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SOIL STRUCTURE INTERACTION (SSI)OF X-TYPE BRACED RC FRAME USING SAP 2000

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Abstract: In this study the seismic response of reinforced concrete structure using steel bracing considering soil structure interaction to increase the horizontal stability of structure and rigidity of the structure. In which it is assumed that the building is fixed at it bases, but in reality the soil medium allows movement to some extent due to its property to deform. Therefore, this may decrease the stiffness of the structure and hence may increase the natural periods of the system. Thus, the process in which soil influences the movement of the structure and further this movement of structure influence the response of the soil is termed as Soil-Structure Interaction. Using X-type bracing in mid positions and with effect of SSI and without of SSI to strengthening the R.C. structure .

***Index Terms* - Soil Structure Interaction , X-type Bracing , Earthquake proof structure , SAP 2000**

I. INTRODUCTION

Population of India is estimated about 1.42 billion as of 2022 and India is the second most populous country in the world. Further complexity is lent by the great variation that across this population on social parameters such as income and education. Dynamic program analysis of tall or high rise building with considered all safety factors have a great and big challenge for the civil engineers. Earthquake resistant of structural systems for tall buildings behaving good and better in the all types of soil condition, Especially for soft soil are necessary to be constructed. Wind program analysis is also a plays most important role in the tall buildings.

The main aim of the earthquake resistant construction is to build the structures that expense better during seismic analysis activity than their normal counterparts. For earthquake resistant of structural system design, the effect of local soil conditions & safety calculation is much needed. The linear dynamic program analysis of structure considering a SSI (soil structure interaction) is most essential. Most of design codes have advised that the effect of SSI can reasonably be neglected for the seismic analysis of structures. Maximum civil engineering projects involves some of the structural elements are directly contact with the ground. When the external forces like earthquakes, act on these type of systems, nor this structural displacements or ground displacements, are unconnected or unconstrained each other.

The common structural design methods are neglecting the effects of soil structure interaction. So neglecting the soil structure interaction is reasonable only for light weight structures are relatively stiff soil like low rise buildings and rigid retaining walls. The soil structure effects are considered for the tall buildings which are resting on the soft soil. Suppose for example nuclear power plant, tall buildings and elevated high ways on smooth soil.

II.LITERATURE SURVEY

Zhenyun Tang (2012) Because of the limitations of testing facilities and techniques, the seismic performance of soilstructure interaction (SSI) system can only be tested in a quite small scale model in laboratory. Especially for long-span bridge, a smaller tested model is required when SSI phenomenon is considered in the physical test. The scale effect resulting from the small scale model is always coupled with the dynamic performance, so that the seismic performance of bridge considering SSI effect cannot be uncovered accurately by the traditional testing method. This paper presented the implementation of real-time dynamic sub structuring (RTDS), involving the combined use of shake table array and computational engines for the seismic simulation of SSI. In RTDS system, the bridge with soil-foundation system is divided into physical and numerical substructures, in which the bridge is seen as physical substructures and the remaining part is seen as numerical substructures. The interface response between the physical and numerical substructures is imposed by shake table and resulting reaction force is fed back to the computational engine. The unique aspect of the method is to simulate the SSI systems subjected to multisport excitation in terms of a larger physical model. The substructuring strategy and the control performance associated with the real-time substructuring testing for SSI were performed. And the influence of SSI on a long-span bridge was tested by this novel testing method.

Dr. S.A. Halkude (2014) Structural redundancy is constraint in the analysis which is of paramount importance from seismic consideration. The masonry in the framed structure is used primarily to create an enclosure and safety to occupants. Such masonry walls are known as infill walls. There will be structural interaction between framed members and infill walls. The combined behavior of the infill wall and structural frame is studied by many researchers from previous occurred earthquakes by modeling the masonry infill walls by compression strut elements. The steel frames with infill walls are general systems in the construction of usual residential buildings in some countries. It is obviously found that the seismic performance of structures is getting changed by considering the masonry infill walls in the analysis. In order to investigate the effect of infill walls on the steel frame, constructed with masonry infill walls, the seismic parameters like Time period, Base shear and Displacement were extracted for the frames with masonry infill's. The present research work aims to study the seismic analysis of steel and RCC plane frames with and without masonry infill walls. The Seven storeyed frames with varying number of bays are analysed by seismic coefficient method for obtaining Time period, Base shear and displacement. It is observed that consideration of brick infill indicates considerable effects on performance as compared to bare frames. It is found that infill wall reduces the time period, displacement for steel as well as RCC frames. The time period is found decreased for frames with infill walls. Base shear has substantially increased for frame with infill wall. The displacement and time period has been found to be reduced for bare frame and infill frame for steel as well as RCC frames when numbers of bays are increased from 2 bays to 10 bays. The inclusion of infill wall produces substantial improvement for steel frame whereas for RCC frames the improvement is marginal

