*IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*
*e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 18, Issue 5 Ser. II (Sep. – Oct. 2021), PP 12-16*
*www.iosrjournals.org*

# Seismic Performance of Raft in Foundation High Rise Building with Soil Structure Interaction Effect

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***ABSTRACT:****Vertical expansion, few land and small space available in construction make the high rise building (HRB) the most effective solution. HRB is special structure behave with different conduct under seismic excitation.Soil structure interaction (SSI) be more effective under earthquake load. Two approach of the soil models used to represent the soil effect on the structure to check the accuracy of each model in the representation of soil under dynamic loads. The SSI is the most effective parameter in design HRB whatever the type of foundation, the medium soil characteristics are widely spread. Raft foundation for HRB is the best foundation solution for such special buildings. SAP2000 program used to show the effect of SSI in HRB under seismic excitation. Three effective actions under earthquake are occurred: 1) large displacements, 2) high values of damping, and 3) low values of straining actions. In medium soil the straining action reduced by 55% than the fixed model, but the displacement the most effective parameter which gauged the collapse damages in HRB are very high, and the most effective soil model was the elastoplastic model which the soil was modeled as spring and dashpot.*

***KEYWORDS*** *-earthquake loads; HRB; SSI; straining action; SAP2000; seismic analysis; safety analysis.*

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Date of Submission: 14-09-2021 Date of Acceptance: 29-09-2021

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## I. Introduction

HRB is the most effective solution in the solving housing problems all over the world, (the vertical extension). The SSI plays a crucial role in behavior of HRB especially in the raft foundation type (shallow foundation). The soil-structure interaction (SSI) effects play an important role in determining the realistic behavior of the structures.

Mughieda et al. 2017 improved in a parametric study that the soil subgrade reaction has no effect on straining action of raft foundation, but the deformation decreases with increasing subgrade of soil which behave as rock, with spring high values stiffness under columns, for high values of subgrade modulus values.

Jeong et al. 2017 made comparative studies to show that the method development is useful for computational saving and improving performance in engineering practice.

Mahajan, 2017, concluded that SSI increase time period, the big spring stiffness values the building behave as fixed base model, Winkler model is represented as good model for raft foundation.

The study concentrated on the effect of SSI on the raft foundation of the HRB with different kinds of soil with modelling the raft foundation and superstructure in SAP2000 with SSI model as modified Winkler model. With two probably approach to represent the soil model to estimate the seismic response of HRB. Numerical results obtained using soil structure interaction model conditions are compared to those corresponding to fixed-base support conditions. The peak responses of story shear, story moment, story displacement, story drift, moments at beam ends, as well as force of inner columns are analyzed.

## II. Model Description

Reinforced concrete HRB with 15 stories square in plan with square columns 600x600 mm cross section, 600x250mm beam cross section 120mm thickness slab all over the height of the model. The foundation thickness 2.00 m with top and bottom steel bars meshes 7Ø22/m' with projection of 1.00 m from the outer columns around the model. The earthquake wave is El-Centro excitation as shown in Fig. 1. The pick ground acceleration was 0.36g for such earthquake.

