Dynamic Response of High Rise Building for Different Types of Sub-Structures

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Abstract- *The paper presents the study of building foundations of reinforced concrete multistoried buildings for G+15designed for seismic forces seismic zone IV of Indian subcontinent with varying soil conditions. The foundation types considered are; isolated footings, raft foundation, raft and pile foundation, pile foundation under different allowable bearing pressure values of the supporting soils. For the foundation analysis, convetional fixed based method, Winkler spring analysis and FEMA 356 method is used. The response spectrum analysis of the soil-structure model was carried out using the general software STAAD.Pro. In all the cases of modeling the structure, the earthquake records have been scaled according to the Indian Standard 1893-2016.*

Keywords- Soil interaction, Fixed base, Winkler spring analysis, FEMA 356 method, isolated pad footing, raft foundation, pile foundation.

I. INTRODUCTION

If the structure is supported on soft soil deposit, the inability of the foundation to conform to the deformations of the free field motion would cause the motion of the base of the structure to deviate from the free field motion. Also the dynamic response of the structure itself would induce deformation of the supporting soil. This process, in which the response of the soil influences the motion of the structure and the response of the structure influences the motion of the soil known as Soil Structure Interaction. According to the seismic improvement of current structure provision, the members of Structure and foundation must be modeled together in unified model to consider soil structure interaction. In this study two orthogonal springs, a vertical spring and three Rotational springs were used in main direction of structures to simulate soil structure Interaction.

II. OBJECTIVES OF THE PROJECT

An attempt is made in this thesis to evaluate the seismic soil interaction response of regular building. The main objectives of the report are

1. To study the seismic performance of the regular building for different types of soils.
2. To study the seismic performance of the regular building for isolated pad, raft slab, pile with raft slab and pile with pile cap types of foundations.
3. To analyze the displacement of the structure along different direction by using response spectrum method
4. To study base shear, axial force and moments of the structure along different direction by using response spectrum method

III. METHODOLOGY

RCC Frames with G+15 have been considered in the study. Fundamental period of vibration of the frame with fixed support using codal formula in IS 1893(Part I):2002 and model analysis has been evaluated. In order to understand the effect of soil structure interaction on fundamental period of vibration soil has been modeled as winkler spring and Fixed base model using STAAD.Pro.

Response spectra method of analysis of the models are performed using STAADPro. Effects of soil interaction on different parameters are studied i.e. Natural Time Period, Roof Displacement, Shear force and Bending moment.

IV. MODELING

The building has been modeled as 3D Space frame model with six degree of freedom at each node using STAD-Pro software for stimulation of behavior under gravity and seismic loading. The isometric 3D view and elevation of the building model is shown as below.

Site Properties:

Details of building:: G+15
Outer wall thickness:: 230mm
Inner wall thickness:: 230mm
Floor height ::3 m
Depth of foundation :: 1500mm

Seismic Properties
Seismic zone:: IV
Zone factor:: 0.24
Importance factor:: 1.2
Response Reduction factor R:: 3
Soil Type:: Hard,medium,soft

Material Properties

Material grades of M35 & Fe500 were used for the design.

Loading on structure

Dead load :: self-weight of structure
Weight of 230mm wall
Live load:: Floor 2.5 kN/m²
Roof 1.5 kN/m²
Wind load :: Not considered
Seismic load:: Seismic Zone IV

Optimized Sizes of members

Column:: Hard soil - 1000mm x 500mm
Medium soil - 1200mm x 600mm
Soft soil - 1300mm x 600mm
Beam:: 300mm x 500mm
Slab thickness:: 125mm
Raft slab thickness::500*500mm
Pile size:: 80*80mm
Pile length:: 20mm
Pile cap size::300mm

Models to be considered for study are:

Model 1- RCC Frame with eccentric pad footing.
Model 2- RCC Frame with raft foundation.
Model 3- RCC Frame with raft and pile foundation.
Model 4- RCC Frame with pile cap and pile foundation.
Above types of foundation are analyzed for hard, medium and soft soil by conventional fixed base, winkler spring and FEMA 356 methods. So total thirty six models are prepared for analysis.

