Comparison of Soil Structure Interaction effect on Regular and Irregular Buildings with Soil Stratum

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Abstract - *The purpose of this work is to study the behavior of regular and irregular structures subjected to static loading considering the effect of 'Soil-Structure Interaction'. In this paper, displacements and differential settlements in buildings with Ground (G), (G+2) and (G+5) floors resting on soft and hard soil layers is presented. The study reflects that, the lateral deformations depend on soil conditions beneath and can not be ignored.*

***Key Words*: ANSYS Mechanical APDL, Soil structure interaction, Regular and Irregular Structures.**

1.INTRODUCTION

Due to rapid urbanization and increase in population one has been compelled to build structures on all available types of soils. All structural loads arriving from buildings are finally transferred to the ground through the column foundations. The reaction of the earth influencing the action of the structure and the action of the structure influencing the reaction of the soil is known as Soil-Structure Interaction (SSI).Conventional structural design methods neglect the SSI effects. Neglecting SSI effect is reasonable in case of light structures resting in relatively stiff soil and simple rigid retaining walls. The effect of SSI, however becomes, prominent in case of heavy structures resting on relatively soft soils such as high rise buildings and elevated-highways on soft soil.

The contact between the building, ground and soil layer underneath the footing modify the genuine performance of the building significant. Flexibility of soil layer beneath footing reduces the rigidity of the supports. In the particular investigation, the base loads on the foundation are computed without considering soil settlement, that is, the structure is assumed to be completely flexible. The stress- strain features of soil layers area accountable for differential settlement. The forces of the structural members may change because of differential settlement. It is essential to consider building frame, base and soil as single important structural unit

1.1 Objectives

The aim is to study and compare the deformation or settlement and stresses of the regular and irregular shape buildings with different soil layers. Two soil stratums were considered with a depth of 2.5m each. Ground floor, (G+2), (G+5)regular and irregular structures is modelled using ANSYS mechanical APDL software.

1.2 Methodology

Here the study is carried out on the behaviour of G, G+2 and G+5 storied buildings with two layers of soil stratums supporting the structure, each of 2.5m with a floor to floor height of 3.0 m. Here six different building models created in Ansys Mechanical APDL software and tested. Different geometrical configurations are assigned to the models to differentiate regular from irregular. Models are analysed under statics, differential settlements, load conditions in order to study the displacement, von mises stress and stresses in X, Y and Z directions.

1.3 Software used for Analysis

ANSYS is finite element analysis software. It is the best tool for analyzing and simulating the structural behavior very efficiently and more accurately as on today. It is a useful finite element modelling software consisting of a wide range of elements and meshing options. The primary unknowns computed in the structural analysis are displacements and differential settlements. On post processing, stresses, strains, etc., are obtained. ANSYS mechanical APDL is extensively used in thermal analysis, coupled-physics capacity relating acoustics, piezoelectric, thermal-structural as well as thermo-electric examination.

2. BUILDING DESCRIPTION

A framed building with four bays is considered for the study. The material properties and dimension of the members are as listed below.

Table -1: Description of RC framed structure

Description	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
No. of stories	Ground floor	Ground floor	(G+2)	(G+2)	(G+5)	(G+5)
Total height	3m	3m	9m	9m	18m	18m
Overall Dimension of the structure	10.9m x 12.7m	10.9 m x 12.7 m	10.9 m x 12.7 m	10.9 m x 12.7 m	10.9 m x 12.7 m	10.9 m x 12.7 m

Table- 2: Material Properties of Concrete and Steel

Property	**Value**
Grade of steel (N/mm^2)	Fe 415
Grade of concrete for all structural members (N/mm^2)	M-25
Modulus of elasticity of concrete (kN/m^2)	25x10^6
Poisson's ratio for concrete	0.15
Concrete density	25 kN/m^3

Table- 3: Material Properties of soil

Soil Type	**Modulus of elasticity (kN/m^2)**	**Poisson's ratio**
Hard Soil	65x10^3	0.3
Soft Soil	15x10^3	0.4

Table-5: Details of Dead Load and Live Load

Load	**Value**
Live Load	3 KN/m^2
Floor Finish Load	1 KN/m^2

Dead loads are considered as per IS 875 (Part 1)-1987 and live load IS 875 (Part II)-1987

Table-4: Geometric Parameters

Parameter	**Value**
Slab thickness	0.15m
Beam size	0.23m x 0.45m
Column size	0.23m x 0.45m
Height of each storey	3m
Depth of soil layer	2.5m
No. of bays in X direction	2
Spacing of bay in X direction	4m
No. of bays in Z direction	2
Spacing of bay in Z direction	5m
Footing size	2.9m x2.7m x0.7m