Mohamed M. Ahmed (2015) : Author has consider moment resisting frame carried out three different methods of seismic analysis i.e response spectrum analysis, and nonlinear time method with nine different time history inputs recorded during earthquake.

M. G. Kalyanshetti (2016) Conventional fixed-base analysis ignoring the effect of soil- flexibility carried out for the seismic design of buildings may result in unsafe design. Therefore, the effect of SSI is an important issue from the viewpoint of design considerations. Thus to evaluate the realistic behavior of structure the soil structure interaction (SSI) effect shall be incorporated in the analysis. In seismic analysis provision of bracing system is one of the important option for the structure to have sufficient strength with adequate stiffness to resist lateral forces. The different configuration of these bracing systems alters the response of buildings, and therefore, it is important to evaluate the most effective type and location of the bracing systems in view point of stability against SSI effect. In present study, two RC building frames, G+10 and G+15 with six different combinations of steel bracing system at alternate locations incorporating the effect of soil flexibility is considered in order to investigate the effectiveness of bracing system to control SSI. The seismic analysis is carried out using equivalent static method as per IS 1893-2002 The study is carried out using Elastic continuum approach(ECM) The influence of SSI on various seismic parameters and the flexural parameters are presented. The changes in all these parameters due to provision of steel bracing system are studied in order to evaluate its effectiveness in controlling the SSI effect. The study reveals that, steel bracing system plays important role to control SSI effect and it is observed that diagonal bracing placed at mid periphery are more effective, in resisting seismic load considering SSI

Mr. Magade S. B (2018) 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. 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 suggested 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

Dr.B.R.Patagundi(2019) In the construction of high rise structure the SOIL STRUCTURE INTERACTION (SSI) should be consider in evaluation of stiffness and strength of structure. Usually in the seismic design of ordinary bldg, soil structure interaction is neglected. But the lateral loads (Seismic & wind forces) work as an main role in the construction of high rise structures. The structure is analyzed for its structural behavior assuming base condition as fixed base. it is observed that effect of soil structure interaction is changes as the flexibility of soil varies. i.e., for fixed as well as for various flexible base conditions, i.e., for hard, medium and soft soil. In this study G+20 structure is analyzed with the help of STAAD-Pro V8i software, by equivalent static method with Winkler's approach method. considering three different soil types and compared with different arrangements of bracings system. This study reveals that SSI significantly affects the response of structure. The different parameters like Base shear, roof Displacement, Drift-ratio are considered to evaluate the output of plane frame and structures with different bracing system of models. and it is represented in the form of tables & graphs which will help us to understand the behavior of braced structure under the effect of soil structure interaction and also to suggest the better performance among the structure.

I. PROBLEM STATEMENT

Conventional fixed-base analysis ignoring the effect of soil-flexibility carried out for the seismic design of buildings may result in unsafe design. Therefore, the effect of SSI is an important issue from the viewpoint of design considerations. Thus to evaluate the realistic behavior of structure the soil structure interaction (SSI) effect shall be incorporated in the analysis. In seismic analysis provision of bracing system is one of the important option for the structure to have sufficient strength with adequate stiffness to resist lateral forces.

II. AIM

To study soil structure interaction of x-type braced RC frame on highrise building(G+10,G+20 and G+30) using sap 2000

III. OBJECTIVES

- To study soil structure interaction (SSI) of x-type braced RC frame using sap2000.
- Comparison of G+10 ,G+20 AND G+30 building with and without SSI.
- Result analysis and comparison of G+10, G+20, G+30 X-braced R.C. building

IV. METHODOLOGY

6.1 Literature Review

- Review existing literature on soil-structure interaction and X-braced frames to understand key concepts and methodologies used in similar studies.

