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Effect of SSI Model on the Response of Building

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Abstract: The interaction between a structure and its supporting soil, known as Soil-Structure Interaction (SSI), plays a crucial role in accurately predicting the seismic response of buildings. Traditional structural analysis often assumes a fixed-base condition, neglecting the flexibility and energy dissipation characteristics of the underlying soil. However, recent studies and advancements in numerical modelling have demonstrated that SSI can significantly alter the dynamic response of buildings, especially under seismic loading. This paper investigates the effect of SSI models on the seismic performance of buildings by comparing fixed-base and flexible-base conditions using various analytical and numerical approaches. The results highlight that incorporating SSI leads to modifications in natural frequencies, mode shapes, base shear forces, and understory drifts. In particular, softer soils tend to increase system flexibility and period elongation, potentially reducing seismic demand but increasing displacement. The findings emphasize the necessity of including SSI effects in structural design, especially for critical infrastructure and buildings situated on soft or variable soil profiles. Understanding and accurately modelling SSI is essential for improving seismic resilience and ensuring the safety and performance of structures during earthquakes.
Keyword: SSI, Ansys, Abaqus, Design, Process, Characteristics, Calculation.

I. INTRODUCTION

Soil-Structure Interaction (SSI) is the process by which the motion and deformation of the ground influence the dynamic response of a structure, resulting in a coupled behaviour that must be considered for accurate structural analysis and design.

In other words, the response of the soil influences the motion of the structure influences the response of the soil is termed as SSI. In this case, neither structure displacement nor the ground displacement is independent from each other. SSI refers to the mutual response and influence between a structure and the underlying soil during loading, such as from buildings, bridges, embankments, or dynamic forces like earthquakes. Unlike, traditional design approaches that treat soil and structures separately, SSI recognizes that the behaviour of the soil and the structure are interdependent. In reality, soil is a nonlinear, deformable medium, and it can significantly affect the structural performance in terms of settlement, stability, vibration, and load distribution. When a structure is loaded, it induces stresses in the supporting ground, which in turn affects the deformation and internal forces in the structure. This interaction becomes especially critical when dealing with soft soils, deep foundations, or dynamic loading conditions.

Understanding SSI is essential for designing safe and efficient foundations and superstructures. It requires integrated analysis that considers both geotechnical and structural engineering principles, often using tools such as numerical modelling, laboratory tests, and field monitoring. With the advancement of computational tools and a growing need for infrastructure development on challenging soils, SSI has become a key area in modern geotechnical and structural engineering practice. The interface shear stress–displacement function, which is the relationship between the sliding displacement and shear stress at the interface between two materials in contact, is commonly used to characterize the soil– pile interaction system. The development of interface shear stress–displacement functions to consider the nonlinearity in the interaction response between the soils and the structures has received a lot of attention in recent years. For the purpose of pile behaviour analysis, it is commonly assumed that the load–settlement response of the pile shaft and base resistances is hyperbolic or exponential functions.

II. LITERATURE REVIEW

S.N.	Title of Paper	Author Name	Title of Journal	Year	Remark
1	Dynamic SSI effect on the pounding response of a series of adjacent buildings equipped with linear and nonlinear fluid viscous dampers.	Hytham Elward any Ayman Sleeman	Structures	2025	The dynamic soil structure interaction (SSI) significantly influences the pounding response between adjacent buildings, especially under seismic excitations.