Table -6: Details of Study models

S. No	**Model No**	**Description**
1	Model 1	Regular with ground floor
2	Model 2	Irregular with ground floor
3	Model 3	Regular with G+2 floors
4	Model 4	Irregular with G+2 floors
5	Model 5	Regular with G +5 Floors
6	Model 6	Irregular with G +5 Floors

Model 1

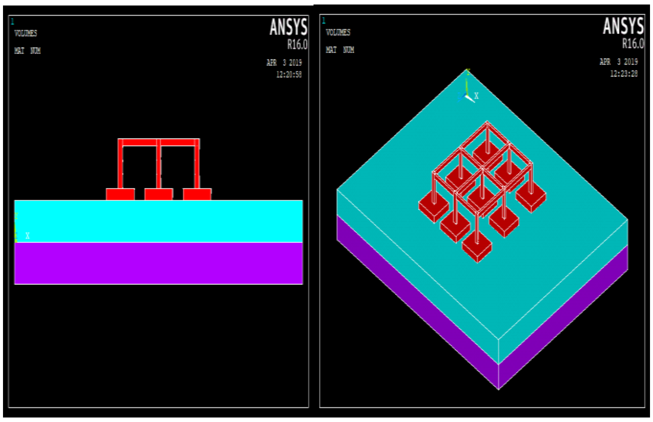

Fig.-1: Elevation and Isometric view of Model 1

Model 2

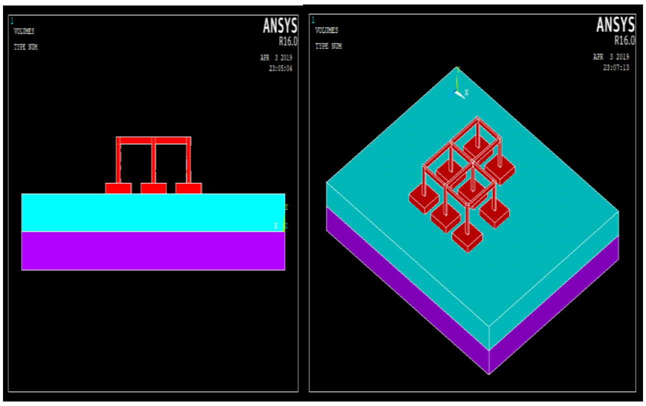

Fig.-2: Elevation and Isometric view of Model 2

Model 3

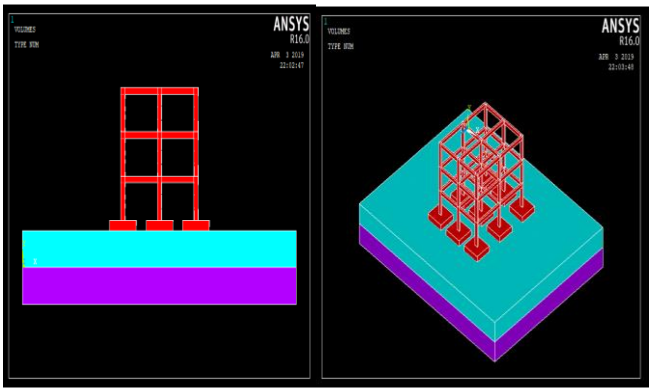

Fig.-3: Elevation and Isometric view of Model 3

Model 4

