SSRG International Journal of Civil Engineering
ISSN: 2348 – 8352 /doi:10.14445/23488352/IJCE-V7I6P109

Volume 7 Issue 6, 71-79, June 2020
©2020 Seventh Sense Research Group®

Soil structure interaction for basement system of malty storey building for different soil condition using static analysis in Etabs

Mr.Gopal Dabhi[1]; Prof.Vimlesh V. Agrawal[2]; Prof. Vishal B. Patel[3]

[1]*Department of Structural Engineering, Student, Birla Vishvakarma Mahavidyalaya, Anand 388 120, India*
[2]*Department of Structural Engineering, Professor, Birla Vishvakarma Mahavidyalaya, Anand 388 120, India*
[3]*Department of Structural Engineering, Professor, Birla Vishvakarma Mahavidyalaya, Anand 388 120, India*

Received Date: 24 May 2020
Revised Date: 25 June 2020
Accepted Date: 30 June 2020

.

Abstract
In the present scenario due to less availability of land, the construction is going in the vertical direction. Due to the higher cost of land as well as lesser availability of land engineers prefer to grow in the vertical direction both upward and downward side. The more use of the ground as a basement or foundation the interaction between soil and foundation of the structure is increased. As we provide deeper foundation sometimes with more number of the base storey the soil-structure interaction is more for the building and neglecting of soil-structure interaction is not conservative for the structure. In the present study the different areas of the basement system, different floor numbers, and different soil conditions like rocky, hard soil, medium soil, and soft soil are considered for dynamic (Time history Analysis) and static-analysis using tabs software. Analysis of the fixed base condition is also carried for the same. The soil is defined as a spring and its spring parameters/ Spring Constants i.e. Shear modulus, Poison's ratio are calculated as per the FEMA-356 guidelines. For the different soil conditions, various results like Base shear, Base moment, Displacement, Storey drift, and period were compared with the fixed base condition. It is found that for the 3 storey buildings there was no change in any results for the different soil conditions. The 6,9 and 12 storey buildings result from almost the same for the rocky strata, hard strata, and fixed base, and different for Medium and soft soil. As we increasing the basement area the base shear and base moment are decreased, and displacement, storey drift, and period are increases.

Keywords: *Soil-Structure Interaction, Basement System, Time History Analysis, Spring Constant*

I. INTRODUCTION

When the Earthquake occurs, the Building And Ground vibrate and influencing each other. This Phenomenon is called "Dynamic soil Structure interaction", and is Recognise as being very important for the seismic design of Structure. To estimate the Earthquake motions at the site of a structure is the most important phase of design as well as retrofit of a structure. In a classical method for the Structural analysis, it assumed that the motion in the foundation level of equal structure is to ground free-field motion. This assumption is correct only for the structures constructed on a rock or very stiff soil. For the structures constructed on soft soil, foundation motion is usually different from the free field motion and a rocking component caused by the support flexibility on the horizontal motion of foundation is added. After the 1964 niigata earthquake (M 7.5), the importance of soil type and its behavior in the response of superstructure was understood. In the niigata earthquake, the failure of the structure was mainly due to foundation failure. In this earthquake, the whole foundation of the structure sinks into the ground due to liquefaction of soil. The city is located on the bank of the Shinano river so most of the soil was sandy soil and it leads to liquefaction. After that several investigations were done analytically, numerically, experimentally, and field observation also. From this investigation, it was understood that the response of the soil during earthquake load plays an important role in evaluating the damage to the structures. During an earthquake, the response of soil becomes much more complex and it is necessary to consider it in the analysis. Dynamic analysis of soil-structure interaction can be done using the Direct method and Substructure method.

A. Basic outline of soil-structure interaction

1) Role of foundation

- Under normal condition

• Support the Dead Load and Live Load Of the structure Transmitting this load to the ground

- During an Earthquake

• Transmitting the ground motion to the building Bearing the building vibration and transmitting them to the ground.

2) Degree of influence of SSI on the response of building depends on:

• Stiffness of ground

• Dynamic characteristics of building itself, that is natural period and damping.

• Foundation type

3) The position where the SSI takes place in different types of foundations.

(a) Spread foundation:- Through the bottom surface of the foundation.

(b) Pile foundation without basement:- Through the pile foundation

(c) Basement without pile:- Not only at the bottom surface but also sidewall surface.

(d) Basement with a pile:- Through the basement surface and the piles.

B. Linear Lumped Parameter Of Soil (Spring constant for modeling of soil)

In these types of modeling the linear lumped-parameter soil model, the interaction between the soil and structure is simulated with the translational and rotational spring system. The values of spring stiffness in both axis and right angle directions are given in FEMA356 Chapter-4 page no. 20

Non-Linear Winkler foundation

In the SSI, the spring of the model is assigned with a nonlinear spring-dashpot system along the pier embedded depth. Strain-dependent material nonlinearity is implemented using the nonlinear soil model. The soil under moderate and strong seismic loading, pile foundations undergo major displacement and the behavior of the interaction system can be nonlinear.

Winkler Foundation model

k = q /w, where

q = pressure by foundation on soil,

k = coefficient of subgrade reaction or subgrade modulus(KN/m3)

W = deflection.