2	The effect of soil structure interaction (SSI) on structural stability and sustainability of RC structures.	Ragi Krishana, Vidhya Lakshmi Sivakumar	Civil and environment engineering report	2024	By realistically accounting for the flexibility and damping characteristics of the supporting soil.
3	Seismic response of a stilted mid–story isolated structure in mountainous areas based on variable parameters soil structure interaction effect.	Feng Wan, Wangwang Zhou, Dewen Liu	Structures	2024	This study emphasizes that overlooking SSI effects can lead to significant underestimation or overestimation of seismic demands, particularly in structures with elevated base levels.
4	Seismic response control of tall building using semi-active tuned mass damper considering soil structure interaction.	Liangkun Wang, Ying Zhou	Soil Dynamics and Earthquake Engineering	2024	This study demonstrates that SSI alters the dynamic characteristics of the building–soil system.
5	Seismic Assessment of Large-Span Spatial Structures considering soil structure interaction (SSI).	Puyu Zhan, Suduo Xue	Faculty of Architecture, Civil and Transportation Engineering	2024	By incorporating realistic soil behaviour, the analysis enhances structural safety, informs better foundation design.
6	Numerical investigation of nonlinear soil structure interaction effects on response of irregular RC building	Nolaraj Poudel, Hemchandra Chaulagain	Results in Engineering	2024	This study underscores the necessity of incorporating nonlinear SSI effects in the analysis and design of irregular RC buildings.
7	Seismic performance investigation of building structures equipped with MTMDS considered.	Yangzhou Wu a, Mi Zhao a, Zhidong Gao	Journal of Building Engineering	2023	These findings confirm that MTMDS can effectively mitigate seismic demands, making it a promising solution.
8	Seismic control of vertically and horizontally irregular steel high-rise building by tuned mass dampers including SSI.	Denise-Penelope N. Kontoni1,	Asian Journal of Civil Engineering	2023	The seismic control of vertically and horizontally irregular steel highrise buildings using Tuned Mass Dampers.
9	Seismic control of T-shape in plan steel high-rise buildings with SSI effect using tuned mass dampers.	Denise-Penelope N. Kenton	Asian Journal of Civil Engineering	2023	These findings highlight the importance of considering both structural irregularities and SSI effects in the design
10	Evaluation of soil structure interaction effects on structural performance of historical masonry building considering earthquake input models.	Ali Fuat Genc, Esin Ertürk Atmaca	Structures	2023	The study demonstrates that SSI tends to increase displacement demands and prolong structural periods.

III. SUMMARY

This study examines how dynamic soil-structure interaction influences the seismic pounding response between adjacent buildings. Traditional seismic design often assumes a rigid foundation, but this research demonstrates that neglecting SSI can lead to inaccurate and potentially unsafe results. The issue of Soil Structure Interaction concerns how the soil and a structure influence each other’s behavior, especially under dynamic loads such as earthquakes. The interaction depends on both the properties of the soil and the characteristics of the structure, affecting stress distribution, deformation, and overall movement of the system.

Soil-Structure Interaction influences the performance of tuned mass dampers (TMDs) in tall buildings and proposes a semi-active tuned mass damper to improve seismic response control under uncertain soil and structural conditions. SSI alters the structural characteristics of RC buildings by increasing system flexibility, reducing natural frequencies, and changing damping behavior Structures founded on soft or deformable soils tend to experience larger displacements and settlements, while those on stiffer soils face higher seismic forces due to reduced energy absorption in the foundation. SSI can either mitigate or amplify seismic responses, depending on soil stiffness, foundation type, and structural configuration. Neglecting SSI may lead to unsafe design predictions, underestimating inter-story drifts or overestimating structural strength.

The seismic response of stilted mid-story isolated structures located in mountainous regions, emphasizing the role of variable-parameter Soil-Structure Interaction (SSI). Mountainous terrains have complex geological conditions and uneven topography, which cause significant differences in dynamic behavior compared to flat-ground structures. Traditional seismic analyses often neglect SSI effects in such environments, leading to inaccurate evaluations of structural safety.

The seismic response control of tall buildings using a semi-active tuned mass damper (STMD) while considering the effects of Soil-Structure Interaction (SSI). Traditional passive tuned mass dampers (TMDs) are widely used to reduce structural vibrations; however, their performance is highly sensitive to frequency detuning and damping uncertainties, especially when SSI effects alter the dynamic characteristics of the structure. To address these limitations, the STMD system is introduced, capable of real-time adjustment of both frequency and damping ratio. By modifying its mass and eddy current damping through a controlled algorithm, the STMD can adapt to changes in soil and structural conditions during seismic events.

The seismic assessment of large-span spatial structures while accounting for the effects of Soil-Structure Interaction (SSI). Large-span structures, such as stadiums, exhibition halls, and airports, possess complex geometry and flexible foundations, making their dynamic behavior highly sensitive to the properties of the supporting soil. Traditional seismic analyses often assume fixed-base conditions, which can lead to inaccurate evaluations of their real performance during earthquakes.

IV. CONCLUSION

From the above literature review paper, it is observed that the Abaqus software has lot of advantages as compare to the other software available at present. From the literature review paper, it can be depicted that there is lot of saving in material and overall cost of the project. Thus, in our project we are taking as case sample of the existing SSI and designing the same with software with comparison of the cost will be carried out. The study demonstrates that SSI has a substantial impact on the seismic performance of mountain structures. To ensure accurate and safe design, SSI effects especially with variable soil conditions should be incorporated into seismic analysis and design of buildings in mountainous regions.

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