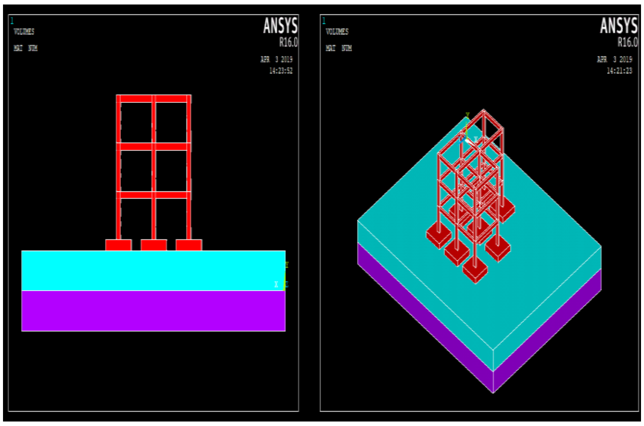

Fig.-4: Elevation and Isometric view of Model 4

Model 5

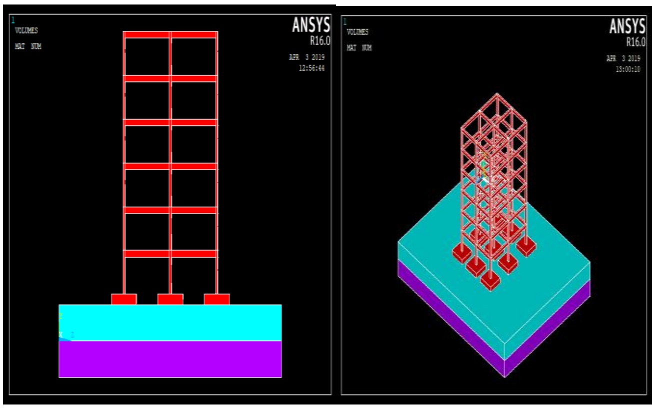

Fig.-5: Elevation and Isometric view of Model 5

Model 6

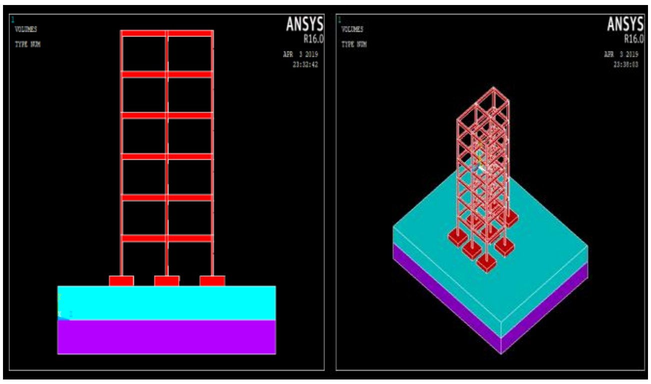

Fig.-6: Elevation and Isometric view of Model 6

3. RESULTS AND DISCUSSION

The results of the static analysis of various building models considered are explained through Figure 7 to Figure 10 and Table 7 for models 1 and model 2. For models 3 and 4 are explained through Figure 11 to 14 and Table 8.For models 5 and 6the results are explained through Figure 15 to 18 and Table 9.