6.2 Define Objectives:

- Clearly define the objectives of your project, specifying the aspects of soil-structure interaction and behavior of X-braced RC frames you aim to investigate

6.3 Modeling in SAP2000:

- Develop a detailed 3D structural model of the X-braced RC frame(G+10,G+20,G+30) in SAP2000.
- Assign material properties, sections, and boundary conditions accurately.

6.4 Define Soil Properties:

- Model the soil beneath the structure, incorporating relevant geotechnical properties.
- Consider soil-structure interaction parameters such as foundation stiffness and damping.

6.5 Load Application:

- Apply lateral loads and other relevant loads to simulate real-world conditions.
- Implement earthquake or wind loads based on your study objectives.

6.6 Analysis Types:

- Perform linear static analyses to assess the structural response.Consider dynamic analyses for earthquake scenarios, studying the response spectrum.

6.7 Soil-Structure Interaction Analysis:

- Incorporate soil-structure interaction effects using appropriate methods available in SAP2000.
- Analyze and interpret the results, focusing on the influence of soil on structural behavior.

6.8 Results Interpretation:

- Analyze and interpret the results obtained from SAP2000 simulations, focusing on the performance of the X-braced RC frame under different conditions.

6.10. Comparison:

- Compare result analysis of (G+10,G+20,G+30) RC frame with and without SSI using SAP 2000.

V. MODELS AND ANALYSIS

The model has been done SAP 2000 in scale. SAP 2000 is a sophisticated, very easy to use. Its analysis and design software by computers and system inc. now a day it's considered as very popular analysis and design software. It can also handle largest and most difficult & complex models. The proposed buildings G+10,G+20,G+30 storied an RC frame structures which is located at **CHATRAPATI SAMBHAJI NAGAR** (assuming). The structures are located in earthquake zone II, subjected to equivalent static analysis method and analysis of response spectrum method. The structure is rectangular shape in plan **assuming as apartment type structure has G+10 , G+20 ,G+30 floor**

1	Structure	X Braced RC frame structure
2	No of Stories	10 (G+10)
3	Storey Height	3 m
4	Bays Length	12m
5	Building Height	33m
6	Bays Width	12m
	Material property	
7	X Bracing (ISWB300)	Fe 250
8	Grade of concrete	M25
9	Grade of steel	Fe 415
	Member Properties	
10	Thickness of slab	150mm
11	Beam Size	350mmx350mm
12	Column Size	700mmx700mm
	Load Intensities	
13	Live load	4 KN/ m2
14	Seismic Zone	Zone II (Factor - 0.24)
14	Soil Type	Type I,III, clayey, gravel
15	Seismic Analysis	Response spectrum Method
16	Importance Factor	1
17	Damping Ratio	0.05

