COMPARATIVE STUDY ON SEISMIC ANALYSIS OF SOIL STRUCTURE INTERACTION WITH VARIOUS SOIL PROPERTIES BY VARYING FLOOR LEVELS

Bhavani Shankar [1], Dheekshith K [2]

[1]*Assistant Professor, Department of Civil Engineering, Srinivas School of Engineering, Mangaluru*

[2]*M.Tech Student, Department of Civil Engineering, Srinivas School of Engineering, Mangaluru*

---***---

Abstract- *In the current circumstances, an attempt is made to investigate the soil structure interaction when the erection is built on numerous under lying soil types. The structure, foundation and soils are modeled using 20 node solid 95 element in ANSYS software. The type of footing used in the study is isolated footing. Building is investigated under subsequent dissimilar situations. (a) Single storey on three soil layers having gravel well graded soil at the topmost, then gravel silty at intermediate and sand silty at the bottommost, (b) single storey on three soil layers having Gravel poor graded soil at the uppermost then sand poor at the intermediate and sand silty at the bottommost, (c) (G+5) storey on three soil layers having Gravel well graded soil at the top, then Gravel silty at middle and sand silty at the bottom, (d) (G+5) storey on three soil layers having Gravel poor graded soil at top then sand poor graded at middle and sand silty at the bottom, (e) (G+3) storey on three layers of soil with Gravel well graded at the upper, gravel clay at the central and sand silty at the bottom, (f) (G+3) storey on three layers of soil having Gravel poor graded soil at the top, gravel clay at the middle and sand silty at the bottom. In this study, static nonlinear modal analysis is done under earthquake loading. The displacement or settlements in soil, Von Mises Stress developed is studied and compared.*

***Key Words*: ANSYS CIVIL FEM, FINITE ELEMENT ANALYSIS, MULTI-STOREY BUILDING, SOIL-STRUCTURE INTERACTION.**

1. INTRODUCTION

In the construction of any structure it is very necessary to identify the interaction of soil with the structure, since some components of the building will be in contact with soil. During the earthquake the soil will behave like a plastic material and will undergo irreversible changes leading to the settlement of the structures. So in order to decide the type of foundation to be constructed for a particular structure it is very necessary to study the behavior of soil. Hence in this project an attempt is made to study how earthquake will affect the stress and displacement of structure built in different types of layered soil. During the earthquake, there will be displacement of structure which will cause settlement of soil and movement of soil particles will add to the deformation of structure. This kind of process is known as soil structure interaction. If the soil is hard, then shallow footings are preferable and if the soil is loose then we have to with deep foundations. Earthquake ground motion will cause the soil to displace freely but the foundation within the soil cannot match with the motion of soil, this will cause kinematic interaction of structures. This kinematic interaction of structure is because of two reasons: (1) Foundation placed on the soil is very stiff which will reduce the foundation motion when compared with free field motion. (2) Fictitious forces developed in the structure will develop shear and moment in the foundation reducing its free motion. Hence if we study the soil behavior and build or retrofit the structure accordingly, it is possible to reduce the damage to structure during earthquake.

2. BUILDING DESCRIPTION

Type of the structure	Multi-storied RC framed structure
Number of stories	
Model-1 and Model-2: Ground Floor	
Number of stories	Ground floor
Total height of building	3.5m
Dimension of building	10m x 8m
Model-3 and Model-4: (G+5)	
Number of stories	(G+5)
Total height of building	21m
Dimension of building	10m x 8m
Model-5 and Model-6: (G+3)	
Number of stories	(G+3)
Total height of building	14m
Dimension of building	10m x 8m
Dimension of members:	
Column	0.45m x 0.23m
Beam	0.23m x 0.45m
Thickness of slab	0.150m
Material property:	
Grade of concrete	25 M Pa
Grade of steel	Fe 415
Density of concrete	25 k N/m³
Salient observations of IS 1893 (Part 1):2002	
Seismic zone	Zone II
Soil type	Type II (Medium soil)
Spectrum type of analysis	Design basis earthquake
Importance factor (I)	1.0 [IS:1893-2002] part-II Table-6 ,cl., 6.4.2, pp.18
Response Reduction Factor (R)	3.0 (OMRF) [IS:1893-2002] part-II Table-7
Damping factor	5%

