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Soil Structure Interaction Analysis of Multi Storey Building Frame for Seismic Load Using SAP2000

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Abstract
Presently a day the human life and the climate have often been jeopardized by the characteristic perils like seismic tremor, torrent, flood, twister and avalanches. As an outcome of which the human culture and the country's economy get hampered following the event of a catastrophic event. In agricultural nations like India, where the populace is huge and is expanding step by step, the social and financial components power individuals to live in weak territories, because of which the impacts of these cataclysmic events are disastrous. Among every one of these dangers, liquefaction of soil can be brought up as one of the most appalling seismic perils. Consequently assessment of liquefaction helplessness is a significant part of geotechnical designing. Soil-structure connection impact in the examination and plan of RC outline structures is progressively perceived yet not infiltrated to the grass root level attributable to different complexities included. It is settled reality that the dirt structure collaboration impact significantly impact the plan of multi-story structures exposed to parallel seismic burdens. In this examination we are performing seismic appraisal utilizing Analytical apparatus SAP2000 over a midrise building outline where we will give sidelong load to zone V (0.36) to decide soil structure communication for parallel burdens, for this investigation a midrise even structure of G+7 storey is considered.

Keywords:- Mid Rise Building, Support Reaction, Soil Interaction, Analysis Tool, Forces, SAP2000.

Introduction

The traditional basic examination of a RC space casing is done expecting establishment laying on fixed end underpins. The investigation is completed by considering base part of the arrangement fixed and ignoring the impact of soil distortions. In all actuality, any building casing lays on deformable soil bringing about redistribution of powers and minutes because of soil-structure interaction. In this manner, traditional examination is ridiculous and might be dangerous. The interaction impact is increasingly articulated if there should be an occurrence of multi-storeyed buildings because of overwhelming burdens and may turn out to be additionally disturbed when such buildings are exposed to seismic burdens.

It is ordinarily accepted that SSI is a simply useful impact, and it can advantageously be dismissed for traditionalist design. SSI arrangements of seismic design codes are discretionary and enable designers to diminish the design base shear of structures by considering soil-structure interaction (SSI) as a gainful impact. The fundamental thought behind the arrangements is that the soil-structure framework can be supplanted with a proportionate fixed-base model with a more drawn out period and typically a bigger damping proportion. A large portion of the design codes use distorted design spectra, which achieve consistent increasing speed up to a specific period, and from that point diminishes monotonically with period. Considering soil-structure interaction makes a structure progressively adaptable and along these lines, expanding the common time of the structure contrasted with the comparing unbendingly bolstered structure. In addition, considering the SSI impact expands the viable damping proportion of the framework. The smooth glorification of design range recommends littler seismic reaction with the expanded normal time frames and successful damping proportion due to SSI, which is the principle defense of the seismic design codes to diminish the design base shear when the SSI impact is considered.

In this study we are comparing a high rise unsymmetrical structure of G+7 storey considering seismic zone V with two different soil conditions i.e. soft soil (black cotton soil) and medium soil (loamy soil), In this study we are interacting structure and soil using analysis tool SAP2000.

II. Soil Structure Interaction

Soil-structure interaction examination assesses the aggregate reaction of these frameworks to a predefined ground movement. The terms Soil-Structure Interaction (SSI) and Soil-Foundation-Structure Interaction (SFSI) are both used to portray this impact in the writing. In this report, the establishment is viewed as a major aspect of the structure, and the term SSI has been received. A seismic soil-structure interaction examination assesses the aggregate reaction of the structure, the establishment, and the geologic media basic and encompassing the establishment, to a predetermined free-field ground movement. The term free-field alludes to movements that are not influenced by basic vibrations or the dissipating of waves at, and around, the establishment. SSI impacts are missing for the hypothetical state of an inflexible establishment bolstered on unbending soil. In like manner, SSI represents the distinction between the genuine reaction of the structure and the reaction of the hypothetical, unbending base condition.