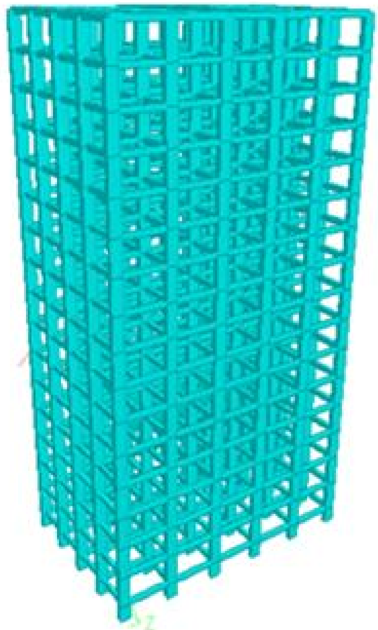


Figure 1 : 3D view of Model 1

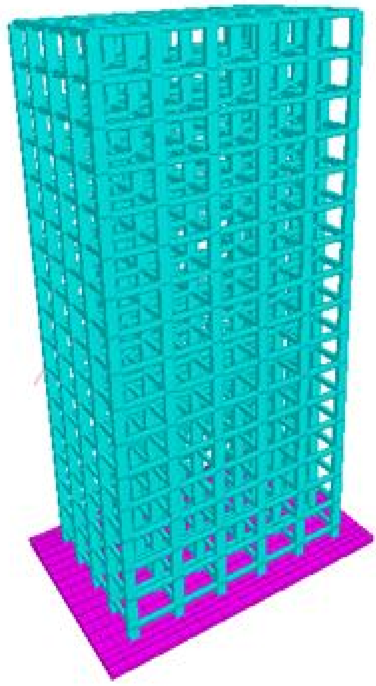


Figure 2: 3D view of Model 2

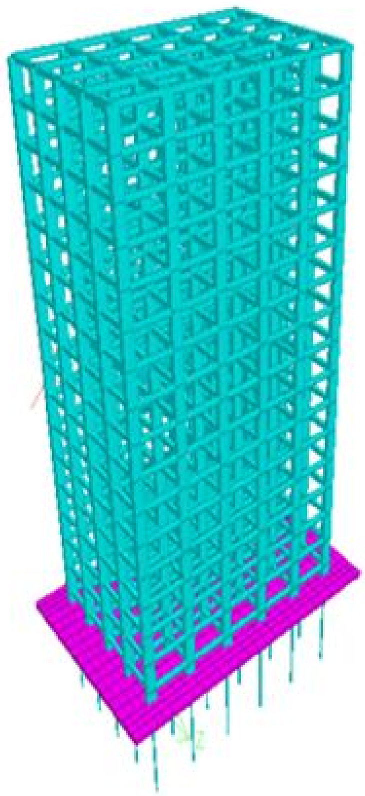


Figure 3: 3D view of Model 3

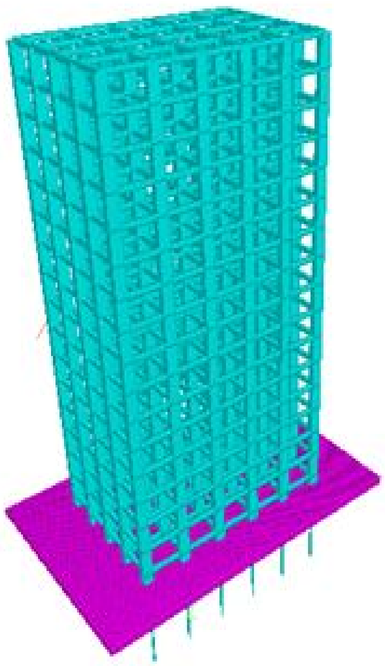
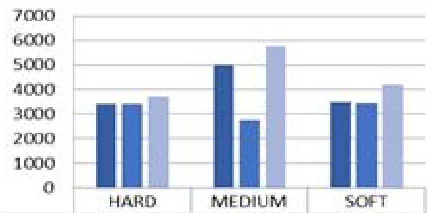