Table 7.1 Model data of RC frame (G+10) structure

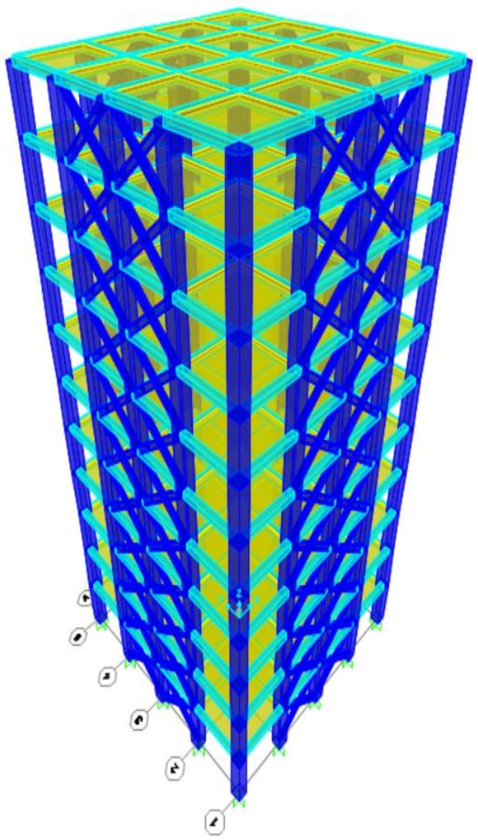


Fig no.7.1G+10 X-type braced RC frame without SSI

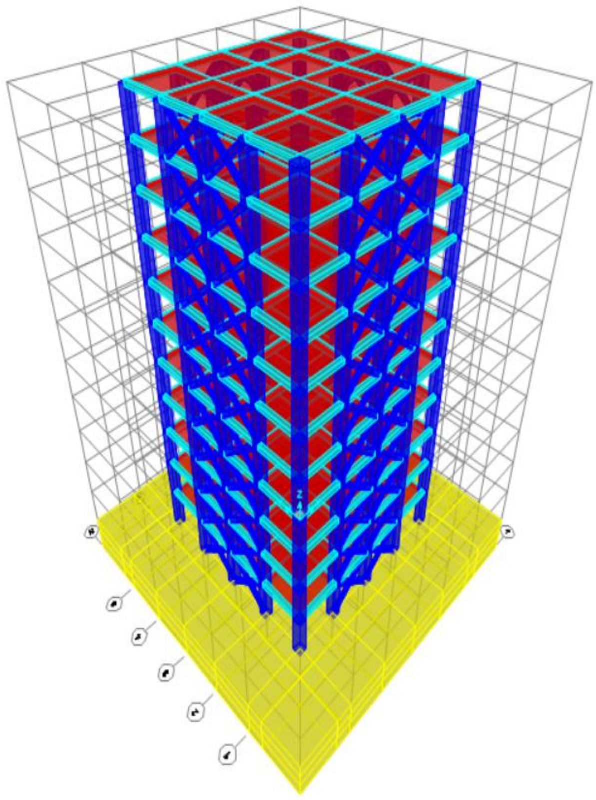
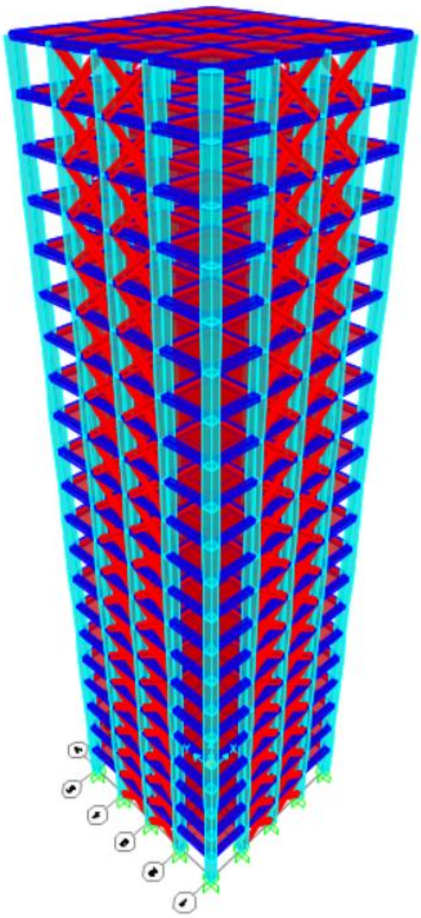


Fig no.7.2 G+10 X-type braced RC frame with SSI

1	Structure	X Braced RC frame structure
2	No of Stories	20 (G+20)
3	Storey Height	3 m
4	Bays Length	12m
5	Building Height	63m
6	Bays Width	12m
	Material property	
7	X Bracing (ISWB400)	Fe 250
8	Grade of concrete	M 30
9	Grade of steel	Fe 500
	Member Properties	
10	Thickness of slab	150mm
11	Beam Size	350mm x 500mm
12	Column Size	750mm x 750mm
	Load Intensities	
13	Live load	4 KN/ m2
14	Seismic Zone	Zone II (Factor - 0.24)
14	Soil Type	Type I,III, clayey, gravel
15	Seismic Analysis	Response spectrum Method
16	Importance Factor	1
17	Damping Ratio	0.05