Model-1: The building is an RC framed erection with two bays having 10m along X direction, 3.5m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

Model-2: The building is an RC framed erection with two bays having 10m along X direction, 3.5m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

Model-3: The building is an RC framed erection with two bays having 10m along X direction, 21m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

Model-4: The building is an RC framed erection with two bays having 10m along X direction, 21m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

Model-5: The building is an RC framed erection with two bays having 10m along X direction, 14m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

Model-6: The building is an RC framed structure with two bays having 10m along X direction, 14m along Y direction and 8m along Z direction with three soil layers at bottom having 3m depth each with various soil layers.

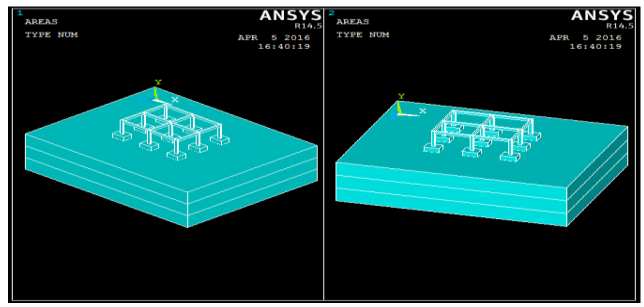


Figure1: Isometric view And Oblique view of Model-1 and Model-2

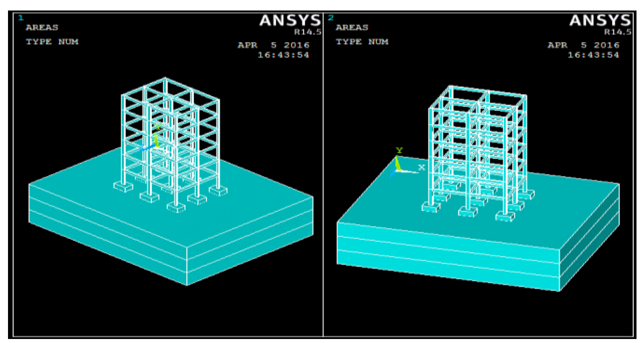


Figure2: Isometric view And Oblique view of Model-3 and Model-4

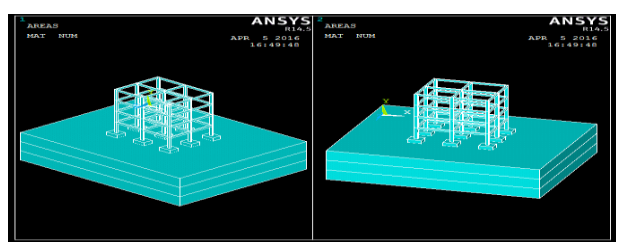


Figure3: Isometric view And Oblique view of Model-5 and Model-6

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 10 | Oct -2016 www.irjet.net p-ISSN: 2395-0072

3. RESULTS AND DISCUSSIONS

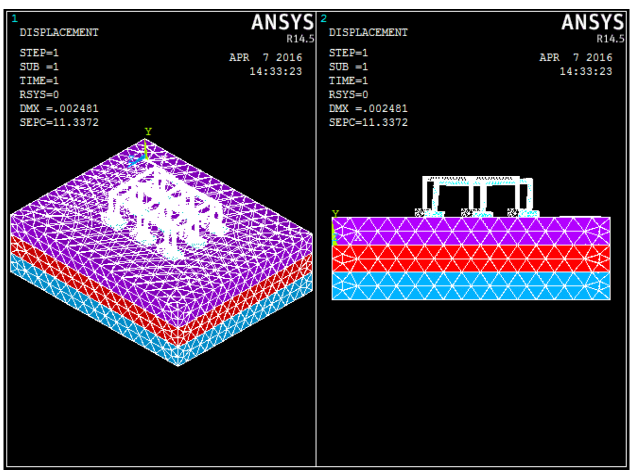
The analysis carried obtainable remain equivalent static analysis and static nonlinear analysis, results are obtained for Ground, (G+3), (G+5), for various soil layers at bottom of 3m depth each and building with two bays in X direction with isolated footing, beams and columns.

