Comparative Analysis of Infilled RC Building Frame with Fixed Base and Flexible Base by Considering SSI for Seismic Load

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Abstract - *In conventional approach of analysis and design of structure, the structural engineer consider the base of R.C. building as fixed and avoid the compressible nature of soil. Compressible nature of soil causes decrease in the overall lateral stiffness of R.C. building. This may increase the natural time periods of the structural system. Such increase in lateral natural period, considerably effect the seismic behaviour of R.C. building frame. In this study a G+7 infill masonry RC building is analysed considering effect of infill stiffness using modelling approach given by Hendry for fixed Base and flexible Base. Equivalent static analysis of these two building models is carried out to compare the performance of infill masonry building resting on Raft foundation with fixed base and flexible base by considering Soil Structure Interaction for seismic loading seismic on the basis of Story shear, Floor displacement, Story drift, Time period and Settlement of Raft. Results shows that maximum increases in story shear for flexible base infill frame models compare to fix base infill frame model, displacement for flexible base infill frame is considerably increase compare to fixed base infill frame, story drift is increasing inflexible base infill frames compare to fixed base infill frame. This study also reveals that time period and settlement of raft foundation also increases in case of building with flexible base. This study shows that considering the Soil structure interaction in dynamic analysis of RC building frame the settlement is increased. The effects of soil structure interaction on total and differential settlement is critical factor for soft soil.*

Key Words: Structural designing ,Analysis, Soil Structure Interaction, Stadd.pro, Seismic analysis

1. INTRODUCTION

In conventional approach of analysis and design of structure, the structural engineer consider the base of R.C. building as fixed and avoid the compressible nature of soil. But in reality it has been seen that the supporting soil system allow the deformation upto some extent due to its compressibility. This compressible nature of soil causes decrease in the overall lateral stiffness of R.C. building. This may increase the natural time periods of the structural system. Such increase in lateral natural period, considerably effect the seismic behaviour of R.C. building frame resting over raft foundation. In general the effect of masonry infill wall is ignored in design and analysis of R.C. structures which may cause unsafe design. In analysis if the effect of infill is taken then the weight of the R.C. building got increased. The earthquake movement generates inertial forces and these forces are proportional to the weight of the structure, although, infill will increase the strength and stiffness of the R.C. building and reduces natural period. Hence for safe design, the effect of infill masonry wall should be considered.

1.1 OBJECTIVE OF STUDY

Objective of this study is to evaluate "the performance of RC infilled building frame by comparing it with their fixed base and flexible base by considering soil structure interaction for seismic load". The parameters under consideration are as follows:

i. Story shear.
ii. Floor displacement,
iii. Story drift,
iv. Time period and
v. Variation in Support settlement pattern between fixed base and flexible base infilled building frame model.

1.2. NEED OF THE STUDY

1. For realistic estimation of the response of structure and accurate design of structures, the effect of soil structure interaction should be considered on infilled building frame for seismic loading.
2. To avoid failure and ensure safety of the structure, during analysis effect of masonry infill should be considered.

2.0. LITERATURE REVIEW

Several investigators performed the various type of studies considering the effects of soil compressibility which broadly falls in the area of soil-structure interaction studies.

Malviya et al (2017) tried to consider the impact of soil compressibility in investigation and outline of structure. A

(G+7) 4 straights X 4 bayous RC structure upheld on sandy soil and arranged in seismic zone V according to May be: 1983 (section 1)- 2002 was dissected utilizing STAAD PRO programming. They at first dissected considered building outline by tradition approach i.e. taling settled base condition and bolster responses were processed for various load mixes and the sizes of establishment for various backings were figured by utilizing STAAD FOUNDATION programming. At that point they supplanted the settled help by a spring of proportional establishment solidness to perform adaptable base examination and computed the most extreme aggregate settlement and differential settlement between footings. In light of results, they presumed that dirt compressibility causes settlements of establishments, change the help responses, redistribution of powers in pillar and segment and furthermore influences the prerequisite of fortification for plan .

