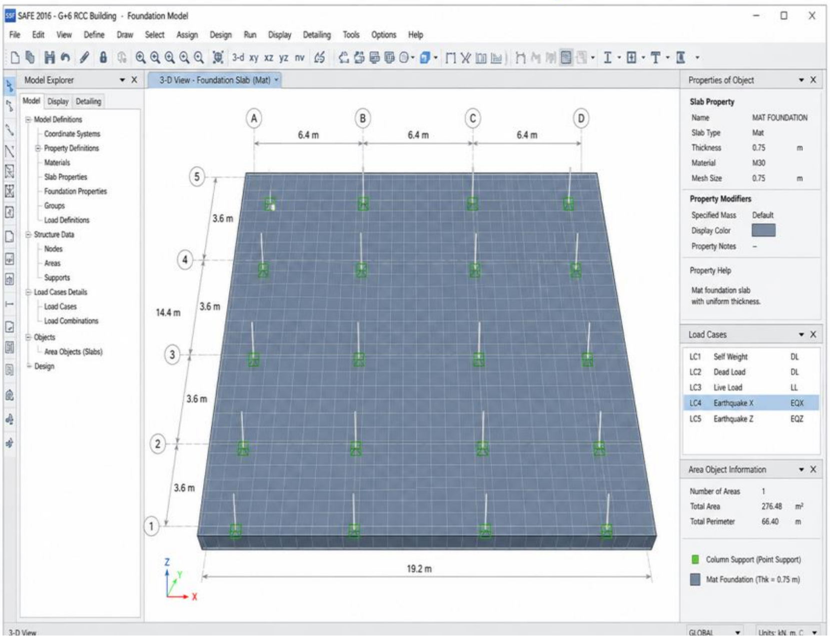

Fig. 1. 3D SAFE model of raft foundation for G+6 RCC building.

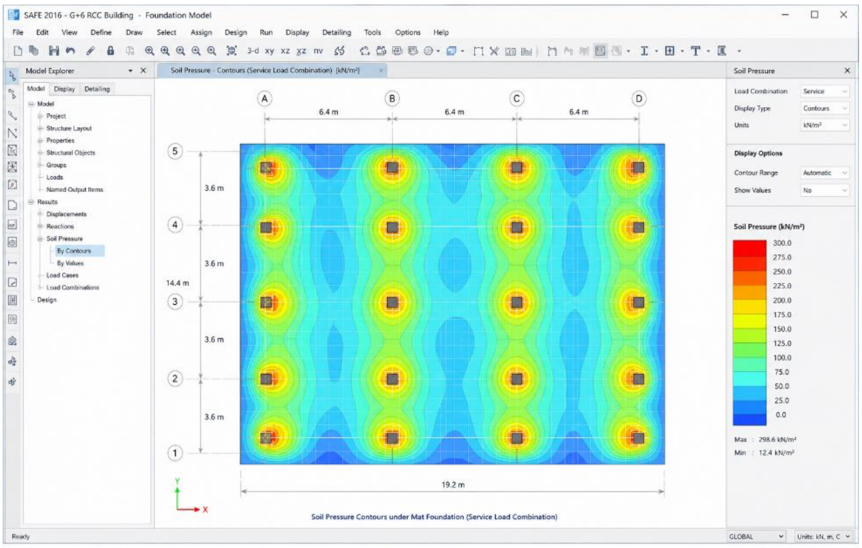

Fig. 2. Soil pressure contour under raft foundation from SAFE.

Table I. Comparative response of fixed-base and SSI models.

Parameter	Fixed Base	SSI Model	Observed Change
Fundamental time period	Lower	Higher	Increase of about 18–24%
Base shear	Higher	Lower	Reduction of about 12–18%
Lateral displacement	Lower	Higher	Increase of about 28–35%
Inter-storey drift	Lower	Higher	Noticeable increase
Contact pressure	Not captured in detail	Non-uniform	Higher near columns
Settlement	Ignored	Measurable	Differential settlement observed

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VI. CONCLUSION

This study used an integrated ETABS-SAFE approach to examine the effect of Soil-Structure Interaction on a G+6 RCC building resting on stiff soil. The results show that even when the soil is stiff, its flexibility still affects both the building and the foundation. In the SSI model, the time period, displacement, and drift increase, while the base shear decreases when compared with the fixed-base model.

The raft foundation results also show non-uniform soil pressure and measurable settlement. This means the foundation does not behave like a fully rigid support and that its response affects the overall structural behaviour. So, SSI should be considered in the seismic analysis of mid-rise RCC buildings, especially when serviceability and foundation performance are important.

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