3.1 Comparison of displacement values for different models and various soil layers

SOIL LAYERS USED IN MODEL-1	
First layer	Gravel Well Grad (GW)
Second layer	Gravel Silty (GM)
Third layer	Sand Well Grad (SW)
Displacement Obtained from Analysis is 2.481 mm	

3.1.1 MODEL-1

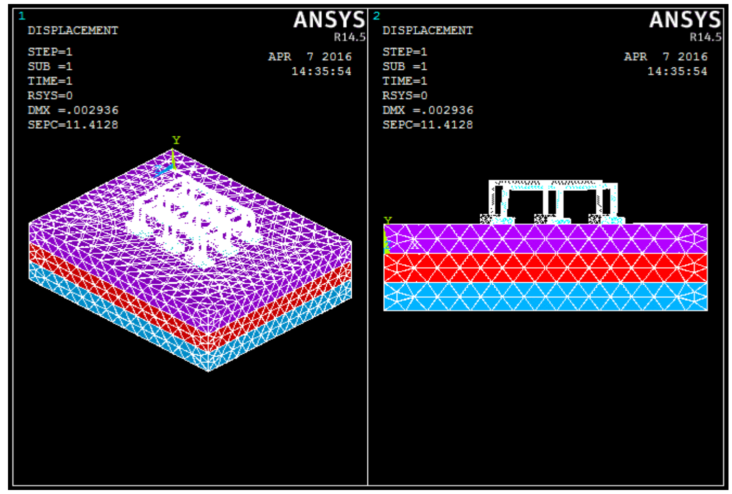
The deformed shape + undeformed shape of MODEL 1 is as shown in beneath fig.



3.1.2 MODEL-2

SOIL LAYERS USED IN MODEL-2	
First layer	Gravel Poor Grad (GP)
Second layer	Sand Poor Grad (SP)
Third layer	Sand Silty (SM)
Displacement Obtained from Analysis is 2.936 mm	

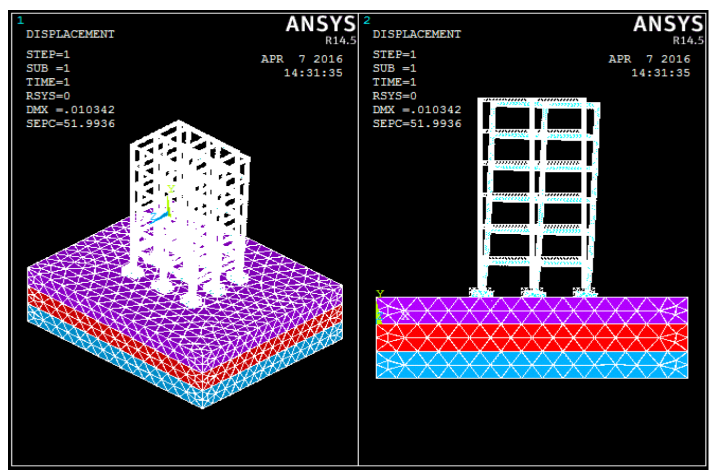
The deformed shape + undeformed shape of MODEL 2 is as shown in beneath fig.



3.1.3 MODEL-3

SOIL LAYERS USED IN MODEL-3	
First layer	Gravel Poor Grad (GW)
Second layer	Sand Silty (SM)
Third layer	Sand Well Grad (SW)
Displacement Obtained from Analysis is 10.342 mm	

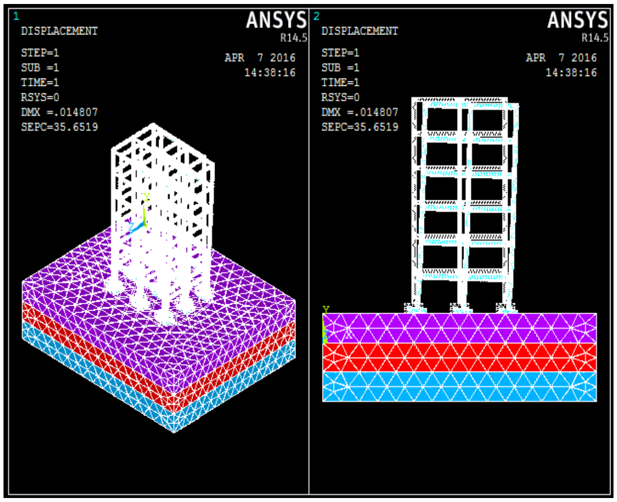
The deformed shape + undeformed shape of MODEL-3 is as shown in beneath fig.