Table 7.2 Model data of RC frame (G+20) structure



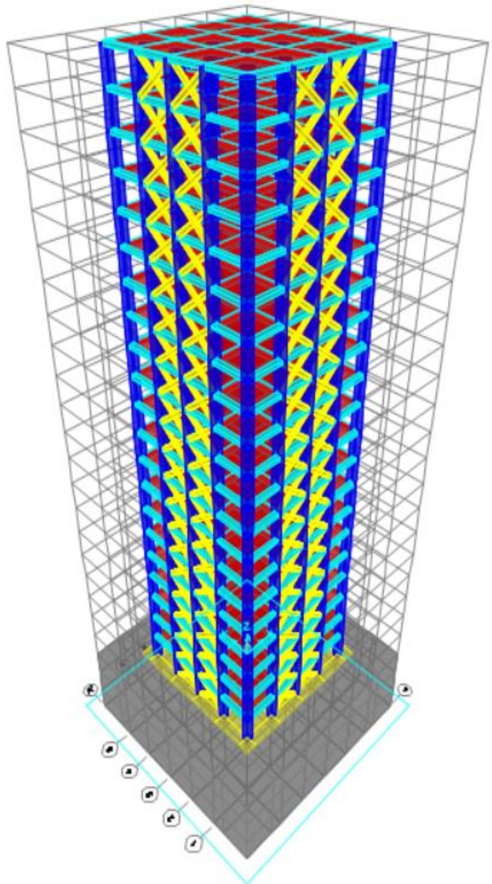


Fig no. 7.3 G+20 X-type braced RC frame without SSI

Fig no.7.4 G+20 X-type braced RC frame with SSI

1	Structure	X Braced RC frame structure
2	No of Stories	30 (G+30)
3	Storey Height	3 m
4	Bays Length	12m
5	Building Height	93m
6	Bays Width	12m
	Material property	
7	X Bracing (ISWB450)	Fe 250
8	Grade of concrete	M 35
9	Grade of steel	Fe 550
	Member Properties	
10	Thickness of slab	150mm
11	Beam Size	400mm x 600mm
12	Column Size	800mm x 800mm
	Load Intensities	
13	Live load	4 KN/ m2
14	Seismic Zone	Zone II (Factor - 0.24)
14	Soil Type	Type I,III, clayey, gravel
15	Seismic Analysis	Response spectrum Method
16	Importance Factor	1
17	Damping Ratio	0.05