Model 1

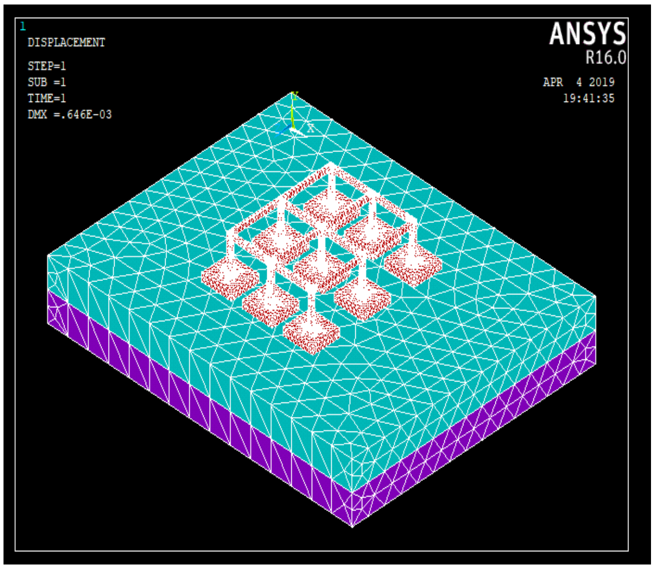

Fig -7: Meshing of model

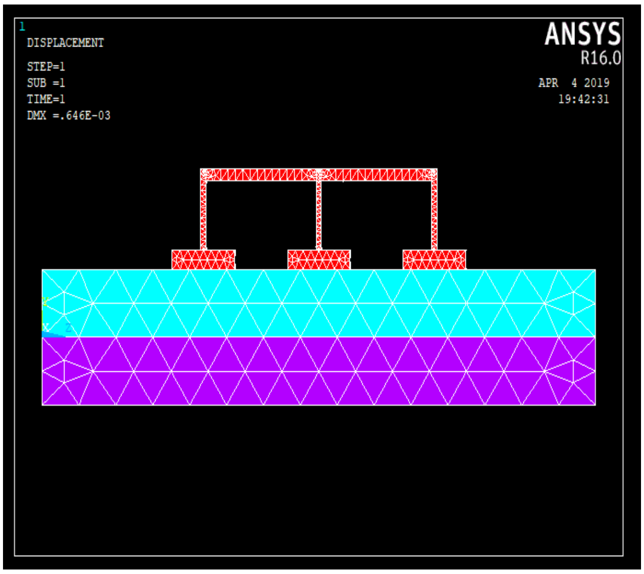

Fig - 8: Deformation in model 1

Model

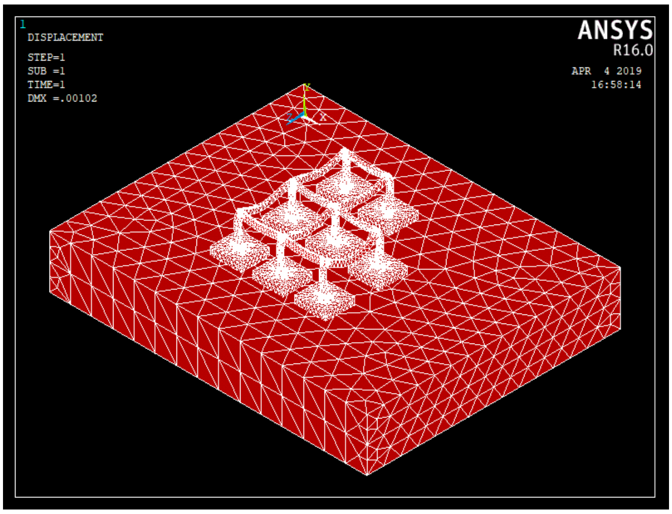

Fig -9: Meshing of model 2

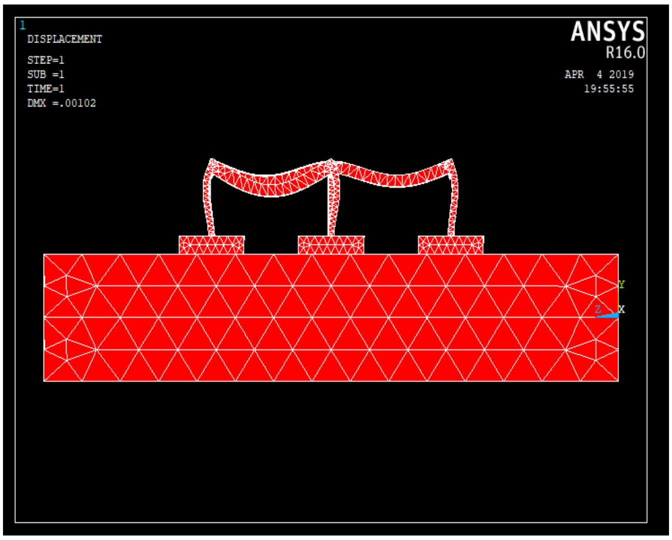

Fig-10: Deformation in model 2

Table -7: Lateral Displacements

Description	Model-1 Regular building with ground	Model -2 Irregular building with ground
Maximum lateral Displacement	0.646mm	1.02mm