3.1.4 MODEL-4

SOIL LAYERS USED IN MODEL-4	
First layer	Gravel Poor Grad (GP)
Second layer	Sand Poor Grad (SP)
Third layer	Sand Silty (SM)
Displacement Obtained from Analysis is 14.807 mm	

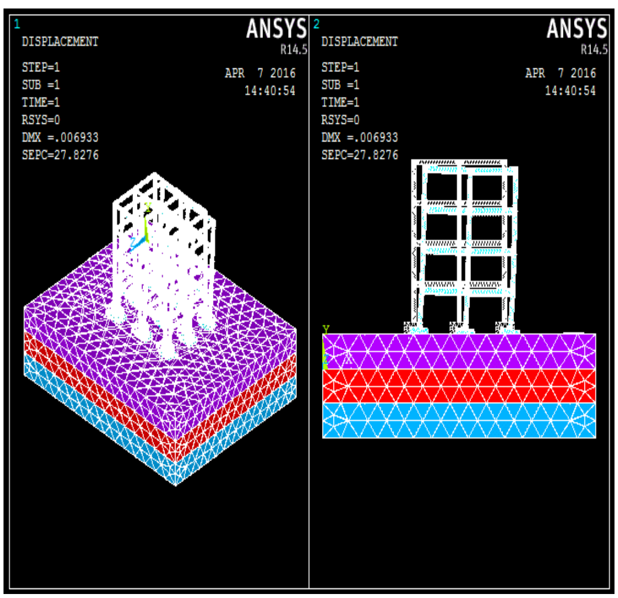
The deformed shape + undeformed shape of MODEL-4 is as shown in beneath fig.



3.1.5 MODEL-5

SOIL LAYERS USED IN MODEL-5	
First layer	Gravel Poor Grad (GW)
Second layer	Gravel Clay (GC)
Third layer	Sand Clay (SC)
Displacement Obtained from Analysis is 6.933 mm	

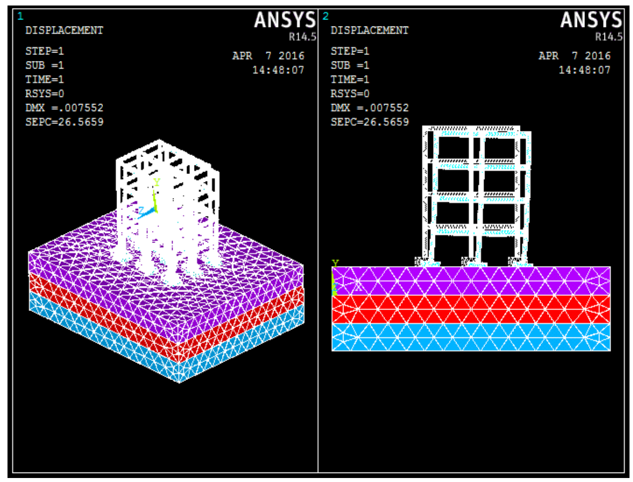
The deformed shape + undeformed shape of MODEL-5 is as shown in beneath fig.



3.1.6 MOD EL-6

SOIL LAYERS USED IN MODEL-6	
First layer	Gravel Poor Grad (GW)
Second layer	Gravel Clay (GC)
Third layer	Sand Clay (SC)
Displacement Obtained from Analysis is 7.552 mm	

The deformed shape + undeformed shape of MODEL-6 is as shown in beneath fig.

