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SOIL-STRUCTURE INTERACTION ANALYSIS OF MULTI-STOREY BUILDINGS

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ABSTRACT

The impact of soil-structure interaction on the execution of a moment resistant structure frame sitting on an isolated type footing is investigated in this work. Because soil-structure interaction has a significant impact on a structure's seismic response. Our primary goal is to research the seismic demand of structures in zone IV. Seismic analysis takes into account the fundamental normal construction for the superstructure (G+3). Medium type soil is utilised to investigate the influence of soil-structure interaction. The E.TAB programme does the analysis. The results demonstrate the difference in displacement values with and without the soil model. The displacements are fewer in the absence of dirt. Because of the increased seismic reaction, the model requires additional seismic demand in conjunction with soil condition.

Keywords - Seismic response; Seismic Demand; Soil Structure Interaction

INTRODUCTION

The initial goal of the article is to assess the structure's seismic demand. When a structure vibrates, a radiation energy discharges to the surrounding structures; unexpected vibrations may cause the structure to collapse. As a result, the interaction between adjacent buildings must be managed.

Soil structure interaction is a technique in which the response of the soil influences the movement of the structure and the movement of the structure influences the reaction of the soil (SSI). There are two types of soil-structure interaction:

(a) Inertial Soil-structure interaction
(b) Kinematic Soil-structure interaction

Inertial interaction is the study of superstructure vibration, rotation, and displacement at the foundation level of a structure caused by inertia-driven forces such as moment and base shear. These rotations and displacements are energy dissipation sources in the soil structure system. The displacement caused by ground motion caused by an earthquake is characterised as free field motion. When a foundation is entrenched in the soil, the phenomena of free field motion does not occur. The kinematic soil-structure interaction is caused by the establishment's failure to coordinate free field motion. In general, the effect of inertial interaction is significantly greater than the effect of kinematic interaction because it increases overall displacement of the structure owing to additional soil deformation and decreases the effect of kinematic interaction.

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Gorakhpur lies in seismic zone IV. Zone IV lies in the active seismic zone. It is a high causality danger zone that includes the zone responsible for MSK VIII. For zone IV, an IS Code: 1893-2002 suggested zone factor is 0.24. The Gorakhpur region is experiencing haphazard development and fast population expansion on a daily basis.

The primary goal is to produce concurrence observation for use in response spectrum analysis using SSI (Soil-Structure Interaction). As a result, we obtain a precise reaction from the input ground motion at the structure's input base. A structural model is made up of foundation elements, and the geotechnical condition is linked to the structure.

STEPS FOR MODELLING IN E.TAB 2016 SOFTWARE

Step - 1: Firstly we set the standard code such as IS 456: 2000, IS 1893: 2002 and other codes.

Step - 2: We launch ETABS and then pick a new model; as a result, a window appears in which we enter the grid dimension and storey dimension of the building.

Step - 3: We define the property in this stage. We pick the define menu material properties and then define the material's property. According to the specifications, we incorporate new material for our essential structural components such as a beam, column, and slab. Following that, we choose the frame section and describe it, as well as add the essential sections for a beam, column, and slab.

Step - 4: We assign the property and draw the structural components using the command menu in this stage. We construct lines for beams and produce columns in the provided location where the property is assigned to beams and columns.

Step - 5: In this step, we assign the supports. Firstly we select all columns and base of the structure and then we fixed the support by assigning menu for joint or frame.

Step - 6: In this step, we defined the all load consideration in ETABS and then we assign the load. In ETABS loads are defined in the defined menu by using static load cases command.

Step - 7: In this step, we assign the dead load. In ETABS dead load is assigned automatically such as dead load for the external and internal wall.

Step - 8: In this step, we assign the live load. Live loads are assigned to an overall structure as well as floor finishing.

Step - 9: We assign the wind load in this stage. Wind load is calculated using IS 875 1987 PART 3 by giving a wind angle and a wind speed. We construct a G+3 building with a height of less than 12 m for analysis purposes, thus we don't need to include wind load.

Step - 10: In this step, we assign the seismic loads. According to IS 1893:2002 we define and assign the seismic load by providing response reduction factor in both X and Y direction.

Step - 11: In this step, we assign the combination of the load. We use load combinations command in define menu for assigning the load combination.

Step - 12: In this step, we perform analysis and check for errors after completion of all the above step.

Step - 13: In this step, we design the structure according to IS 456:2000 after completion of analysis. From ETABS we design each structural element.

INPUT DESIGN DATA FOR BUILDING

(A) **Geometric Properties**

- Medium soft soil layer = 8 m
- Thickness of slab = 140 mm
- Column size = 300 mm × 300 mm
- Beam size = 250mm × 400 mm

(B) **Material Properties**

i. For medium soft soil layer
  - Density = 18 kN/m^3
  - Elastic modulus = 3500 kN/m^2
  - Poisson's ratio = 0.4

ii. For RCC building
  - Elastic Modulus (E_C) = $5000\sqrt{F_{ck}} = 5000\sqrt{20} = 22360 kN/m^2$
  - Poisson's ratio = 0.2
  - Density = 24 kN/m^3
  - ➢ Assign earthquake load according to IS 1893 (Part- 1): 2002
  - ➢ Soil type : Medium soil or Type II soil according to soil classification and IS 1893 (Part- 1): 2002
  - ➢ Height of storey = 3 m
  - ➢ Foundation depth below soil = 1.0535 m
  - ➢ Building type : Residential