II. Description of buildings (Geometric Details and Loading condition)

The frame chosen for the investigations is a three-bay malty storeyed RCC frame. It is designed as an ordinary moment-resisting frame. Height of each story 3m.Plan area of building 10m x 10m and area of the basement is also 10m x 10m for basement system-1, and for basement system-2 plan area10m x 10m and area of the basement is 20m x 20m. Each bay 5m x 5m.The thickness of the slab is 150mm. Size of beam width 300mm and depth 600mm, which is resting on the column. Size of the column:-central column 500 x 500 mm, remaining are 420 x 420 mm thickness of RCC basement wall is 200mm. Type of Footing is spread footing Interaction between basement wall and soil is neglected. Live load is 3kN/m2 and floor finish load is 0.5kN/m2

The different parameters to be considered Nos. of story, Nos. of the basement, and type of Soil with and without a fixed base.

NOs. Of Storey:- 3, 6, 9, 12

NOs. Of basement :-1, 2

Area of Basement System:- 1, 2

Type of soil: - soft, medium, dense, rock

.A. soil parameters

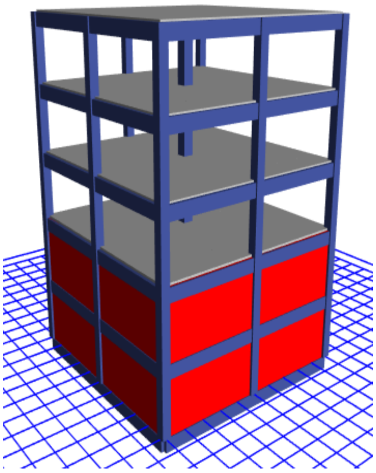
Properties of soil used in the study (Mehta and Gandhi, 2008)

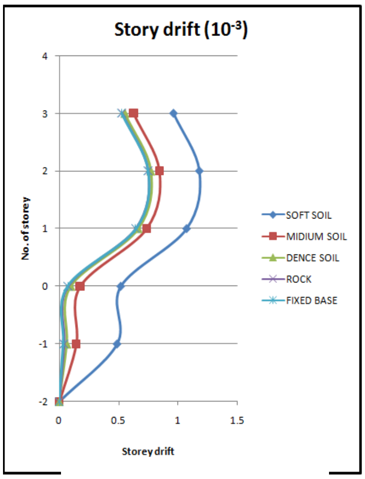
Table A :- property of soil

Velocity of shear waves(m/s)	Soil type	Unit Weight,kN/m³	poisson's ratio, v	Shear modulus, G (kN/m²)	Elastic Modulus (kN/m²)
150	Soft soil	16	0.49	36700	$14.95x10^4$
300	Medium soil	20	0.45	183500	$25.84x10^5$
600	Dence soil	22.4	0.35	822000	$50.53x10^7$
1200	Rock	25.6	0.3	3758900	$30.42x10^7$