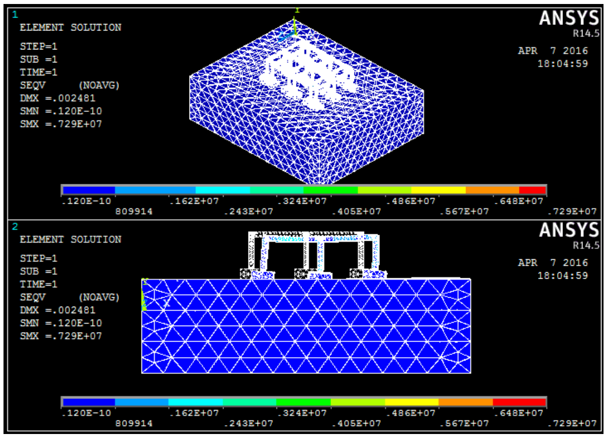


3.2 COMPARISON OF VON MISES STRESS RESULTS FOR EACH MODELS

3.2.1 MODEL-1

SOIL LAYERS USED IN MODEL-1	
First layer	Gravel Well Grad (GW)
Second layer	Gravel Silty (GM)
Third layer	Sand Well Grad (SW)

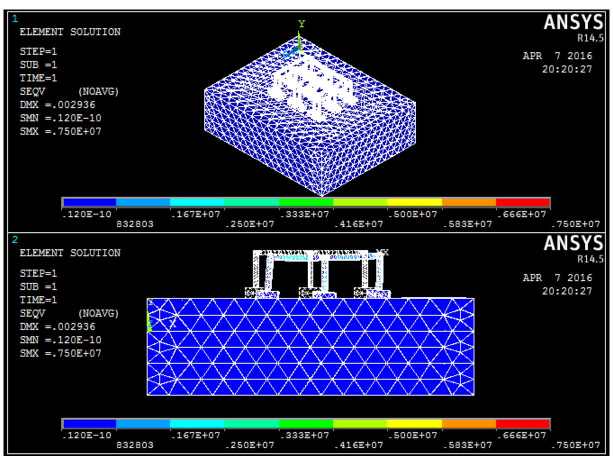
Von Mises Stress Results is Obtained from Analysis is 0.729 x 10^7 N/m^2



SOIL LAYERS USED IN MODEL-2	
First layer	Gravel Poor Grad (GP)
Second layer	Sand Poor Grad (SP)
Third layer	Sand Silty (SM)

3.2.2 MODEL-2

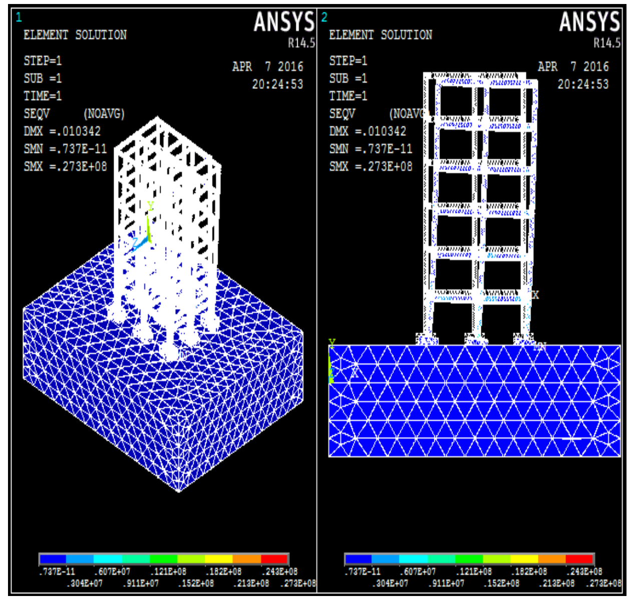
Von Mises Stress Results is Obtained from Analysis is 0.750 x 10^7 N/m^2



3.2.3 MODEL-3

SOIL LAYERS USED IN MODEL-3	
First layer	Gravel Well Grad (GW)
Second layer	Gravel Silty (GM)
Third layer	Sand Well Grad (SW)

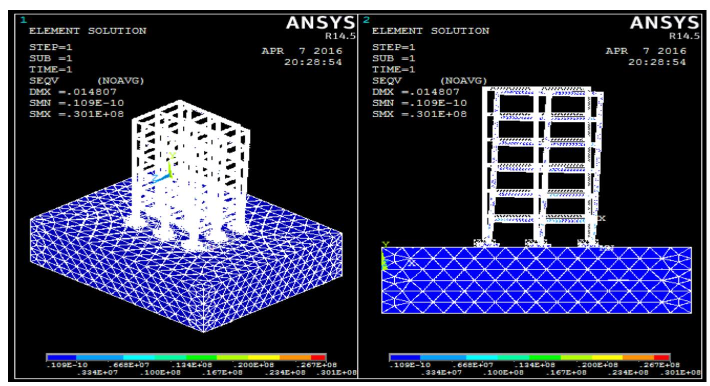
Von Mises Stress Results is Obtained from Analysis is 0.273 x 10^8 N/m^2