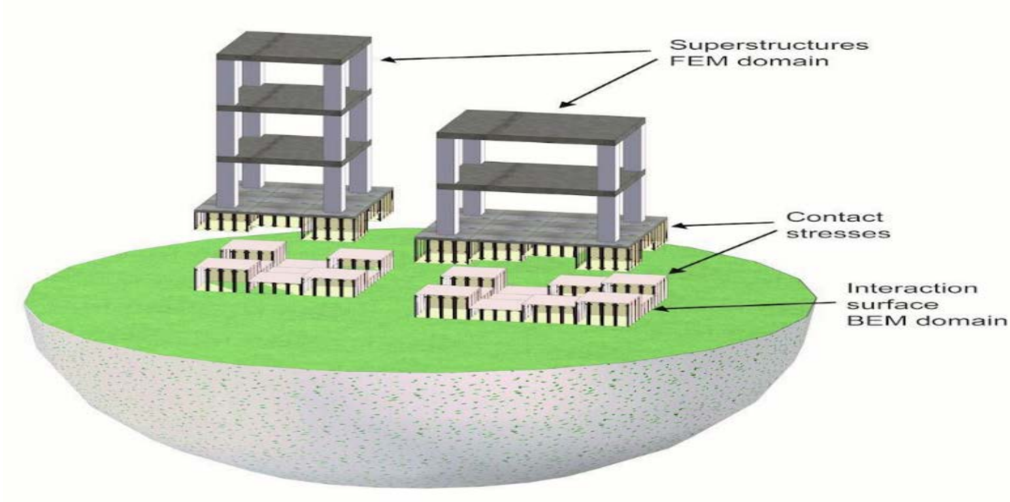

Fig 1: Soil Structure Interaction.

III. SAP2000

SAP2000 information, including model data, investigation results, and configuration results, can be gotten to utilizing a forbidden information structure. Forbidden information can be altered and showed in the interface, or traded to a Microsoft Access database document, a Microsoft Excel spreadsheet record, or a straightforward book document. You can utilize traded information to make reports or to perform specific computations. This equivalent unthinkable information can be brought into SAP2000, empowering you to produce or alter models outside SAP2000. Import and fare abilities additionally exist for other prevalent drafting and configuration programs.

IV. Objectives

1. To check the stability of soil - structure interaction in Seismic hazard.
2. To determine the effect of lateral load over two different soil type i.e. Loamy & Black cotton soil.
3. To determine the Utilization of Analytical tool SAP2000 in soil & Structure Interaction.
4. To determine the variation in forces, stability, displacement and other important criteria or safe structure.

V. Literatyre Review

Supriya and Reddy (2019) this research paper presented the effects of soil interaction on building frame design parameters as change of modulus of sub-grade reaction from 0.010 to 0.050 N/mm3 the analysis was done on parameters namely shear force, bending moment and settlements for different footing sizes of 1mx1m to 4.5mx4.5m the effect of SSI was quantified using finite element analysis. The conclusion derived from the research paper stated that the shear force and axial force value in the beam and column is constant from finite element analysis was not having considerable difference. The analysis was predicting that percentage difference in bending moment in beam, column and footings was at lower EFS value i.e 0.010N/mm3 at lower footing size 1mX1m was greater than when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mX4.5m which considers soil interaction. But in case of the footings they undergo some settlement the percentage difference of settlement was 14.41% and 6.72% at lower EFS value i.e 0.010N/mm3 at lower footing size 1mx1m when compared to higher EFS value i.e 0.050N/mm3 at higher footing size 4.5mx4.5m respectively, which considers soil interaction.

Magade S. B and Prof. Patankar J. P (2018)this research paper presented different parameter such as soil structure interaction, types of soil, stiffness of infill walls, and location of walls influences time period, displacement and base shear of building frame considerably. Hence it was important to consider to all these parameters in the analysis of structures. Shear walls located in the central part of the multistoried building gives lesser displacement and more base shear compared to other locations.

HailuGetachewKabtamu et al. (2018)this research paperdynamic analysis of Soil Structure Interaction (SSI) effect on multi story reinforced concrete (RC) frame founded on soft soil (flexible base) and comparison was made with fixed base. Two model 2D RC frames with 7 and 12 story are selected for analysis. Winkler Spring and half space direct method models are used for flexible base for the frames founded on two types of soft soils with shear velocity Vs< 150 m/s Asper Seismic Codes of Chinese GB50011-2010 Soil IV and Ethiopian ES8-2015 soil D. The frames are subjected to strong ground motion matched to response spectrums of soft soil of Chinese GB50011-2010 and Ethiopian ES8-2015 for linear time history analysis. The dynamic analysis result showcased Spring and Fixed base mass participation 90% reaches in 2 or 3 modes but in direct method 11 to 30 modes for story 12 and 7 respectively. The results led to the conclusion that SSI effect may not be always beneficial in multi-story RC frame compared to fixed base. Because the beneficial effect reduction in base shear may be smaller than detrimental effect of P-delta increment on vertical load carrying members. The results obtained in this study is limited to linear time history analysis regular 2D RC frame; however it is good indicator of SSI effect.

VI. Methodology

Following steps are required in a sequence for proper completion:

Step-1 Select Geometrical data and modelling of structure using SAP2000.