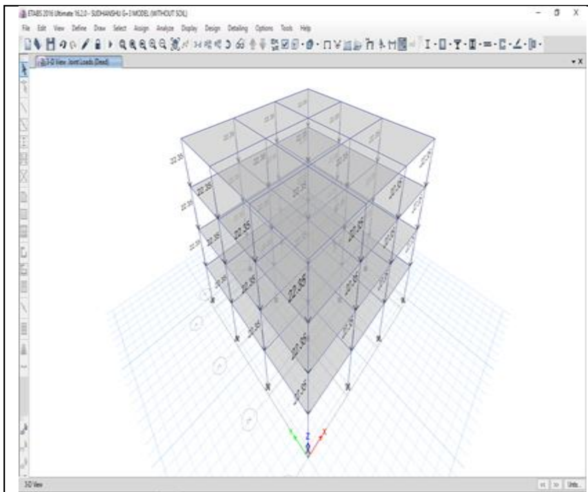

Figure 1(a): Load acting on joint without soil

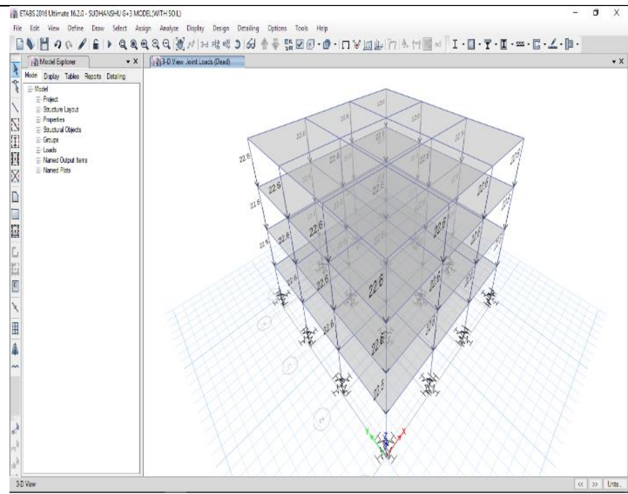

Figure 1(b): Load acting on joint with soil

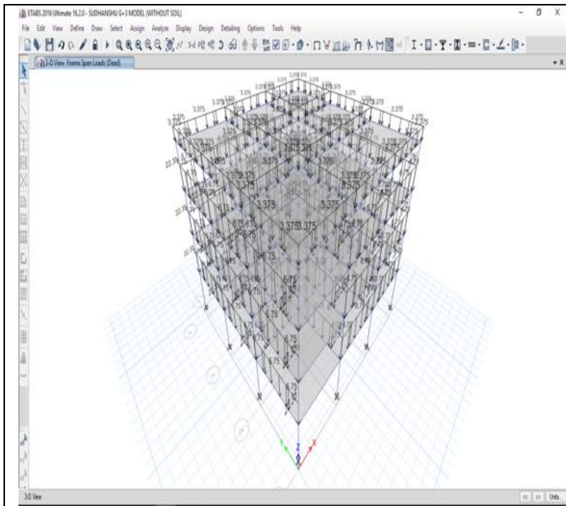

Figure 2(a): Load acting on frame without soil

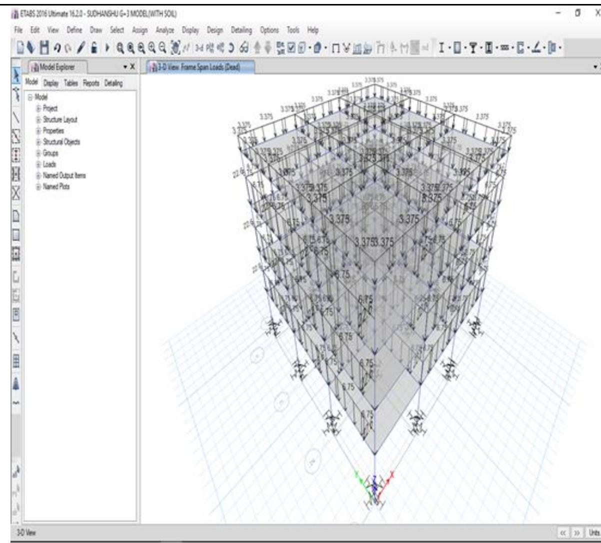

Figure 2(b): Load acting on frame with soil

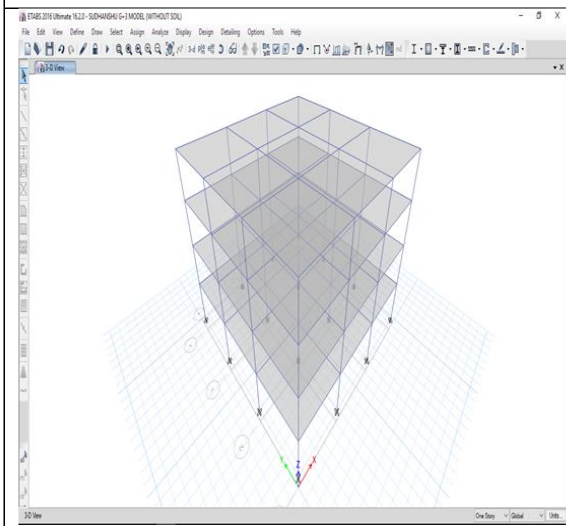

Figure 3(a): Actual model of building without soil in 3D

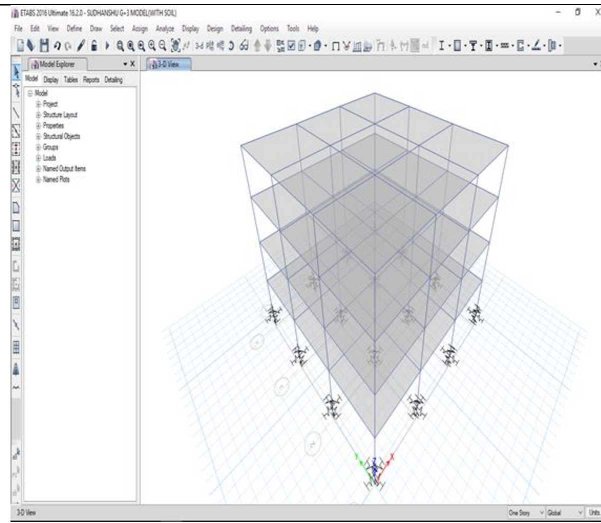

Figure 3(b): Actual model of building with soil in 3D

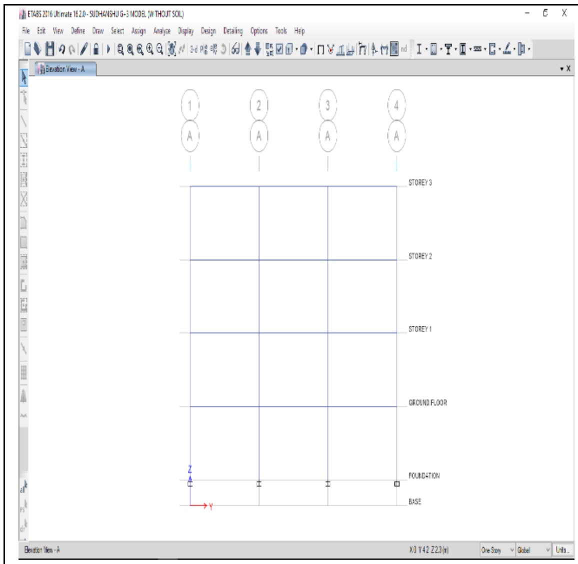

Figure 4(a): Actual elevation of building without soil

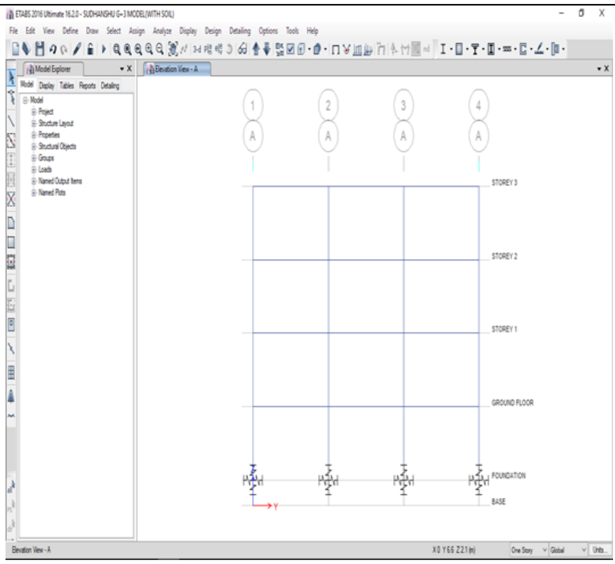