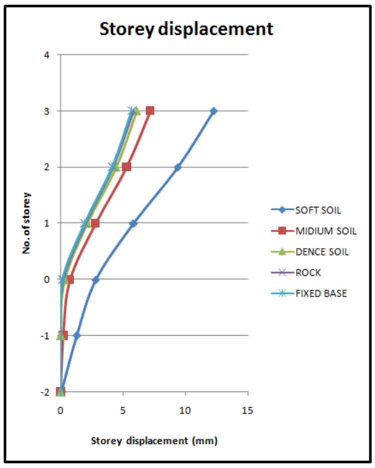
III. Modelling & Analysis in software

A. 3storey building with 2 storey basement & system-1

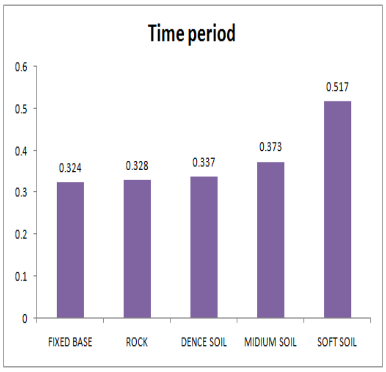




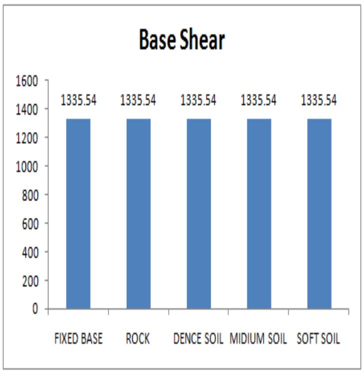
Graph 1(a) :- Storey



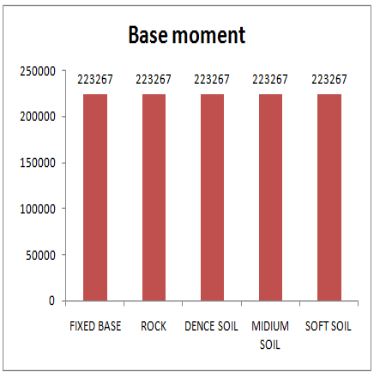
Graph 1(b):- Storey Displacement



Graph 1(c) :- comparison of time

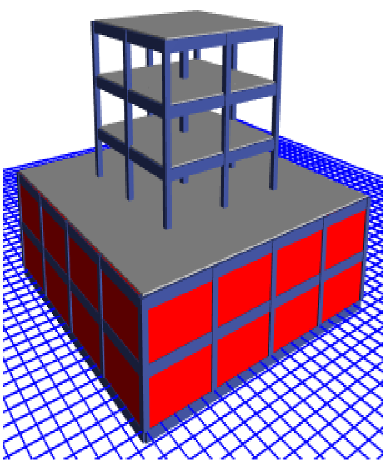


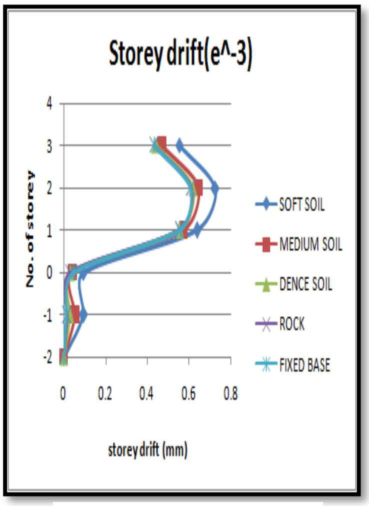
Graph 1(d) :-Comparison of Base Shear



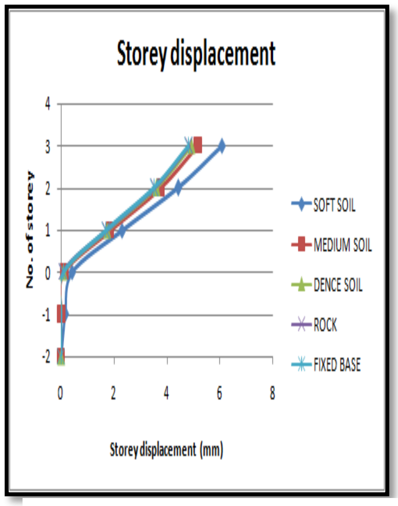
Graph 1(e) :- comparison of base moment

B. 3storey building with 2 storey basement & system-2

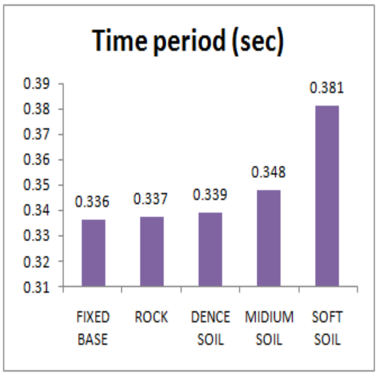




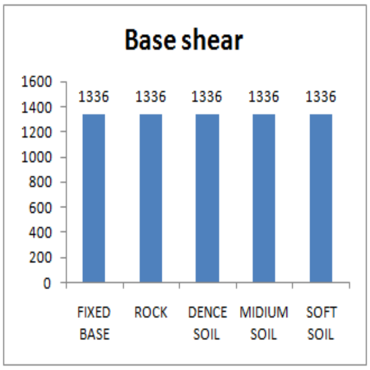