Gaonkar et al (2016) tried to introduce the concept of structure-soil-structure interaction by conducting a literature review in the area of study. They done three case studies on dynamic structure-soil-structure interaction analysis that considers adjacent tall buildings modelled by computer programs as a reference and concluded that the taller building increased the response of a shorter building adjacent to it and a shorter building decreased the response of a taller adjacent building when the distance between the adjacent buildings are varied and the base shear in taller buildings is higher as compared to shorter adjacent building. They also observed that the effects of structure-soil-structure increases time period, base shear and displacement when the distance between adjacent buildings are varied.

Badry et al (2016) made an attempt to reduce the computational cost by using equivalent pier method for deep foundation system and found their approach to be effective in optimising the computational efficiency. They used it in the analysis of L-shaped eleven storey building resting on pile foundation with homogenous soil conditions under dynamic loading.

Mohod et al (2014) studied a 3 bay three-storey regular RCC space frame supported on isolated footing resting on homogeneous soil mass and subjected to gravity loading using finite element method. They considered the three cases for analysis as fixed base analysis, elastic analysis and elastoplastic analysis. It was investigated that during non-interaction analysis displacement is purely a deflection of beams and during elastic analysis displacement is due to settlement as well as deflection, whereas in case of elastoplastic analysis displacement is majorly due to settlement and very small due to deflection and an increase in displacement was found with the increase in number of storeys.

Jamkar et al., (2013)conducted the investigation for RC frame with the different arrangement of infill masonary work boards subjected to dynamic seismic loading. In his investigation he compared the results for different cases and made conclusion in aspect of IS 1893(2002) code. In their paper he concluded that by considering stiffness of infill wall beneath plinth the response of the structure for earthquake motion can be enhanced as compared to the soft basement.

3.0. METHODOLOGY 3.1. Description of the Structural Model

A G+7 4 bay by 4 bay multi storeyed reinforced concrete infilled frames supported on raft foundation on soft soil is analysed as per Indian Standard Codes under gravity and seismic loading in finite element package STAAD Pro. The plan dimension 24 m × 24 m and a storey height of 3.5 m each in all the floors and raft foundation is taken at depth1.5m below ground-level and thickness of Raft is taken as 800mm. The building is kept symmetric in both the perpendicular directions in plan to avoid torsional response under lateral force. Stiffness of infill wall is considered using Hendry's approach. The size of beams and columns are optimised as per safety and economy for each building frame. The analyses is performed as both fixed support analysis and flexible support analysis. For flexible support analysis, the springs of equivalent foundation stiffness at each support are used as per Gazeta's theory. It is considered that building is constructed in seismic zone III as per IS: 1893 (Part 1)-2002 and intended purpose of the building is for residential use. The building is constructed on Soft soil and resting over Raft foundation. The load of floor finish on the floors is taken to be 1.0 kN/m^2. The live load acting on floor is taken as 3.0 kN/m^2.

Table 4.1: Details of Structure

S.No.	Type of structure	Building (G+7)
1	Plan dimensions	24 m X 24 m
2	Total height of building above GL	28m
3	Height of each storey	3.5m
4	Plinth level	1.5m
5	Number of bay in Longitudinal direction	4
6	Number of bay in Lateral direction	4
7	Width of way in Longitudinal	6m
8	Width of way in Longitudinal	6m
9	Beam Dimension	350mm × 500mm
10	Column Dimension	650mm × 650mm
11	Thickness of slab	150mm
12	Thickness of Raft	800mm
13	Thickness of walls	200 mm

4.2. MATERIAL PROPERTIES

Table 4.2: Material properties

S.NO.	Material property	Values
1	Concrete grade	M-25
2	Density of reinforced cement concrete	25kN/m^3
3	Young's modulus of concrete, Ec	2.17x10^4 N/mm^2
4	Poisson ratio of concrete,µ	0.2
5	Young's modulus of brick, Ec	1.38x10^4 N/mm^2
6	Poisson ratio of Brick ,µ	0.15

4.3. LOADS AND LOAD COMBINATION

In the present study dead load (self-weight of the frame, slab and masonry walls), live load and seismic load is considered for analysis and design. The seismic load is taken as per IS: 1893–2002 Criteria for Earthquake Resistance Design of Structures. The various parameters taken for seismic load calculation are shown in table 4.4.