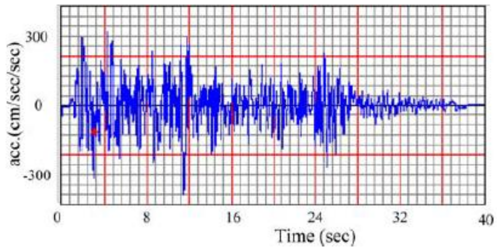
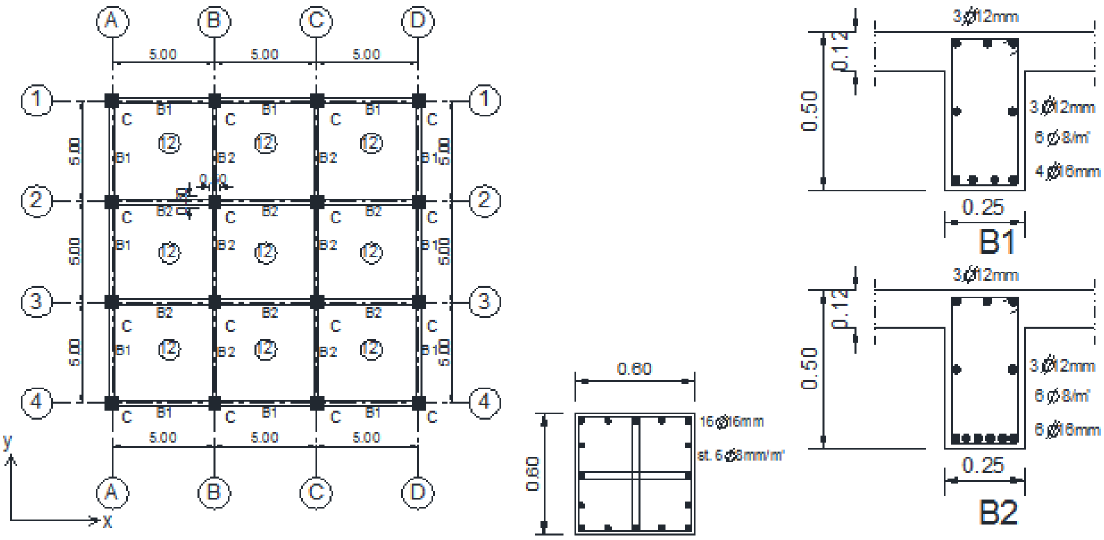



**Fig.1: Earthquake wave El-Centro**

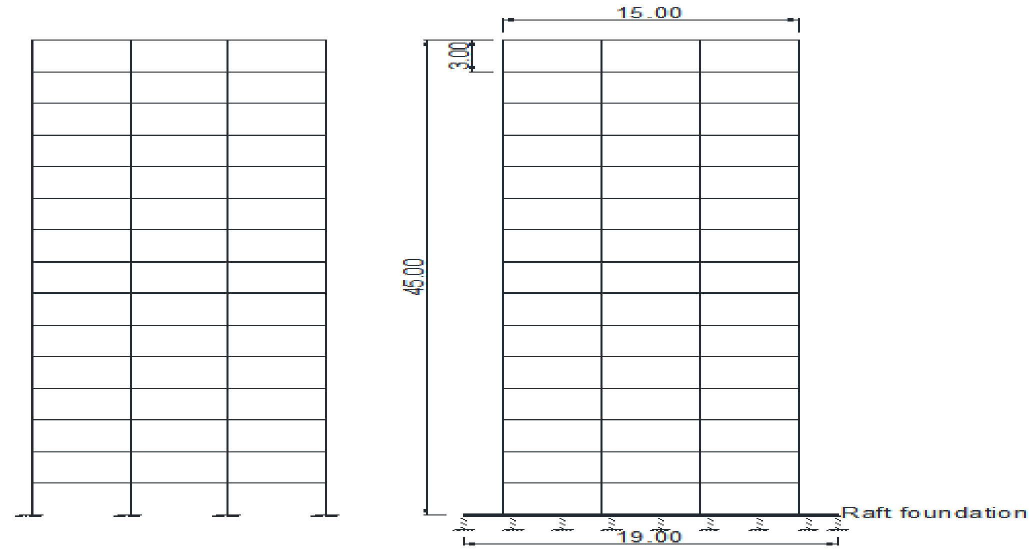
Figure 2 shows the model drawing for different plans and with RC cross section descriptions. Fig. 2-i shows the structural plan of the repeated floor with columns and beams sections, Fig.2-ii represents the column cross section details and Fig.2-iii represents beams cross section details.