Model 3

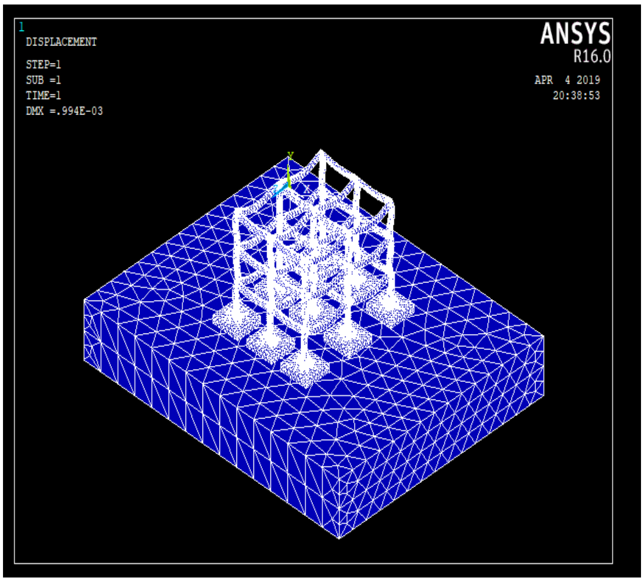

Fig- 11: Meshing of model 3

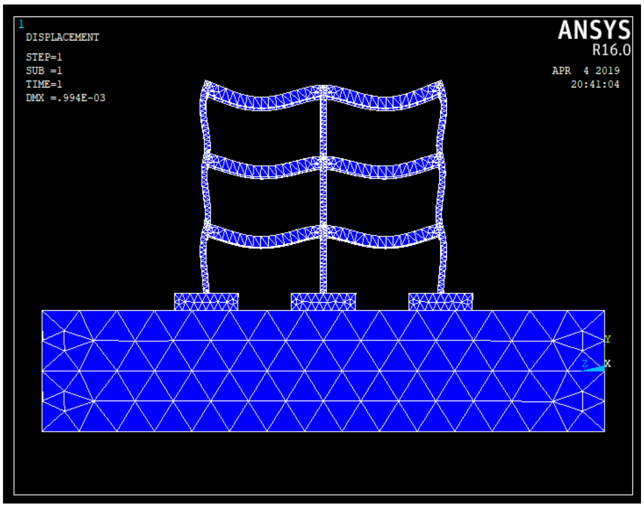

Fig-12: Deformation of model 3

Model 4

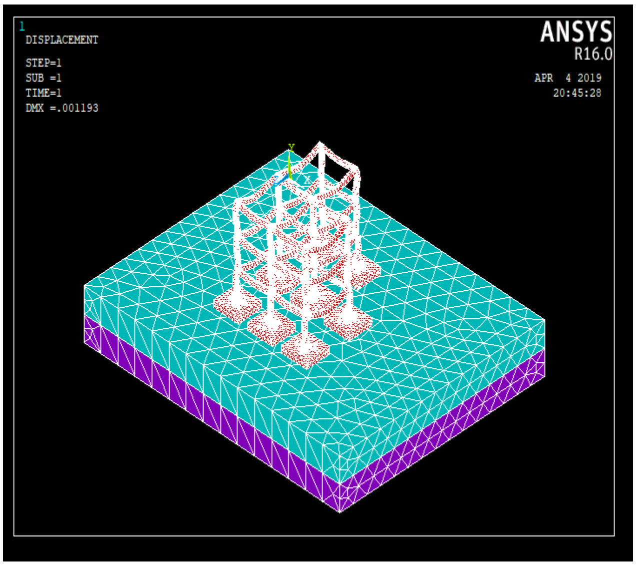

Fig -13: Meshing of model 4

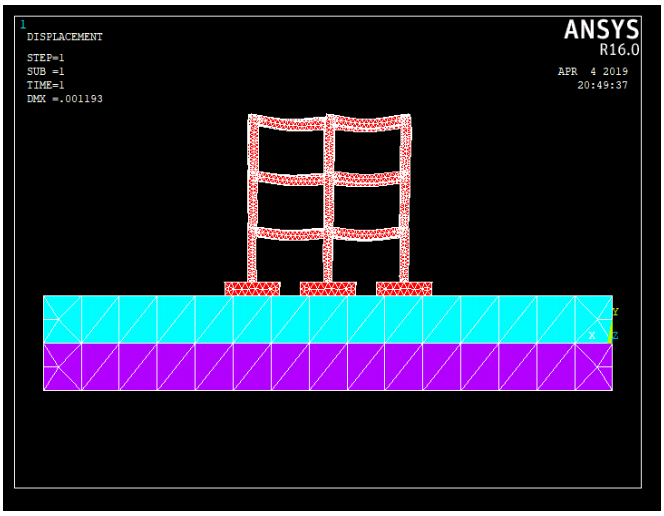

Fig- 14: Deformation of model 4

Description	**Model-3** Regular buliding with ground + 2 floors	**Model -4** Irregular building with ground + 2 floors
Maximum Displacement	0.994mm	1.193mm