Table 4.3: Various parameters for seismic load calculation

S.NO.	Parameter	Value
1	Seismic zone	III
2	Response reduction factor	5
3	Importance factor	1
4	Soil site factor	3 (soft soil)
5	Damping ratio	0.05

The various load combinations for analysis and design of structure (as per IS: 456-2000)

- 1.5DL + 1.5LL
- 1.2DL + 1.2LL + 1.2EQ +X
- 1.2DL + 1.2LL + 1.2EQ -X
- 1.2DL + 1.2LL + 1.2EQ +Z
- 1.2DL + 1.2LL + 1.2EQ -Z
- 1.5DL + 1.5EQ +X
- 1.5DL + 1.5EQ -X
- 1.5DL + 1.5EQ +Z
- 1.5DL + 1.5EQ -Z
- 0.9DL + 1.5EQ +X
- 0.9DL + 1.5EQ -X
- 0.9DL + 1.5EQ +Z
- 0.9DL + 1.5EQ -Z

4.4. MODEL CONSIDERED FOR ANALYSIS Following 2 models are analysed using equivalent static analysis. 1. Fixed Base infill frame model. 2. Flexible Base Infill frame model (effect of stiffness is considered) with modelling approach given by Hendry.

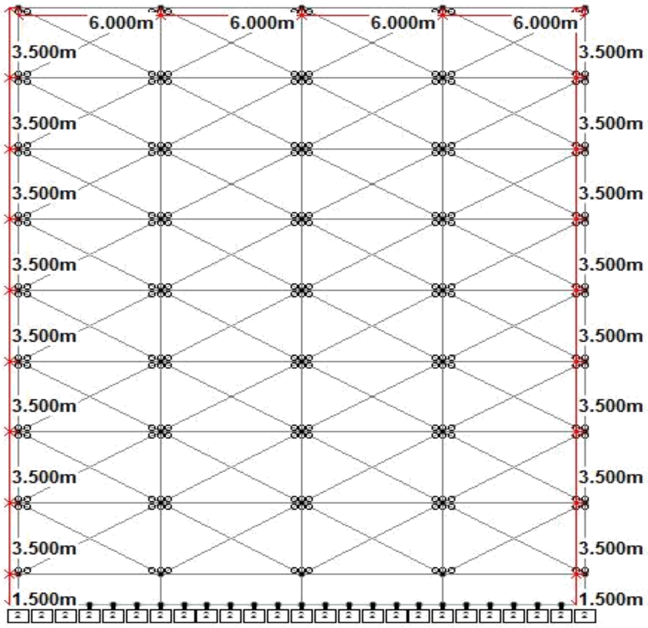


Fig. 3.1: Elevation

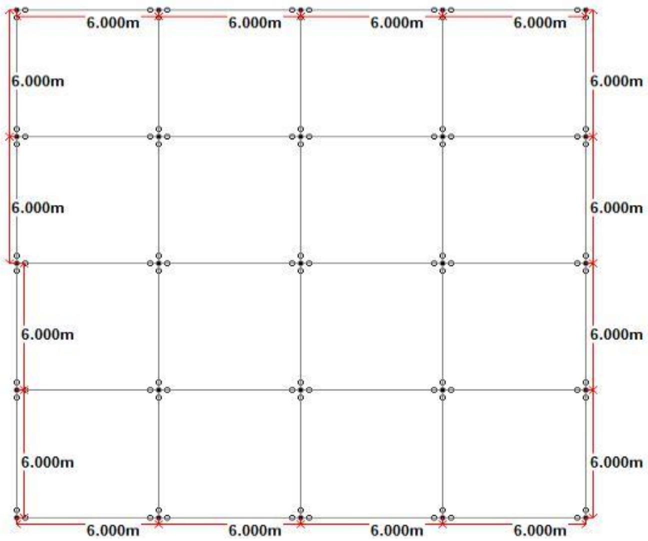


Fig. 3.2: Plan

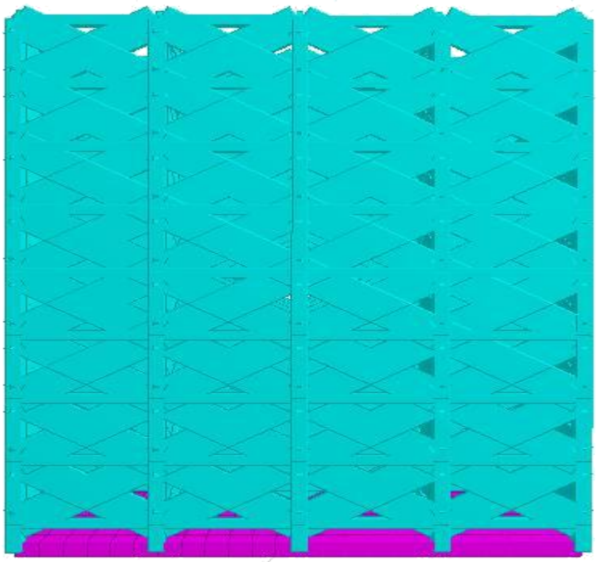
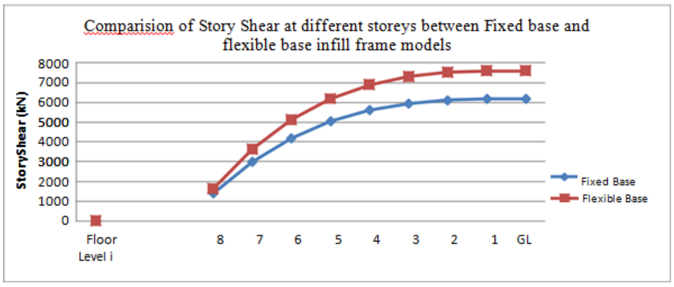


Fig. 3.3: Infill frame (Equivalent diagonal structure)