Graph 2(a) :- Storey Drift



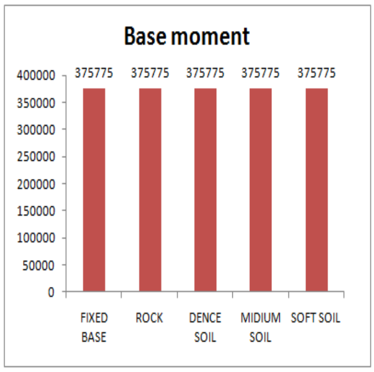
Graph 2(b):- Storey Displacement



Graph 2(c) :- comparison of time period

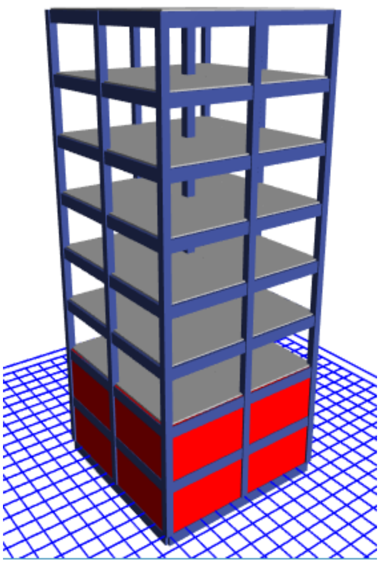


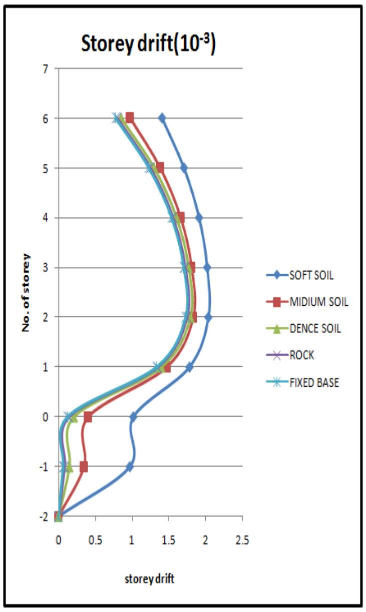
Graph 2(d) :-Comparison of Base Shear



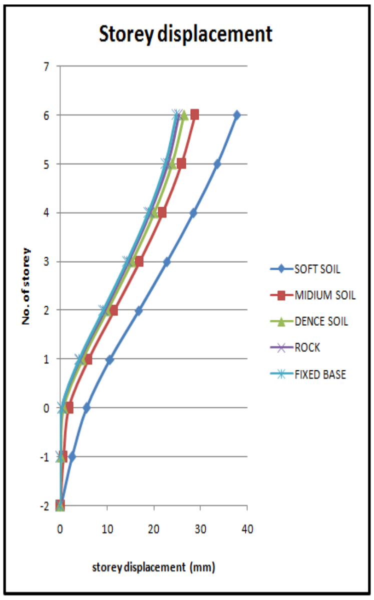
Graph 2(e) :- comparison of base moment

C. 6 storey building with 2 storey basement & system-1

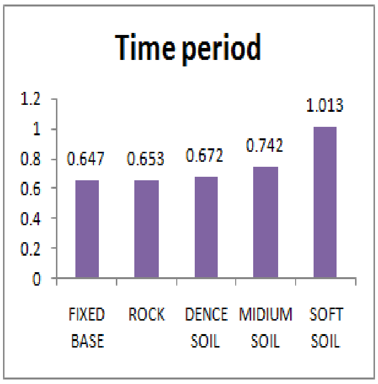




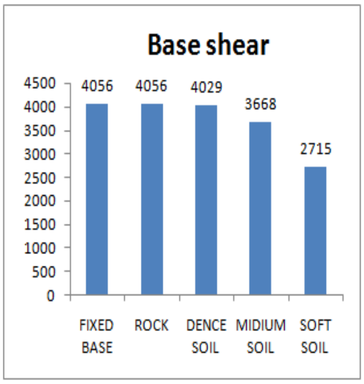
Graph 3(a) :- Storey Drift



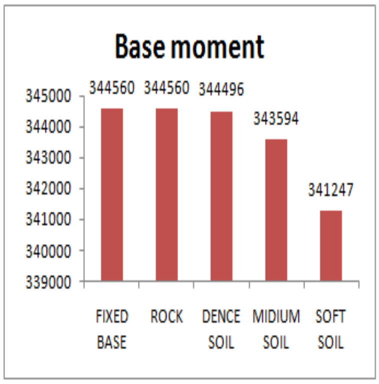
Graph 3(b):- Storey Displacement



Graph 3(c) :- comparison of time period

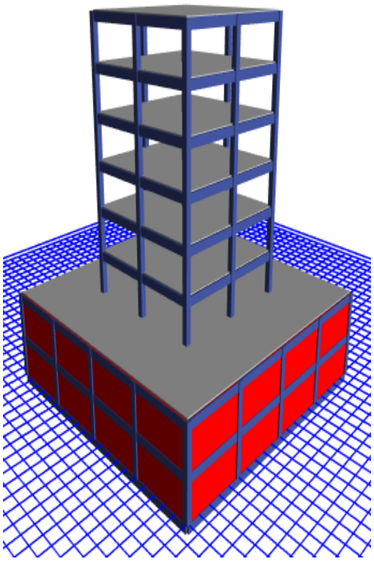


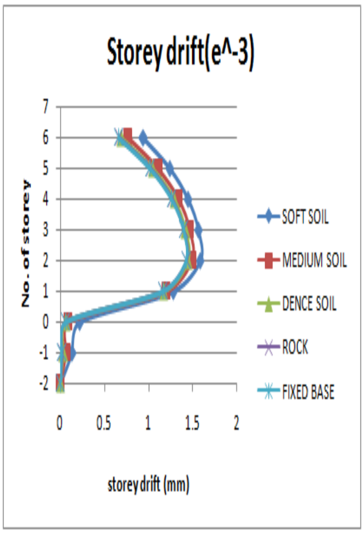