Model 5

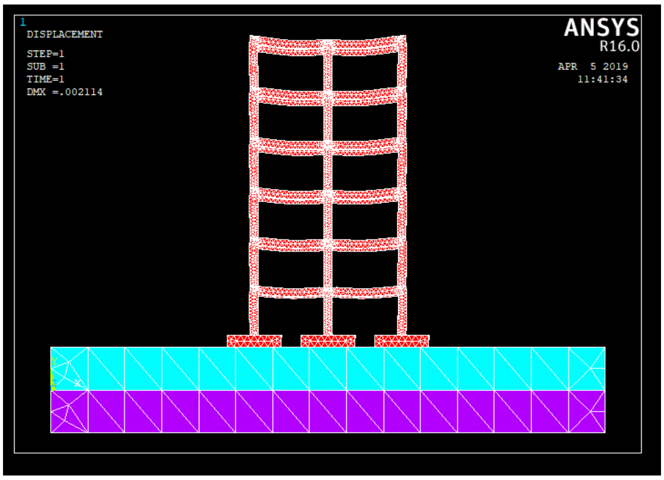

Fig.-15: Meshing of model 5

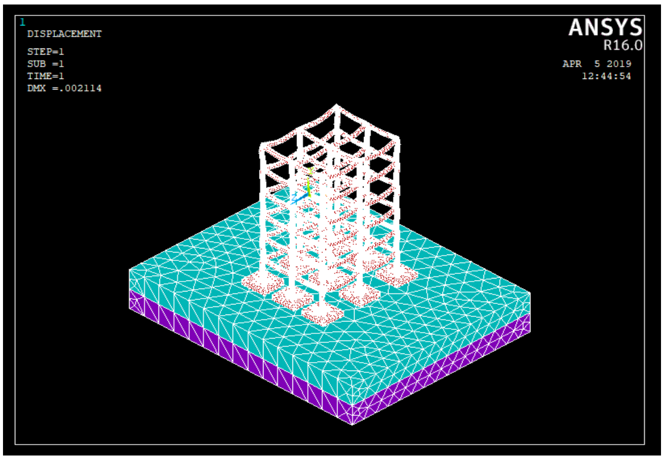

Fig.-16: Deformation of model 5

Model 6

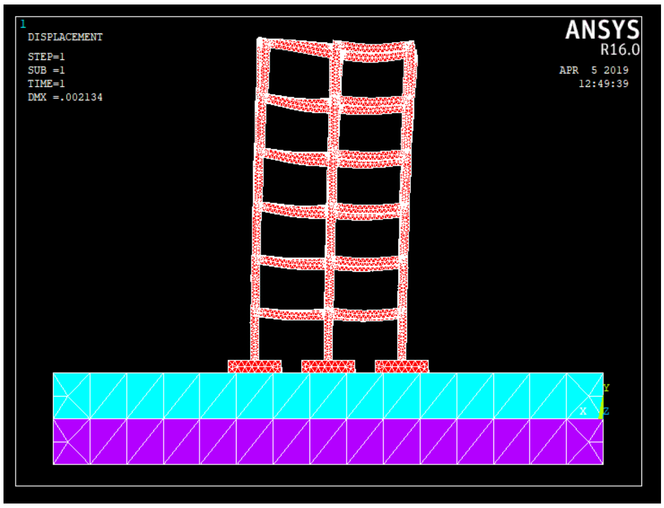

Fig.- 17: Meshing of model 6.

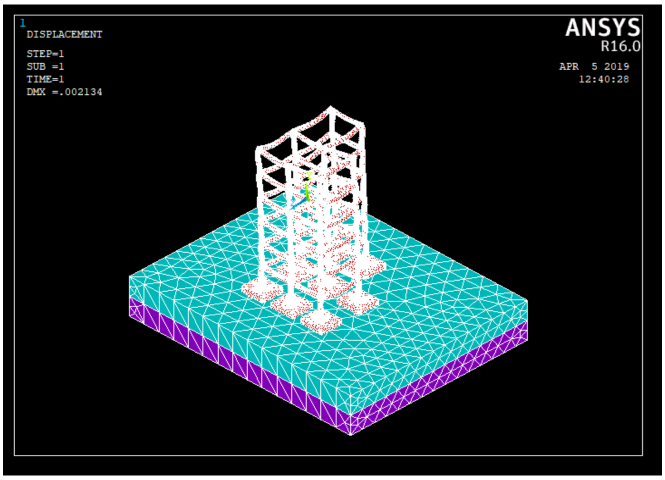

Fig.-18: Deformation of model 6

Table- 9: Lateral Displacements

Description	**Model-5** Regular building with ground + 5 Floors	**Model -6** Irregular building with ground + 5 floor
Displacement	2.14mm	2.13mm