Figure 4(b): Actual elevation of building with soil

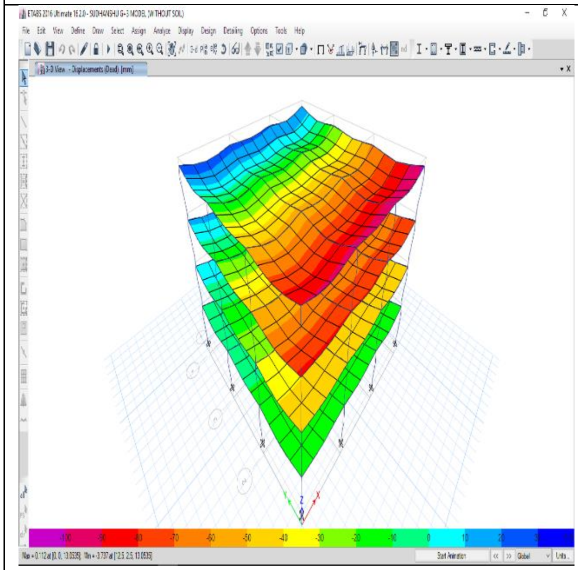

Figure 5(a): Model of Building after deformation in 3D without soil

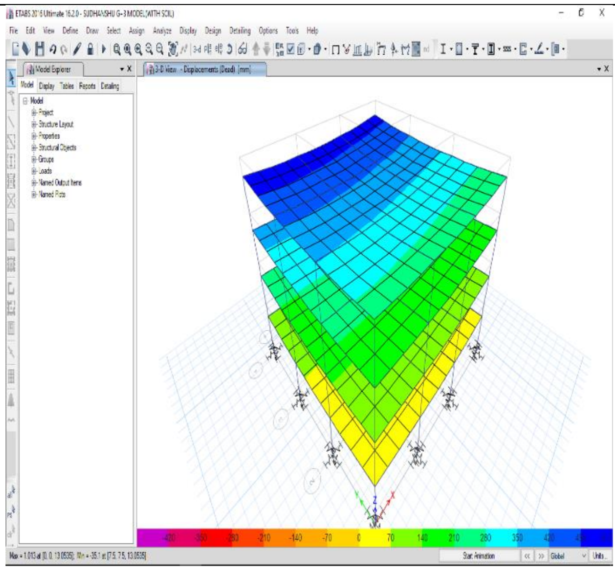

Figure 5(b): Model of Building after deformation in 3D with soil

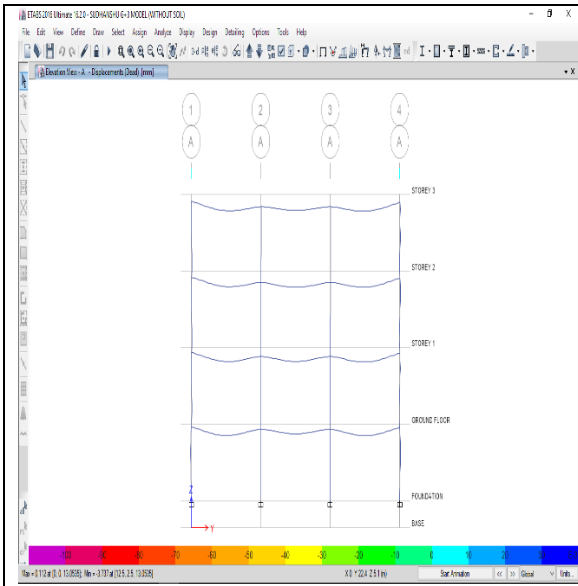

Figure 6(a): Deformation in elevation without soil

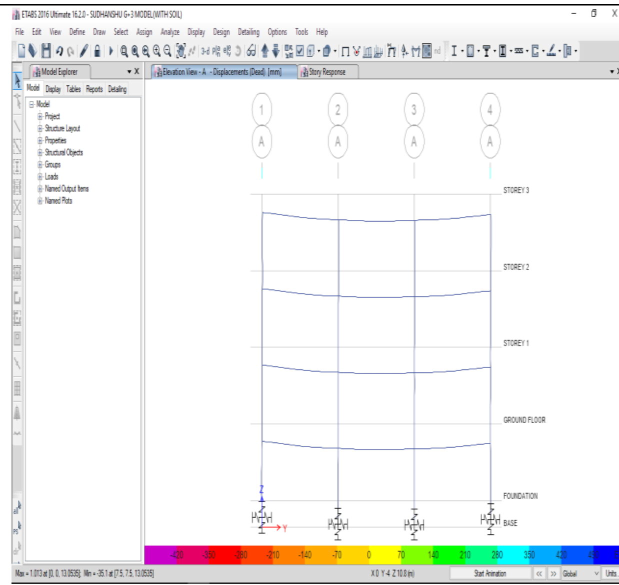

Figure 6(b): Deformation in elevation with soil

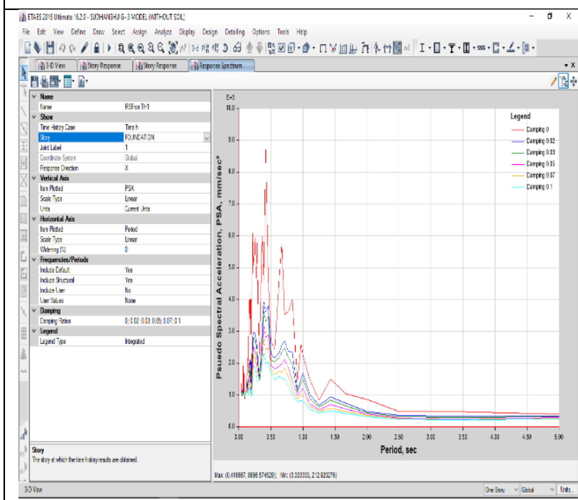

Figure 7(a): Graph between PSA and period of storey 3 without soil

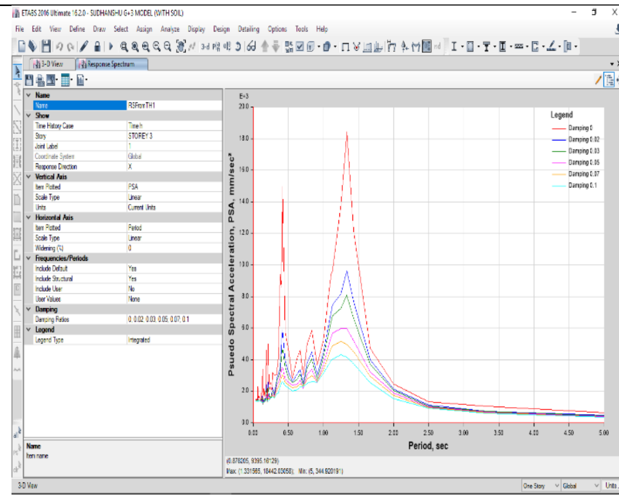

Figure 7(b): Graph between PSA and period of storey 3 with soil