Graph 3(d) :-Comparison of Base Shear



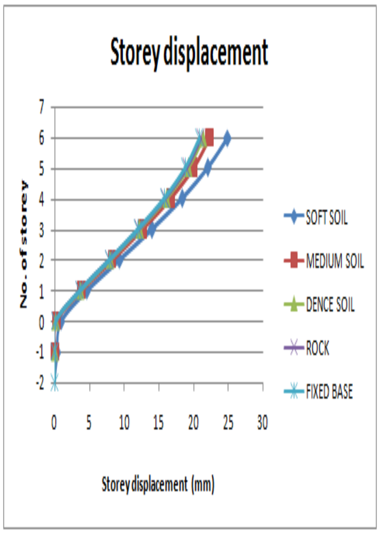
Graph 3(e) :- comparison of base

D. 6 storey building with 2 storey basement & system-2

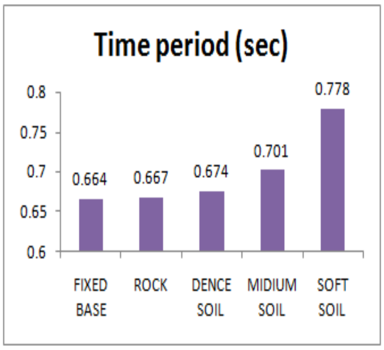




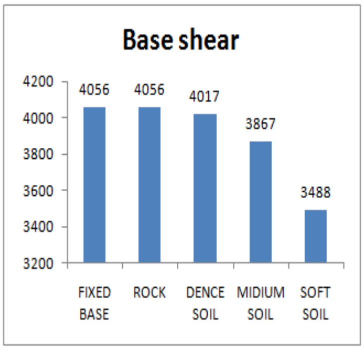
Graph 4(a) :- Storey Drift



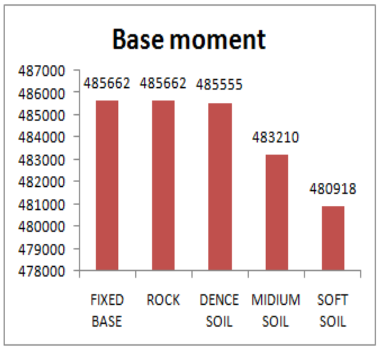
Graph 4(b):- Storey Displacement



Graph 4(c) :- comparison of time period

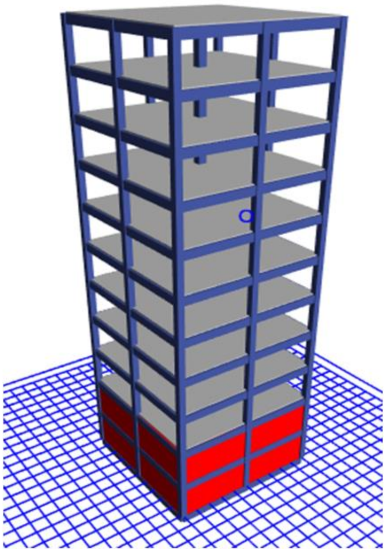


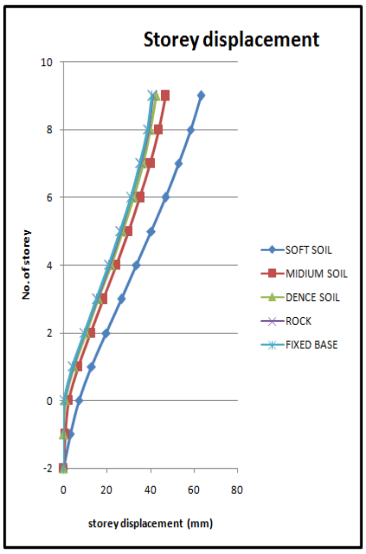
Graph 4(d) :-Comparison of Base Shear

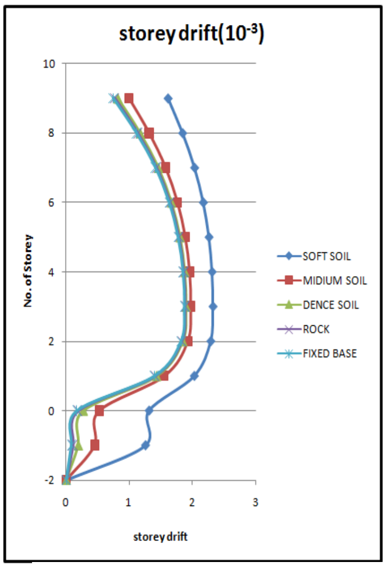


Graph 4(e) :- comparison of base

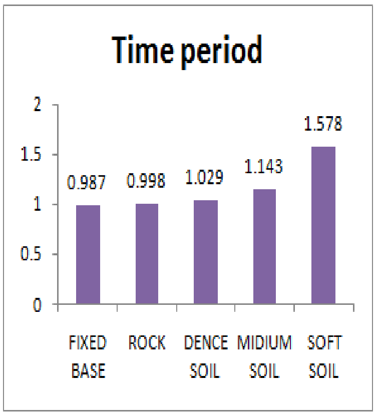
E. 9 storey building with 2 storey basement & system-1