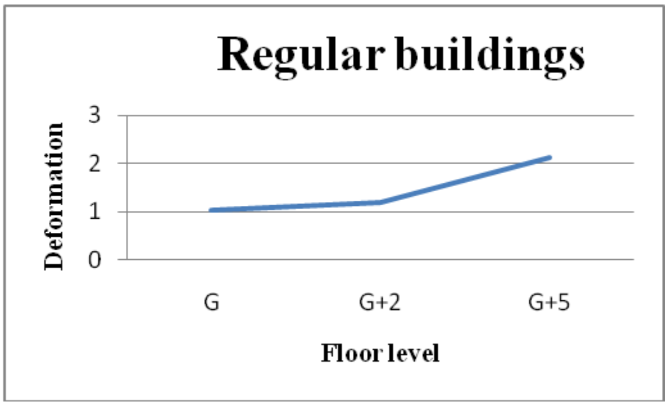

Fig.-19: Lateral deformation

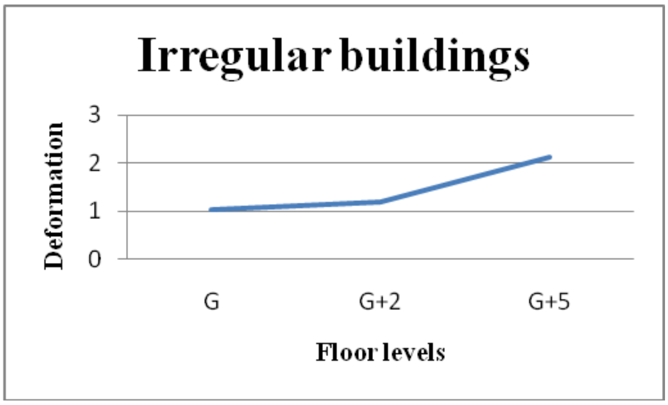

Fig.-20: Lateral deformation

4. COMPARISON OF STRESS VALUE FOR DIFFERENT MODELS

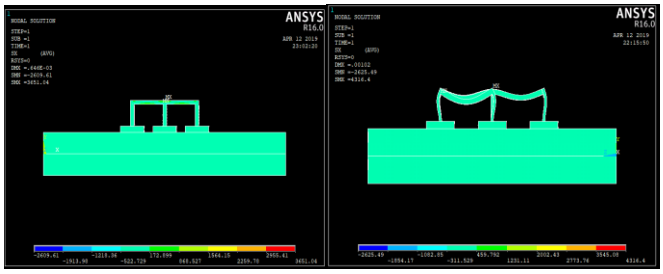

Fig. -19: Stress in X direction of Model-1 & Model 2

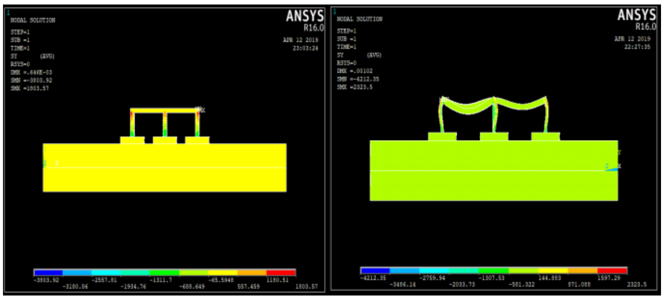

Fig.-20 : Stress in Y direction of Model-1 & Model 2

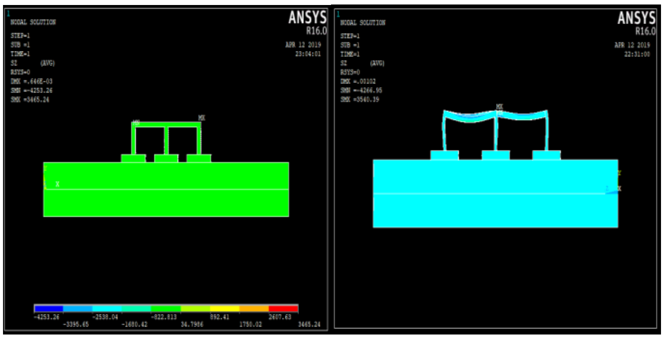

Fig.-.21: Stress in Z directionof Model-1 & Model 2

Comparison of stress in Model-1 and Model-2

Description	Model 1 Regular building	Model 2 Irregular building
Stress in X direction	3651.04 kN/m^2	4316.4 kN/m^2
Stress in Y direction	1803.57 kN/m^2	2323.5 kN/m^2
Stress in Z direction	3465.24 kN/m^2	3540.9 kN/m^2