An RCC Structure is rigid to get together of Beams, Columns, Slabs, and establishment between associated with one another as a solitary unit. For the most part, the uniform load in these structures is from chunk to bar, from shaft to the segment lastly section to the establishment which thus exchanges the whole load to the soil.

Step-2: Defining material and soil property for study.

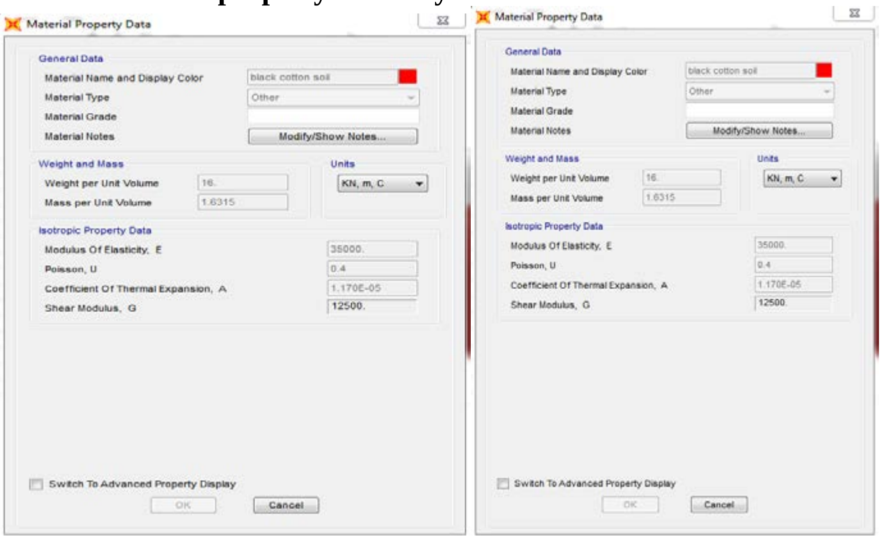

Fig 2: Material & Soil Property.

Step-3: Creating Soil Mass below the structure:

SAP2000 give us a development alternative to give material properties in a particular way to dole out in structure. In SAP2000 we are allowed to dole out any sort of material as it gives a practical altering device to make the material

Step-4: Assigning Boundary Conditions

In SAP2000 we are allowed to assign out any sort of help either settled, stick or roller for which we have to tap on dole out instrument on the menu bar > then we will choose joint > after that we have select the kind of help we have to assign it.

Step-5: Interacting RCC Structure over the soil

In this study we are assigning G +7 Structure above soil which is fixed 1.5 m below the soil to have interaction and load distribution.

Step-6: Load Combinations

The accompanying burden blends will be accounted as given in I.S. 1893 (Part I): 2016 (Sec. 6.3.1.2).

Step-7: Interacting Soil and structure

Soil mass and structure is done by fixing structure 1.5 meter below the soil for proper distribution of support reaction to the soil mass.Which is effected to 18 m beneath the soil as observed after analysis.

Step-8: Analysis of soil structure

Finite element analysis is performed using SAP2000 software, for this analysis soil mass is meshed in elements to determine the minute variation in different elements of the soil.

Step-9: Comparative Analysis

This step we will compare results of both type of soil to determine the variation in reactions, forces and moment.

VII. Problem Formulation

7.1 Modelling of Building Frame

SAP2000 is a multipurpose program for investigation of structure. The accompanying three exercises must be performed to accomplish that objective.

- Modeling of the diverse cases in SAP2000
- Calculation and Provisions according to Indian principles can be connected.
- Analysis of structure to decide forces, reactions and moment producing in a casing.

VIII. Analysis Result

The fundamental standards hidden the FEM are generally straightforward. Consider a body or designing part through which the conveyance of a field variable, for example relocation or stress, is required. Models could be a part under load, temperatures subject to a warmth input, and so forth. The body, for example a one-, a few dimensional strong, is demonstrated as being speculatively subdivided into a gathering of little parts called elements – 'finite elements'. The word 'finite' is utilized to portray the constrained, or finite, number of degrees of opportunity used to display the conduct of every element. The elements are thought to be associated with each other, yet just at interconnected joints, known as hubs. Note that the elements are notionally little districts, not separate substances like blocks, and there are no breaks or surfaces between them.

8.1 Soil Mass at Top of the soil:

Table 1: Soil Stress in X Direction.