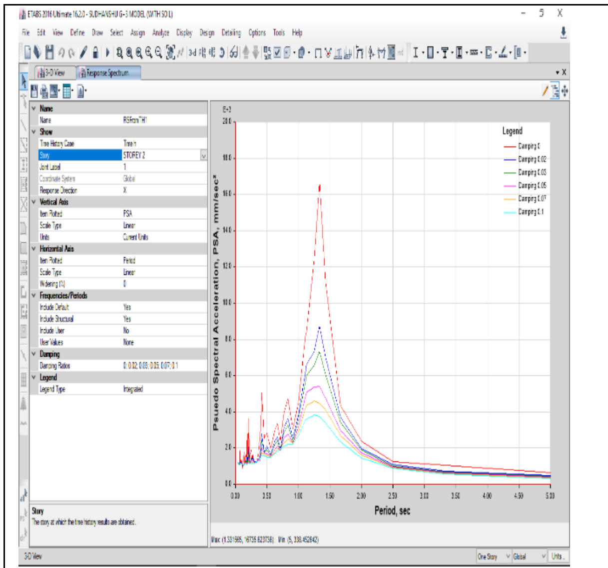

Figure 8(a): Graph between PSA and period of storey 2 without soil

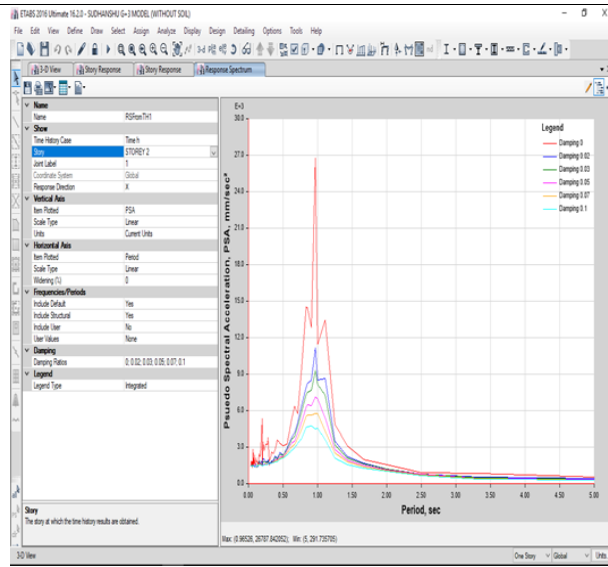

Figure 8(b): Graph between PSA and period of storey 2 with soil

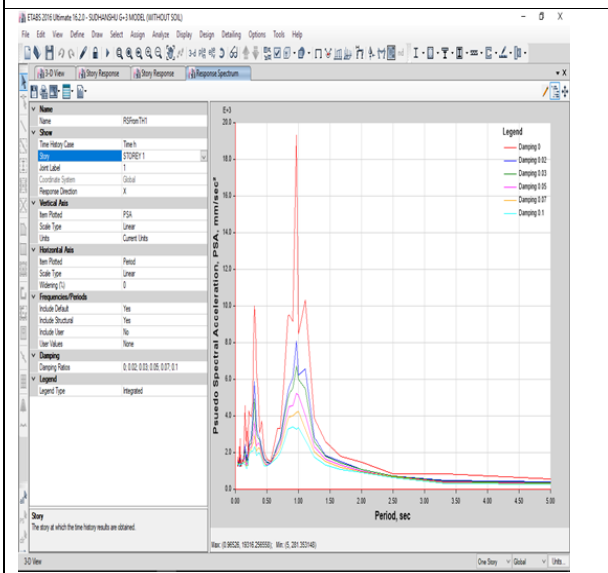

Figure 9(a): Graph between PSA and period of storey 1 without soil

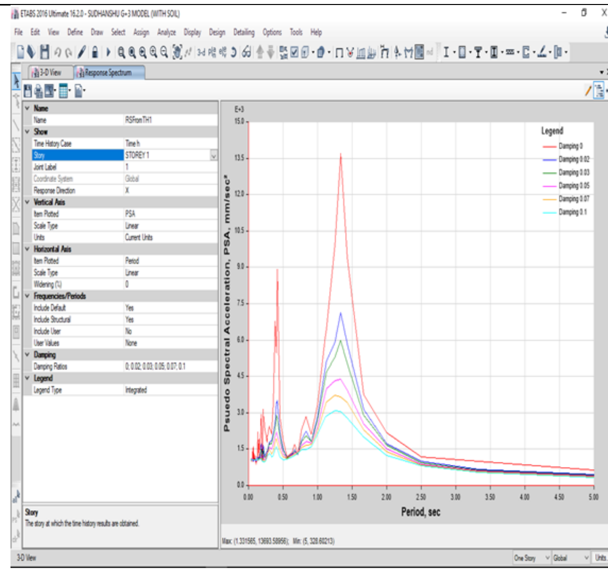

Figure 9(b): Graph between PSA and period of storey 1 with soil

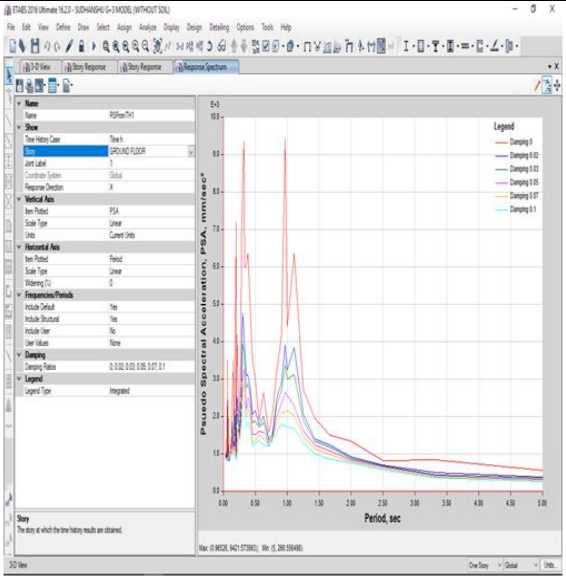

Figure 10(a): Graph between PSA and period of ground floor without soil

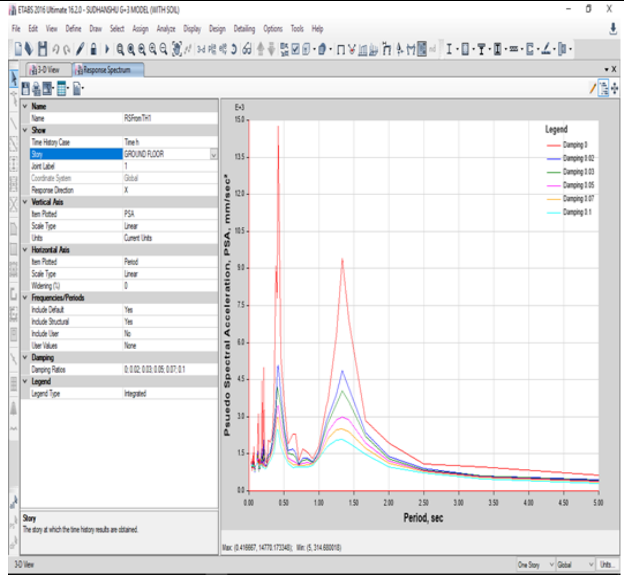

Figure 10(b): Graph between PSA and period of ground floor with soil