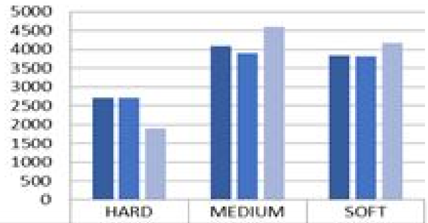
Figure 4 : 3D view of Model 4

V. RESULTS



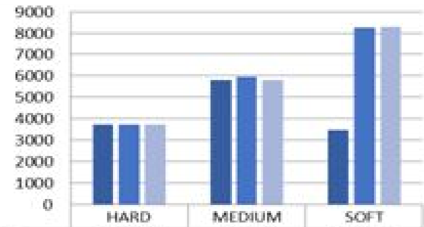
	HARD	MEDIUM	SOFT
FIXED BASE	3402.3	4996.97	3470.44
FEMA 356	3401.48	2754.32	3464.15
WRINKLER SPRING	3711.4	5749.5	4217.95

Figure 5: Base shear (kN) in X direction for RCC Frame with eccentric pad footing



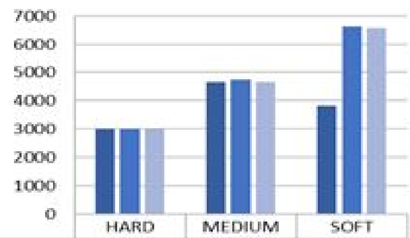
	HARD	MEDIUM	SOFT
FIXED BASE	2723.93	4078.91	3833.69
FEMA 356	2722.03	3906.38	3821.07
WRINKLER SPRING	1900.91	4597.53	4158.67

Figure 6: Base shear (kN) in X direction for RCC Frame with eccentric pad footing



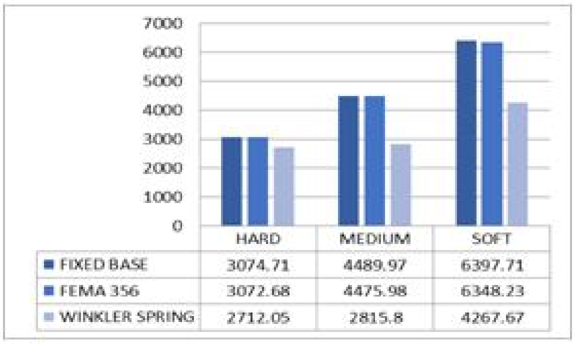
	HARD	MEDIUM	SOFT
FIXED BASE	3737.47	5823.71	3470.44
FEMA 356	3740.62	5940.33	8269.21
WINKLER SPRING	3738.37	5826.03	8270.35

Figure 7: Base shear (kN) in X direction for RCC Frame with raft foundation



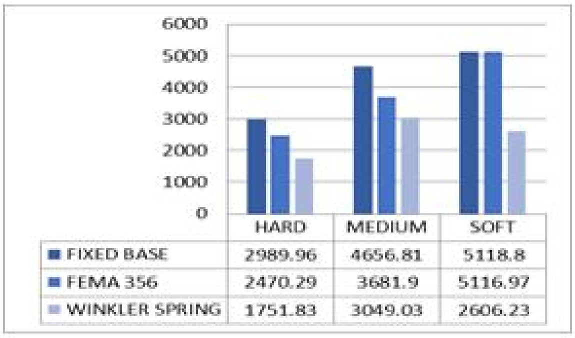
	HARD	MEDIUM	SOFT
FIXED BASE	2992.42	4655.21	3833.31
FEMA 356	2991.6	4754.53	6610.37
WINKLER SPRING	2989.96	4656.81	6568.8

Figure 8: Base shear (kN) in Y direction for RCC Frame with raft foundation



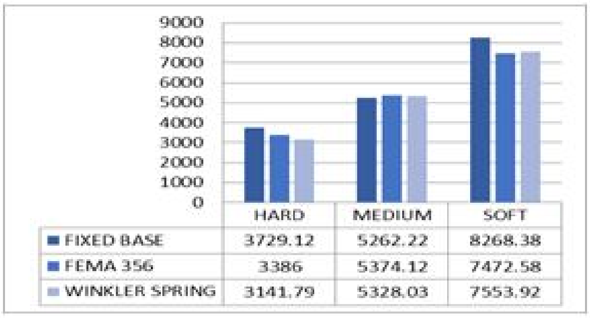
	HARD	MEDIUM	SOFT
FIXED BASE	3074.71	4489.97	6397.71
FEMA 356	3072.68	4475.98	6348.23
WINKLER SPRING	2712.05	2815.8	4267.67