Soil Stress in X Direction kN/m^2	
Black Cotton Soil	Loamy Soil
S11	**S11**
KN/m2	**KN/m2**
-3.37	**-13.37**
-3.37	**-13.36**
-4.48	**-13.68**
-4.48	**-13.68**
-6.11	**-15.19**
-6.11	**-15.19**
-7.27	**-15.57**
-7.27	**-15.57**

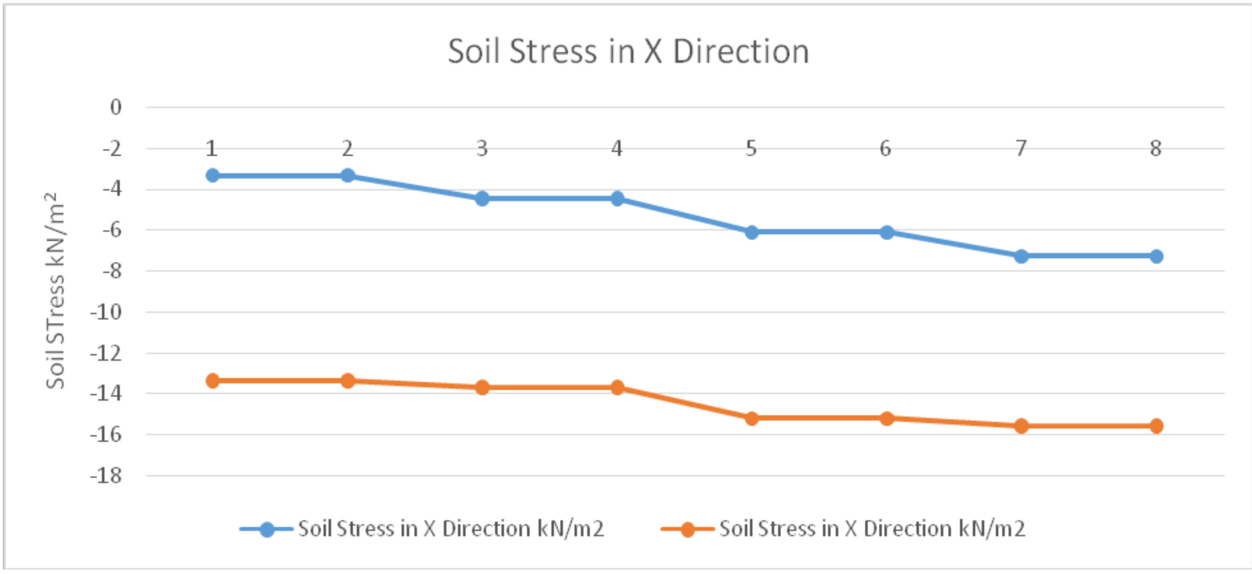

Fig 3: Soil Stress in X Direction.

A) Shear Force:

Table 2: Shear Force.

Shear Force KN		
	Black Cotton Soil	Loamy Soil
7th	**-18.406**	**49.721**
6th	**10.579**	**-17.017**
5th	**0.372**	**-4.211**
4th	**-1.232**	**-13.971**
3rd	**-4.153**	**-0.637**
2nd	**-0.45**	**9.005**
1st	**-0.649**	**-1.626**
0th	**-1.908**	**-0.976**

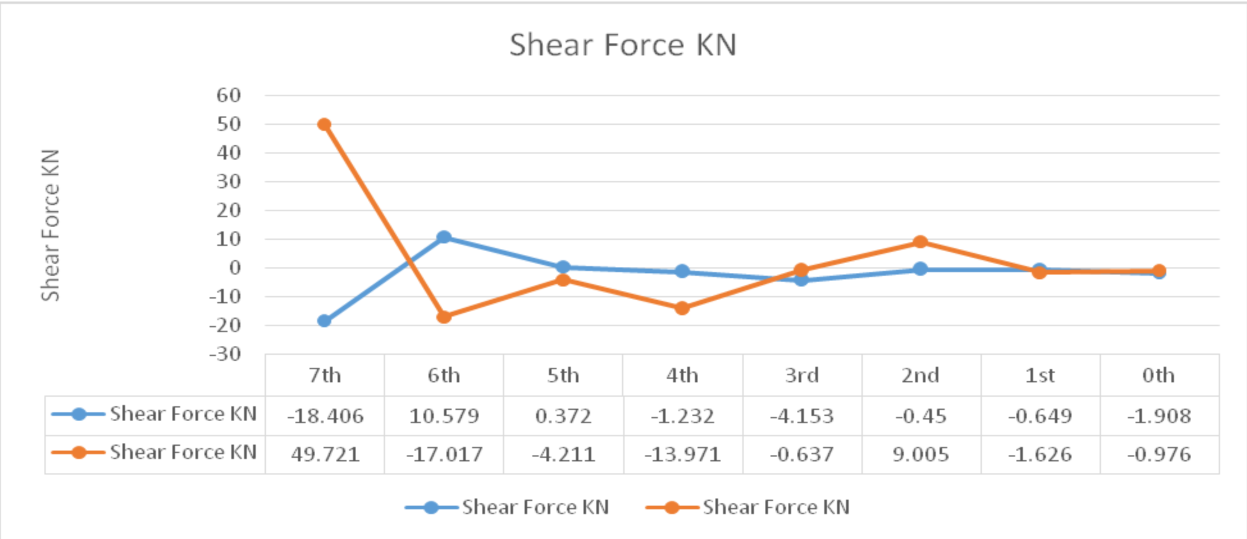

Fig 4: Shear Force in Column C1.