4. RESULTS AND DISCUSSION 4.1. Story Shear

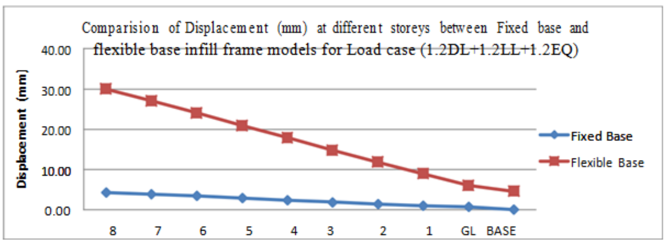
Comparison of story shear at different story for Fixed Base and Flexible Base infill frame models shown in figure.



Story shear increases for flexible base infill frame models as compare to fixed base infill frame model. The increase in story shear is found 1.23 times for Flexible base infill frame model.

4.2. FLOOR DISPLACEMENT

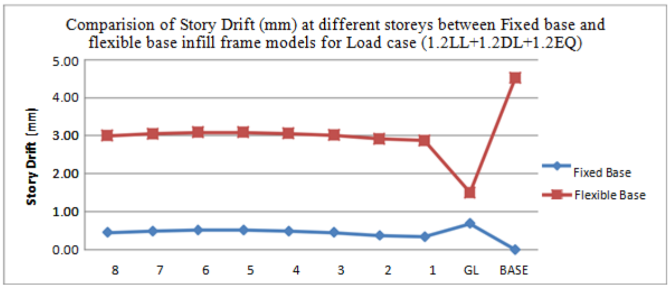
The Average displacement of all the floors for bare and infill frame models in the longitudinal and transverse direction different load combinations.



Displacement for Flexible base infill frame is considerably increase compare to Fixed base infill frame. The displacement increases about 6.98 to 8.8 times, the ratio found to be more at base compare to all other story because of Soil Structure interaction.

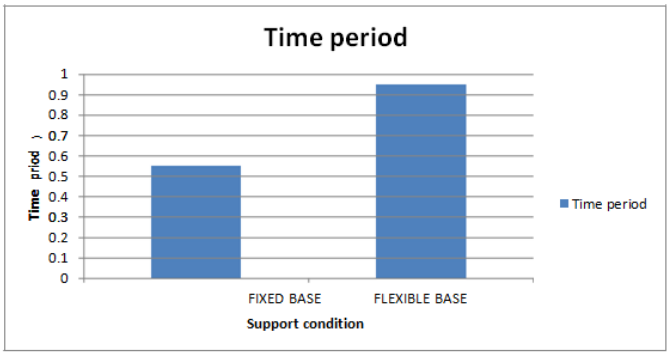
4.3. STORY DRIFT

Story drift is increasing in Flexible base infill frames compare to Fixed base infill frame. The maximum increase in story drift is about 2.20 to 8.41 times by fixed base infill frame model.