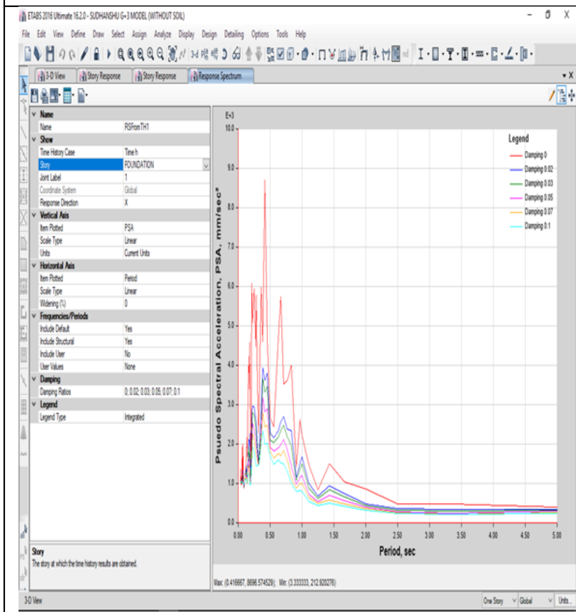

Figure 11(a): Graph between PSA and period of foundation without soil

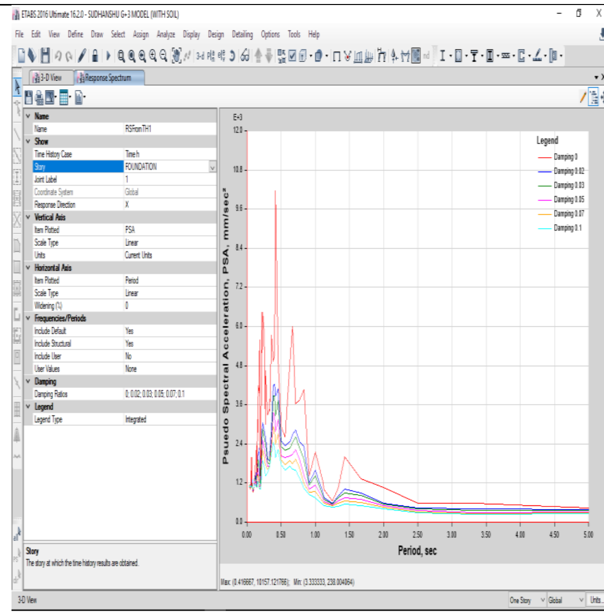

Figure 11(b): Graph between PSA and period of foundation with soil

RESULT AND DISCUSSION

Comparison of result between maximum displacement in building without considering soil condition and maximum displacement building with considering soil condition.

Table 1: Comparison of results

Storey	Maximum Displacement without soil in mm	Maximum Displacement with soil in mm
3	39	52
2	33	50
1	26	41
Ground Floor	12.5	29

Discussions from above-stated results are below:

The displacement in each storey of the building is different in with soil and without soil conditions. It is greater in with soil condition for each storey.

- For Ground floor, Displacement with soil condition is 2.32 times greater than displacement without soil condition.
- For storey 1, Displacement with soil condition is 1.57 times greater than displacement without soil condition.
- For storey 2, Displacement with soil condition is 1.51 times greater than displacement without soil condition.
- For storey 3, Displacement with soil condition is 1.33 times greater than displacement without soil condition.

The displacement in storey is larger when we consider soil than when we don't consider the soil due to soil structure interaction effect.