3.2.4 MODEL-4

SOIL LAYERS USED IN MODEL-4	
First layer	Gravel Poor Grad (GP)
Second layer	Sand Poor Grad (SP)
Third layer	Sand Silty (SM)

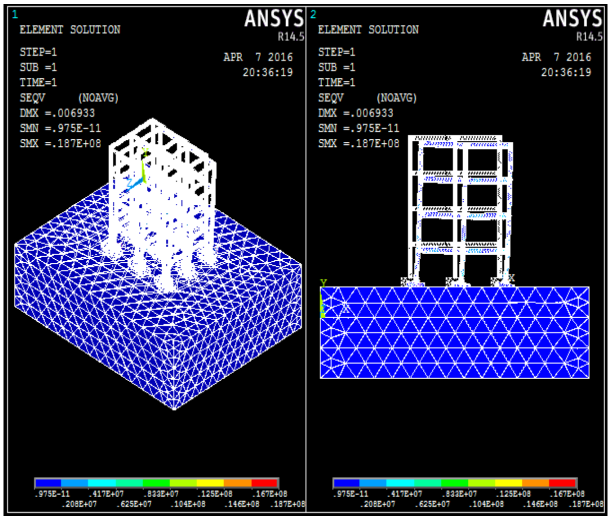
Von Mises Stress Results is Obtained from Analysis is 0.301 x 10^8 N/m^2



3.2.5 MODEL-5

SOIL LAYERS USED IN MODEL-5	
First layer	Gravel Well Grad (GW)
Second layer	Gravel Clay (GC)
Third layer	Sand Clay (SC)

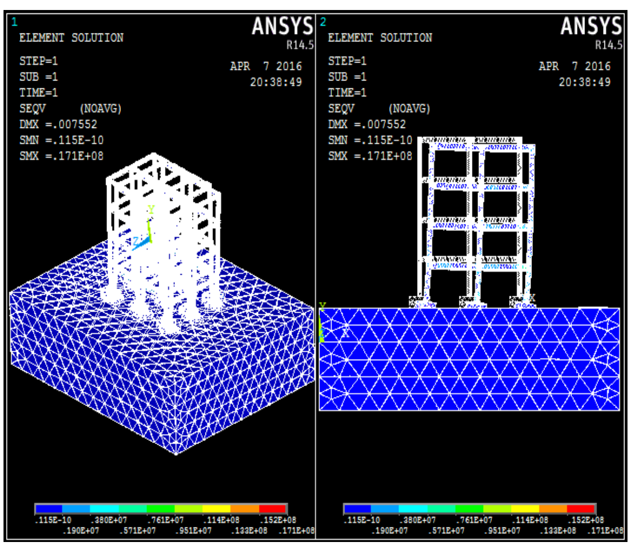
Von Mises Stress Results is Obtained from Analysis is 0.187 x 10^8 N/m^2



3.2.6 MODEL-6

SOIL LAYERS USED IN MODEL-6	
First layer	Gravel Poor Grad (GP)
Second layer	Gravel Clay (GC)
Third layer	Sand Clay (SM)

Von Mises Stress Results is Obtained from Analysis is 0.177 x 10^8 N/m^2



4. CONCLUSION

This learning determined that RC framed structure placed on numerous soil coatings on 3m depth to find the existing soil layers for the soil structure interaction, following conclusions were derived.

1. Displacement or settlement results on cohesion less soil i.e., Gravel well graded soil is comparatively less than cohesive soil.
2. Stress results obtained shows that there is necessity to give importance for the soil before construction.
3. By changing the soil layers, we will get some variation of displacements. Hence we can conclude that by changing the soil layers we will get slight change of settlements of soils.
4. Also if we interchange the soil layers, we will get some variation in displacement, stresses in all three directions and also Von Mises Stress results.
5. By giving extra loads to the structure, we can conclude that the foundation may get settled into the soil layers and also some variation of displacement, stress values and Von Mises stress values.
6. By giving strength to soil layers by fixing the soil layer in all the side so that no extra settlement may not occur and also problem of bulging would not occur.
7. Von Mises Stress results will assistance us to find the appropriate settlement of soil layers due to all the conditions for all the models.