Figure 9: Base shear (kN) in X direction for RCC Frame with raft and pile foundation



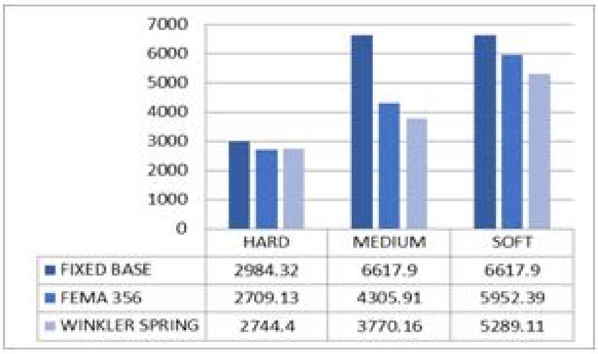
	HARD	MEDIUM	SOFT
FIXED BASE	2989.96	4656.81	5118.8
FEMA 356	2470.29	3681.9	5116.97
WINKLER SPRING	1751.83	3049.03	2606.23

Figure 10: Base shear (kN) in Y direction for RCC Frame with raft and pile foundation



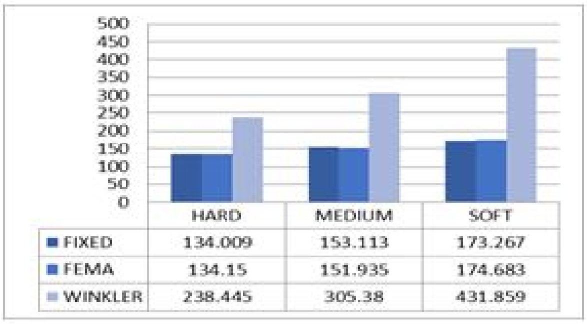
	HARD	MEDIUM	SOFT
FIXED BASE	3729.12	5262.22	8268.38
FEMA 356	3386	5374.12	7472.58
WINKLER SPRING	3141.79	5328.03	7553.92

Figure 11: Base shear (kN) in X direction for RCC Frame with pile cap and pile foundation



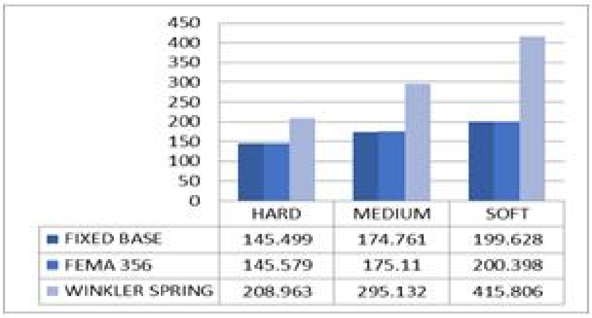
	HARD	MEDIUM	SOFT
FIXED BASE	2984.32	6617.9	6617.9
FEMA 356	2709.13	4305.91	5952.39
WINKLER SPRING	2744.4	3770.16	5289.11

Figure 12: Base shear (kN) in Y direction for RCC Frame with pile cap and pile foundation



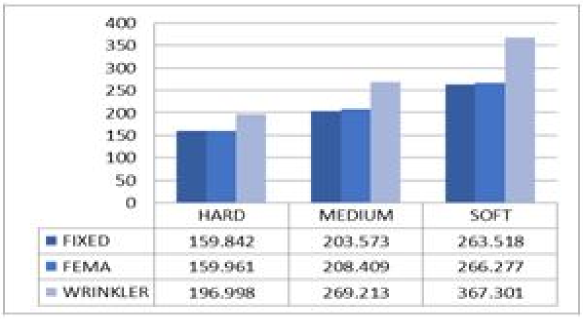
	HARD	MEDIUM	SOFT
FIXED	134.009	153.113	173.267
FEMA	134.15	151.935	174.683
WINKLER	238.445	305.38	431.859

Figure 13: Maximum lateral displacement (mm) in X direction for RCC Frame with eccentric pad footing