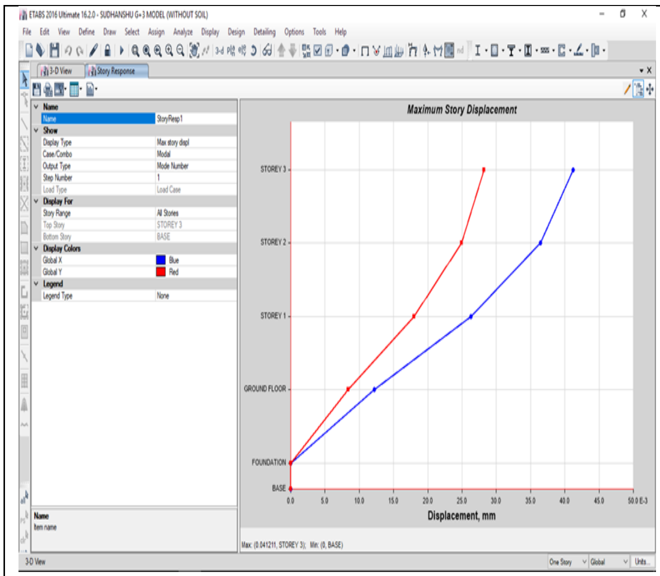

Fig 12(a): Maximum displacement in storey without soil

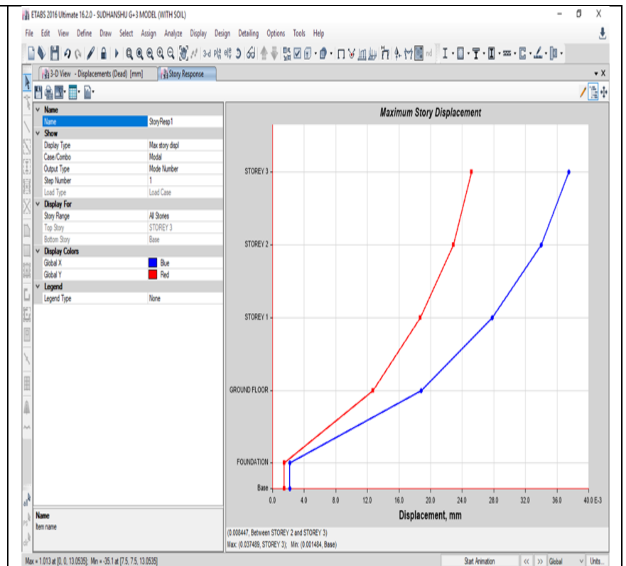

Fig 12(b): Maximum displacement in storey with soil

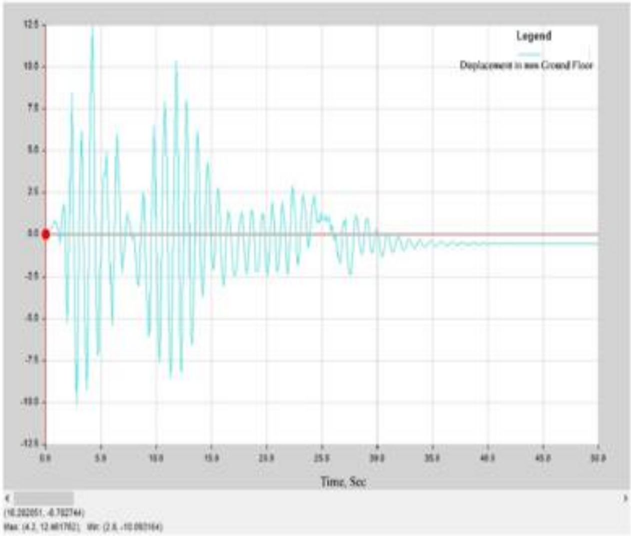

Figure 13(a): Displacement vs. Time graph of ground floor without soil condition

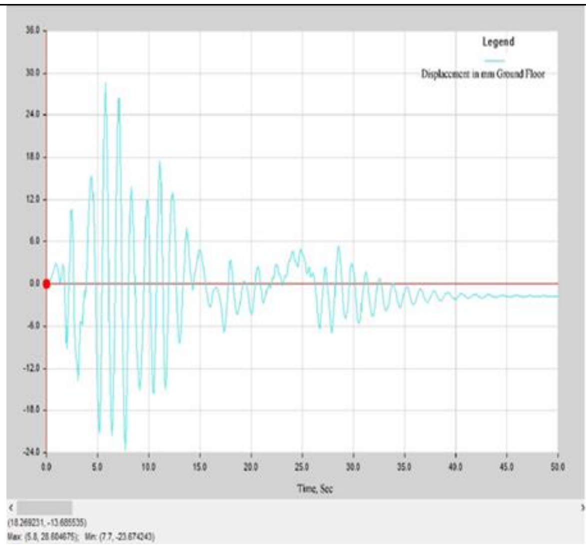

Figure 13(b): Displacement vs. Time graph of ground floor with soil condition

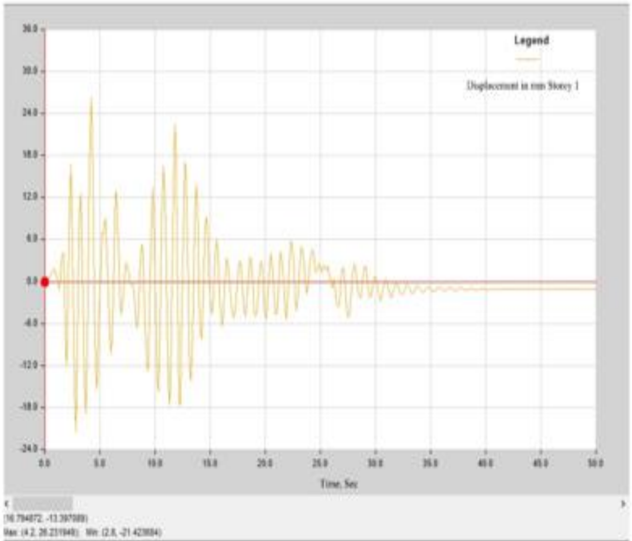

Figure 14(a): Displacement vs. Time graph of storey 1 showing without soil condition

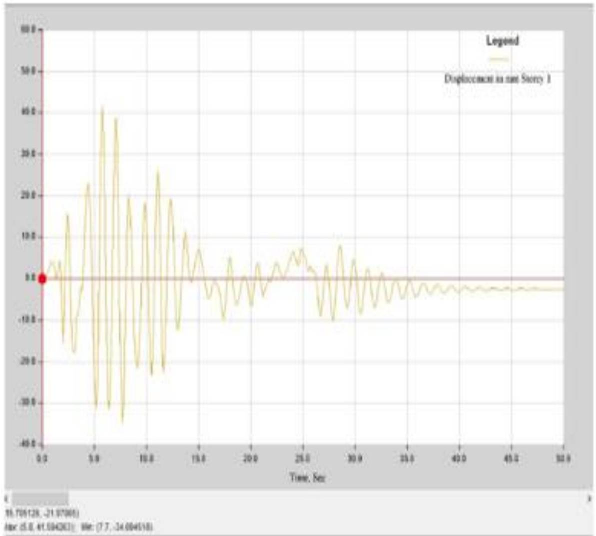

Figure 14(b): Displacement vs. Time graph of storey 1 showing with soil condition