REFERENCES

[1] F. K. Chang and K. Y. Chang. "A Progressive Dam age Model for Laminated Composites Containing Stres s Concentration". Journal of Composite Materials, 21. pg. 834-855. 1987a.

[2] J. H. Wilkinson. Then Algebraic Eigen value Proble m. Clarendon Press. Oxford. 515-569.1988.

[3] Michael E. McCormick. Ocean Engineering Wave M echanics. Wiley & Sons. New York. 1973.

[4] M. C. Imgrund. ANSYS® Verification Manual. Swan son Analysis ystems, Inc. 1992.

[5] W. Flugge. Stresses in Shells. Springer Verla. Berlin. 1967.

[6] W. C. Schnobrich and M. Suidan. "Finite Element Analysis of Reinforced Concrete". ASCE Journal of the Structural Division. ST10. 2109-2122. October, 1973.

[7] E. L. Wilson, A. Der Kiereghian, and E. Bayo. "A Replacement for the SRSS

Method in Seismic Analysis". Earthquake and Structural Dynamics. Vol. 9, No. 2.
University of California, Berkeley. 187. March 1981.

[8] T. Sussman and K. J. Bathe. "A Finite Element Formulation for Nonlinear
Incompressible Elastic and Inelastic Analysis". Computers and Structures. Vol. 26, No. 1/2. 357-409. 1987.

[9] ATC-3 (1978). “Tentative provisions for the development of seismic regulations of buildings: a cooperative effort with the design profession, building code interests, and the research community”, National Bureau of Standards, Washington DC.

[10] Bielak, J. (1975). “Dynamic behavior of structures with embedded foundations”, Earthquake Engineering Structural Dynamics, Vol. 3, pp. 259-274.

[11] Celebi, M. (1998). “Turkish earthquakes: Two reports. Lessons from the Adana-Ceyhan Quake and the Dinar Aftershock”, EERi Newsletter, Vol. 32, No. 9, 8 pages.

[12] Ciampoli, M. and Pinto, P.E. (1995). “Effects of soil-structure interaction on inelastic seismic response of bridge piers“, Journal of Structural Engineering, ASCE, Vol. 121, No. 5, pp. 806-8 14.

[13] Gazetas, G. and Mylonakis, G. (1998). “Seismic soil-structure interaction: New evidence and emerging issues”, State of the Art Paper, Geotechnical Earthquake Engineering and Soil Dynamics Gee-Institute ASCE Conference, Seattle, August 3- 6, 1998, Vol. II, pp. 1116-l 174.

[14] Guin, J. and Banerjee, P.K. (1998). ‘Coupled soil-pilestructure interaction analysis under seismic excitation”, Journal ofstructural Engineering, ASCE, Vol. 124. No. 4. pp. 434-444.

[15] Gerolymos, N, Gazetas, G., and Mylonakis, G. (1998). “Fundamental period and effective damping of pile-supported bridge piers”, I Ilh European Conference on Earthquake Engineering, Topic 3, Paris, September 1998.

[16] Hidalgo, P.A., and Arias, A. (1990). “New Chilean code for earthquake resistant design of buildings”, Proc. 4’h U.S. Conjbence on Earthquake Engng, EERI, Vol. 2. pp. 927-936.

[17] Jennings, P.C. and Bielak J. (1973). “Dynamics of building soil interaction “, Bulletin of Seismological Society of America, Vol. 63, No. 1, pp. 9-48.

[18] Chile Earthquake Reconnaissance Team,(1986),”Performance of structures”, Earthquake Spectra, vol.2 EERI pp 293-371.

[19] Ghobrah, A; and Youseef, M ;(2000),”Rehabilation of RC Buildings using structural Walls” 12th world conference
in earthquake engineering, CDROM Paper no 0153.

[20] REGAN, P. E.; BRÆSTRUP, M. W.,Punching Shear in Reinforced Concrete. Comité Euro-International du Béton, Bulletin d›Information, No. 168, Jan. 1985, 232 pp.