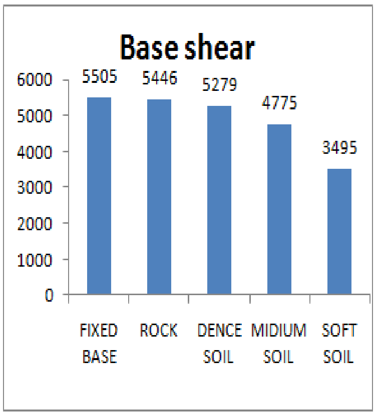




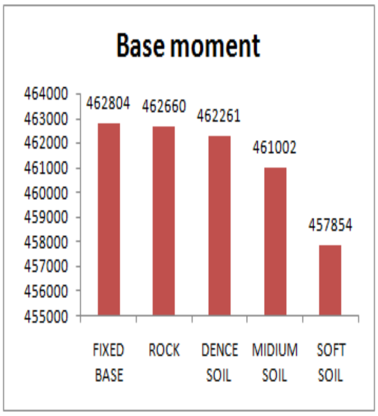
Graph 5(b):- Storey Displacement



Graph 5(c) :- comparison of time period

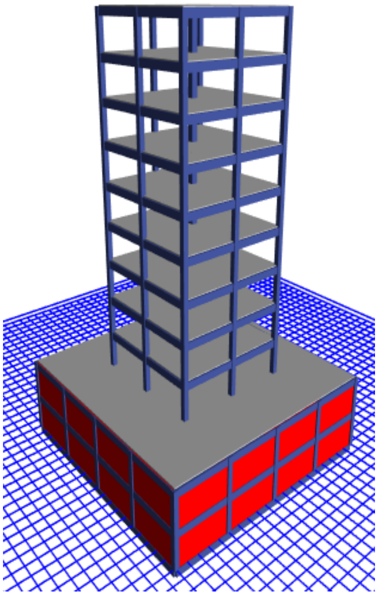


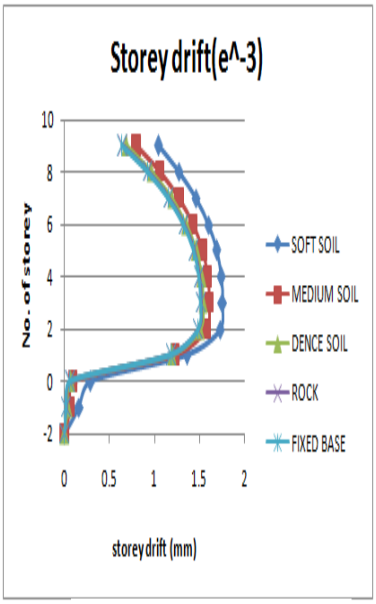
Graph 5(d) :-Comparison of Base Shear



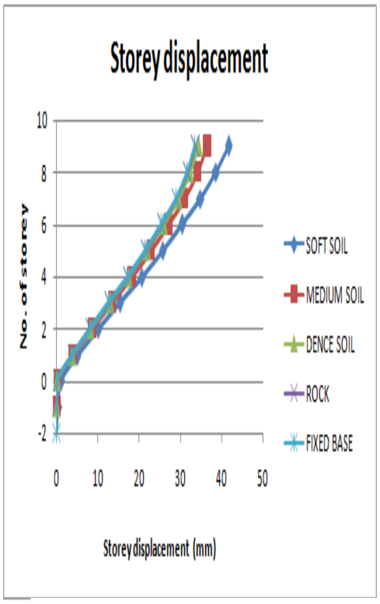
Graph5(e) :- comparison of base moment

F. 9 storey building with 2 storey basement & system-2

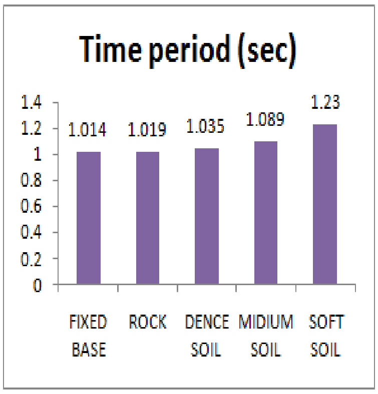




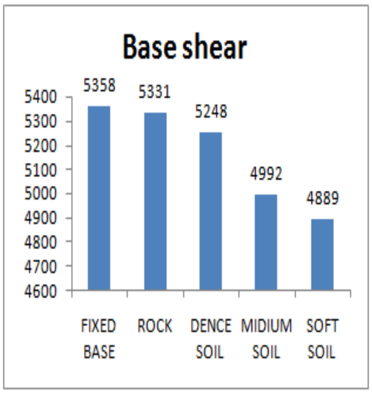
Graph 6(a) :- Storey Drift



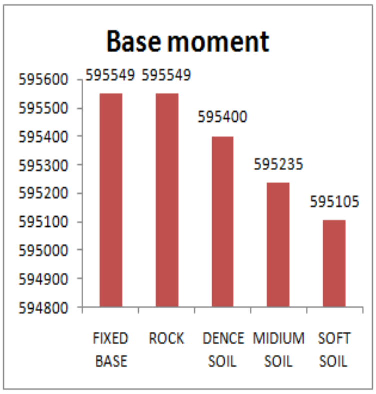
Graph 6(b):- Storey Displacement



Graph 6(c) :- comparison of time period

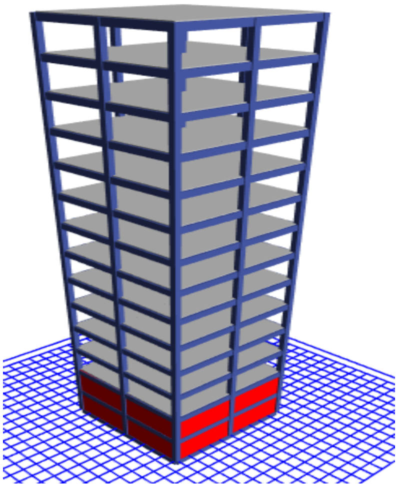


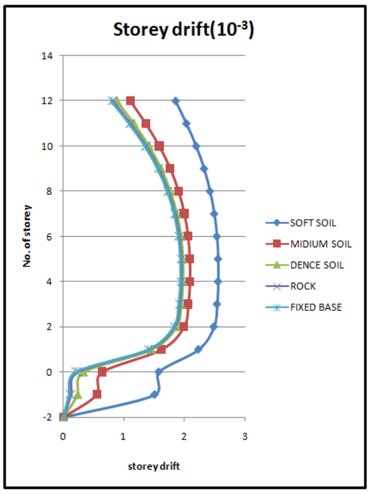
Graph 6(d) :-Comparison of Base Shear



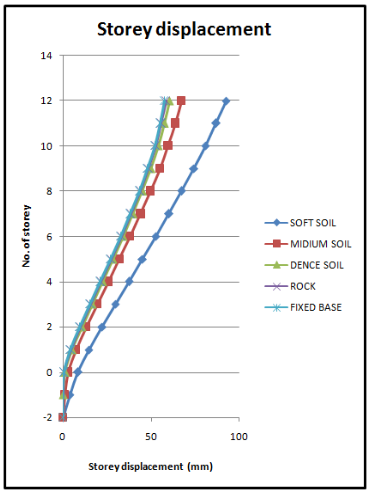
Graph 6(e) :- comparison of base moment

G. 12 storey building with 2 storey basement & system-1

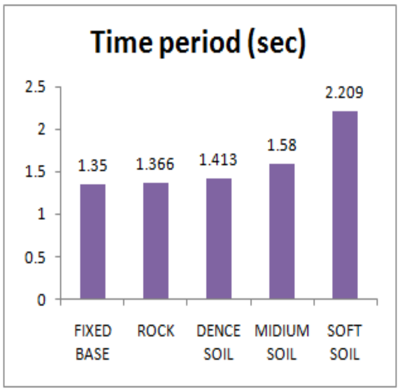




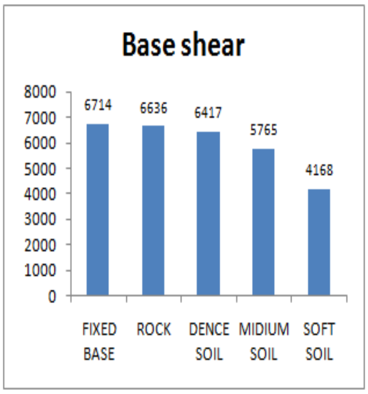
Graph 7(a) :- Storey