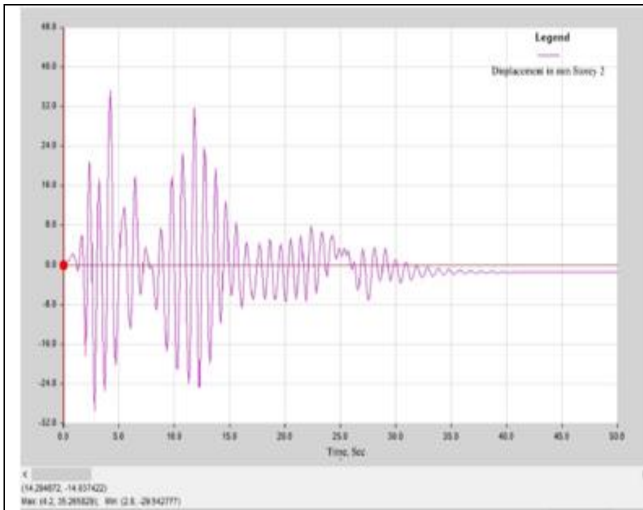

Figure 15(a): Displacement vs. Time graph of storey 2 showing without soil condition

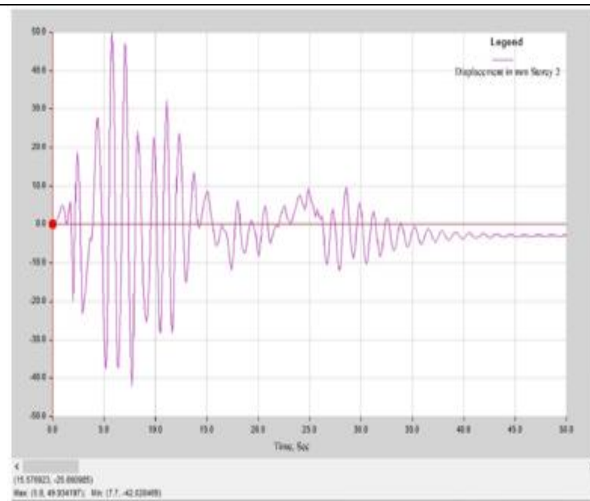

Figure 15(b): Displacement vs. Time graph of storey 2 showing with soil condition

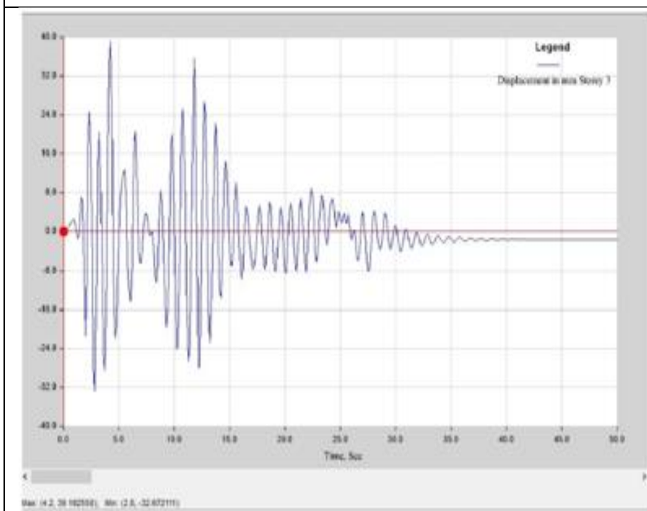

Figure 16(a): Displacement vs. Time graph of storey 3 showing without soil condition

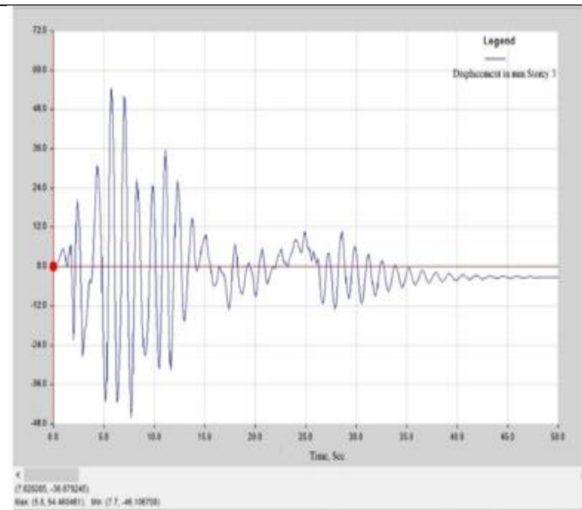

Figure 16(b): Displacement vs. Time graph of storey 3 showing with soil condition

CONCLUSION

The following conclusions have been drawn on the basis of research work:

- The structure is design based on the E-TABS, and the theory of finite element method which provide adequate strength, serviceability, and durability besides economy. Displacement variation has been shown. If any beam fails, the dimensions of beam and column should be changed and reinforcement detailing can be produced.
- Generally base of structure is assumed to be fixed to analyze the seismic response of structure when structure lies on solid rock. In every other case, (genuine circumstances) consistence of the soil may induce different effects on the response of the structure. The seismic demand of building is directly proportional to seismic response.

- Comparing the inter-storey displacements, it is observed that the values are differ much for both with soil and without soil conditions. As a result, the performance level of the without soil model is better.
- Taking overall soil behavior, it is found that structure resting on medium soil requires more seismic demand as their seismic response is more.
- Thus, as a conclusion, a design procedure including the SSI is needed in order to guarantee the structural safety of the design especially for construction projects on medium soils.

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