4.4. TIME PERIOD OF BUILDING

Time period for Flexible base infill frame is more than fix base infill frame. This ratio shows that the fundamental time period is changing as compressibility of soil is taken into consideration.



4.5. SETTLEMENT OF RAFT

For flexible base infill frame model Maximum vertical settlement is at Centre of Raft i.e. 62.07mm. Maximum differential settlements between centre and corner are computed 5.28 mm.

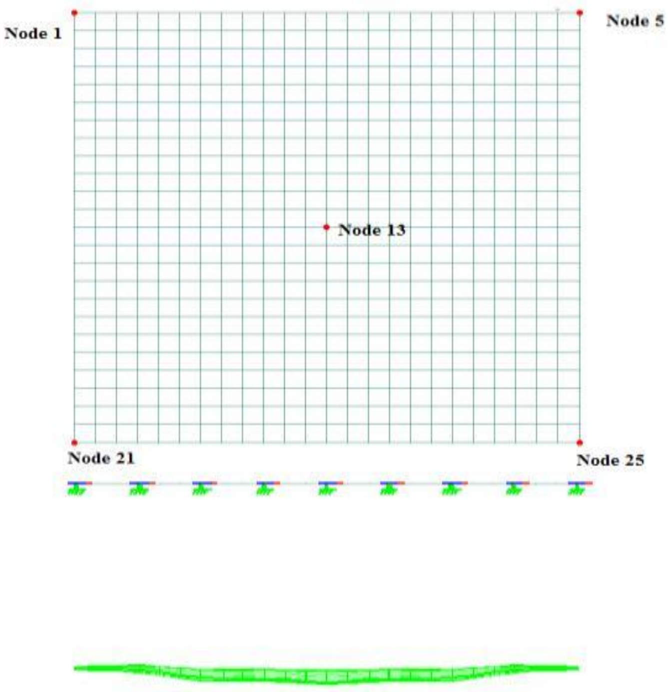


Figure 4.2 Settlement pattern of raft foundation

5.0. CONCLUSION

The effect of Soil Structure Interaction on the analysis results are considered and compared with Fixed base frame model. Story shear, Floor displacement, Story drift, Time period and Settlement of Raft between Fixed base and Flexible base infill frame models are compared between.

5.1. Story shear

Maximum increases in story shear for flexible base infill frame models compare to fix base infill frame model. The increase in story shear is found 1.23 time of fixed base infill frame model. The design value of story shear is underestimated in conventional approach.

5.2. Floor displacement

Displacement for flexible base infill frame is considerably increase compare to fixed base infill frame. The increase in displacement is found 4.03 to 5.04 times of fixed base infill frame.

5.3. Story Drift

Story drift is increasing inflexible base infill frames compare to fixed base infill frame. This increase in story drift is found to be 1.26 to 4.86 compare to fixed base infill frame.

5.4. Time Period

Time period for flexible base infill frame is considerably increases compare to fixed base infill frame. The time period increase is found 1.7 time of fixed base infill frame model. This ratio shows that considering the Soil structure interaction in dynamic analysis of RC building frame the time period is increased. Hence ignoring effect of SSI may leads to Seismic vulnerability.

5.5 Settlement of Raft

Settlement for flexible base infill frame is considerably increases compare to fixed base infill frame. The value of settlement for flexible base model 62.07 mm more than fixed base infill frame model. Differential settlement between center and corner of raft with magnitude of 5.28 mm occurs with non-uniform pattern. This shows that considering the Soil structure interaction in dynamic analysis of RC building frame the settlement is increased. The effects of soil structure interaction on total and differential settlement is critical factor for soft soil.

6.0. REFRENCES

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