Table 7.3 Model data of RC frame (G+30) structure

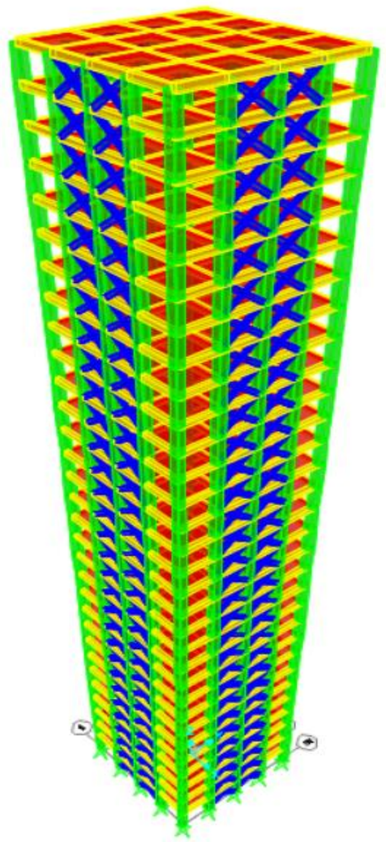


Fig no. 7.5 G+30 X-type braced RC frame without SSI

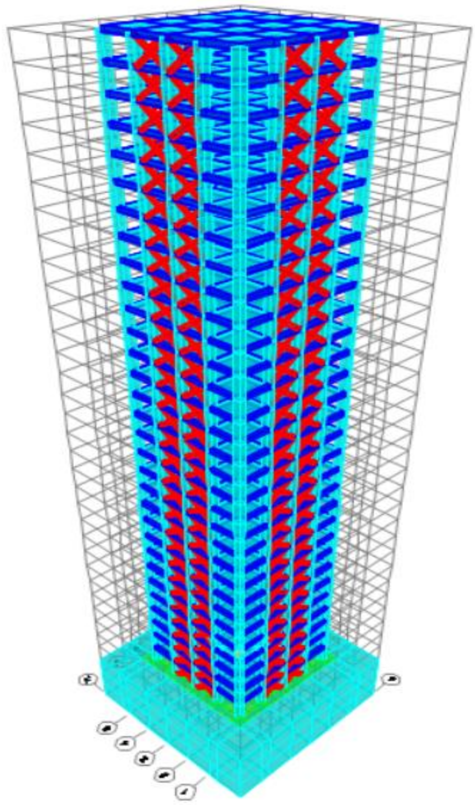


Fig no.7.6 G+30 X-type braced RC frame with SSI

VI. COMPARISON

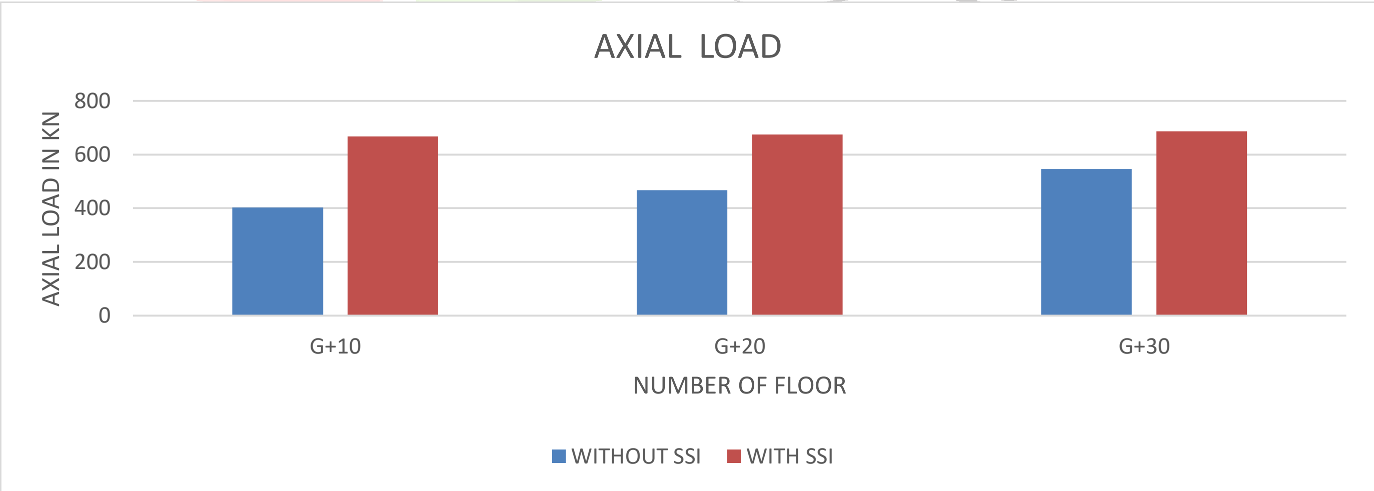


Chart No. 8.1 Axial Load Comparison

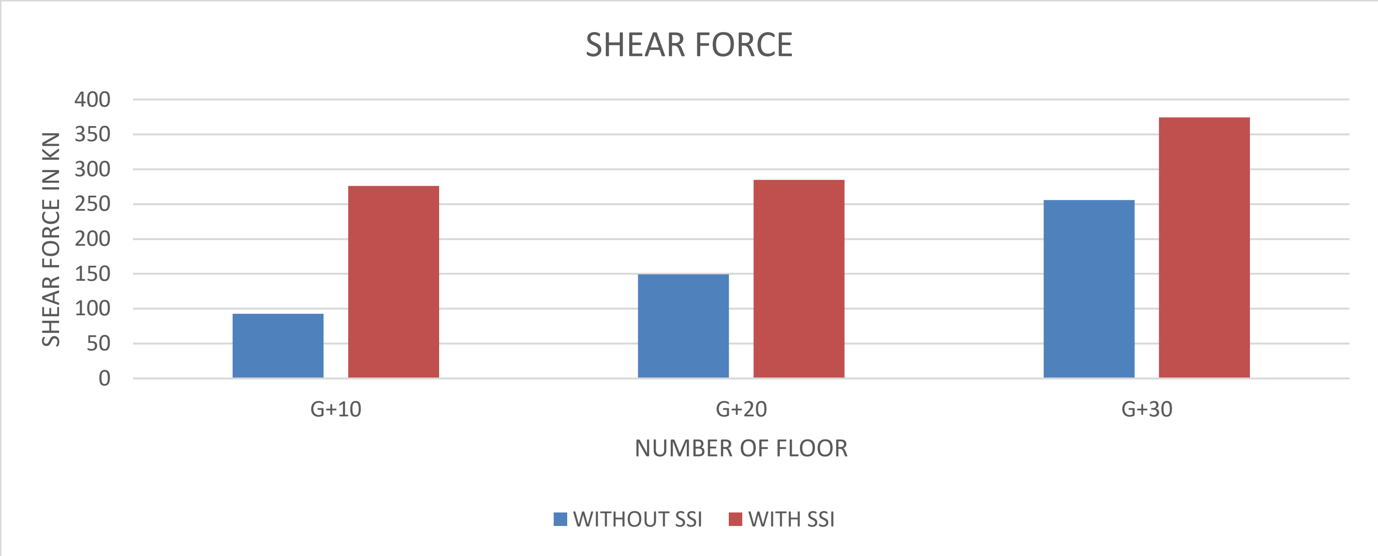


Chart No 8.2 Shear Force Comparison

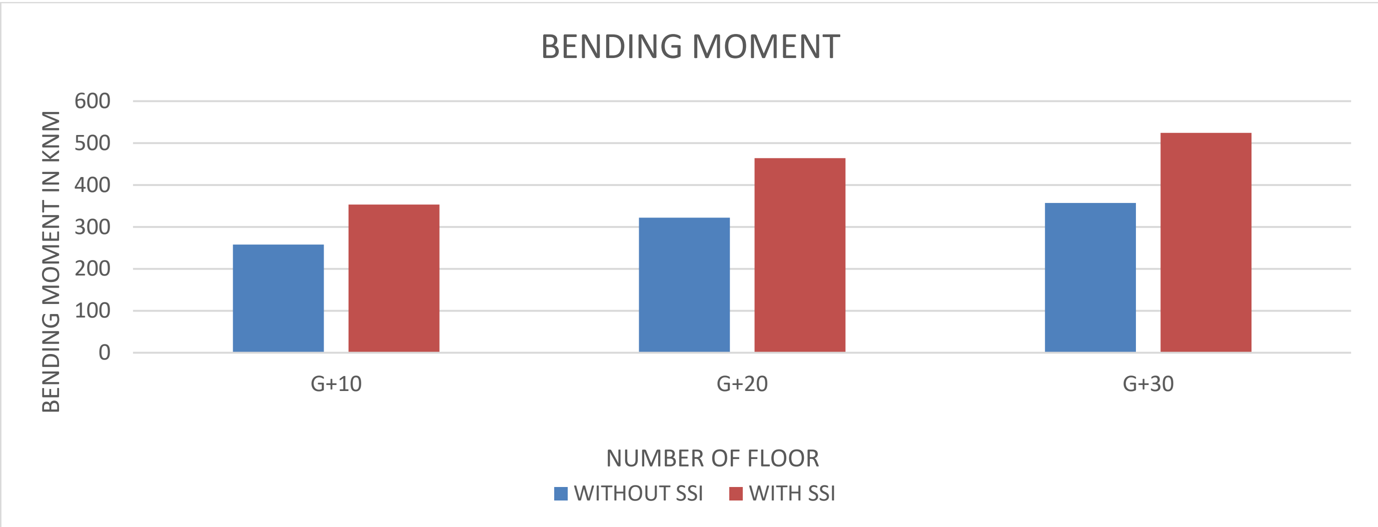


Chart No 8.3 Bending Moment Comparison

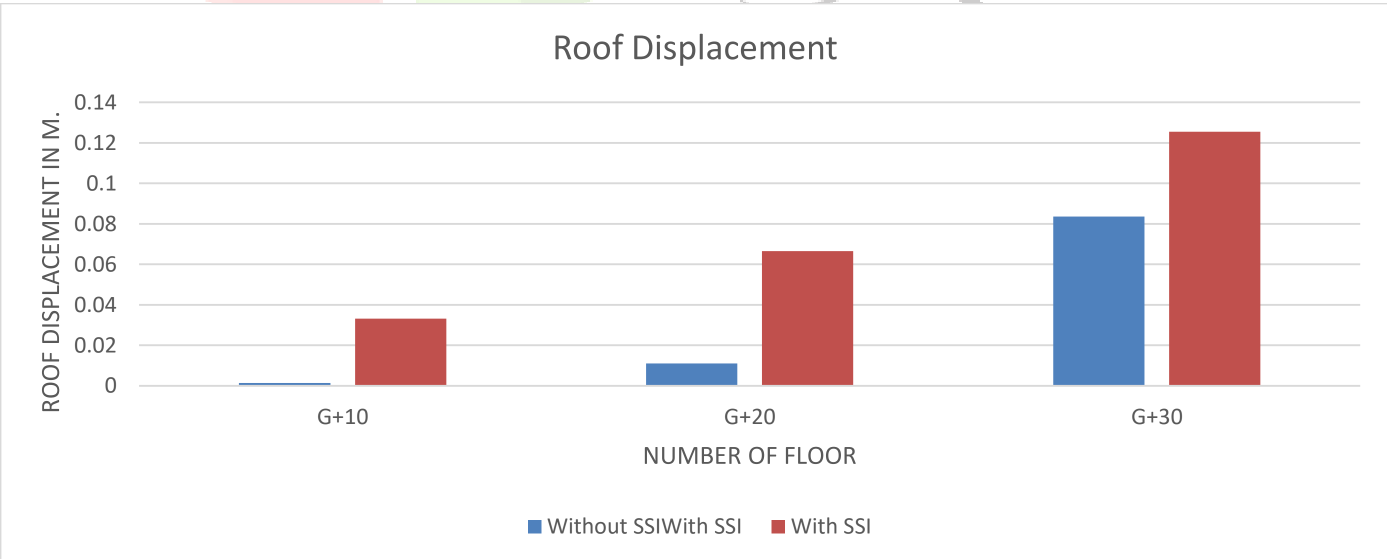


Chart No 8.4 Roof Displacement Comparison

VII. RESULTS

1. Axial Load:

- In G+10,G+20,G+30 Axial load in structure without SSI shows percentile increase 13.70% and 14.43% respectively
- In G+10,G+20,G+30 Axial load in structure with SSI shows percentile increase 1.22% and 1.74% respectively
- IN G+10 structure Without SSI and with SSI Axial load shows percentile increase39.57%
- IN G+20 structure Without SSI and with SSI Axial load shows percentile increase 30.83%
- IN G+30 structure Without SSI and with SSI Axial load shows percentile increase 20.54%

2. Shear force :