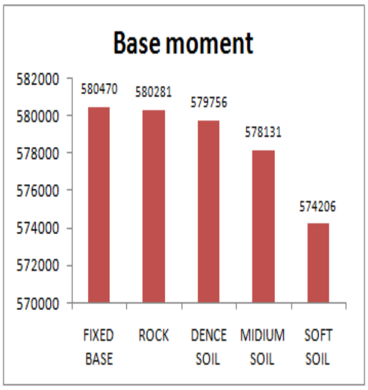
Graph 7(b):- Storey Displacement



Graph 7(c) :- comparison of time period

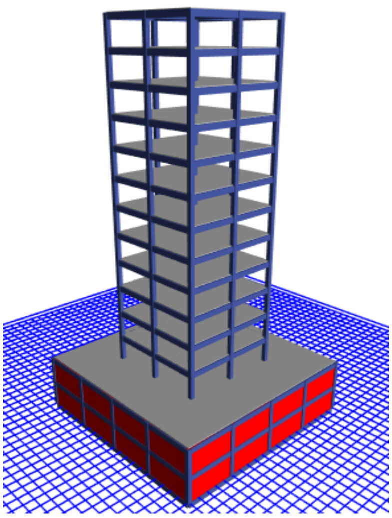


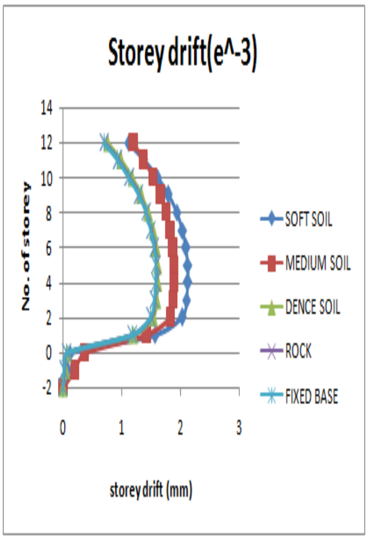
Graph 7(d) :-Comparison of Base Shear



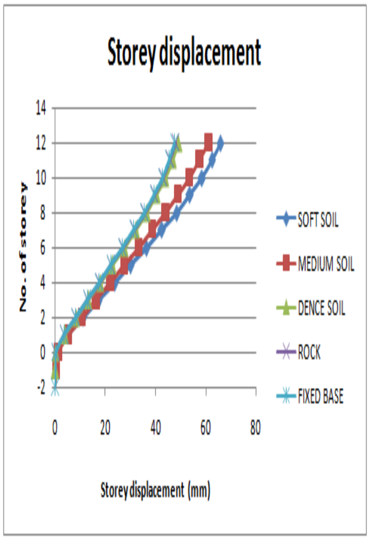
Graph 7(e) :- comparison of base moment

H. 12 storey building with 2 storey basement & system-2

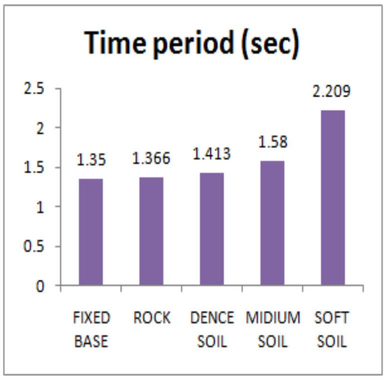




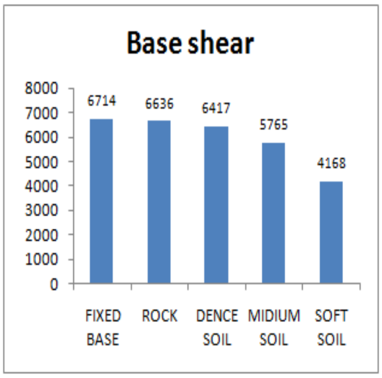
Graph 8(a) :- Storey Drift)



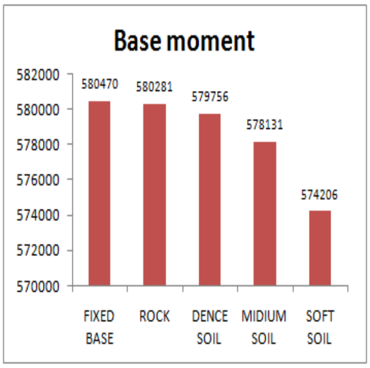
Graph 8(b):- Storey Displacement



Graph 8(c) :- comparison of time period



Graph 8(d) :-Comparison of Base Shear



Graph 8(e) :- comparison of base moment

Result and Discussion

- Graph (a) shows the variation of story drift for the particular floor. from the graph, it has been found that at the basement level there is very low storey drift, because of the very high inertia due to the basement wall.
  From the graph, it has been found that drift is less on the top floors as compared to the middle storey.