Figure 3 shows the elevation of the 15 floors each floor height 3 m building with raft foundation system.




i) Plan ii) ( C ) column details iii) beams details

**Fig. 2: Model Description**




i) Fixed base model ii) Raft foundation model with SSI

**Fig. 3 elevation of the model**

## III. SOIL STRUCTURE INTERACTION

The first representation soil model is a viscoelastic model which represents the real structure of the soil under the static and dynamic loads. Table 1 represents the formula used to get the values of stiffness and damping of the soil elements under the raft foundation of the model are represented, the soil elements under the raft foundation will be represented as 3D elements stiffness and damping in x, y and z directions (Fig.4) to satisfy the effect of the SSI in all direction when the soil subjected to earthquake waves. The soil in this study will be taken as three types of soil like hard, medium and soft soil (the properties of the soils were summarized in table 2).

**Table 1: Soil parameters (stiffness and damping) K&C (Newmark and Rosenblueth, Prentice, 1971)**

| Side | Stiffness (k) | Damping (C) | Mass |
|---|---|---|---|
| Vertical (z) | $K=\frac{4Gr}{1-\nu}$ | $1.79\sqrt{K}\rho r^3$ | $1.50\rho r^3$ |
| Horizontal (x, y) | $18.2Gr\frac{(1-\nu^2)}{(2-\nu)}$ | $1.08\sqrt{K\rho r^3}$ | $0.28\rho r^3$ |

Plate radius (r), shear modules (G), poission ratio (□ ), and mass density (□ )

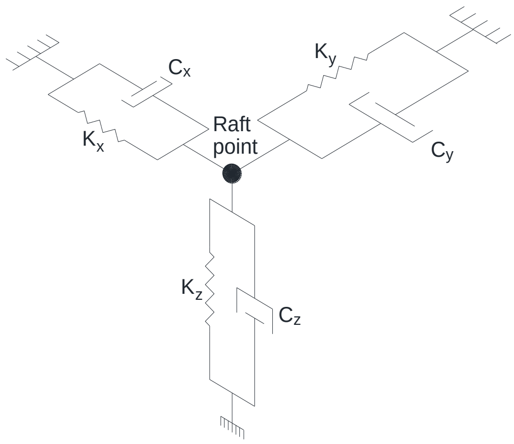



Fig.4: 3D view of the soil element

Table 2: Soil properties

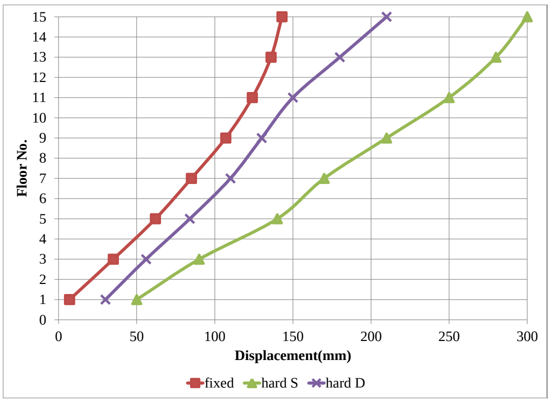
| Soil type | Hard | Medium | Soft |
|---|---|---|---|
| □ □ (Mg/m$^3$) | 2.1 | 1.95 | 1.75 |
| G (kPa) | 200 | 25 | 10 |
| □ | 0.35 | 0.40 | 0.45 |
| E (N/mm$^2$) | 70 | 30 | 15 |

The second kind of the soil model representation is the spring model (Winkler model) elastic springs (work at the linear stage of the structure and soil), (Winkler 1867).

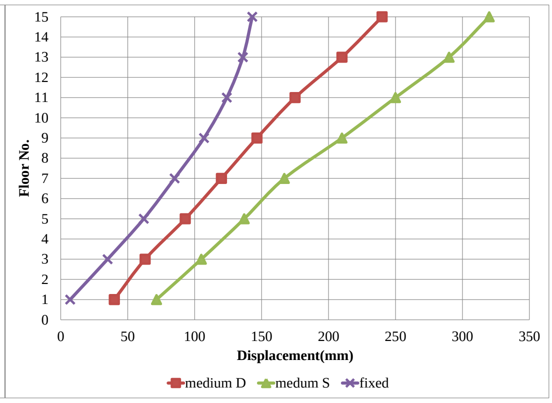
## IV. RESULTS AND DISCUSSION

The effect of the SSI was modeled by two approaches the first as springs in the three directions as Winkler model and the second by Kelvin model as spring and dashpot in parallel in three directions (x, y, and z) on a HRB of 15 floors under seismic load. The response of the HRB were check in the results of lateral displacements of the HRB and the base shear, base moment and base axial force.