B) Bending Moment:

Table 3: Bending Moment kN-m.

Bending Moment KN-m		
	Black Cotton Soil	Loamy Soil
7th	**834.3382**	**1114.696**
6th	**834.3382**	**1114.696**
5th	**1273.4892**	**1372.6329**
4th	**1273.4892**	**1372.6329**
3rd	**1193.0957**	**1086.2582**
2nd	**1193.0957**	**1086.2582**
1st	**149.4738**	**-41.2863**
0th	**0.03709**	**0.07276**

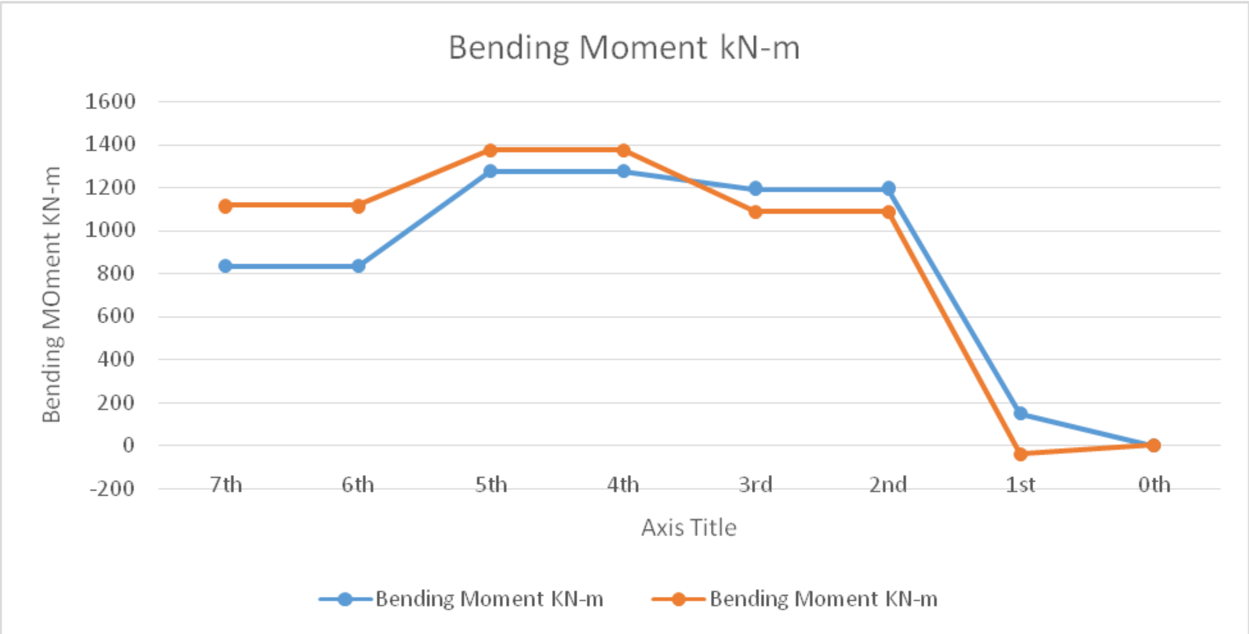

Fig 5: Bending moment in Column C1.

IX. Conclusion

This study explores the SSI effect on the overall risk of a mid rise building structure with respect to two failure modes: strength in terms of plate and joint forces, moment, Displacement and Support reaction at the base of the structure

1. It is observed in the above analysis that loamy soil is 18.50 % more stable in resisting forces.
2. It is observed that effect of lateral forces is more in black cotton soil as compared to loamy soil.
3. It is observed that soil mass is meshed finitely in SAP2000 which provide accurate and linear results.
4. It can be concluded that there is variation in both the cases i.e. structure under black cotton soil and loamy soil, as forces and moment are varying by 16% and 14 % respectively.
5. The consideration of SSI shows a complete conflicting effect on the seismic fragility and risk depending on the two different soil failure modes. This has a positive effect regarding the strength failure mode, but this brings a negative effect regarding the displacement failure mode.

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