- In G+10,G+20,G+30 Shear force in structure without SSI shows percentile increase 37.70% and 41.76% respectively
- In G+10,G+20,G+30 Shear force in structure without SSI shows percentile increase 3.06% and 23.97% respectively
- In G+10 structure Without SSI and with SSI Shear force shows percentile increase 66.34%
- In G+20 structure Without SSI and with SSI Shear force shows percentile increase 47.63%
- IN G+30 structure Without SSI and with SSI Shear force shows percentile increase 31.63%

3. Bending Moment:

- In G+10,G+20,G+30 Bending Moment in structure without SSI shows percentile increase 19.9% and 8.84% respectively
- In G+10,G+20,G+30 Bending Moment in structure with SSI shows percentile increase 23.73% and 11.60% respectively
- In G+10 structure Without SSI and with SSI Bending moment shows percentile increase 27.09%
- In G+20 structure Without SSI and with SSI Bending moment shows percentile increase 30.55%
- In G+30 structure Without SSI and with SSI Bending moment shows percentile increase 31.91%

4. Roof displacement:

- In G+10,G+20,G+30 Roof displacement in structure without SSI shows percentile increase 87.24% and 86.94% respectively
- In G+10,G+20,G+30 Roof displacement in structure with SSI shows percentile increase 50.18% and

47.11% respectively

- In G+10 structure Without SSI and with SSI Roof Displacement shows percentile increase 58.03%
- In G+20 structure Without SSI and with SSI Roof Displacement shows percentile increase 64.15%
- In G+30 structure Without SSI and with SSI Roof Displacement shows percentile increase 33.49%

VIII. CONCLUSION

Incorporating SSI in the design of high-rise buildings (G+10, G+20, G+30) using SAP2000 significantly influences the structural response. The increased flexibility of the foundation and potential settlement effects lead to higher column loads, shear forces, bending moments, and roof displacement. Therefore, detailed SSI analysis is crucial, especially for taller buildings, to ensure safety, stability, and serviceability. Adjustments in design, such as reinforcing columns and lateral load-resisting systems, are necessary to accommodate the additional demands induced by SSI.

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