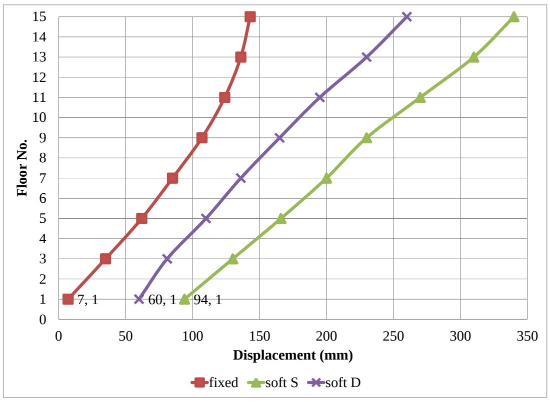
Figure 5 shows the lateral displacements of the HRB with different kinds of soils and different kinds of soil elements representations (Winkler and Kelvin models), Fig.5-i shows lateral displacement of hard soil in spring and spring dashpot models of soil, and fixed base HRB the most close values with fixed base case were for spring and dash pot soil model and the large values were for the spring only soil model (nearly equals 1.25 times the fixed base lateral displacements). Fig.5-ii represents the lateral displacements for HRB for medium soil with different soil modeling and fixed base cases (equals to 1.5 times the fixed base lateral displacements). Fig. 5-iii shows the lateral displacements the ratio between displacements in spring and dashpot soil model and fixed base HRB nearly equals 1.6 times the fixed base lateral displacements.