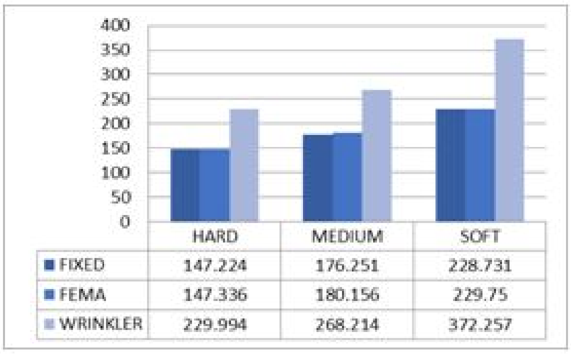
	HARD	MEDIUM	SOFT
FIXED BASE	145.499	174.761	199.628
FEMA 356	145.579	175.11	200.398
WINKLER SPRING	208.963	295.132	415.806

Figure 14: Maximum lateral displacement (mm) in Z direction for RCC Frame with eccentric pad footing



	HARD	MEDIUM	SOFT
FIXED	159.842	203.573	263.518
FEMA	159.961	208.409	266.277
WRINKLER	196.998	269.213	367.301

Figure 15: Maximum lateral displacement (mm) in X direction for RCC Frame with raft foundation



	HARD	MEDIUM	SOFT
FIXED	147.224	176.251	228.731
FEMA	147.336	180.156	229.75
WRINKLER	229.994	268.214	372.257

Figure 16: Maximum lateral displacement (mm) in Z direction for RCC Frame with raft foundation

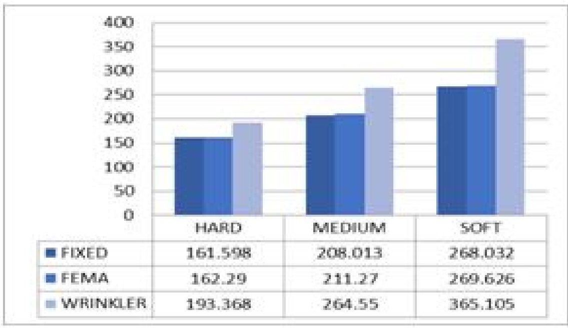


Figure 17: Maximum lateral displacement (mm) in X direction for RCC Frame with raft and pile foundation

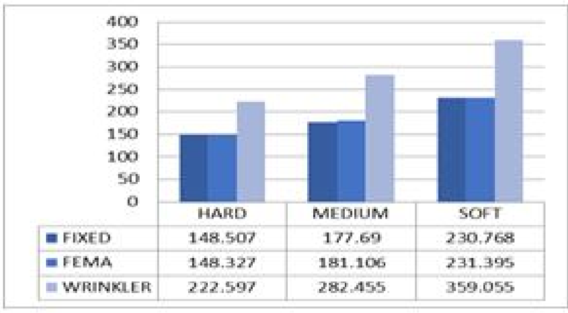


Figure 18: Maximum lateral displacement (mm) in Z direction for RCC Frame with raft and pile foundation

Figure 19: Maximum lateral displacement (mm) in X direction for RCC Frame with pile cap and pile foundation

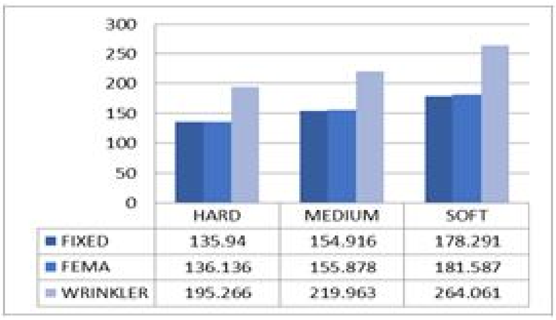


Figure 20: Maximum lateral displacement (mm) in Z direction for RCC Frame with pile cap and pile foundation

VI. CONCLUSIONS

1. **Base Shear** - Buildings with eccentric pad footing have less base shear compared to buildings with raft and pile foundation. Also base shear value is maximum for soft soil condition. In all winkler spring analysis shows maximum base shear value for all types of foundations.
2. **Lateral Displacement -** Buildings with eccentric pad footing have less lateral displacement compared to buildings with raft and pile foundation. Also lateral displacement is maximum for soft soil condition. In all winkler spring analysis shows maximum lateral displacement for all types of foundations.

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