- Graph (b) shows the displacement of the building from the graph it has been found that for the fixed base, rocky base, and the dence soil base displacement shows low value as compared to the soft soil base and medium soil base.

- Graph (c) shows the value of the period if the soil is soft then the period is more and if the soil is rockey then the period is less. For the fixed base and rockey base variation in the value of period is Negligible.

- Graph (d) shows the value of base shear. It has been found that in graph 1(d) the value of base shear is the same for all types of soil because in code criteria are given for a particular value of the period the value of sa/g is the same. so the base shear is the same.
  in graph 2(d) the value of the base shear is the same for the fixed base, rockey base, and dence soil base because of the same reason.

- Graph (e) Shows the value of the Base moment. It has been found that if base shear increases then the base moment is also increased.

Conclusion

- From the analysis, it has been found that if the contact area of the structure is more the effect of the SSI is more.

- Up to the 3 storey building, there is no change in base shear and base moment in any basement system because the period is within criteria so, the sa/g value for all cases is the same. Hence base shear and base moment are the same.

- Up to the 6 storey building there same value of base shear and base moment in the fixed base, rockey strata, and dence soil condition, but minor change for medium and soft soil condition.

- For the 9 Storey building as we increase basement area base shear and base, the moment is increased for all cases and the period is decreased.

- More than 12 storey building period is the same in both basement system but the base shear and base moment is increased

- From the analysis, it has been found that up to the 3 storey building there is no effect of ssi, and for the 6 storey minor change in result. Hence, we can conclude that we can neglect ssi analysis up to the 6 storey building.

- To accurately estimate the response of the structure, the effect of soil-structure interaction is needed to be considered under the influence of both static and dynamic loading.

- The forces in the superstructure, foundation, and soil mass are significantly altered due to the effect of soil-structure interaction. For accurate estimation of the design force quantities, the interaction effect is needed to be considered.

References

[1] Désirée Hanna Khoueiry And 2michel Farid Khouri Integrating Soil-Structure Interaction Along Basement Walls In Structural Analysis Programs, International Journal Of Development Research 5(04)(2015) 4061-4068.

[2] M.J. Givens & J.P. Stewart, C.B. Haselton, S. Mazzoni Assessment Of Soil-Structure Interaction Modeling Strategies For Response History Analysis Of Buildings The 15 The World Conference On Earthquake Engineering, (2012).

[3] Julio A. García 1 , Soil-Structure Interaction In The Analysis And Seismic Design Of Reinforced Concrete Frame Buildings. The 14 Th World Conference On Earthquake Engineering October (2008) 12-17, Beijing, China.

[4] Ravi Kant Mittal, Aditi And Sanket Rawat, Soil-Structure Interaction In Indian Seismic Code: Recommendations For Inclusion Of Potential Factors. International Journals Of Earth Sciences And Engineering Issn 0974-5904, 09(03) (2016) .

[5] A. Massumi And H.R. Tabatabaiefar, A Criterion For Considering Soil-Structure Interaction Effects In Seismic Design Of Ductile Rc-Mrfs According To Iranian Codes The 14 Th World Conference On Earthquake Engineering 12-17 (2008), Beijing, China.

[6] Nitesh M. Patel, AnujChandiwala, Hitesh K. Dhameliya Parametric Study of Flat Slab Building with Shear Wall at Different Location, International Journal of Engineering Trends and Technology (IJETT), 47(4), (2017), 243-249.

[7] Dynamic Analysis Of Soil-Structure Interaction Of Pile Supported Frame Structure (International Journal Of Scientific & Engineering Research, 6(10)(2015).

[8] Fema 356-2000 Guidelines

[9] Is 456-2002 (Plain And Reinforced Concrete – Code Of Practice)

[10] Is 1893-2016 (Criteria For Earthquake Resistant Design Of Structure)

[11] Fumal, T.E., and Tinsley, J.C., Mapping shear wave velocities of near-surface geologic materials, in evaluating earthquake hazards in the Los Angeles region-an earth-science perspective, U.S. Geol. Surv. Profess. Pap, 1360, (1985) 101-126.

[12] NEHRP Consultants Joint Venture, Soil-Structure Interaction for Building Structures, Report NIST/GCR 11-917-14, prepared by the Applied Technology Council and Consortium of Universities for Research in Earthquake Engineering for the National Institute of Standards and Technology, Washington, D.C. (2012).

[13] B. Deepa and C. Nandakumar, Seismic Soil-structure Interaction Studies on Multistorey Frames, International Journal of Applied Engineering Research and Development, 2(1)(2012) 45-58.