**i) Lateral displacement for hard soil**



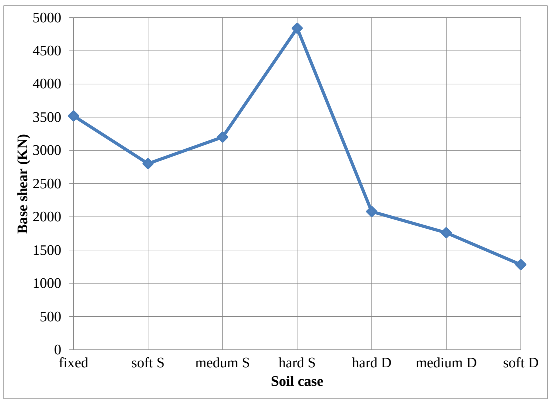

**ii) Lateral displacement for medium soil**



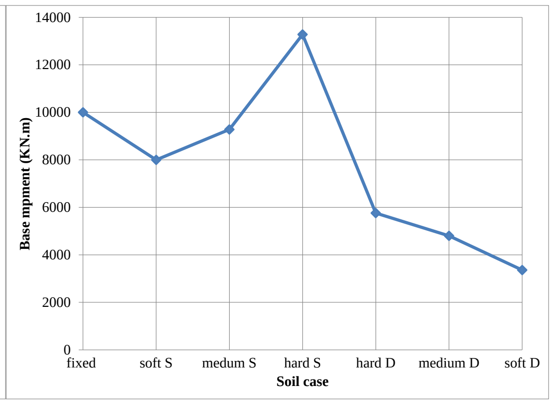

**iii) Lateral displacement for soft soil**

**Fig. 5: Lateral displacement of building under different conditions**

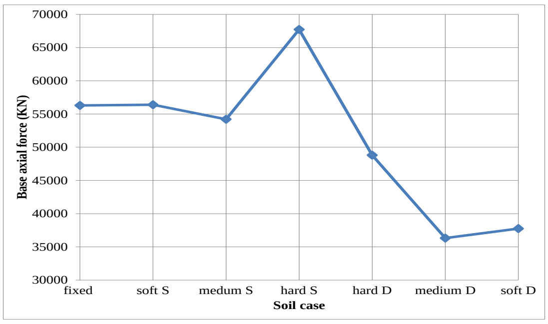
Figure 6 represents the response of the HRB with different soil model with different soil kinds (hard, medium and soft soils). Fig. 6-i represents base shear of HRB with different soil kinds and soil models, the minimum base shear was for soils with spring and damper representation, the maximum values of base shear were in soil with spring soil representation, the ratio between base shear in spring and spring dashpot soil models equals nearly to 1.83 times. Fig.6-ii represents the base moment for the HRB with different soil kinds and soil model, the maximum values of base shear were in soil with spring soil representation, the ratio between base shear in spring and spring dashpot soil models equals nearly to 1.83 times. Fig. 6-iii shows the base axial force in the HRB with different soil kinds with different soil models, the axial force records high value in hard soil with spring soil model but the corresponding value for spring and dashpot model reduced by 1.4 times than the spring soil model and for soft soil and medium soil spring soil model increased by nearly 1.58 times than spring and dashpot soil model.




**i) Base Shear**




**ii) Base moment**




**ii) Base axial force**

**Fig.6: Response of the building under seismic load**

The period time of the building increases with increasing softness soil and the time period increases in spring soil than spring-dashpot soil models as shown in Fig.7.

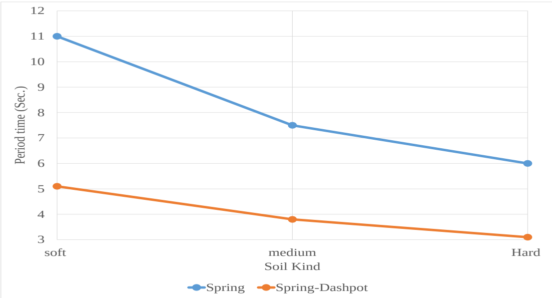



**Fig. 7: time period of the HRB with different soil kinds and soil model.**

## V. CONCLUSION

A 15 stories HRB was analyzed with different soil kinds (hard medium and soft soil) and with different soil model representation (spring and spring-dashpot models), to emphasize the efficiency of the soil models representation and the effect of the soil kinds on the raft foundation HRB type under seismic load. The lateral displacements, base shear, base moment and base axial forces were used as a comparison aids to jug the effect of the soil kinds and the soil model representation on the response of the HRB subjected to earthquake. The results founded can be summarized as follows:

- Spring – dashpot is the most stable and suitable to represent the soil model for HRB subjected to earthquake.
- The lateral displacements for fixed base HRB decreased by 1.25 times for hard soil, and 1.5 times for medium soil and 1.75 times for soft soil for spring – dashpot soil model.
- The lateral displacements for fixed base HRB decreased by 2 times for hard soil, and 2.5 times for medium soil and 3 times for soft soil for spring soil model.
- Base shear decreased in spring – dashpot soil model than spring soil model.
- Base moment decreased in spring – dashpot soil model than spring soil model.
- Base axial force decreased in spring – dashpot soil model than spring soil model.
- Period time decreased in spring – dashpot soil model than spring soil model.
- Period time increased with increased the soften soil.

## REFERENCES

[1]. Mughieda O, Mehana M S, and Hazirbaba K, 2017, "Effect of soil subgrade modulus on raft foundation behavior", MATEC Web of Conferences 120, 06010 (2017).

[2]. Jeong S, Park J, You K, 2017, "Analytical Method of Mega Foundations for High-Rise Buildings", Proceedings of the 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul 2017, pp. 2789- 2792.

[3]. Mahajan S., 2014, "representation of equivalent soil spring under a raft foundation", Master, Indian institute of technology, Roorkee, Roorkee.

Ahmed A. Farghaly, et. al. "Seismic Performance of Raft in Foundation High Rise Building with Soil Structure Interaction Effect." *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 18(5), 2021, pp. 12-16.