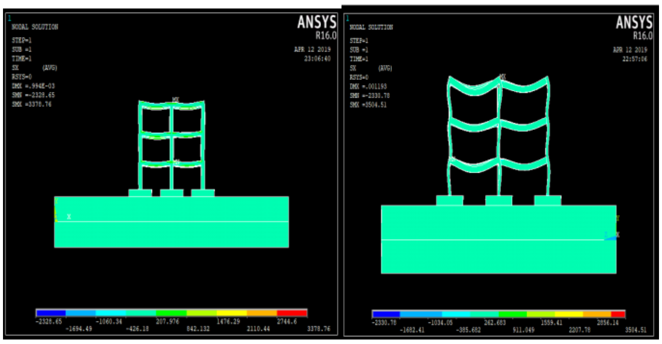

Fig.-22: Stress in X direction of Model-3 & Model 4

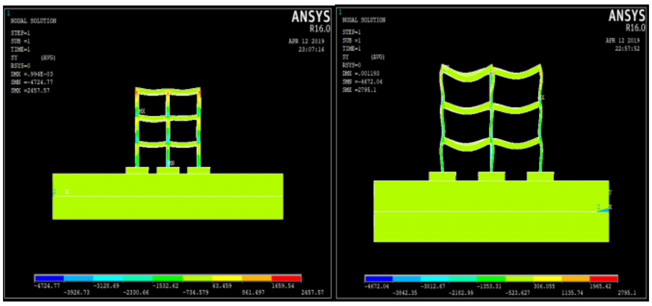

Fig.-23: Stress in Y direction of Model-3 & Model 4

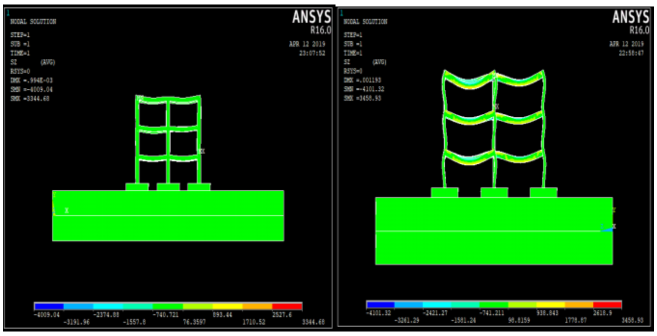

Fig.-24: Stress in Z direction of Model-3 & Model 4

Comparison of stress in Model-3 and Model-4

Description	Model 3 Regular building	Model 4 Irregular building
Stress in X direction	3378.76kN/m²	3504.51 kN/m²
Stress in Y direction	2457.57 kN/m²	2795.1kN/m²
Stress in Z direction	3348.3kN/m²	3458.93kN/m²

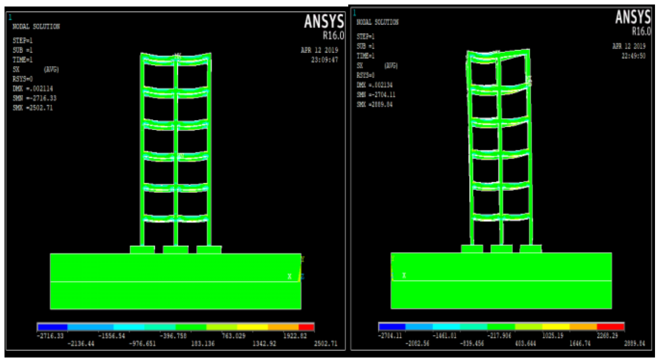

Fig.-25 : Stress in X direction of Model-5& Model 6

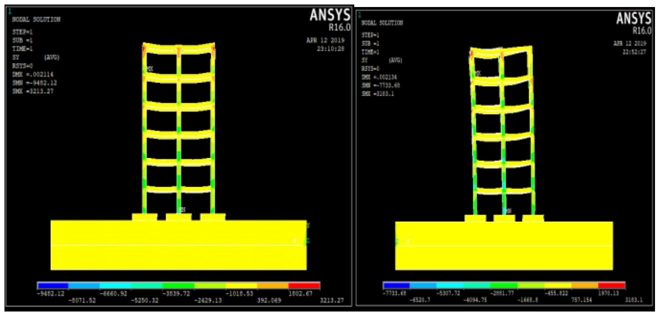

Fig.-26: Stress in Y direction of Model-5 & Model -6

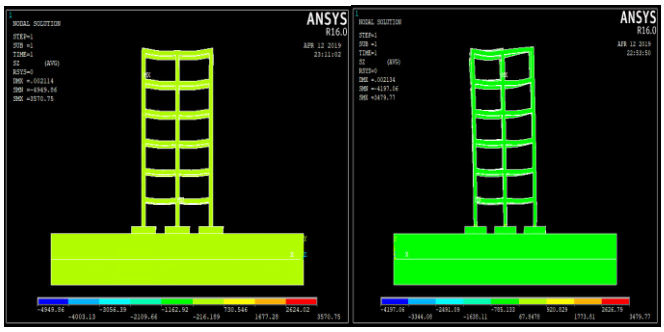

Fig.-27: Stress in Y direction of Model-5 & Model-6

Description	Model 5 Regular building	Model 6 Irregular building
Stress in X direction	2507.1 kN/m²	2889.54 kN/m²
Stress in Y direction	3213.7 kN/m²	3183.1 kN/m²
Stress in Z direction	3570.75N/m²	3479.77kN/m²

4. CONCLUSIONS

From the present study it is observed that, the soil structure interaction effect depends on soil type.

The lateral deformations in buildings depend on soil-structure interaction.

For single storey buildings the effect is objectionable for regular or for irregular building while, it is reasonably small in multi-storeyed buildings.

Though it is contradictory to what is generally thought, the study insists to consider soil beneath while modelling in any software.

Stress values obtained from the analysis is more for irregular buildings when compared to regular buildings

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